UNIVERSITY OF GHANA, LEGON

WATER THIRST IN TESHIE AND THE DESALINATION INTERVENTION

BY

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DECLARATION

I, Lincoln Tei Nyade, with this declare that the content is a product of my original work and to the best of my knowledge, it comprises no part that has been formally accepted and awarded for a degree in the University of Ghana or other universities.

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DEDICATION

I dedicate this work to my family and friends; your tremendous support and encouragements to my academic journey give me a special feeling.

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ABSTRACT

Desalinated water is vastly being pursued globally to augment existing freshwater water supply in urban coastal areas. In Ghana, multiple small and large-scale water interventions have been implemented to diversify water portfolios in cities; increasing the reliability of the flow of water. However, embracing alternative technological innovations has intended and unintended consequences. Drawing on the access model and political-economy, the study assessed desalination as an alternative solution to the shortage in water supply, its result on water access, the local support for desalination, and coping strategies after the plant was shut down. The study employed a mixed-method approach with a cross-sectional descriptive design. Questionnaires were used to collect data from 329 households. The qualitative data constituted nine in-depth interviews and two Focus Group Discussions. Quantitative data were analysed with SPSS through a range of statistical methods such as univariate descriptive statistics, bivariate chi-square analysis and multivariate binary logistic regression and factor analysis.

The results showed that desalination generally improved water supply and increased access, however water quality was poor, leading to low support for the desalination. The study found an active dissatisfied social group in the community who disapproved of the water company's decision to restore the operations of the desalination plant. Although water challenges have not been entirely mitigated, citizens used diverse strategies to cope with the water situation after the desalination plant was shut down.

The study recommends that Befesa Ghana and the GWCL should restore the desalination plant and sustainably re-designed it to augment the existing water supply. Also, the quality of the desalinated water should be improved to generate more community support. Again, the study recommends that the GWCL and other stakeholders should educate the community to change their perception of desalinated water. The GWCL should also involve

the traditional council and other opinion leaders of the community in taking decisions concerning the desalination plant and water supply in Teshie.

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LIST OF ABBREVIATIONS

AVRL	**:**	Aqua Vitens Rand Limited
BDDGL	**:**	Befesa Desalination Developments Ghana Limited
BOOT	**:**	Build Own Operate and Transfer
CHFI	**:**	Cooperative Housing Foundation International
DWB	**:**	District Water Boards
EA	**:**	Electoral Area
EFA	**:**	Exploratory Factor Analysis
ERP	**:**	Economic Recovery Programme
GAMA	**:**	Areas in Greater Accra Metropolitan Area
GWI	**:**	Global Water Intelligence
GoG	**:**	Government of Ghana
GONU	**:**	Government of National Unity
GWCL	**:**	Ghana Water Company Limited
GSS	**:**	Ghana Statistical Service
HDIS	**:**	High Density Indigenous Sector
HH	**:**	Household Head
HQ	**:**	Head Quarters
IDA	**:**	International Desalination Association
IMF	**:**	International Monetary Fund
JICA	**:**	Japan International Cooperation Agency
JMP	**:**	Joint Monitoring Programme
LDMCS	**:**	Low Density Middle Class Sector
LWB	**:**	Local Water Boards
MDG	**:**	Millennium Development Goals

MDMCS	**:**	Medium Density Middle Class Sector
MENA	**:**	Middle East and North African countries
MWRWH	**:**	Ministry of Water Resources, Works and Housing
NGO	**:**	Non-Governmental Organisations
PHC	**:**	Population and Housing Census
PPP	**:**	Public-Private Partnership
PUB	**:**	Public Utility Board
PURC	**:**	Public Utility Regularity Commission
SDG	**:**	Sustainable Development Goals
TCCA	**:**	Teshie Concerned Citizens Association
TTC	**:**	Teshie Traditional Council
UN	**:**	United Nations
UNDP	**:**	United Nations Development Programme
UNEC	**:**	United Nations Economic Commission
UNICEF	**:**	United Nations Children Fund
UNDESA	**:**	United Nation Department of Economic and Social Affairs
UNEP	**:**	United Nations Environmental Programme
UNWWAP	:	United Nations World Water Assessment Programme
USGS	**:**	United State Geological Survey
WHO	**:**	World Health Organisation
WRADC	**:**	Water Reuse Association Desalination Committee
WSRP	**:**	Water Sector Restructuring Project
WWDR	**:**	World Water Development Report

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Providing adequate water to all human civilisation is one, if not the greatest challenge of the twenty-first century. As regards the 1977 water conference in Mar del Plata (Argentina), the United Nation (UN) declared that “All peoples, whatever their stage of development and social and economic condition, have the right to have access to drinking water in quantities and of a quality equal to their basic needs” (UN, 1977: 66). Under the circumstances of growth of cities, land uses and resource extraction, reforms on international frameworks such as Millennium Development Goals (MDG’s) and Sustainable Development Goals (SDG’s) continues to highlight the need to prioritise and make water readily accessible and sustainable.

Globally, demand for freshwater increases by 640 billion litres a year (Johnston, 2015). While the urban population is projected to be more than 8 billion by 2050, the freshwater stock is likely to remain unchanged (UNDESA, 2015; UNWWAP, 2018). Moreover, estimates show that 2 billion people use poor quality water (UNEP, 2016). Out of this figure, 36 per cent live in water-scarce regions (WHO/UNICEF/JMP, 2017). These indicate that the pressure on freshwater is a function of population growth and changing patterns of individual consumption (WWDR, 2018). In the face of the inefficiencies in conventional global water supply, desalination technology has emerged as a necessity (Wada *et al*., 2016).

Most developed and developing nations can consistently boost their water security through effective operations of traditional and emerging alternative means, such as desalination (MacArthur and Darkwa, 2013; Siska and Takara, 2015). Desalination is increasingly becoming a reliable water supply in arid and water scare regions, particularly, America, Europe, Australia and the Middle East (Ghaffour, 2009; March *et al.*, 2014; Gorjian and

Ghobadian, 2015; JICA, 2016; Heck *et al.*, 2016a). For instance, as cited in Haddad *et al*. (2018) in Perth (Australia), 47 per cent of its water comes from desalination plants (Water Corporation Desalination, 2014). Also, desalination provides Israel with about 85 per cent of domestic water (Marin *et al*., 2017). Comparatively, countries in Africa have little achievement in urban water security (Grey and Sadoff, 2006). Amid steady population growth in few countries like Morocco, Cabo Verde (*Cape Verde*) and Tunisia, unimproved economic growth has caused degeneracy in necessary urban infrastructure, notably, existing water infrastructure (UNEC, 2019). These countries, including South Africa, have applied desalination to mitigate drought crisis (Scheba and Scheba, 2018).

In 2010, Sub-Saharan African cities had only 35 per cent of households using tap water (WHO/UNICEF/JMP, 2010). Consequently, a significant proportion of inhabitants rely on relatively expensive informal sources coupled with uncertain quality (UNDP, 2011; Braimah *et al.*, 2018). The aggregated stock of water projects improved water access in Sub-Sahara from 83 per cent to 87 per cent between 1990 and 2015 (JICA, 2016). Despite the increase in access, the volatile political and economic landscape impedes meeting sustainable levels (Ndikumana and Pickbourn, 2017). Seeking alternative solutions to challenging water situation in Sub-Sahara Africa, desalination is noted to be a substantive adaptive model (JICA, 2016; Crookes, 2018). Given the circumstance, several North African countries such as Morocco, Algeria and Egypt have adopted desalination to secure their urban water supply particularly in the coastal towns (Schiffler, 2004; Trieb and Müller-Steinhagen, 2008).

Ghana has experienced slow urban water development, which culminated into forming a National Water Policy in 2007 (Bohman, 2010; Monney and Ocloo, 2017). Generally, water infrastructure lags behind current population growth; this has left marginal gaps in local service delivery (Doan and Oduro, 2012; Owusu and Oteng-Ababio, 2015; Gronwall, 2016). Despite these infrastructural challenges, communities in Accra have experienced water flow since

1915. In 1959, Accra experienced a severe shortage, which indicated that public water utility needed expansion to sustain future population (Amoah, 1964). Till today, residents of Accra have been very dependent on water supplied by public utility services, yet, still insufficient to meet the demand (Adank *et al.*, 2011; Stoler *et al*., 2012). This challenge compels people to adjust their living conditions due to diverse access to water (Peloso and Morinville, 2014). Coping with an irregular supply of water may vary significantly in different communities due to the differential water supply points and access capacities. Moreover, people rely on alternative means of accessing water as a survival instinct, particularly in the poor and informal urban areas (Ainuson, 2010; Stoler *et al.*, 2013).

Areas in Greater Accra Metropolitan Area (GAMA) including Adenta, Ashaiman, Nima, Teshie are areas that draw a thought-provoking paradox in the water landscape (Fiasorgbor, 2013; Peloso and Morinville 2014; Manu, 2015; Ablo and Yekple, 2018). Geographically, these areas are within the catchments of Weija and Kpong water treatment facilities, yet, communities in this catchment have limited access to water. The apparent remark about the current state of water suggests that every effort to improve existing shortage in water supply and its corresponding access have been a significant challenge. So far, efforts to reform urban water delivery has long persisted (Bohman, 2010; Chan and Effah, 2013).

Following the model of alternative water of other countries, the desalination facility has been used to augment water supply (Water Technology, 2015). This alternative method was a substantive attempt to eliminate water shortage. The plant was designed to supply 13.2 million gallons of fresh water to about 500,000 residents in Teshie and other sections of the city (Befesa Ghana, 2011). The cessation of the plant resulted in diverse coping mechanisms. The study interrogates the role of desalination on water access and its associated coping methods when the operation of the plant ceased.

1.2 Problem statement

Securing and maintaining an acceptable level of water supply in Accra continues to be a growing concern. Notwithstanding government and private sector resource commitment, the deficiency persists; a status quo that demands a more conscious and systematic approach to resolve. The SDG's set in 2015 necessitated a complete potable water coverage by the end of 2030 for all countries including Ghana. While water coverage was 64 per cent at the time, domestic water demand was projected to reach 5 billion m^3 by 2020 (GoG, 2014; Kusi *et al.*, 2015).

Actors in the water sector tend to focus on meeting urban water needs through infrastructure expansion and augmentation. However, uncontrollable population growth in cities has outpaced infrastructural development and therefore has limited government's ability to provide adequate amenities (Owusu and Afutu-Kotey, 2010). This impediment has induced citizens, particularly the urban poor, to access water from diverse and unsafe sources (Emenike *et al.*, 2017). Consequently, accessing water from doubtful sources may potentially expose people to water-related diseases—diarrhoea, cholera and typhoid, contributing to 70 per cent disease burden in the country (Günther and Schipper, 2013); posing severe sanitation and public health concern (Boateng *et al.*, 2013).

Teshie (particularly the southern part/Teshie south) epitomises this state of affairs, where the population has been battling inadequate water supply. In an attempt to ameliorate the water situation, GoG first implemented institutional reform through a funding partnership with the World Bank and International Monetary Fund (IMF) (Hirvi and Whitfield, 2015). From thence, there have been alterations in water arrangements where state and non-state apparatus have collaborated to recuperate urban water supply through a Public-Private Partnership (PPP) (Ainuson, 2010; Dapaah and Harris, 2017; Bediako *et al*., 2017). A classic example was the mandate given to Aqua Vitens Rand Limited (AVRL) to oversee urban water management from 2006 to 2011 (Harris and Morinville, 2013). Later there were small-scale water interventions such as drilling of boreholes, and overhead tanks in some communities. For instance, Teshie camp tapped water from overhead tanks filled with groundwater. Similarly, a pipe project in Sagonaa (Old Teshie) worth Gh₵ 30,000 was implemented to ease the water stress (The Chronicles, 2011).

Since the problem is protracted, the conventional scheme of water supply could not be solely reliable. As the GoG continued to encourage PPP, the framework stimulated the water sector to subscribe to actualise more alternative water schemes (GoG, 2014). Ghana Water Company Limited (GWCL) in partnership with Befesa Ghana under Build Own Operate and Transfer (BOOT) contract commissioned the desalination project in 2015 to augment the level of water supply in Teshie and the surrounding towns (Taylor, 2017). Notwithstanding, the overarching purpose of the desalination project to immediately provide adequate water supply and intensify water access for communities within its catchment, its operation was curtailed nearly after three years; resulting from financial distress (Water Desalination Plus Reuse, 2018; Daily Graphic, 2019:3). Desalination was a large scale and a cost-effective alternative to conventional water supply, its potency in alleviating water stress cannot be overlooked. It is therefore unclear whether the desalination plant achieved its intended purpose of improving water supply and increasing access.

Several researchers have studied the awareness (Aldaghma and Montano, 2018), acceptance (Hurlimann and Dolnicar, 2010b; Dolnicar *et al.*, 2010; Gibson *et al.*, 2015; Hurlimann and Dolnicar, 2016), domestic use (Fielding *et al*., 2015; Shomar and Hawari, 2017), local support (Heck *et al.*, 2016a), and opposition (Hurlimann and Dolnicar, 2010a) of desalination in other countries. However, in Ghana the commercial and, or domestic use of desalination is novel. Very little of the previous research on alternative water supply (Abbey, 2013; Alexander *et al.,* 2015; Dwumfour-Asare *et al.,* 2017; Dwumfour-Asare *et al.,* 2018) could examine issues concerning its implementation. What appears to be absent in alternative water-related literature in the Ghanaian context is the revolution of desalination on water supply and access, its uses and local support. With this background, the research seeks to investigate the role the desalination project on water supply and access in Teshie, the local support for the plant and the coping strategies employed by citizens after the project was shut down.

1.2 Research Questions

i. What is the nature of water supply and access in Teshie before and during the operation of the desalination?
ii. How does the use of desalinated water affect local support for the desalination in Teshie?
iii. What coping strategies have the population adopted after the shutdown of the desalination plant at Teshie?

1.4 Main research objective

The main objective of the study is to assess the role of the desalination project on water supply and access in Teshie.

1.4.1 Specific research objectives

Specifically, the research seeks to:

i. Examine the water supply and access in Teshie before and during the desalination.
ii. Ascertain the uses of desalinated water and its effect on support for the plant in Teshie.
iii. Ascertain coping strategies adopted by residents of Teshie after the desalination project was shut down.

1.5 Hypothesis

i. H_o: There is no statistically significant relationship between demographic variables (gender, education, occupation and income) and awareness of desalination.

   H_a: There is a statistically significant relationship between demographic variables (gender, education, occupation and income) and awareness of desalination.

ii. H_o: There is no statistically significant relationship between willingness to pay for desalination and support for desalination.

   H_a: There is a statistically significant relationship between willingness to pay for desalination and support for desalination.

1.6 Justification

Nations inclinations towards adopting desalination technology to support conventional water supply are increasingly becoming unavoidable in both developed and developing countries especially the Middle East and North African countries (MENA) where drought is pervasive (Shomar and Hawari, 2017). Irrespective of demographic characteristics, through this research, the potential benefits of the project become visible. The researcher is optimistic that the result of the study will help Teshie citizens and other communities within the catchment of the desalination achieve high access to potable water. Also, the research could provide useful information to institutions such as GWCL (district and national level), Non-Governmental Organisations (NGO's) and all other stakeholders on the impact desalination plant has on the economy and national development. The findings of the study could benefit the GWCL and PURC in policy formulation, particularly discussions about large-scale alternative water and the restoration of the desalination plant. The importance of this study to provide an academic reference for further studies on the topic area cannot be dismissed, especially in Ghana and West Africa, where desalination is practically becoming an urban alternative.

1.7 Delimitation of the study

There are numerous communities within the catchment of the desalination plant. The thesis is centred mainly on how improved or recessed access to water became during the operational period of the desalination plant. Also, the study further investigated specific coping strategies and factors of coping of residents after the project was shut down. Most of the research delimited to the timeline of the desalination. What the study could have included was the processes of producing water, based on energy efficiency and environmental impact. However, the study did not cover that, since time and resource would not permit the researcher.

1.8 Operational definition of terms

Water Thirst: The study operationalises "Water Thirst" to underscore the issues or challenges in water supply and access.

Desalination: The study's definition for the term "desalination", is a technological process for subtracting minerals and salt concentration from sea/brackish water to make it consumable for human population (Nair and Kumar, 2013).

Water quality: The study defines water quality to encapsulate the level of salt concentration, smell, colour and particles in fresh/desalinated water.

1.9 Organisation of study

The organisation of this thesis comes in five chapters. Chapter one includes the background of the study, problem statement, research questions, the main and specific objectives, hypothesis, justification, delimitations, operationalisation and organisation of chapters. In chapter two, the study presented the literature highlighting areas concerning water supply and access and issues in desalination and coping strategies. This section also included discussions of theoretical and conceptual perspectives that guided the structure of the study. The next chapter, which is chapter three was essential to the study. Here, research methods adopted for the study was detailed—study area, research philosophy, research strategy, research design, sampling design and sampling size, data and sources, research instruments used for data collection, data processing and data analysis. Chapter four concentrated on discussions of results—demographics of households, water access, water supply, awareness of desalination, use of desalinated water, support for desalination and coping methods. Again in this chapter, discussions of the results were presented based on the objectives. Chapter five summarises the findings. The chapter further concludes and makes recommendations and suggest inclusion for future research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section of the study delved into the research literature on resource availability and water supply, development of water system and infrastructure, actors in water supply, urban water supply, water access and desalination as an alternative water source from developed and developing nations and coping strategies adopted by households. The chapter presents arguments and contents in a manner that elicits the patterns in understanding the subject. The chapter also canvasses the theoretical and conceptual perspective that guides the entire work.

2.2 Water resource availability and water supply

The water resource is the total of all naturally existing water with potential domestic, agricultural and industrial usage (Pimentel *et al.*, 2008). The earth holds more than 326 trillion gallons of water resources (Eppehimer, 2015). Potable water production uses water resources as raw materials. Naturally, these stocks of resources result from precipitation, even so, cumulative global freshwater is estimated under 3 per cent with only 1 per cent obtainable for humans including both surface and groundwater (USGS, n.d.; Wong and Pecora, 2015). As climate change and economic conditions intensify, a significant amount of global water resource is threatened (Haddeland *et al.*, 2014). Regions found to have vast heterogeneous agricultural practices, demographic and industrial development compounds catalyses resource scarcity (AghaKouchak *et al.*, 2015). Africa continues to have a share in both surface and groundwater repository used to support all facets of human and national development, particularly in water supply nexus. But judging from its annual renewable water resource, the possibility of drought could potentially jeopardise the route to achieving the most sustainable agenda (Gan *et al.*, 2016). In the Ghanaian scenario, surface and groundwater remain copious. The total amount of renewable resource is estimated at 53.2 billion m^3 per year (GoG, 2014). Most of the city's water is treated and transported from three river system drains in different catchments in the country (39.4 billion cubic meters per year) (MWRWH, 2007).

These categories are Coastal, Volta and South-Western river system is 8 per cent, 70 per cent and 22 per cent in proportion (MWRWH, 2007; Lacombe *et al.*, 2012). The vast expanse of surface water in the country is of great importance to its citizens. Aside from the use of surface water, extraction of groundwater resources is about 95 per cent predominantly by rural residents (Awuah *et al.*, 2014). Since water resources abound, a couple of devastating issues like river degradation and environmental pollutions affects the quality of water resources (Kusi *et al.*, 2015). For example, a direct consequence of continuous mining has led to the poisoning of water aquifers through embedded chemicals and metals in the water table (Awuah *et al.*, 2014). In reality, Ghana has water resources to support the population, but this has not manifested in the quantity of water supply, as citizens continue to maintain that water supply is insufficient. Reaching a balance between supply and demand continues to be challenging, although significant efforts have been made by the state and non-state agencies to improve the situation.

2.3 Development of water system and infrastructure

Water systems development is retrospective, tracing the pre-independence era after 1920. Cape Coast and Accra became the earliest urban centres to have pipe water infrastructure (Bohman, 2010; Ocloo, 2011). Later, the water infrastructure extended to three urban centres (Tamale, Sekondi-Takoradi and Kumasi) who were developing fast in terms of economy and population or settlement. A catalogue of interventions in the sector from pre-independence to present day includes socio-economic, political and transboundary relations to serve the interest of urban inhabitants. Before political independence, the entire country had 35 water systems of urban concentration (Fuest and Haffner, 2007). In about two-decade pipe water system had increased by 68 per cent, indicating 194 pipe water system (Amoah and Yahaya, 2013). Between 1980 and 1990, a significant number of water systems had retrogressed as a consequence of poor maintenance and inadequate financial support.

Through external funding agencies within Africa and Europe, some of the systems were rehabilitated (Chan and Effah, 2013). Other structural transformations were implemented in the framework of the WSRP; thus, the Water Sector Restructuring Project. After the projected inception, the primary and immediate task was to reduce the loss of water during transmission and at the same time, train workers to achieve high efficiency (Amoah and Yahaya, 2013). In the early 2000s, public-private sector participation that became inept in 1990s rejuvenated to improving urban water services. The assurance in a Public-Private Partnership this time featured a partnership of GWCL with AVRL in a five-year management contract.

2.4 Actors in urban water supply

In Ghana, the Ministry of Water Resources wields a legitimate mandate to facilitate and coordinate stakeholder's activities which encapsulates discrete yet occasionally overlapping decentralised functions. Key institutions responsible for urban water are; GWCL, Public Utilities Regulatory Commission (PURC) and Local Water Boards (LWB) (MWRWH, 2014; Morinville and Harris, 2014). As an active functioning body, GWCL is mandated to supervise water treatment, its storage and distribution for domestic and industrial uses. They implement strategic investment in urban water system most notably, establishing a network of pipelines (MWRWH, 2014). Bearing in mind that, water utilities have to be evaluated, PURC is authorised to regulate water pricing and periodically review utility prices and monitor performance standards of formal and informal water providers. These actors regularly function at a national level yet, coordinates affairs in urban districts.

The LWB's were established in 2007 by GWCL structured for potential water-related decision at the local district level. They also govern and liaison water-related arrangement for the specific district (Harris and Morinville, 2013). These statutory boards are predominant in Accra. Teshie LWB is one of the very active and vibrant forerunners inappropriately serving the community with water due to the districts constant challenge in ongoing water discussions. Subsequently, organisations like the Cooperative Housing Foundation International who are non-governmental established other water boards similar to the LWB (CHF-Ghana, 2012). Examining how fragmented urban water challenges are; consisting inherent locational variance, stakeholder functions and the structure of LWB is disproportionate. Their primary task is to promote the resident's participation in water-related discussions. Irrespective of how relevant LWB's are in the governance of urban water, for years it has been apathetic. For instance, a study by Harris and Morinville (2013), discovered that 84 per cent of residents failed to recognise the importance to participate in a water-related discussion on the tickets of LWB. Considering this skewed demotivation to participate, indeed, political, demographic and socio-economic reasons may be a distinguishing factor but not exhaustive to this level of the detachment of community members in water-related issues. However, in desperate water stress conditions, the LWB implement ad hoc solutions before any significant intervention.

2.5 Urban water supply

A well-organised water supply ameliorates coverage. As a consequence, exudes positive impacts on the health of individuals (Bartram and Cairncross, 2010). Even so, the performance of water supply could be satisfactory and progressively effective if dissociated from influencing factors such as population growth leading to urban sprawl and increased urban appendages. Unfortunately, water supply encounters rapid demand coupled with deteriorating treatment plants (Amoah and Yahaya, 2013). To this end, GWCL reaches only 60 per cent of water required daily by urban people (Peloso and Morinville, 2014). A more recent survey such as that conducted by Oteng-Ababio *et al.* (2017) noted that only 50 per cent of the daily water demand is supplied to the residents of GAMA. Understanding about the causes of urban water shortages remains unchanged, where the operations of state utility providers continue to be impaired by low investment, managerial, financial and technical ineptness (Adank *et al.*, 2011; Amoah and Yahaya, 2013; Acheampong *et al.*, 2016; Oteng-Ababio *et al.* 2017).

Dapaah and Harris (2017) furthered the discussion by adding that, anomalies in the municipal water supply and distribution are not the cause of declining ground and surface water. However, the enumerated challenges mentioned above are not mutually exclusive. Arguably, in focusing on the role of technical support as one of the bridges to urban water supply, attention needs to be given to the fact that, till date, most studies on the subject lacks clarity on infrastructural interventions and its portion in the urban water supply/demand nexus. Recent literature suggests a more conscious and capable community-based water supply to promote innovation in the water industry, combining the power of public and private partners (Adams *et al.*, 2018).

2.5.1 Water situation in urban Ghana

Urban areas in Ghana have a peculiar situation concerning water provision. A classic example is a situation in Accra and other urban centres. Almost all the communities in Accra are supplied with water from a couple of sources: Weija water plant in the Densu catchment and Kpong water plant in the Volta catchment (Lundéhn, 2008). Water supplied from these two treatment plants is far from being uniform in distribution. Few areas, particularly wealthy neighbourhoods can access adequate water and also have an efficient means of storing water.

However, a significant number of poor communities rely on close neighbours, vendors, tanker operators and sachet water to access water (Stoler *et al.*, 2015; Nyarko *et al.*, 2016). Meanwhile, any long-run utility tariffs which are sometimes subsidised only benefits middle and wealthy class leaving the poor communities to even pay higher prices for water (Nyarko *et al.,* 2009; Amankwaa, 2016).

2.5.2 Pipe network and distribution of water

Modes of network and distribution channels are key drivers that determine the current water situation in different areas of the city. Distribution systems include a layout of complex networks of pipelines through which clean water is made accessible in required volume to customers (WaterAid, 2012). Pipe networks classification comes in three classes depending on the structure of layout; these are grid ring, radical and dead-end commonly identified in planned areas. But, in the most informal settlement and haphazard new developing areas, network and distribution are daunting when houses are unintended with poor design (GoNU, 2009). Aside from poor urban planning, unreliable power and cost of connection impact the laying of pipelines which affects distribution in the long run (Foster *et al.*, 2012). Additionally, geographical location and situational factors of an area may have an undesirable or positive influence water distribution (Bakker, 2012; WaterAid, 2012; GWCL, 2018). Again, aside from altering distribution patterns, geographical location (*the long distance on the distribution chain*) may lead to contamination of water in the pipeline through sewage intrusion in areas of poor sanitation (Huang *et al.*, 2011).

2.5.3 Reliability of water

Regular and dependable water supply is considered to represent a situation where the network of pipelines and distribution of water is not only in vast amount but also consistent.

The fractional achievement of few MDG goals at the end of 2015, included vital indicators such as "improved water sources", yet regular water supply has been dramatically absent (Hutton and Chase, 2016; Majuru *et al.*, 2016). Facts or statistics on water reliability may be fragmented at the individual country level. Kumpel and Nelson (2016) noted that globally 300 million people receive water for less than 12 hours in a day with the majority in developing countries particularly Sub-Saharan Africa. Without excluding Ghana, these current issues in the Sub-Saharan region were prevalent (see WaterAid, 2005).

In one study, Nyarko *et al.* (2008), found the reliability of water supply in cities are erratic, largely in the capital. Their survey indicated that on weekly basis, 33 per cent of the people acquired water 1-2 days, between 3-4 days, 16 per cent gained water, 6 per cent of them received water between 5-6 days and 17 per cent received water every day. Similarly, WaterAid (2008) report in Accra, Ghana, noted that about 25 per cent of its inhabitants received uninterrupted water supply, about 30 per cent receives 12 hours daily each day, another 35 per cent receives water for two days per week, and the last 10 per cent of peri-urban characteristics which do not get supplied at all. Interestingly, unreliable water supplies are not conducive to coping strategies, dealing with costs and the willingness of families to pay water bills (Dutta and Tiwari, 2005).

2.5.4 Quality of water

Water quality standards are critical for the wellbeing of humans. There are international standards or guideline for the quality of drinking water. World Health Organisation (WHO) further recommends individual nations to establish their standards using safety parameters designed by them (WHO, 2004). Water quality for domestic purposes may deteriorate because of ineffective policies to enable appropriate implementation (Pedley *et al.*, 2011). For a long time, the quality of urban water has been perceived good, a positive consequence of the growing competence of consumers. The extent to appreciable quality of water is continuously compromised by several sources used as raw materials embedded with heavy anthropogenic and microbial contaminants (Shah *et al.,* 2007; Arnold *et al.,* 2013). Heavy pollutants, therefore, degrades these raw water sources, which may increase treatment cost (Ebdon *et al.,* 2007). There is little knowledge about the correspondence between water quality information and its impact on customers usability of water. However, according to Kumpel *et al.* (2016), pipe water quality is still perceived as improved amongst other sources in the Sub-Saharan African countries.

2.6 Water access

Global consensus on improved water access, including proper sanitation, underpins different sustainable development agenda for 2030 (WHO/UNICEF, 2017). Exploring our understanding of water access, WHO/UNICEF (2017) highlights what access means regarding the share of the population utilising an improved source of water irrespective of the location. From an international perspective, levels of access to unharmful water are burgeoning. As expected, at the end of 2015, over 91 per cent of inhabitants of city centres had access to potable water (WHO/UNICEF, 2015). Also indicated about better-quality water sources, 5.2 billion people were able to access water on their premises which came from non-contaminated sources (WHO/UNICEF, 2017).

The water experience of the global south challenges the narrative of world water access. Thus over 633 million people still face challenges in accessing safe water (WHO/UNICEF, 2015; Alagidede and Alagidede, 2016). Several African countries have been slow in attaining acceptable levels of improved water access (Alagidede and Alagidede, 2016). Despite some African regions having low water access, the situation in the Sub-Saharan region cannot be negligible; thus, only about 55 per cent have access to potable water (WHO/UNICEF, 2014).

Consequentially, these severe backdrops instigate poor health, leading to water related disease and mortalities, particularly in rural areas (Alexander *et al.*, 2015; Kumpel *et al.*, 2016). A case in a study in Senegal, Cameroon and Chad support linkages of low water access to health problems. There was a positive statistical significance established with the likelihood of infantile diarrhoea (*children below five years*) of figures 1.27, 1.29, and 1.03 per cent to households with difficulties in water access than houses who have easy access (Ntouda *et al.*, 2013). Although Sub-Saharan and other African countries have a huge commitment towards mitigating lapses in water access and taking many positive results in improving water sources, the lack of direct in-house pipe connections in urban areas remains critical (Hope and Rouse, 2013).

2.6.1 Accessing water in Ghana

Stability in economic growth has stimulated substantial progress in utility service delivery, specifically water infrastructure. Apart from the existence of infrastructure, allocation and distribution of water are influenced positively or negatively by institution frameworks and political determination (Dos Santos *et al.*, 2017). One or more of these determinants, together with donor support, has projected the state's access to harmless and potable water as progressive, yet not steady. In the ending of the 1990s and early years of 2000s, reaching to safe and clean water in urban areas improved. This improvement was marginal; thus, 9 per cent (84 to 93 per cent) (Mosello, 2017). Surprisingly, different parameters have proven different results where “safe drinking” water in urban Ghana improved from 59.0 per cent in 2009 to 63.4 per cent in 2012 (GoG, 2014) and by the end of 2017, the figures had improved to 82.9 per cent (Mosello *et al.*, 2017). Although this improvement is noteworthy, such values are still unsatisfactory, given the current growth in the urban space. As at now, GWCL is not able to meet above 60 per cent of municipal water demands (Peloso and Morinville, 2014). Therefore, even if the country strives to achieve sustainable water resources, daily access to water is still far below satisfaction. As state institutions are stifling with low investments and managerial constraints, meeting the required water needs will be interrupted (Acheampong *et al.,* 2016).

2.6.2 Women and children involvement in water access

Another critical issue associated with old and current water literature concerns time and resource expended by women and children in managing household water. A lot of attention has been giving to research on the burden of women and children finding water for their household. For advanced countries, such household burden may sporadically occur. In growing regions with persistent water irregularities, women and children are burdened with accessing water for their household depending on family size, income, distance to a water source and season **(**Sorenson *et al.,* 2011; Gambe, 2019). A study in India found that a considerable number of women are deprived of access to water. Those who have access can increases their livelihood income by 14 per cent when the time for water collection is less (Sijbesma *et al.,* 2009). Exemplifying this Indian study parallels their African counterpart as not far off. Out of a figure of 71 per cent of households who are disadvantaged in access to water in Somalia, 66.4 per cent of them are women.

In the same way, Nigeria recorded a proportion of 46.6 per cent and 51.9 per cent women who are completely deprived of water and out of the total cannot access water. Other countries such as Sierra Leone recorded 53 per cent of women out of 69.8 per cent of the entire population who do not have access and lastly, in Mauritania, the numbers were 49.5 per cent out of 70.5 per cent (Sorenson *et al.,* 2011). Concerning this fact, it is clear that women protect the family because they are central in household water use. Notwithstanding, easy access to safe water truncates truancy of school pupils (Rathika and Mohanasundaram, n.d.). Most of these children are burdened by continuous-time exhaustion (Dill and Crow, 2014).

2.7 Linkages of water intervention and level of access

Sustainability of water infrastructure and equality are two contemporary areas emerging as globally accepted approaches to address issues in water access and solving multifaceted water challenges (Roa Garcia, 2014; Wilder *et al.,* 2016; Carley and Spapen, 2017). The fundamental importance of this trend is to provide a platform for which the urge to accelerate achieving goals of "all-inclusive water access" set forth by the SDGs. Even as management and policy are diverse in this particular subject, the year 2015 witnessed more than 750 million people in the world's total population have less access to potable water. It has been possible because the infrastructure for water supply in both developed and developing world are aged assets constructed over several decades (Boyko *et al.,* 2012). Refurbishment and expansion of infrastructure are needed to cope with current conditions and the uncertain future.

Until now, bankroll sponsorship towards other social infrastructure are miles ahead of governmental and private financing for water supply and sanitation (Kumasi, 2018). Whiles state utility service providers may encounter severe bureaucratic structures; private investors may also contemplate on the risk of tariff adjustment, fluctuations in currency and exchange rate devaluation which diminishes water intervention strategies (World Bank, 2015). By default, jurisdictions where water interventions in terms of infrastructure are proliferated, water access significantly upsurges (Veerkamp *et al.,* 2018). Veerkamp and colleagues further opine that for any large-scale municipal water interventions to reflects the complexities of how access levels could be influenced, timelines of these diverse interventions need to be communicated effectively to affected areas.

2.8 Alternative water options to conventional water

Increased uncertainty in water resources has forced water service providers of water-stressed nations to implement non-traditional alternatives. Predominantly, these alternatives are wastewater use, water recycling and desalination. Alternative water has thus become the opium of the world's renewed hope for sustainable water for current and future economies. To successfully implement an efficient alternative water strategy, the need for public support is indispensable (Dolnicar and Hurlimann, 2011; Fielding *et al.,* 2018). Alternative water supplies are limited but relevant to nations water supply and access portfolios (McCann *et al.,* 2018). Yet, not many nations use large-scale alternative (*recycled wastewater and desalination*) to augment their traditional water supply, most notable ones perhaps would be seen in stable economies like Singapore (See PUB, 2014) and the United States, where alternative water provides 3 per cent of domestic and agricultural water supply (McCann *et al.,* 2018). Although the significance of wastewater use cannot be overlooked, Gibson and Burton (2014) posit that many wastewater schemes have backfired in some areas due to mistrust and low acceptance. In a scenario reported by Christen (2005), wastewater treatment in San Diego in the 1990s bottlenecked due to public apathy and poor attitude. Despite the burgeoning use of recycled water and to an extent mechanised rainwater, several decades evidence suggests desalination has leapfrog any other largescale municipal water alternative.

2.9 Desalination

Desalination is a technological process of using energy to remove dissolved minerals and salt in the sea or brackish water to be "pure" for human consumption (Hetal *et al.,* 2014; Fragkou and McEvoy, 2016). Water source and salinity of the desalination process are broadly categorised into seawater (59 per cent) and brackish water (21 per cent) (Hetal *et al.,* 2014). Desalination requires high-levels energy for production, making it less feasible particularly for economic dependent nations (Kalogirou, 2001; Dolnicar and Hurlimann, 2011). Although sea or brackish water treatment is not a panacea for water scarcity, the impetus to use desalination has increased intensely over the past decade. Globally, desalination has produced 80 million

m^3/day of freshwater that served more than 300 million people aggregated between 2008-2013 (March, 2015). By 2016, the total accumulation of installed plants was 18,426 producing at 86.5 million m^3/day (Hamilton, 2017). Saudi Arabia alone occupies 26 per cent desalination operations of the world's total (Al-Zahrani and Baig, 2011).

The pursuit of alternative water continues in different parts of the world and has been strategically adopted in much of the Middle East. It, therefore not an overemphasis to mention that the Middle Eastern region has more desalination installation due to their unfavourable geographical landmark yet also economically viable (Hanasaki *et al.*, 2016). There is evidence of a potential spread of seawater desalination due to lower costs. This strategy has been possibly feasible due to gradual, yet improved technology leading to the cost-effective assembling of the plant (Drouiche *et al.*, 2011) even driving to decline in production cost concerning treatment and distribution (Ghaffour *et al.*, 2013; Burn *et al*., 2015).

Aside from the potential for desalination to avert desperate water conditions, its anticipated quality continues to improve. Since its inception, the quality and safety of water for domestic, agricultural and industrial uses is adequately improved (Swyngedouw, 2013). Regions that have integrated desalination to their national grid have the potential to lessen the poor quality of freshwater from the local civil perspective that desalination inherently constitutes a green technology (McEvoy, 2015). Where sole property, ownership and control facilitate the construction of treatment plants **(**Kloppmann *et al.*, 2018).

In Africa, excluding some parts of North Africa and South Africa (see, Schoeman and Steyn, 2003; Damerau *et al.*, 2011), desalination is not much used in the West Africa sub-region, due to less desperate conditions linked to the scarcity of water resources. Although most urban settlement close to the coast are already experiencing inconsistencies in water supply, desalination options are less pursued (Nyarko *et al*., 2016). It is, however, vastly being considered as an encompassing policy to face impending water scarcity at least within coastal areas.

2.9.1 Linkage of trust in desalination plants to consumption

In the not too distant future, new innovative low energy-efficient technology will dominate urban water supply. These may include but not limited to Reverse Osmosis (RO) (Greenlee *et al.*, 2009; Shemer and Semiat, 2017), Forward Osmosis (FO) (Coday *et al*., 2015) and Membrane Distillation (Spa and Sud, 2011; Schwantes *et al*., 2013; Duong *et al*., 2017). Between 2001 and 2013, desalination water production was extraordinary, constituting an increase from 32 million m^3/day to about 75 million m^3/day and expected to reach 120 million m^3/day by 2020 (Shomar, 2013). This milestone is possible due to rapid growth in different varieties of plants of over 70 per cent increase in installation since 2001: Reverse Osmosis (RO) alone secures a nearly perfect monopoly of 63 per cent of all installation (Gude, 2017).

Countries are now up for desalination model in their respective water sector; which has come to be a futuristic option towards urban water supply sustainability. Zotalis *et al.* (2014), have maintained that recently desalination had significantly increased domestic consumption of seawater. For instance, in 2017, drinking of desalinated water was figured at 585 mm^3/year (Marin *et al*., 2017). Substituting long-standing municipal water supplies with alternative desalination for consumption may be profound in terms of development and nation-building. Desalination is increasingly utilised for drinking based on increasing freshwater scarcity (WHO, 2011). In Saudi Arabia, 4 per cent of total water supplied and 30 per cent of household water consumption is accessed from desalination plants (Al-Zahrani and Baig, 2011). A multiplicity of factors influences the level of consumption of desalinated water such as cultural or ethnicity, age, gender, intellectual competence and even spirituality (Dolnicar *et al.*, 2011; Fielding *et al.*, 2018). As cited in Morote Seguido *et al*. (2017), the International Desalination

Association (IDA) reported that globally 300 million people drink desalinated water, but in no small extent, desalinated water uses are essential for other domestic purposes rather than drinking. To this time, places where desalination predominates conventional water supply, people become confused about their choices. For instance, in an Australian study, citizens were willing to utilise desalinated water. Nonetheless, they become conservative about its potential effect on the environment and health care (Dolnicar and Hurlimann, 2009). In a further study using a comparative schema for alternative water sources, Dolnicar and Hurlimann (2010), found that drinking water from the desalination plant is appreciated compared to recycled water. Additionally, Marks *et al.*, (2008) conclusion on drinking desalinated water in their study was that 91 per cent of respondents would drink desalinated water where precisely 51 per cent of them are within the city limits.

Despite this positive feedback, consumers still feel information and knowledge are inadequate to make a non-bias judgement on account of trust. Finding from two Latin American studies concludes that confidence in the desalination is absent (Fragkou and McEvoy, 2016). Their findings corroborate Australian research in 2009 (See Dolnicar and Hurlimann, 2009). Aside from the trustworthiness, Fragkou and McEvoy demonstrated the linkages of trust in manufacturing companies to consumption where, even with state-of-the-art treatment plants, a significant portion of consumers preferred bottled water to desalinated water. In the Gulf region, seawater desalination is considered detrimental for human consumption—inhabitants mostly rely on imported or locally produced bottled water for consumption (Shomar and Hawari, 2017).

2.9.2 How awareness and perception affect the use of desalination

Adopting and accepting alternative sources of water encapsulates technological and social dimension through the rubrics of government regulatory bodies, municipal actors and the general public (Hurlimann *et al.*, 2009). In order not to undermine desalination in promoting the foundations of agriculture, household and industrial uses, if not all, but some different experiences should gravitate such technology in its margins of operation (Fragkou and McEvoy 2016). Differences in geographical settings and previous expectations in water discussions can influence the usage and preferences of desalination. Since it has become a sufficient urban alternative in coastal towns particularly in the arid and Mediterranean regions, users must become aware and understand the processes involved in the treatment of seawater (Aznar-Sánchez *et al.*, 2017; Giwa and Dindi, 2017). As a substitute for a conventional supply of water, desalination must be socially acceptable (Mankad and Tapsuwan, 2011).

Users of desalinated water would appreciate using it for other domestic uses as already established, what often compromises any effort to consider drinking centres on the quality. To most clients, the amount of salt concentration in the water is synonymous to “quality” of water produced (Shaffer *et al.*, 2012). Having such an idea solely based on salt concentration after water treatment continues to shape public attitude, which further influences the acceptance of the complexities in alternative water (Haddad *et al*., 2018). In Australia where desalination is used vastly in both rural and urban settlements, Fielding *et al*. (2015), noted that the domestic use of desalination is possible because the public is aware/conscious and accepts the workable policies and sound measures on matters concerning alternative water sources. Perhaps, the potential insight into Dolnicar and Hurlimann’s research output in 2010 is that individuals may have rationalised the safety of desalinated water as “wholesome and healthy” or as a “pure-water” because of its source. If this assumption is found to be an accurate illustration of people’s beliefs, then it would be rational to conclude that applying the culture, social norms and other social belief systems influence people’s acceptability in using alternative water sources such as desalinated water for household and other domestic use.

2.9.3 Linkages of information to awareness, perception and acceptance of desalination

A key factor to consider assessing perception and awareness of any alternative source (desalination) of water is through the diffusion of information about that alternative more closely on the different phases of treatment or production. For success in implementing a municipal project, awareness is crucial for policymakers to thoroughly assess its impact on people and the environment (Aldaghma and Montano, 2018). As long as the public accepts factual information about how water is processed before the final distribution to the consumer; their determination will be heightened (Dolnicar *et al.*, 2010). Due to public education about desalination and proper channels for spreading information, the studies of Marks *et al.* (2008) and Dolnicar and Schäfer (2009) established that Australians were willing to drink desalinated water. Again, in a 2012 survey by Dolnicar *et al.* (2014), 74 per cent of research participants of the area surveyed perceived desalination as healthy for consumption.

As rightly emphasised by these researchers on the influence of information sharing on accepting alternative water, the structures and total fabric of their communities where demographic characteristic such as education is more pronounced than other developing regions were emphasised. Compared to Marks *et al*. (2008) and Dolnicar and Schäfer (2009), a more recent study argues that public acceptance of desalination changes over time often influenced by a multiplicity of factors such as environments and potential benefits (Gibson *et al.*, 2015).

Much of the available literature that deals with the question of public and individual awareness and acceptance of desalination has been presented. Other studies propose trust in alternative water sources as a significant social issue that borders on the installation of processing plants (Mankad and Tapsuwan, 2011). King and Murphy (2009) and King *et al.* (2012) show ample evidence to demonstrate community resistance to desalination schemes and stresses on the importance of education or knowledge sharing. However, Ben Brahim-Neji *et* *al.* (2019) found little evidence on community resistance yet, few people willing to pay for desalinated water. Their study was conducted in a region where desalination had been utilised for several decades, therefore, not uncommon for citizens to repel such a colossal intervention.

The researcher views local community resistance to be plausible in territories where extensive political and economic factors may adversely affect the adaptability of technology. A principal concern that may determine the suitability and smooth operation of desalination to meet community demand are centred on quality, quantity (volume) and trust (Werner and Schäfer, 2007). Lack of trust and confidence in the water quality arouses people's negative attitudes (Gude, 2017). The use of desalinated water is rising rapidly in different countries, which means that regulations and guidelines are also evolving in the direction of country-wide public health (Shomar and Hawari, 2017). In the social sense, desalination has become a contemporary necessity, yet sceptics have raised questions on whether the "so-called" purified water has any undesirable health implication on human consumers (Cotruvo *et al.*, 2010).

WHO has published codes and international Standard Operating Procedures (SOP) for regulating the quality of desalinated water, which also resonates with individual country's standards (WHO, 2011). Despite WHO's designated procedures for purifying water, the potential adverse effect of consuming desalinated water is perceptible. Gude (2017), has stressed the need for hard evidence on water quality to win consumers support for desalinated water, which may significantly boost the local economy. Agitations and protest against such cost-effective projects can only be controlled by ensuring management and monitoring programmes are supported with evidence-based water quality analyses (Nriagu *et al.*, 2016). Although national-level monitoring of water supplied from conventional and alternative sources has been non-stop, alternative water like desalination requires a conscious policy to guarantee its sustainability (Bartram *et al.*, 2014). Meanwhile, desalination, a substantial forerunner among other alternatives have gained momentum over several decades now. This impetus compelled policy formulation in national water strategies in developed countries (Sellers, 2008; Molina and Melgarejo, 2016) and also developing countries (Sadi, 2004; Mahmoudi *et al.,* 2009; El-Sadek, 2010). Policy incorporation reduces social speculations into the operations of desalination through weakening unnecessary political interest (Sellers, 2008). For example, Spain's policy on desalination as a programme for urban water and regional growth is wired in its legal framework for the non-conventional water source. Consequently, this moved the country form dissident water politics to change desalination from a mere supplementary water supply to a model to resolve the countries water crises particularly in the south (Swyngedouw, 2013; Swyngedouw and Williams, 2016; Navro, 2018). In the MENA region, Algeria and Israel also have a comprehensive policy on desalination hinged on the importance of renewable energy like solar and forecasting environmental sustainability (Mahmoudi *et al.,* 2009; Spiritos and Lipchin, 2013).

2.9.5 Alternative Water Policy in Ghana?

Augmenting water supply with alternative sources have been promoted in a lot of communities. Rainwater harvesting has been under the umbrella of the National Policy of 2007 to be harnessed to beef up water supply (MWRWH, 2007). These initiatives have been possible to overcome water supply and access challenges, yet, not sustainable. New emerging alternatives particularly greywater treatment and household water recycling in urban areas (Dwumfour-Asare *et al.,* 2017; Dwumfour-Asare *et al.,* 2018) and desalination (Befesa Ghana, 2011) have slowly rolled out. Even with the calls for policy change or amendments (Ainuson, 2009), there is no comprehensive policy on alternative water (*reuse, recycle and desalination*). Currently, desalination has become part of the countries water portfolio. Therefore, if this type of water supply alternative would continue to be prioritised and sustained in the urban coastal towns, then it should be suitably structured in existing national policy as other countries have done.

2.9.6 Desalination and conventional water supply

Desalination may not be an ultimate solution for supplying freshwater in areas of water stress and water scarcity. But the growing interest to concurrently use desalination and conventional water have been activated in the different regions with diverse priorities under dire humanitarian and environmental conditions. Soon, desalination will increase to coexist with dwindling water resources, increasing urban population and industrialisation. Bennett (2013) noted that from 2007, the use of desalination to augment mainstream water supply upsurges from 47.6 million m^3 /d to 97.5 million m^3 /d by the year 2015. These statistics paint the picture of desalination emerging steadily as a future dependable alternative. However, at the moment the technology has been commercialised as the last lender of a resort in many water-stressed regions due to the continuous reduction in the cost of installation and energy for operation. Desalination concurrently operates with conventional means to distribute water in a pipe network. This method is successfully being practised in Israel (Lahav and Birnhack, 2007).

2.9.7 Cost and energy of desalination technology (RO)

Economics of desalination has grown from direct and indirect cost-effective and energy-driven technology of rare economic stability in water-stressed countries to being luxurious alternative utilisation in water stress regions (Younos, 2005; March, 2015). Since the latter part of the 1990s, globally, the cost of producing desalinated water has reduced to almost US $ 0.75 /m^3 in 2008 (Bennett, 2011). This new height was possible mainly through technical improvement, leading to diverse and highly efficient varieties than their debut technology (Karagiannis and Soldatos, 2008).

Despite this technical improvement, treating sea or brackish water is expensive in current desalination market. It is thought-provoking to know that desalination treatment cost twice as much as treating wastewater and thrice treating water through conventional means (Ziolkowska, 2015). To produce quality and safe desalinated water, the variables involve are multi-facet aside energy, which is a common determining factor. Ziolkowska argued that some of these factors (*salinity, production capacity and operational cost)* vary across countries. In terms of energy intake, RO technology operational cost is reasonably priced in the world market (Table 2.1) compared to its close competitors (WRADC, 2012). RO treatment plant requires an electrical current of 3.5 kilowatt-hours (kWh) to desalinate 1 cubic meter of seawater and 1.3 kWh to pump seawater to the plant and 2.2kWh to complete the treatment process (Johnston, 2015).

Table 2.1: Top 10 countries utilising desalination

Country (Continent)	**Capacity (M m^3/d)**	**Share of Market (%)**
Saudi Arabia (Asia)	9.9	16.5
United State of America (North America)	8.4	14.2
United Arab Emirate (Asia)	7.5	12.5
Spain (Europe)	5.3	8.9
Kuwait (Asia)	2.5	4.2
China (Asia)	2.4	4.0
Japan (Asia)	1.6	2.6
Qatar (Asia)	1.4	2.4
Algeria (Africa)	1.4	2.3
Australia (Australia)	1.2	2.0

Source: *The state of desalination, International Desalination Association (IDA) and Global Water Intelligence (GWI) Desal Data service V03. 2010 as cited in Nair and Kumar (2013).*

2.10 Defining coping strategies as a response to water challenges

The environment for expressing coping strategies are diverse and often has different connotations in other disciplines. Davies (2016) explained the coping as strategies employed in response to any crises. The thesis describes the term "coping strategy" as State and household response to the shutdown of the desalination plant.

In any community faced with a water crisis, residents logically tend to find diverse ways to endure the stressful moments while waiting for the state actors to respond. The urge to cope is grouped into two by Few (2003): planned and autonomous coping mechanism. A planned coping mechanism is an orthodox and systematic appeal to inhabitants of the affected area to cope with a situation for a period due to management changes or restructuring of water supply arrangement (Adeniji-Oloukoi *et al.*, 2013). Alternatively, the autonomous coping mechanism is a response to the water crisis implemented by a household which is not coordinated by state actors (Bates *et al.*, 2008). Research across borders have enumerated diverse strategies for coping through shifting livelihood focus (Huho *et al.*, 2011; Rufino *et al*., 2013). Another way is through purchasing water from non-conventional sources, notably by low and middle-income households (Adeniji-Oloukoi *et al.*, 2013; Pearson *et al.*, 2015). In arid areas of the Saharan region, the desperation associated with coping leaves nomadic pastoralist with no other alternative decision than to migrate (Pearson *et al*., 2015).

2.11 Common coping strategies adopted by households

A deficit in water supply and demand has been known to coerce especially the urban poor to rely on informal water which includes but not limited to water vendors, tanker services and other sources (Pearson *et al.*, 2015). Coping could be practical depending on household social networking skills, especially in a more organic neighbourhood (Peloso and Morinville, 2014). Ideally, water supply and use of water should be formal. The case of developing regions including Ghana, intermittent and inequitable distribution of water lay foundation for the informal sector to thrive. Here, multiple private owners and suppliers emerge parallel to public utility providers (Bartels *et al.*, 2018). In response to the dire water situation, particularly in low-income communities, residents tend to rely on vendors, tankers, and neighbours or social network. Ablo and Yekple (2018) posit that several households resort to informal water uses because they lack in-house pipe water connection.

Identifying informal water use is key to understanding possibilities to cope or adapt to situations effectively. For instance, in the GAMA alone, 47 per cent of residents in Teshie and Ashaiman purchase water from vendors, including tankers and standpipes (Harris *et al.* 2012). Similarly, a more recent study highlighted the relevance of informal water merchandise (Ablo and Yekple, 2018). Their research indicated that 83 per cent of people in Ashaiman rely on the informal water sector. With a vast swath of informality in the water sector, they have operated for several years, without the support of state institutions, yet their sector supports the formal service providers.

2.11.1 Tanker services

During a regime of a water crisis, quality and safe water could be accessed at points beyond 5 kilometres from the immediate community (Frenierre, 2009). Generally, tanker operators especially private ones, buy wholesale water from state-owned hydrants and retail to either water vendors or individual household mostly on request. As a way to reduce the dearth of water in some parts of Accra, tanker service points were established by GWCL in the community which is cost-effective than providing water directly from GWCL (MWRWH, 2014).

2.11.2 Community water vendors

Informal water vending market is flooded with high or middle social status individuals who are residents of the specific neighbourhood. Actors involved in water vending business buy water in wholesale and retail it to customers who are in close proximity to their location. Water vending in informal and formal settlements is a viable profit-oriented venture. Even though private tankers are their primary source of acquisition, some either directly syphon from the maze of the water company for storage or rely on a mechanised well. Their contribution to water supply continues to be efficient for their role in satisfying the demand for water of poor urban communities (Braimah *et al.*, 2018). Braimah pointed out that the market value placed on these unregulated waters bring economic burden to households. Therefore, it is imperative to understand water vendors role in the urban water supply is not only a resourceful alternative in the supply chain, but low-income neighbourhoods are ardent beneficiaries when the connection of pipe to the national grid is challenging to implement.

2.11.3 Rainwater harvesting

Rain is a single source of all water resources. Storing rain is ancient yet a seasonally potent method of accessing water commonly of rural focus. Rainwater harvesting is a process that involves accumulating atmospheric water before its final destination into the aquifers. Usually, pipes or tunnels are connected from roofs into simple or complex collecting equipment's (Campisano *et al.*, 2017). This water strategy is now appreciated in cities (Karim *et al.*, 2015; Campisano *et al.*, 2017). In a tropical region like West Africa with highly variable rainfall, if rainwater resources are utilised efficiently, floods and erosion would be contained but also likely to make rainwater collection inconsistent (Boelee *et al*., 2013). Rainwater source is bracketed as an improved source for fetching water outlined by the JMP (WHO/UNICEF, 2017). However, rain harvesting such as roofs (asbestos, aluminium), and others used could compromise the quality by contaminating it (Ahmed *et al.*, 2011). Aside from its potential negative health implications, rainwater harvesting could be inexpensive and achievable with essential elements such as suitable roof and clean storage space (Martinson and Thomas, 2007). It has been valuable in rural and urban areas in Ghana where households use homegrown knowledge to collect water. A significant drawback on rain harvesting sustainability in urban and peri-urban areas pertain to short tenancy status of resident (Owusu and Teye, 2015).

2.11.4 Household water storage

Storing water is almost inevitable in households in developing countries (Boateng *et al*., 2013; Vásquez, 2016). In most cases, changes in attitude towards the frequency of water flow stir people to store water at the household level. Storage containers such as barrels, poly tanks, gallons, buckets and earthenware pots are used in some areas, complementary other than singly used (Kumwenda, 2009). A household ability to store water is socio-economically determined (Vásquez, 2016). Storing has become a significant adaptation option for inadequate supply. In Abuja, Abubakar (2018) demonstrates that 90 per cent of households in his study stored water as a coping mechanism.

2.11.5 Sachet water utilisation

The supply of 500ml pack water, hereafter, referred to as “pure water” or “sachet water”, is burgeoning in the water supply nexus, wielding a legitimate market for many years across different African countries especially West Africa (Stoler, 2017). Sachet water is now the most ordinary household commodity in both rural and urban areas; for a lot of domestic activities, even bathing (Doe, 2007). Beck *et al.* (2016), estimated that 70.6 per cent of people in Accra relies on sachet water for drinking. Amongst poor urban communities, nearly 9 per cent of this figure relies on pure water for all form of household-level uses (Stoler *et al.*, 2013).

With over 3000 pure water producing points in Accra (Daily Graphic, 2014), concerns have been raised on the source and quality of the sources of water used in this neo-liberal economy of domestic water supply (Sarpong and Abrampah, 2006).

The importance of sachet water as a supplement to existing water supply schemes cannot be overemphasised (Stoler *et al.*, 2012), yet, much challenge resides in the ability to test the quality by end-user for these different brands. There has not been the slightest likelihood that consumers of sachet water would soon relinquish intake even if pipe water become ubiquitously accessible. If so, then citizens are compelled to understand the matrix of pure water production and supplies.

Researchers have interrogated the quality and safety of sachet water and revealed adequate gaps (Ngmekpele, 2015). For instance, Addo *et al.* (2009), claimed the quality of pure water in Teshie-Nungua is of poor quality due to microbial contamination. Unlike, Addo and colleagues, Mosi *et al.* (2018), after their microbial assessment of sachet water, argues that most of these water productions have attained levels to be classified as wholesome for consumption. Currently, if any household access to water increases, the possibility is probably centred on growth in sachet water, bottled water and public taps with less access to piped water which is significantly accompanied with economic sacrifices (Stoler *et al.*, 2013; Mosello, 2017).

2.11.6 Spatial relocation

Coping with water, as well as any form of crises may involve moving in between locations (Pearson *et al*., 2015). A study conducted in Australia by Dolnicar and Hurlimann (2010), showed residents intention to relocate were under different water scenarios: when recycled alternative overtakes traditional water supply, when desalinated water exceeds conventional water for domestic purposes, if their area had insufficient water supply beyond their basic needs and if a household had to over-rely on treated rainwater. From their finding, the urban resident would relocate based on inadequate water beyond basic needs was 65 per cent, followed by situations where recycled water is used was 40 per cent, desalinated water overtaking traditional water supply was 27 per cent, relying on household treated rainwater was 24 per cent. In other regions, relocation to evade water crisis would not be indented or likely to be considered, especially when residents have alternatives—tanks or containers for water storage. These figures are only reflective of regionalism. Perhaps in other areas where such options may not be present, spatial relocation theoretically would be considered as seasonal migration.

2.11.7 Rationing as a way of coping at the institutional level

Restricting the consumption of relatively scarce water resources in the form of distribution plans have been utilised in many areas where commodities are limited. Regardless of government financial investment towards institutional reforms in the urban water system, the aim to achieve financial autonomy in these sectors have partially materialised. For that matter, many urban areas struggled to attain sustainable municipal water supply galvanised by socio-economic, managerial and political characteristics. This leaves rationing not just as an ad hoc but dependable way to distribute water to residents (Acheampong *et al.*, 2016).

There are six (6) rationing methods: fixed allotment, a percentage reduction, price, restricting specific water users, service outage, and accumulating conservation credit (Lund and Reed, 1995). In most developing countries, including Africa, effective rationing is implemented through service outage method where sections of the city are allowed specific hours of water during flow days. Within the city limits, the government has instituted rationing structure to regulate small volumes of water produced for its citizens (Van-Rooijen *et al.*, 2008). Despite the effectiveness of rationing, Stoler *et al.* (2012) contend that the distribution of water is geographically and socioeconomically diverse. Consequently, leaving more than 60 per cent of urban residents with low water storage due to a few hours of water being supplied (Kessey and Ampaabeng, 2014).

2.12 Theoretical and Conceptual Framework

Two theoretical orientations underpinned the study: The Access Model and Political Economy. These two theories guided the formulation of a conceptual framework. A framework such as the Urban Water Provision framework (UWP) has been used to study water supply (McDonald *et al.*, 2011). The Urban Water Provision framework provides three tenets: water availability, quality, and delivery. The tenets of this framework could not be adequate for the study. Instead, the study considered the access model and political economy.

2.12.1 Access Model

This section delves into the access model by discussing its components put forth by Penchansky and Thomas's (1981). The model has five (5) tenets—accessibility, availability, affordability, acceptability, and accommodation. These tenets are mutually exclusive but interconnected. Penchansky and Thomas defined access as a degree of fit between "customer" and "system." By looking at a "system", Clark and Coffee (2011), explained access as the appropriate use of services according to need between two locations. Strasser *et al.* (2016) noted that the proper use of services is essential to the effective formulation of policy since people deserve equal levels of resources. The access model was initially established to examine the degree of fit between the health system and its client. Here, the use of service, customer satisfaction and system practice influence access (Penchansky and Thomas, 1981). The model initially dominated the literature on health accessibility. Other researchers have adopted, modified and applied it in areas diverse from healthcare (Obrist *et al.*, 2007; Dillip *et al.*, 2012; Adjakloe, 2014; Saurman, 2015).

Table 2.2: Six components of access

Concept	Alternative meaning	Definition
Accessibility	Location	Accessible service is within reasonable proximity to the consumer in terms of time and distance
Availability	Supply and demand	An available service has sufficient services and resources to meet the volume and needs of the communities
Acceptability	Consumer perception	An acceptable service responds to the attitude of the provider and the consumer regarding characteristics of the service and social or cultural concerns.
Affordability	Financial and incidental cost	Affordable services examine the direct costs for both the service provider and the consumer
Accommodation (Adequacy)	Organisation	Adequate service is well organised to accept clients, and clients can use the services.
Awareness	Communication and information	A service maintains awareness through effective communication and information strategies with relevant users (Residents and the community)

Source: Penchansky and Thomas (1981) and Saurman (2015)

Obrist *et al.* (2007) built on this framework in the context of sustainable livelihood and vulnerability approach by arguing that the degree of access depends on the interplay between the components of access. Dillip *et al.* (2012), even though they applied the model in the health sector, they suggested that the concept of access should be made to fit better into both the consumer and producer system. Adjakloe (2014), used the access model to study challenges in access to domestic water (Ghanaian context). The works of Saurman (2015), argued that the five dimensions of access put forth by Penchansky and Thomas' is incomplete. Therefore, she suggested an additional component: "awareness" to be added to the fundamentals of the access model. Table 2.2 combines Penchansky and Thomas and Saurman's work. Although Saurman (2015) considered "awareness" as an addition to the existing five dimensions, the model, however, fails to address expected coping or adaptations to obstacles that may delay or hinder a client/people from accessing a complete service. Liu *et al.* (2003) noted that if any of the components of access is compromised, then ultimate access to a service becomes challenging to achieve. The study utilised three (3) components of the access model and incorporated awareness and coping into the original model which considers the perspective of the consumer and the provider (Van der Ree *et al.*, 2007).

2.12.2 Political economy

The political economy approach explains how power and resources are distributed and contested to reveal the underlying interests, incentives, and institutions that provokes change (Cole, 2012)—the approach at times intertwines political ecology as being "concerned with a far broader notion of the political dimension of the interaction between the state and other actors" (Page, 2003: 359) concerning the control and use of an environmental resource (water). In essence, information, social capital, and political power is used to explore resources to benefit the population.

The theory further identifies and articulates the differing perspective of the state agencies and the local community. Like most developing countries, political ideas play a role in shaping infrastructure development. In Ghana, the implementation of the desalination project can be conceptualised as part of the new development policy aiming to revolutionise the sector-wide approaches to increasing supply and improving access. In this study, it is essential to distinguish institutions and social groups and their roles in shaping global and local developmental agendas. Water supply intervention through PPT or BOOT is gradually becoming a monopoly considering a potential shift of public control towards privatisation. Yet, public and private partnerships to supply water has a long-established history since the inception of urban water systems (Swyngedouw, 2009). In conceptualising political economy in this study, the role of power, which often interlocks decisions to provide water, is critical.

Although the political economy may result in power struggle and conflict, the approach analyses the invention and implementation of public policy (Levesque *et al.*, 2013; Heynen, 2014). The non-Marxist political economy approach highlight the contestations influenced by complex interactions between the utility service providers (Institution) and actors (individual or community). Thus, projecting an interplay between "community power" and "institutional power." These linkages are pertinent to the role of institutional players in infrastructure decisions as part of government policy towards social interventions. There are considerable limitations relying on political economy. The approach highlights institutions point of view and mostly overlook social groups. The study adopts this theory to delve into the contestations arising from the infrastructural intervention (desalination) that was implemented by a political system.

2.13 Conceptual framework for the study

Regardless of the limitations aimed at the theories discussed, the conceptual framework (figure 2.1) is built to account for some modifications to the concept. The study relies on the key fundamental aspect of the ideas and components to achieve the objective of the research. The component of Penchansky and Thomas (1981) considered for the conceptual framework is acceptability, affordability, and accommodation (adequacy). Acceptability (*Table 2.2*) in this framework involves the quality of water. With regards to acceptability, Basbas *et al.* (2015)

outline socio-economic and cultural factors as possibilities for household members and the community at large to accept a service even with little or no alternative. Also, accepting a utility service may be determined by spatial and temporal factors (Oteng-Ababio *et al.*, 2017) and influenced by power (Levesque *et al.*, 2013). Levesque *et al*. (2013) argue that the community and its members become more determined to accept a municipal service when they have adequate representation in the decision-making process. Here, the focus is the capacity of people to support or reject government policy. Affordability involves the willingness to pay for the services of desalination to support its continuity. Accommodation (adequacy) in this framework involves the use of the service—uses of desalinated water.

The framework attempts to answer questions on whether interactions between state institution (GWCL) and the community (Teshie) affects the component of the access model and the possibility that, the decisions of institutions and other actors influence coping strategies. The water access phase (*acceptability (quality), affordability, accommodation (adequacy) and awareness*) influences demographic characteristics (*age, sex, education, income, household size etc*). There is interdependency between the components of access, water supply, distribution and coping strategies. Water rationing schedules come under the water supply phase. Rationing at this phase is operated as "rationing by service outage" (Lund and Reed, 1995: 451), which is an institutional strategy used to regulate volumes or quantities of water supplied in cities. Rationing timetable assists residents in marking specific days and hours to store water which is a factor of coping.

At the water intervention phase (*institutional response*), utility service providers (GWCL) provides an alternative intervention distinct from conventional means of water supply. At this point, responding to the water challenges generates two different interaction: GWCL may decide to supply water while adopting rationing to distribute, by acting alone based on their discursive power or consensus based on pressure groups (social groups) from the community.

On the decision-making phase (*Institution, community*) of the water intervention framework (figure 2.1) the outcome of interactions and actors may influence the project after the shutdown. Also, the decision-making phase may be futuristic. Furthermore, there is an interaction between the decision making phase and the coping phase: because a positive or negative conclusion of the operation of the treatment plant could influence the coping strategies of the residents in the affected community. At the community phase (*Traditional authority and social groups*), the voice of the local authorities and vibrant social groups could also influence the decisions to restore the plant or otherwise. Here, there is a recognised interaction of this phase and the coping phase. The demographic characteristics influence the access phase and directly links to coping strategies. All the linkages between the aspects of the framework demonstrate an intervention and its implications on water supply and access.

2.14 Chapter summary

This chapter presented related literature pertinent to the phenomenon under study. The areas discussed are water supply, water access, desalination as an alternative water source and coping strategies used by urban residents who face challenges in accessing potable water. Also, the section outlined and explained the access model and political economy theory on which the conceptual framework is built. The conceptual framework analyses the interactions of the state and other actors in the whole process of alternative water. Access model and Political economy are systematically dichotomous, which is essential in understanding access and power relations.

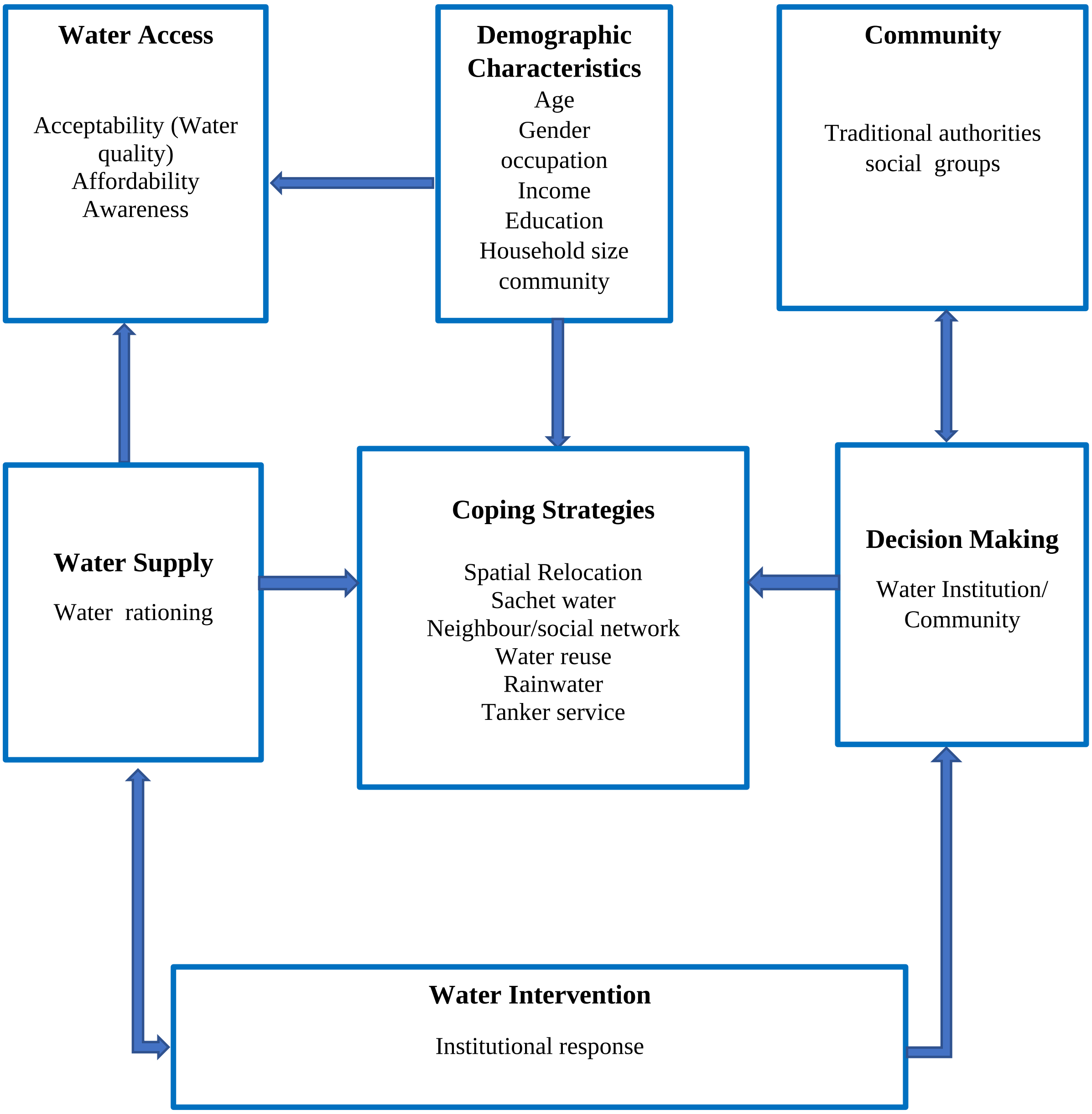

Figure 2.1: Water Intervention and Access Framework

Source: Adopted and modified from Penchansky and Thomas (1981) and Saurman (2015)

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 Introduction

This section of the thesis presents background information on the study area and the methodology that justify the study. The geographies of the study area are presented first, followed by the methodology. Discussions of the methodology include; research philosophy, research design, target population, sampling technique and sampling size determination, data process and analysis, and including data management. The chapter ends with experiences on the field encompassing challenges and how it was overpowered to make data analysis and discussions possible.

3.2 Profile of the study area

Teshie is one of the indigenous towns situated along the Greater Accra coast. The city embodies the same customary eminence of its neighbouring aboriginal communities such as Nungua (Little Ningo), James Town (Ngleshi), Labadi (La), Osu, Ussher and James Town (Kinka). The area began as a fishing settlement that gradually evolved to have more than four landing grounds (Akuetterh, 1983). It has continuously maintained a respectable traditional status, although the area has been urbanised due to decentralisation and migration (Odotei, 1991; Addo *et al.*, 2009). In 2018, Teshie became the district capital for the Ledzokuku Municipal Assembly (LMA) after the detachment of Krowor Municipal Assembly (KMA) from Ledzokuku-Krowo Municipal Assembly (LeKMA). However, currently, these new districts are still developing (Ghanaian Times, 2018:7).

3.3 Location and physical settings

The area under investigation is located about 10 kilometres east of Accra. The municipality is bordered on the east by Nungua, La to the west, Okpegono to the north and the Gulf of Guinea to the south. Teshie constitutes a land area close to 47, 57510 kilometres square (Km^2). The study delimited Teshie into four different areas modelled based on the residential and income classification of Songsore *et al*. (2009) (see Figure 3.1).

The geological formation underlying Accra of which Teshie is part is the Accraian series consisting of laterite, shale, and sandstone (Dickson and Benneh, 1998). The area is low lying of heights ranging between 250 and 500 feet above sea level (Befesa Ghana, 2011).

3.3.1 Climate, Rainfall and Temperature

The climatic condition in Teshie is classified under the tropical equatorial climatic zone (Dickson and Benneh, 1988). Within this climatic zone, the average precipitation is 750 mm. Throughout southern Ghana, the rainy season is experienced twice with minor differentials in specific months of occurrence. Usually, the first season begins in April-May and ends in July and the second season starts towards the end of August to the end of October. Yearly temperatures come with slight variation. The mean temperature for cold months (July-August) is 24.7°c and the mean temperature for warm months (March-April) is 28°c (GSS, 2014).

3.3.2 Population

As urban economies continue to grow, it drives population change (Grant and Yankson, 2003). Likewise, the population of Teshie has undergone some changes over the years. In 2000, the area had a total population of 89,452. The male population 43,343 constituting a proportion of 48.5 per cent and the female population was 46,109, which represents a proportion of 51.5 per cent.

The household population of Teshie in 2000 was 19,700 housed in about 7682 houses (GSS, 2005). Currently, the population structure of Teshie is similar to that of the entire region. From the 2010 census report, the district had a population of 133,942 which constituted 3.34 per cent of the region's total population with an annual growth of 3.28. Male population represent 47.7 per cent, and Females constituted the highest percentage of 52.3 per cent. Comparing the male-female population proportion from 2000 to 2010, the male population increased by 67.8 per cent with a marginal decrease in the male population (0.8 per cent). The female population changed by 65.8 per cent, with a 0.8 per cent increase in the total female population.

Currently, Ghana has a youthful populations age structure (GSS, 2010). Teshie's age structure is also similar to the national and regional one, which is about 20-30 years. The metropolis at 2010 had 11,557 houses with a total household population of 36,240 constituting an average household size of 2.8 per cent. Again, between 2000 and 2010, the number of houses in Teshie increased by 54.4 per cent, and the number of households increased by 65.2 per cent. Considering this background, it is not uncommon to project that this perceptible changes in the population could negatively impact on levels of water supply and access in the district.

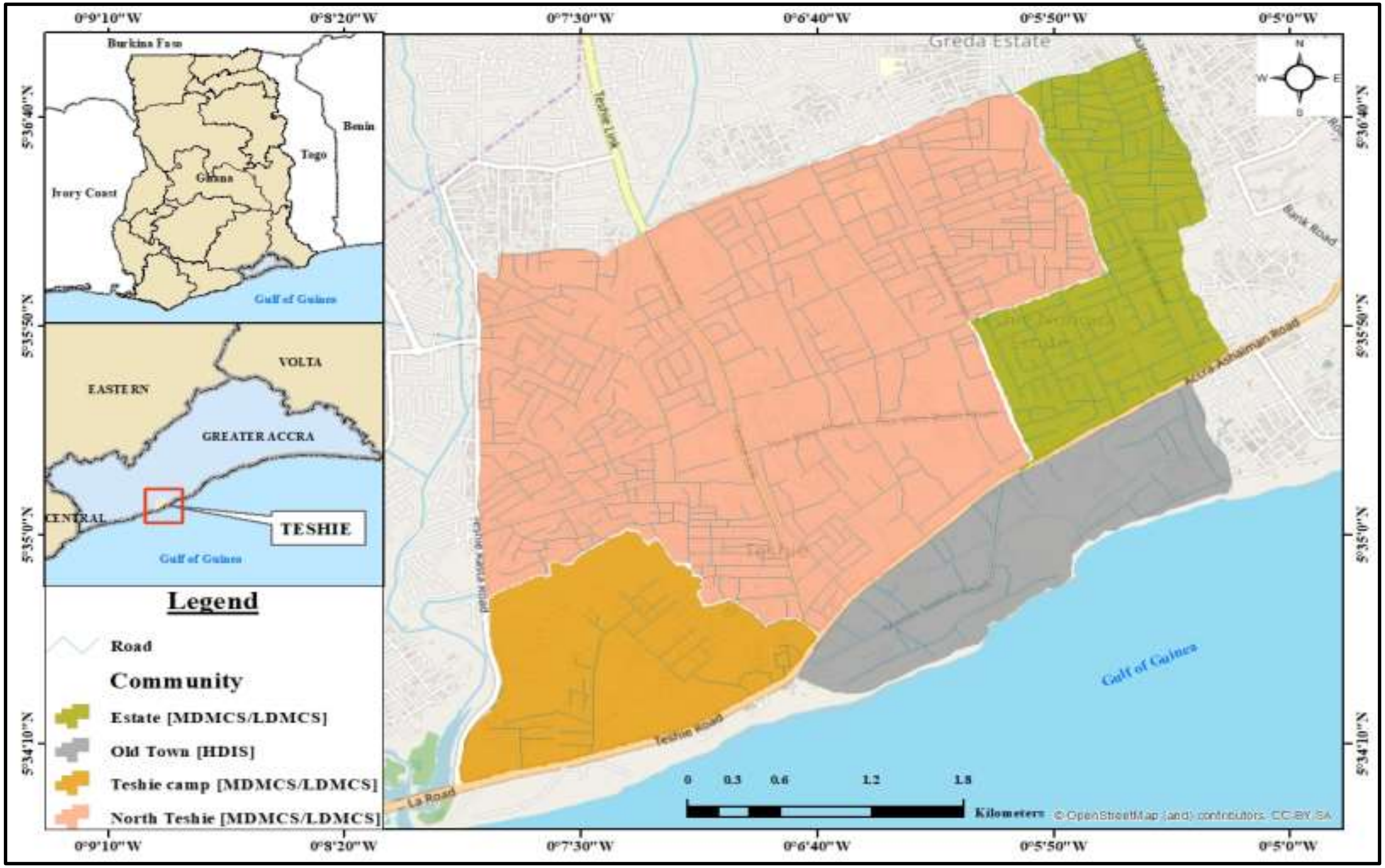

Figure 3.1: Map of the study area (under residential classification)

Source: Author's Construct, 2019.

3.3.3 Economy and Settlement

Teshie amongst other coastal towns within the Greater Accra Metropolitan Area was a low-income community which has for years developed from fishing and farming economy to a middle or medium-income economy coupled with high unemployment. Residents broadly engage in primary, secondary and tertiary occupation. Until now, most occupants situated close to the coast continues to engage in light fishing activities (Agyekum, 2016). Aside from the fishing landmark, the informal sector is the largest employment sector where females are the majority (GSS, 2014). Businesses in the informal sector are mainly trading, commercial driving and other artisanry trade. Until recently, water vending was a major employment opportunity for most households especially areas withing the middle-income class zone. This mode of economic activity indirectly increased water supply through the utilisation of private water tanker operators. The municipality is gradually taking on the role of an emerging business centre (economic zone) having few manufacturing companies such as Printexe and Coca Cola (Fiasorgbor, 2013).

The settlement in Teshie south (Old Town) is clustered (Plate 3.3). The building pattern shows less planning layout, leaving narrow spaces. On the contrary, areas such as Teshie north has some clustered and nucleated buildings (Plate 3.4). Areas such as Teshie estate (Plate 3.2) and Teshie camp (Plate 3.1) are nucleated settlement consisting of a well-planned layout. Songsore *et al*. (2009), in their work, partitioned Greater Accra Metropolitan Area (GAMA) based on residential classification or zones. Here, residential areas are classified into high income, middle income and low-income areas. High-income communities come under the Low-Density High-Class Sector (LDHCS) and the Low Density Newly Developing Sector (LDNDS).

The middle-income areas include the merger of the Medium Density Middle Class Sector (MDMCS) and the Low-Density Middle-Class Sector (LDMCS). Communities placed under low-income consists of the High-Density Indigenous Sector (HDIS) and High-Density Low-Class Sector (HDLCS), Middle Density Indigenous Sector (MDIS), and Rural Fringe (RF). By using this stratification in this study, Teshie comes under four (4) primary classification—North Teshie (MDIS/LDMCS), Teshie camp (MDMCS/LDMCS), Teshie estate (MDMCS/LDMCS) and Old Town (South Teshie) (HDIS) (figure 3.2).

Plate 3.1: Houses and the environment in parts of Teshie camp

Source: Field survey, 2019.

Plate 3.2: Houses and the environment in parts of Teshie Estate

Source: Field survey, 2019.

Plate 3.3: Houses and environment in parts of Old Teshie (South Teshie)

Source: Field survey, 2019.

Plate 3.4: Houses and environment in parts of North Teshie

Source: Field survey, 2019.

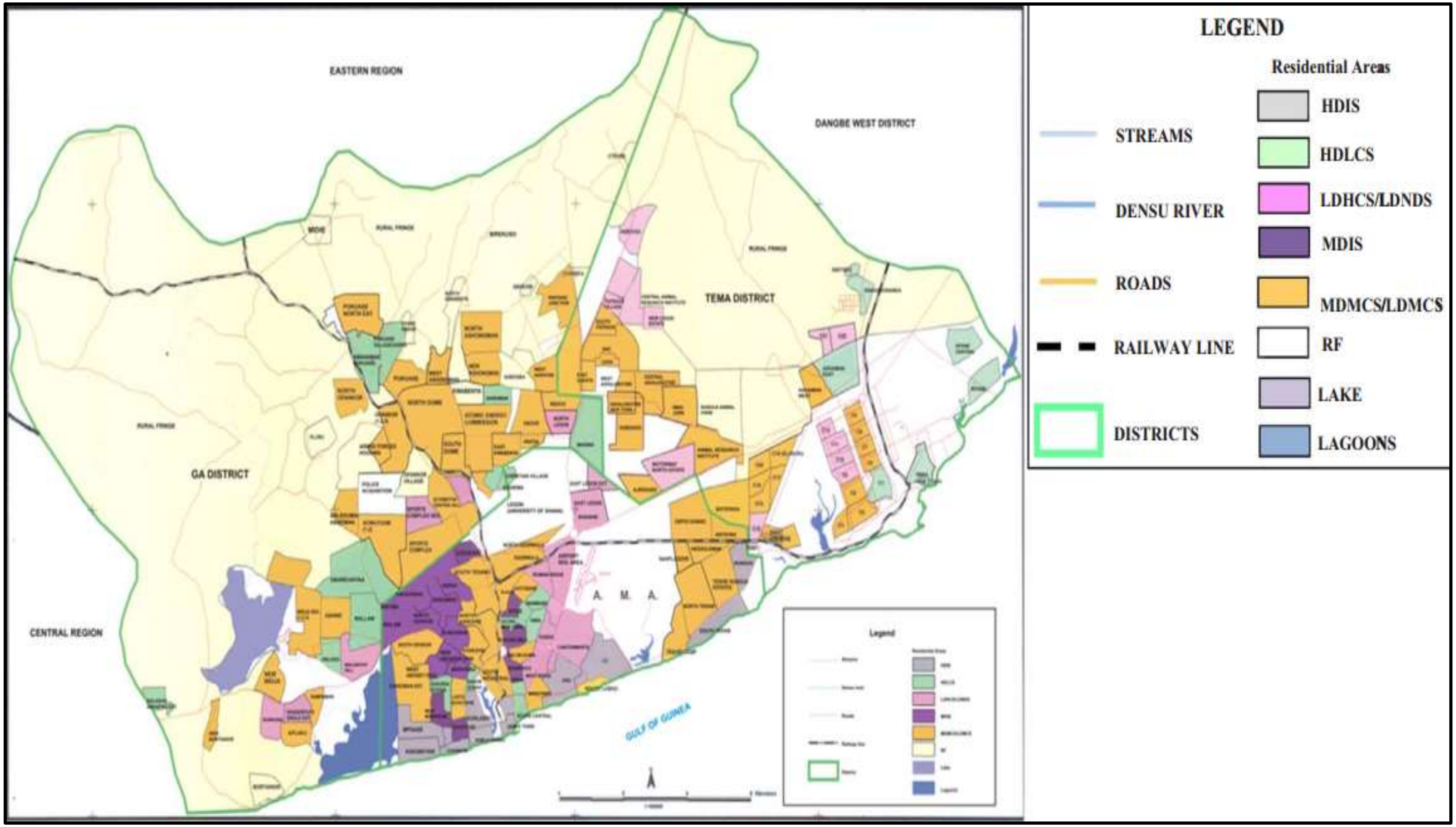

Figure 3.2: Residential classification of GAMA

Source: Songsore *et al.* (2017).

3.3.4 Water landscape in Teshie

The drainage of Teshie is within the Kpeshie catchment of about 62.6 square kilometres (Km^2) and the Sango lagoon (Nyarko, 2007). The basin has been in recent years polluted through anthropogenic causes. Water supply in Teshie is not from a single source. There are two (2) treatment Plants (Weija Treatment Plant [WTP] and Kpong Treatment Plant [KTP]). Weija supply water to the central and west of part of Accra and Kpong supply to the eastern side of Accra. From Kpong treatment plant, water travels about 60 kilometres in mains and subsidiary pipelines before it finally gets to the reservoirs in Teshie. The district water company distributes the water stored. Apart from water supplied from these two sources, residents also rely on other sources such as water tankers and water vending points to augment household water usage (Addo *et al.,* 2009).

As the population continues to increase without expansion in infrastructure, existing water channels keeps diminishing; for that matter, apart from the intermittent flow of tap water, rainwater is also utilised during the rainy season particularly in the old-town. Accessing pipe water in Teshie south and some part of the north is challenging. Bediako *et al.* (2017) have argued that urban water stress may not be a function of physical location, but, financial constraints and haphazard settlement. Interestingly, one major causal factor underlying erratic water supply in Teshie is geographical (GWCL, 2018). Consequently, transportation and distribution of water from the WTP and KTP do not reach the district in a significant amount.

Pipe-water connection in the Medium Density Middle-Class Sector's (MDMCS) such as Teshie Camp and the Estate is very high. These areas are likely to receive enough water than the High-Density Indigenous Sector (HDIS) including Teshie south. Residents in the MDMCS often use large storing containers to store water. Unlike the MDMCS, households in the HDIS ability to store enough water is negligible (Doe, 2007). Based on the premise that climate change, increasing population growth and water pollution threaten inland freshwater resources (Roma *et al*., 2013), a large-scale alternative supply scheme (desalination) was utilised to augment existing water supply arrangement.

3.4 Philosophical underpinning

Research philosophy or paradigm is a set of assumptions, values, concepts, and practices that provide guidance for conducting research (Johnson *et al.,* 2017). These underlying assumptions are acknowledged from the positivists, interpretivists and pragmatist ideology (Johnson and Onwuegbuzie, 2004). The Positivist philosophy positions on a highly structured research method that has been critiqued as biased, especially in the natural sciences. These natural sciences often manifest fewer human interactions, impressions and participatory approaches (Creswell, 2014).

Similarly, the interpretative paradigm inculcates subjectivism or human interest in the research. Here, researchers interact with the environment and how members in a social group interpret the world around them (Brannen, 2005; Bryman, 2015). Also, the Interpretivist paradigm used in research has been criticised because of the possibility of bias, which obstructs generalisation (Bryman, 2006; Teye, 2012). The nature of the research question was unpacked using a pragmatic paradigm. Research underscored by this paradigm is not a modern philosophy to the latter approaches (Johnson and Onwuegbuzie, 2004), but its assumptions underpin knowledge and inquiry that significantly distinguishes the method from positivist and interpretivist approach (Frels and Onwuegbuzie, 2012; Hickson, 2016).

3.4.1 Pragmatism

Pragmatism is a philosophical model that seeks to find the "practical consequences of a theory, concept or hypothesis by describing its role as an instrument of thought in inquiry and practical deliberation" (Hookway, 2010: 4). Therefore, it is a realistic representation of the worldviews of a phenomenon by providing truthful and fair information (Baker and Schaltegger, 2015). Pragmatism emphasises on the research problem and uses all available approaches to understand a problem in social science research (Creswell, 2014). It is developed from actions, situations and consequences rather than antecedent condition (Creswell, 2014; Baker and Schaltegger, 2015). One of the core tenets of applying pragmatism is based on "truth" (Baker and Schaltegger, 2015). The notion of truth is key to elucidating the variances between pragmatic ideas and other philosophical positions but not revealed as an accurate representation of the external world.

Under this philosophical construction, triangulating different research approaches can be explored (Modell, 2009). Pragmatist researchers employ quantitative/qualitative methods to analyse and reflect what people think and accepting what they believe in from which conclusions are drawn. Pragmatism like Positivism and Interpretivism is subjected to critique. Researchers like Popper (1994) and Russell (2004) have argued that the paradigm is vague and limits creativity from the real world. While the fundamentals of pragmatism have been challenged as not reliable and valid, its purpose and practicality for a specific type of research remain definite. The study adopted Pragmatism to provide the researcher with the avenue to use a mixed-method approach to unearth the dynamics of water supply and access in connection with desalination as a large-scale water intervention.

3.5 Research design and strategy

The research design involves the conceptual structure within which a phenomenon can be studied. The planned structure and principles that underpin this research work conform to the non-experimental divide. The study consents to a cross-sectional descriptive approach. Descriptive design is an effective conduit for understanding and analysing a wide range of research methods for variation, patterns of associations, and relationships between variables

(Mayoux, 2006; Murphy, 2014). The cross-sectional design also supports the use of different methods to collect data from selected respondents in a single study (Sarantakos, 2005; Findlay and Taylor, 2006).

The mixed-method technique, popularly known as Concurrent triangulation strategy, was used in this research (Creswell, 2003). It involved triangulating both qualitative and quantitative methods to collect and analyse data (Neuman, 2014). Here, both quantitative and qualitative data were collected in the same period. Concurrent triangulation best fitted the study due to time constraints in data collection and analysis. Additionally this approach (*qualitative and quantitative*) in social research are vital for complementarity (Teye, 2012; Creswell, 2014). However, more quantitative analysis was done using the survey data because qualitative data used to support the quantitative analysis was limited. The mixed-method approach was appropriate for the study because it aligns with the philosophy underpinning the research. Hence, the adoption of this approach provides the avenue for the researcher to utilise the strength of triangulating both quantitative and qualitative methods.

3.6 Target population

The study targeted households in Teshie. A member of the household who was eighteen (18) years or more were considered. The number of years a household had lived in Teshie was relevant to the research. Because of the large size of the population (N=133,942, which is an aggregate from large communities in Teshie according to PHC, 2010), a sample was used rather than a census. Also, the study targeted institutions such as Ghana Water Company Limited (GWCL), Teshie Concerned Citizens Associations (TCCA), the Teshie Traditional Council (TTC), Assembly members and water vendors.

3.7 Sample size determination and sampling technique

3.7.1 Sample size determination

The study adopted Fisher *et al.* (1998) formula to obtain a representative sample size of the population. Since a finite population (N) is challenging to achieve, with an assumption of a normal distribution considering parameters for analysis and interpretation of data, the formula was appropriate for the study. The Fisher *et al.* (1998) formula is detailed below;

$$\boldsymbol{n = \frac{\beta^2 bd}{\lambda^2}}$$

Where:

n = Sample size [i.e. N > 10,000]

$\boldsymbol{\beta}$ = Standard normal deviation [set at 1.96 corresponding to 95% level of confidence]

b = Proportion of the target population estimated as having particular characteristics

d = 1.0-p

$\boldsymbol{\lambda}$ = Precision level [5% or 5/100 = 0.05]

With $\boldsymbol{\beta}$ statistic being 1.96, level of precision $\boldsymbol{\lambda}$ set at **0.05** and the proportion of the target population with particular characteristic **b** at **50%** which is equivalent to 0.5 (according to Angwenyi (2012), 0.5 % is set if there is not an identified estimate). In this study, the "**b**" was maintained at 50% since water supply and access from the desalination covered everyone. Subsequently, there was no peculiar characteristic identified from the population who accessed other large-scale alternative schemes. Therefore **"n"** was;

$$n = \frac{1.96^2 * 0.5 * 0.5}{0.05^2}$$

$$n = \frac{3.8416 * 0.25}{0.0025}$$

$$n = \frac{0.9604}{0.0025}$$

$$n = 384.16\ [384]$$

Fisher *et al*. (1998) strategy for obtaining sample size was critical for the study purposely due to its robustness for populations (N) beyond 10,000 (Israel, 2012). The choice for a sample formula aims for precision. However, Fisher's sample size formula may subject the sampling to some errors since some communities within the study area are less stratified and not planned adequately. These errors are, however, tolerable (± 5) when the sample size is above 300 (Lyons, 2015).

The Bowley (1926) method was used to calculate the proportion for each community.

$$f = \frac{\boldsymbol{\alpha}}{\mathbf{N}} \times \boldsymbol{\eta}$$

α = Specific household population (community)

f = Sample fraction

η = Sample size

N = Total population of the households

Based on time constraints the calculated sample size was adjusted (Table 3.1) to sufficiently represent the community.

Table 3.1: Sample size the for communities

Community	Class	Household population	Sample size	Adjusted sample size
Estate	MDMCS/LDMCS	4,991	53	53
Teshie South (Old Teshie)	HDIS	8,444	90	98
Teshie Camp	MDMCS/LDMCS	3, 898	41	38
North Teshie	MDMCS/LDMCS	18,907	200	140
Total		**36,240**	**384**	**329**

Source: Author’s construct, 2018.

3.7.2 Sampling technique

The study utilised a multi-stage sampling method for data collection. Stage one designated the study area into four (4) stratum based on residential and income classification by Songsore *et al.* (2009)—HDIS and MDMCS/LDMCS. The HDIS are the low-income areas, and the MDMCS/LDMCS are mostly middle-income areas currently with few high-income residents. At the second stage, a systematic sampling technique was used to select houses. Using the number of houses computed (11,775) and sample size calculated (384), the systematic sampling interval was 31 (11,775/384=30.6). This means every 31st house unit in a specific community was ideal. Using intervals help researchers to exhaust possibly a larger area within the strata's (Neuman, 2014). However, an interval of 31 could not be adequately applied due to the high-density of the housing unit in some part of the study area. Here, the calculated sampling (Kth) which was every 31st house unit was reduced to every 4th and 10th house unit for high and low clustered areas.

In the Old Town (South Teshie) (Plate 3.3) and part of North Teshie (Plate 3.4), every fourth house in a row (lane) was selected with the first house selected by convenience. However, in Teshie camp (Plate 3.1), the Estate (Plate 3.2) and part of North Teshie where the houses were well arranged, every 10th house unit was selected starting from the 10th house unit which was derived by counting from the first house close to the road. At the third stage, housing units that had more than one household were sampled base on willingness to participate. In situations where more than a household was willing to participate, a simple random-lottery method was used to select one. Here, respondents had a chance to choose answers ("Yes" or "No") written on papers.

For the qualitative sampling, participants were purposively selected for In-Depth Interview (IDI) and Focus Group Discussion (FGD). The in-depth interviews were carried out with people who understood issues concerning the desalination and water issues, particularly in the area. These people constituted three (3) stakeholders from GWCL, one (1) from the Teshie Traditional Council, two (2) Assembly members (*each from 1 EA in the south and* *north part*), one (1) key informant from the Teshie Concerned Citizens Association and two (2) water vendors (*each from the south and north part*).

The FGD's conducted were two. The first FGD constituted seven participants who were representatives from the District Assembly (1), the Traditional Council (1), Local Water Board (1), one person in the water vending business (*who had operated for more than a decade in Teshie*), one Assemblymember (*from an EA different from those selected for the in-depth interview*) and two representatives from the District Water Company (*who were also residents of Teshie*). The second FGD constituted seven (7) adults: four women and three men who had lived in the community over fifteen (15) years.

3.8 Data and Data Sources

In this study, primary and secondary data were used. Primary data was obtained from the field using questionnaires, IDI and FGD's. The IDI and FGD's were recorded and transcribed. The secondary data such as maps and tables were assessed from published documents, articles and journals using google scholar and other portals such as Elsevier, Taylor and Francis and Jstor. A geodatabase containing shapefiles of districts and town locations were integrated with ArcGIS. Also, data from google earth was extracted and digitised to create the study area map.

3.9 Research instrument and mode of data collection

Data collection instruments were used for first-hand information which would later corroborate with the other data (Bastos *et al.*, 2014). Rumsey (2015) noted that poorly designed instrument could result in erroneous and inconsistent data. Therefore, the research instrument was carefully developed. Survey questionnaires were used in this research. The instruments were designed to express measurements and causalities in variables (Teye, 2012).

The questionnaires are a robust instrument for the interviewer and the respondent during the quantitative data collection (Bradburn *et al.*, 2004). However, during the fieldwork, an interview schedule (reading out questions on the questionnaires to the respondent) was used to clarify issues for the respondent. For example, a technical term like "desalination" was explained. According to Kumekpor (2002), "interview schedule" forms a good rapport, create a healthy atmosphere in which researcher and interviewer easily cooperate. The survey instrument was mostly close-ended with a few open-ended questions (*appendix A*). The questionnaire had four sections; the first module captured the demographic background of the respondent, the second module covered water supply and access, the third module captured awareness, acceptance and local support of seawater desalination, and the fourth module captured coping strategies.

IDI is a qualitative technique that involves an interviewer (*researcher*) and respondent (*key informant*) engagement. This technique typically explores perspectives on a particular subject matter often with probing questions to elicit additional information (Kumekpor, 2002). The interview format used for this study was semi-structured, which allows for probes (Price *et al.*, 2017). The study involved nine (9) interviews with stakeholders, key informants and opinion leaders.

FGD's are dynamic discussions and effective qualitative techniques used in diverse ways to gather information, especially in the field of social science (Stewart and Shamdasani, 1998; Harrell and Bradley, 2009). As a qualitative tool, this study used FGD's to explore further insights concerning the research (Edmunds, 1999). The first FGD organised was conducted in February 26th 2019, and the second FDG was conducted in February 27th 2019. Averagely, each of the discussion lasted between 45-70 minutes.

3.10 Data processing

Completed questionnaires, were manually scanned and edited. Templates were developed as a model for data entry where variables or specific questions were coded using numeric types. IBM SPSS Statistic (Statistical Package for Social Sciences) version 25 and Microsoft Excel 2016 were employed to prepare and enter data into a spreadsheet of the software. The interviews and the focus group sessions were transcribed manually into groups or themes based on the question asked.

3.11 Data analysis

Data analysis using univariate, bivariate and multivariate analysis formed the basis of the analysis of the study. Single-use or a combination of these techniques aided in generating tables and graphs to establish patterns in the field data. Demographic attributes of households such as gender, age, marital status, religion, education and household size under the univariate analysis were descriptive statistics (frequencies and percentages). Chi-square (χ^2) was used to analyse relationships between variables such as awareness, support for desalination and coping methods under the bivariate analysis. The multivariate analysis included binary logistic regression on variables such as support for desalination, demographic and other variables. Also, the Exploratory Factor Analysis (EFA) was used to redact coping variables that constituted coping strategies. The EFA was used in the study to conceptualise different coping strategies based on five (5) components.

For objective one, a comparative analysis of eleven (11) variables in two periods (before and during the operational period of the desalination) was analysed through frequencies and percentages explaining similarities and differences in the variables. For objective two, descriptive statistics were used to generate charts and tables of variables such as awareness of desalination. Chi-square (χ^2) was used to analyse the association of awareness of desalination and variables such as age, gender, educational level, occupation, income and community of respondents. Further, binary logistic regression was used to analyse support for desalination with predictor variables like gender, age, the regularity of desalinated water, years lived in community, quality of desalinated water, willingness to pay and type of community or area of respondents. On objective three, descriptive statistics, Chi-square (χ^2) statistics were employed to analyse the association of demographic variables with coping methods. The EFA based on Principal Component Analysis (PCA) was used to conceptualise coping strategies into different levels of coping.

Qualitatively, data from interviews and focus groups were used to support the quantitative data. For the requirement of research philosophy and research methods adopted, qualitative data mirrored the viewpoints of respondents and other key informants. Data analysis using both quantitative and qualitative information brought out the corroborations and diverse issues concerning the study. This mode of data analysis ensure validity and reliability as Cobbina *et al*. (2015) asserted that comparisons in data are critical to correcting anomalies that emerge in the data analysis.

3.12 Data management

The management of data collected in the field was effective. The municipal assembly (LeKMA) and Teshie camp (Headquarters) granted permission for data collection. As ethics are considered vital to any human research (The Belmont Report, 1979), respondents were required to give their consent before the data was collected which including voluntariness or willingness to participate in the data collection process. To ensure anonymity, managing data with the highest precision is key (Mackey and Gass, 2005). Data collected were stored in excel format and zipped using archival software's (*Ashampoo Zip software version 2.0*). Data management was strictly undertaken to safeguard research participants' biodata.

3.13 Limitations of data collection

Befesa Desalination Development Ghana Limited (BDDG) was to be part of the study. After several attempts, the BDDG's was not willing to disclose information about their operations and collaboration with GWCL. The Equipment officer at the plant site shared little unofficial details. Despite this setback, the Headquarters (HQ) of GWCL gave information concerning desalination and its operations in Ghana.

3.14 Chapter summary

The chapter discussed the study area and the methods which included the geographies of the area concerning climate, settlement, population growth or change, local economy. The research method included the philosophy, design, sampling, instrumentation, data gathering, data analysis and data management. A triangulation method: the mixed-method strategy was used to collect data on the field. Out of 384 calculated sample, 329 structured questionnaires were administered to respondents. Both quantitative and qualitative data were collected within three months (November 2018 to February 2019). The quantitative data were analysed using SPSS version 25. Information gathered was adequately protected and stored as part of data management.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

The chapter presents the results and discussions of the field survey. This section starts with the demonstration of the socio-demographic background of respondents or households and the modalities of water in the study area. Furthermore, comparison of the water situation before and during the desalination is presented, followed by an awareness of desalination, uses of desalinated water, and the consequence of using desalinated water on the support for the plant. The chapter ends with coping strategies used by households after the desalination plant was shut down. This section further discusses the results. Tables, bar charts and graphs were used to present results in this chapter.

4.2 Socio-demographic characteristics of household

Table 4.1 presents the background characteristics of respondents. Males represented 46.5%, and females represented 53.5% of the survey. This data reflects Ghana's typical demographic structure, where females are proportionally high (GSS, 2014). The demographic proportion of females and males is similar to LeKMA, which shows the male-female proportions as 47.7% and 52.3% based on the 2010 Population and Housing Census (GSS, 2014). Concerning religion or the faith of the respondent, the majority professed the Christian faith (74.8%). The rest were Islamic faith (16.4%), African traditional faith (4.6%). Respondents who claimed not to have any specific religion were 4.3%. The data shows that more than half of respondents were married (63.5%) while 31.3% had never married, leaving a small group of divorced respondents (5.2%). What stands out in the data is the proportion of respondents that had a formal education at different levels; 25.5%, 41.6%, and 24.6%

representing primary, secondary/technical and tertiary training. Respondents with no formal education were 8.2%.

Table 4.1: Socio-demographic characteristics of respondents

Demographic characteristics	Estate	Old Town	Teshie Camp	North Teshie	Total
Gender					
Male	25 (47.2)	38 (38.8)	19 (50.0)	71 (50.7)	153 (46.5)
Female	28 (52.8)	60 (61.2)	19 (50.0)	69 (49.3)	176 (53.5)
Age					
18-27	5 (9.4)	19 (19.4)	3 (7.9)	31 (15.0)	48 (14.6)
28-37	16 (30.2)	25 (25.5)	10 (26.3)	33 (23.6)	84 (25.5)
38-47	21 (39.6)	23 (23.5)	12 (31.6)	42 (30.0)	98 (29.8)
48-57	6 (11.3)	17 (17.3)	8 (21.1)	32 (22.9)	63 (19.1)
58-67	4 (7.5)	11 (11.2)	4 (10.5)	10 (7.1)	29 (8.8)
68 above	1 (1.9)	3 (3.1)	1 (2.6)	2 (1.4)	7 (2.1)
Religion					
Christian	39 (73.6)	75 (76.5)	30 (78.9)	102 (72.9)	246 (74.8)
Islam	9 (17.0)	10 (10.2)	8 (21.1)	27 (19.3)	54 (16.4)
African Tradition	3 (5.7)	8 (80.2)	0 (0.0)	4 (2.9)	15 (4.6)
No religion	2 (3.8)	5 (5.1)	0 (0.0)	7 (5.0)	14 (4.3)
Marital status					
Never Married	17 (32.1)	41 (41.8)	7 (18.4)	38 (27.1)	103 (31.3)
Married	34 (64.2)	49 (50.0)	27 (71.1)	99 (70.7)	209 (63.5)
Divorced	2 (3.8)	8 (8.2)	4 (10.5)	3 (2.1)	17 (5.2)
Educational status					
Basic (Elementary)	10 (18.9)	38 (38.8)	10 (26.3)	26 (18.6)	84 (25.5)
Secondary (Technical)	18 (34.0)	34 (34.7)	14 (36.8)	71 (50.7)	137 (41.6)
Tertiary	16 (30.2)	16 (16.3)	12 (31.6)	37 (26.4)	81 (24.6)
No Formal education	9 (17.0)	10 (10.2)	2 (5.3)	6 (4.3)	27 (8.2)
Occupation					
Civil/public servant	19 (35.8)	12 (12.2)	17 (44.7)	40 (28.6)	88 (26.7)
Personal business	15 (28.3)	32 (32.7)	8 (21.1)	37 (26.4)	92 (28.0)
Artisanry	8 (15.1)	35 (35.7)	6 (15.8)	33 (23.6)	82 (24.9)
Commercial driver	2 (3.8)	6 (6.1)	1 (2.6)	12 (8.6)	21 (6.4)
Seaman	1 (1.9)	4 (4.1)	1 (2.6)	1 (0.7)	7 (2.1)
Unemployed	8 (15.1)	9 (9.2)	5 (13.2)	17 (12.1)	39 (11.9)
Household size					
1-3	29 (54.7)	41 (41.8)	15 (39.5)	72 (51.4)	157 (47.7)
4-6	24 (45.3)	53 (54.1)	23 (60.5)	63 (45.0)	163 (49.5)
7-9	0 (0.0)	4 (4.1)	0 (0.0)	5 (3.6)	9 (2.7)
Average monthly income (GH¢)					
< 200	2 (3.8)	9 (9.2)	0 (0.0)	9 (6.4)	20 (6.1)
201-500	18 (34.0)	51 (52.0)	6 (15.8)	57 (40.7)	132 (40.1)
501-800	16 (30.2)	21 (21.4)	14 (36.8)	39 (27.9)	90 (27.4)

801>	10 (18.9)	11 (11.2)	15 (39.5)	31 (22.1)	67 (20.4)
Undisclosed	7 (13.2)	6 (6.1)	3 (7.9)	4 (2.9)	20 (6.1)
Years lived in Teshie					
< 5	3 (5.7)	0 (0.0)	0 (0.0)	4 (2.9)	7 (2.1)
6-10	7 (13.2)	7 (7.1)	6 (15.8)	27 (19.3)	47 (14.3)
11-15	17 (26.4)	27 (27.6)	12 (31.6)	49 (35.0)	102 (31.0)
Above 15	29 (54.7)	64 (65.3)	20 (52.6)	60 (42.9)	173 (52.6)
House type					
Non-compound	37 (69.8)	37 (37.8)	31 (81.6)	70 (50.0)	175 (53.2)
Compound	16 (30.2)	61 (62.2)	7 (18.4)	70 (50.0)	154 (46.8)

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019.

Household size between 1-3, 4-6, and 7-9 were 47.7%, 49.5% and 2.7% respectively, but no household had ten or more members in this survey. The number of years lived in the community was essential for the study. More than half of respondents (52.6%) have lived over 15 years in the study area, followed by 31.0% who have lived between 11-15 years. Fourteen point three per cent (14.3%) of the respondents lived between 6-10 years, and 2.1% lived below five years. For the type of dwelling, the data revealed that 53.2% of respondents dwelled in non-compound house (owned or rented house/apartment) whiles 46.8% of respondents resided in compound houses.

4.3 Modalities of water supply and access

The literature explains the influence of pipe water connectivity on supply, distribution, and access to water (WaterAid, 2012). Consequently, considering the regularity of water supply particularly in urban communities, water access is classified as improved if in-house pipe connection is compared to sources outside the house within proximity (Hope and Rouse, 2013). To distinguish between these two possibilities, Table 4.2 gives an overview of respondents who had pipes connected directly to the house regardless of the type of house. It revealed that more than half (52.9%) of the houses were directly connected to pipe whiles 47.1% did not have a direct pipe connection. The 2014 GSS published report illustrated piped water inside the housing unit was 25.9%, and pipe-borne water outside the house was 32% among other sources (GSS, 2014). This finding shows an improvement in pipe connection in the study area.

Table 4.2: Modalities for water supply and access

Water supply and access	Estate	Old Town	Teshie Camp	North Teshie	Total
Pipe connection in the house					
Yes	51 (96.2)	20 (20.4)	36 (94.7)	67 (47.9)	174 (52.9)
No	2 (3.8)	78 (79.6)	2 (5.3)	73 (52.1)	155 (47.1)
In-house water meter					
Yes	50 (94.3)	20 (20.4)	0 (0.0)	64 (45.7)	134 (40.7)
No	1 (1.9)	0 (0.0)	36 (94.7)	3 (2.1)	40 (12.2)
No responses	2 (3.8)	78 (79.6)	2 (5.3)	73 (52.1)	155 (47.1)
Amount paid in a bill (GH¢)					
<50	10 (18.9)	4 (4.1)	0 (0.0)	26 (18.6)	40 (12.2)
50-100	30 (56.6)	14 (14.3)	0 (0.0)	28 (20.0)	72 (21.9)
Above 100	10 (18.9)	2 (2.0)	0 (0.0)	13 (9.3)	25 (7.6)
No bill payment	3 (5.7)	78 (79.6)	38 (100.0)	73 (52.1)	192 (58.4)
Outside water access					
Stand pipe	1 (1.9)	39 (39.8)	1 (2.6)	26 (18.6)	67 (20.4)
Concrete tanks	1 (1.9)	18 (18.4)	0 (0.0)	19 (13.6)	38 (11.6)
Poly-tanks	0 (0.0)	19 (19.4)	1 (2.6)	26 (18.6)	46 (14.0)
Tanker	0 (0.0)	2 (2.0)	0 (0.0)	2 (1.4)	4 (1.2)
No response	51 (96.2)	20 (20.4)	36 (94.7)	67 (47.9)	174 (52.9)

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019.

The study found exceptions regarding metering in one community. Almost all the houses in Teshie camp had in-house pipe connection (94.7%), yet, without a meter (94.7%). A possible explanation could be the mode of state housing development in the past (Larbi, 1996; Kwofie *et al.*, 2011). Concerning houses with a metering device, 12.2% of the respondents spent less than Gh¢50 on the water bill, 21.9% of households spent between Gh¢50-100, and 7.6% spent above Gh¢100. Specifically, amongst the 21.9% who pay between Gh¢50-100 of water bills, more than half (56.6%) are in Teshie estate. However, deducing from the number respondents (137) who paid bills, more than half of the respondents (52.2%) spent between Gh¢50-100, 29.2% spent less than Gh¢50 and 18.2% spent above Gh¢100. The data shows that 54.8% of respondent in this group did not pay bills. Here, exceptions earlier mentioned affected payment of water bills. For instance, respondents in Teshie camp believed that water bills were charged from their wages, but they do not pay directly. Respondents who were not connected directly accessed water from standpipes (20.4%), concrete tanks (11.6%), poly-tanks (14.0%) and private water tankers (1.2%). The JMP categorises these alternatives as improved water sources (WHO/UNICEF/ JMP, 2010).

4.4 Assessment of water supply and access before and during the desalination period

4.4.1 Water situation before desalination

Figure 4.1 illustrates the water situation before the operation of the Teshie desalination plant. An aggregation of responses showed that about 14.9% of the respondents experienced a good water situation. However, the majority of the respondents (85.1%) by aggregate depicted that the water situation was not good. Respondents experienced unimproved conditions even though previously, there had been micro-level intervention (see Doe, 2007). An interview with the spokesperson of the Teshie Traditional Council demonstrated the water situation of Teshie before the implementation of the desalination project.

> *"According to the Ghana Water Company, they did not have enough water for the community. Water was not flowing through most pipes, and it was very difficult to acquire water in Teshie. Almost every household took to the construction of a reservoir in the ground. We were leaving on tanker suppliers before desalination. The water tankers were not enough, too expensive and most people could not buy. Living with this condition affected us every way, especially children. It was tough. Later we got to know that, most underground pipelines in Teshie have gone bad, so any time they open the pipe, you see the water oozing out mostly along the roadside." (Interview with the spokesperson of TTC)*

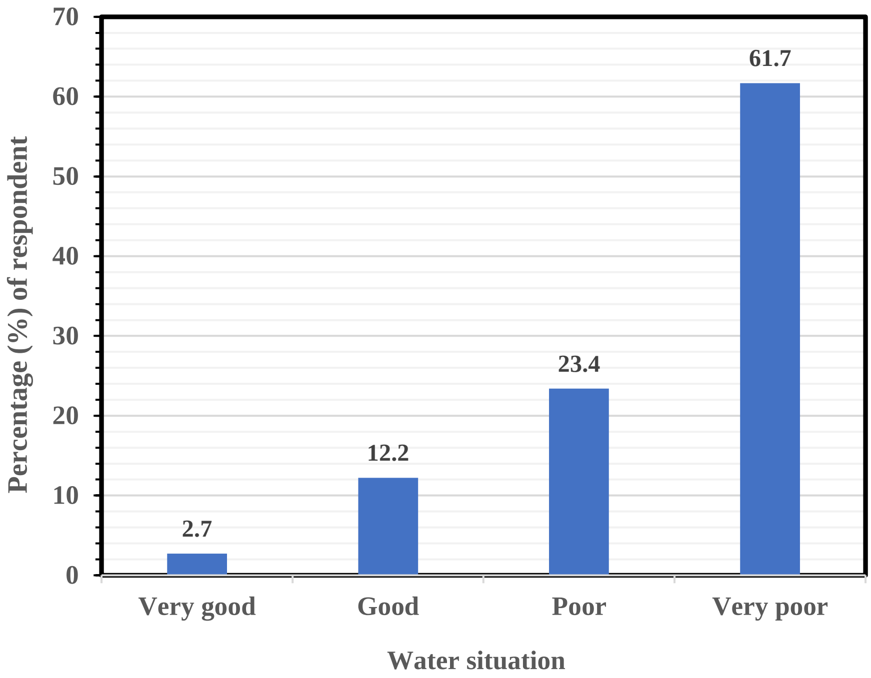

Figure 4.1: General water situation before desalination (n=329)

Source: Field survey, 2019.

Table 4.3: Water situation before the desalination

Variables	Estate	Old Town	Teshie Camp	North Teshie	Total
Water supplied was frequent					
Agree	11 (20.8)	6 (6.1)	0 (0.0)	16 (11.4)	33 (10.0)
Disagree	42 (79.2)	92 (93.9)	38 (100.0)	124 (88.6)	296 (90.0)
Neutral	—	—	—	—	—
Water quality as good					
Agree	33 (62.3)	37 (37.8)	18 (47.4)	76 (54.3)	164 (49.8)
Disagree	19 (35.8)	60 (61.2)	18 (47.4)	63 (45.0)	160 (48.6)
Neutral	1 (1.9)	1 (1.0)	2 (5.3)	1 (0.7)	5 (1.5)
Short distance to an outside water source					
Agree	35 (66.0)	57 (58.2)	21 (55.3)	89 (63.6)	202 (61.4)
Disagree	17 (32.1)	41 (41.8)	17 (44.7)	51 (36.4)	126 (38.3)
Neutral	1 (1.9)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)
Less time to fetch water					
Agree	9 (17.0)	19 (19.4)	8 (21.1)	28 (20.0)	64 (19.5)
Disagree	44 (83.0)	79 (80.6)	30 (78.9)	112 (80.0)	265 (80.5)
Neutral	—	—	—	—	—
Household stored large volumes of water					
Agree	26 (49.1)	60 (61.2)	22 (57.9)	71 (50.7)	179 (54.4)
Disagree	27 (50.9)	38 (38.8)	16 (42.1)	69 (49.3)	150 (45.6)

Neutral	—	—	—	—	—
High price of water *(from vendors)*					
Agree	41 (77.4)	84 (85.7)	29 (76.3)	125 (89.3)	279 (84.8)
Disagree	12 (22.6)	8 (8.2)	2 (5.3)	9 (6.4)	31 (9.4)
Neutral	0 (0.0)	6 (6.1)	7 (18.4)	6 (4.3)	19 (5.8)
Women spent more hours fetching water					
Agree	35 (66.0)	59 (60.2)	26 (68.4)	103 (73.6)	223 (67.8)
Disagree	16 (30.2)	27 (27.6)	7 (18.4)	26 (18.6)	76 (23.1)
Neutral	2 (3.8)	12 (12.2)	5 (13.2)	11 (7.9)	30 (9.1)
Lives of children were at risk					
Agree	23 (43.4)	60 (61.2)	18 (47.4)	75 (53.6)	176 (53.5)
Disagree	22 (41.5)	31 (31.6)	17 (44.7)	51 (36.4)	121 (36.8)
Neutral	8 (15.1)	7 (7.1)	3 (7.9)	14 (10.0)	32 (9.7)
Children were late for school					
Agree	20 (37.7)	40 (40.8)	18 (47.4)	64 (45.7)	142 (43.2)
Disagree	25 (47.2)	35 (35.7)	16 (42.1)	46 (32.9)	122 (37.1)
Neutral	8 (15.1)	23 (23.5)	4 (10.5)	30 (21.4)	65 (19.8)
No proper sanitation					
Agree	36 (67.9)	53 (54.1)	16 (42.1)	72 (51.4)	177 (53.8)
Disagree	12 (22.6)	23 (23.5)	16 (42.1)	41 (29.3)	92 (28.0)
Neutral	5 (9.4)	22 (22.4)	6 (15.8)	27 (19.3)	60 (18.2)
Economic activities slowed down					
Agree	30 (56.6)	46 (46.9)	22 (57.9)	75 (53.6)	173 (52.6)
Disagree	15 (28.3)	34 (34.7)	9 (23.7)	50 (35.7)	108 (32.8)
Neutral	8 (15.1)	18 (18.4)	7 (18.4)	15 (10.7)	48 (14.6)
Total	**53 (100)**	**98 (100)**	**38 (100)**	**140 (100)**	**329 (100)**

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019

As it can be observed in Table 4.3, the water supply was not frequent in the period before the desalination plant became operational. Majority of the respondents in all the four communities disagreed to frequent water flow. This was followed by the quality of water supplied at the time. From the table, more than half of the residents of Teshie estate (62.3%) and Teshie north (54.3%) responded that the water quality was good with about 61.2% of the people of Teshie south attesting that the water quality was poor. Water prices were very high during the period without desalination. From Table 4.3, more than half of the respondents in Teshie north agreed that children were at risk during the period without desalination.

Table 4.4: Water situation during the desalination

Variables	Estate	Old Town	Teshie Camp	North Teshie	Total
Water supplied was frequent					
Agree	45 (84.9)	59 (60.2)	26 (68.4)	107 (76.4)	237 (72.0)
Disagree	8 (15.1)	38 (38.8)	12 (30.6)	32 (22.9)	90 (27.4)
Neutral	0 (0.0)	1 (1.0)	0 (0.0)	1 (50.0)	2 (0.6)
Good water quality					
Agree	14 (26.4)	23 (23.5)	14 (36.8)	43 (30.7)	94 (28.6)
Disagree	38 (71.7)	75 (76.5)	22 (57.9)	96 (68.6)	231 (70.2)
Neutral	1 (1.9)	0 (0.0)	2 (5.3)	1 (0.7)	4 (1.2)
Short distance to an outside water source					
Agree	43 (81.1)	51 (52.0)	27 (71.1)	94 (67.1)	215 (65.3)
Disagree	8 (15.1)	43 (43.9)	9 (23.7)	42 (30.0)	102 (31.0)
Neutral	2 (3.8)	4 (4.1)	2 (5.3)	4 (2.9)	12 (3.6)
Less time to fetch water					
Agree	45 (84.9)	61 (62.2)	29 (76.3)	108 (77.1)	243 (73.9)
Disagree	8 (15.1)	37 (37.8)	9 (23.7)	32 (22.9)	86 (26.1)
Neutral	—	—	—	—	—
Household stored large volumes of water					
Agree	49 (92.5)	85 (86.7)	33 (86.8)	118 (84.3)	285 (86.6)
Disagree	4 (7.5)	13 (13.3)	5 (13.2)	22 (15.7)	44 (13.4)
Neutral	—	—	—	—	—
High price of water *(from vendors)*					
Agree	15 (28.3)	48 (49.0)	16 (42.1)	53 (37.9)	132 (40.1)
Disagree	37 (69.8)	41 (41.8)	19 (50.0)	82 (58.6)	179 (54.4)
Neutral	1 (1.9)	9 (9.2)	3 (7.9)	5 (3.6)	18 (5.5)
Women spent more hours fetching water					
Agree	8 (15.1)	32 (32.7)	15 (39.5)	43 (30.7)	98 (29.8)
Disagree	43 (81.1)	53 (54.1)	20 (52.6)	85 (60.7)	201 (61.1)
Neutral	2 (3.8)	13 (13.3)	3 (7.9)	12 (8.6)	30 (9.1)
Lives of children were at risk					
Agree	7 (13.2)	41 (41.8)	9 (23.7)	44 (31.4)	101 (30.7)
Disagree	44 (83.0)	48 (49.0)	26 (68.4)	77 (55.0)	195 (59.3)
Neutral	2 (3.8)	9 (9.2)	3 (7.9)	19 (13.6)	33 (10.0)

Children were later for school					
Agree	6 (11.3)	26 (26.5)	8 (21.1)	36 (25.7)	76 (23.1)
Disagree	43 (81.1)	55 (56.1)	26 (68.4)	84 (60.0)	208 (63.2)
Neutral	4 (7.5)	17 (17.3)	4 (10.5)	20 (14.3)	45 (13.7)
No proper sanitation					
Agree	23 (43.4)	59 (60.2)	16 (42.1)	83 (59.3)	181 (55.0)
Disagree	30 (56.4)	37 (37.8)	20 (52.6)	56 (40.0)	143 (43.5)
Neutral	0 (0.0)	2 (2.0)	2 (5.3)	1 (0.7)	5 (1.5)
Economic activities slowed down					
Agree	15 (28.3)	38 (38.8)	13 (34.2)	73 (52.1)	139 (42.2)
Disagree	29 (54.7)	43 (43.9)	23 (60.5)	51 (36.4)	146 (44.4)
Neutral	9 (17.0)	17 (17.3)	2 (5.3)	16 (11.4)	44 (13.4)
Total	**53 (100)**	**98 (100)**	**38 (100)**	**140 (100)**	**329 (100)**

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019.

To examine the water situation before and after the implementation, the study used a comparative analysis based on a perception of change of similar features or phenomena. The separation point between the two periods was the year 2015 (when the desalination started). With the frequency of water supply, the majority of respondents (90.0%) disagreed that water was frequent before desalination (Table 4.3). However, during desalination (Table 4.4), majority of the respondents (72.2%) agreed that water supply was regular. Concerning the water quality, almost half of the respondents (49.8%) indicated that the quality of water was good, while 48.6% of them disagreed. It is important to note that water treatment is daily. However, end-user experience may differ because the water transportation process may undermine water quality (Arnold *et al.*, 2013). Unfortunately, 70.2% of the respondents indicated that water quality during the desalination period was substandard.

More than half of the respondents indicated that the distance to a water source outside the house was short before and during desalination, which represented 61.4% and 65.3% respectively. Time spent to fetch water was crucial for the study. Table 4.3 illustrates; before desalination, majority of the respondents (80.5%) disagreed with less time spent to fetch water while only 19.5% agreed. After the desalination intervention, the majority of the respondents (73.8%) agreed to less time spent to fetching water outside the house (Table 4.4). Before desalination, more than half of the respondents (54.4%) stored large volumes of water whiles 45.6% could not. Subsequently, during the operational period of the plant, the majority of the respondents (86.7%) stored large volumes of water whiles only about 13.4% could not store enough water.

From Table 4.3 water prices were high before desalination; thus, the majority of the respondents (84.8%) agreed that water prices were high. Comparatively, during desalination, the cost of water was relatively low, which was indicated by more than half of the respondents (54.5%) (see Table 4.4). With time spent fetching water, specifically concerning women, about 67.8% of respondents agreed that women spent much time to fetch water for the household before the desalination. Desalination lessened the time women spent on fetching water. Majority of the respondent (61.1%) disagreed that women spent much time on fetching water during desalination period. An interviewee said this concerning women and children:

> *"Before desalination, I wasn't an assembly member, I was doing business, but sometimes I had to leave with my children and some of my apprentice to fetch water. But I was relieved when we had the desalination. Water was in abundance, so a lot of women and children were relieved of some water fetching duties"* (Assembly member, Teshie-North)

The data shows that the lives of children were at risk before the desalination intervention. Over half of the respondents (53.5%) agreed that the water crisis had repercussions on children. The statement below is the account of a water vendor;

> *"If we don't have water in our area, we board a car to Demo to fetch water so we can also sell to people. Sometimes we walk, but I once witnessed a car knocked down a young girl who crossed the road on the main street to fetch water."* (Water vender, Teshie-South)

Fortunately, concerning risk associated with children fetching water; during the desalination period, it was mitigated; thus, more than half of the respondents (59.3%) disagreed to children being at risk. Still concerning children, in the period before desalination, about 43.2% of respondents agreed that children were late for school and, 37.1% of them disagreed, and 19.8% of the respondents were indifferent. The statement below presents what interviewees said concerning school attending pupil;

> *"I realised that some children don't even bath when going to school. Especially the old town, before kids wake up; their mothers have gone to search for water. So, the child takes his clothes and go to school. At times when they go to the teachers will beat them for not bathing" (Assembly member, Teshie-South)*
>
> *"During the period before desalination children were truant because they form long queues to fetch water and also because of the time spent they become tired and refuse to come to school" (Water vender, Teshie-North)*

Majority of the respondents (63.2%) indicated that children of school-going age were not affected during the desalination period, which indicates that the desalination intervention reduced truancy. Sanitation issues before desalination were not the best. About 53.8% of the respondents agreed that there was no proper sanitation (Table 4.3). However, 55% of the respondent agreed there was no adequate sanitation during the desalination period. Specifically, the majority of the respondents in two communities; Old Town (60.2%) and North Teshie (59.3%) noted that sanitation was not improved during the desalination period. The interviews and focus group discussion show diverse response concerning sanitation;

> *"Desalination helped in improving sanitation, especially my area. Water was abundant in public places because the desalination plant increases water supply in homes and workplaces." (Assembly member, Teshie-South)*
>
> *"Sanitation had not improved even when desalination was started, you go to the public toilet and sometimes you have to fetch your water from the house to the place" (Water vender, Teshie-South)*
>
> *"During desalination, water price was okay. I sometimes pay 20 pesewas per bucket, but now I pay 50p at the public toilet. It is still not cleaned, but prices have gone up" (Respondent, FDG 2)*

Before desalination was implemented, more than half of the respondents (52.6%) agreed that the water crisis affected economic activities. However, during the desalination period, there was a marginal decrease in respondents (42.2%) who agreed that economic activities were affected. Specifically, activities connected to water merchandise was significantly affected during desalination period. The statement below by interviewees throws light on economic activities connected to water;

> *"Water vending business slows down because of the salt content in the water and people were not patronising it as we want." (Water vender, Teshie-North)*

> *"I realised some of the tankers had gone far from this place. But some vendors are still in business because people do not store enough water and also some houses don't have connected pipelines, but this time they do not buy from the tankers but neighbours at a moderate price, like GH¢ 0.30 for a gallon" (Assembly member, Teshie-South)*

4.4 Uses of desalinated water and its effect on local support in Teshie

4.5.1 Awareness of the desalination plant after its commissioning

Awareness is crucial for any municipal intervention to thrive—this was to unearth the respondent's awareness after the desalination was commissioned to supply water to the community. Table 4.5 shows that the majority of respondents (62.6%) were aware of the desalination, and 37.4% of the respondents were not. Spatially, more than half of the residents in the four communities were aware of the desalination. The respondents who were aware acknowledged various mediums through which they became aware. From Table 4.5, 19.8% of the respondents became aware through GWCL, 17.0% became aware through media houses, 20.7% were informed through their neighbours, and 5.2% of the respondents were aware through rumours. Respondents who were unaware were 37.4%. An interview with an assembly member and the spokesperson of the TCC is presented below;

"After they started operating, the water company announced that if your tap is not flowing report to them. But it was our former Member of Parliament who spoke about the desalination, so people heard it. That was the only way that some of the residents may have gotten to know that there was something in the pipeline." (Assembly member, Teshie-South)

"All the chiefs and opinion leaders were involved. We did a lot of public sensitisation and also community durbars and let them know that idea of establishing the project and they accepted it." (Interview with the spokesperson of TTC)

Table 4.5: Awareness of desalination

Awareness	Estate	Old Town	Teshie Camp	North Teshie	Total
Yes	33 (62.3)	61 (62.2)	24 (63.2)	88 (62.9)	206 (62.6)
No	20 (37.7)	37 (37.8)	14 (36.8)	52 (37.1)	123 (37.4)
Mode					
GWCL	13 (24.5)	17 (17.3)	8 (21.1)	27 (19.3)	65 (19.8)
Media house	8 (15.1)	19 (19.4)	4 (10.5)	25 (17.9)	56 (17.0)
Neighbour	10 (18.9)	21 (21.4)	7 (18.4)	30 (21.4)	68 (20.7)
Rumor	2 (3.8)	4 (4.1)	5 (13.2)	6 (4.3)	17 (5.2)
No response	20 (37.7)	37 (37.8)	14 (36.8)	52 (37.1)	123 (37.4)
Total	**53 (100)**	**98 (100)**	**38 (100)**	**140 (100)**	**329 (100)**

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019.

A bivariate chi-square (χ^2) analysis in Table 4.6 determined which socioeconomic and demographic variable were significant to awareness of desalination. Gender and education were not significant. Therefore, there was no relationship between these demographic variables and awareness of desalination. The community of respondents was not significant indicating that their spatial difference could not influence awareness of desalination. Also, from the same table, it can be observed that income and occupation were significantly associated with awareness of desalination—meaning there is evidence that residents occupation and income aided their awareness of desalination. By limiting the socio-economic variables to income and occupation; then the study rejects the null hypothesis (H_o: There is no statistically significant relationship between demographic variable and awareness of desalination) and accepts the alternate hypothesis (H_A: There is a statistically significant relationship between demographic variable and awareness of desalination). Nonetheless, these results corroborate some aspects of the study's conceptual framework (figure 2.1) where some demographic variables may influence awareness.

Table 4.6: Awareness of desalination and selected socioeconomic and demographic variables

Variables	Awareness of desalination					
	Yes	**No**	**Total**	**Df**	χ^2	**p-value**
Gender				1	2.413	0.120
Male	89 (43.2)	64 (52.0)	153 (46.5)			
Female	117 (56.8)	59 (48.0)	176 (53.5)			
Education				3	0.877	0.831
Basic (Elementary)	53 (25.7)	31 (25.2)	84 (25.5)			
Secondary /Technical	85 (41.3)	52 (42.3)	137 (41.6)			
Tertiary	53 (25.7)	28 (22.8)	81 (24.6)			
No Formal education	15 (7.3)	12 (9.8)	27 (8.2)			
Occupation				5	17.821	**0.003***
Civil/public servant	55 (26.7)	33 (26.8)	88 (26.7)			
Personal business	63 (30.6)	29 (23.6)	92 (28.0)			
Artisanry	57 (27.7)	25 (20.3)	82 (24.9)			
Commercial driver	11 (5.3)	10 (8.1)	21 (6.4)			
Seaman	0 (0.0)	7 (5.7)	7 (2.1)			
Unemployed	20 (9.7)	19 (15.4)	39 (11.9)			
Income (GH¢)				4	22.862	**0.000***
Below 200	4 (1.9)	16 (13.0)	20 (6.1)			
201-500	87 (42.2)	45 (36.6)	132 (40.1)			
501-800	63 (30.6)	27 (22.0)	90 (27.4)			
801 and Above	44 (21.4)	23 (18.7)	67 (20.4)			
Undisclosed	8 (3.9)	12 (9.8)	20 (6.1)			
Community						
Estate	33 (16.0)	20 (16.3)	53 (16.1)	3	0.017	0.999
Old Town	61 (29.6)	37 (30.1)	98 (29.8)			
Teshie camp	24 (11.7)	14 (11.4)	38 (11.6)			
Teshie North	88 (42.7)	52 (42.3)	140 (42.6)			
Total	**206 (100)**	**123 (100)**	**329 (100)**			

Figures in parentheses are percentages while those not in brackets are the respondent counts;
** means significant difference at* ***p < 0.050 (5% level of significance)***

Source: Field Survey, 2019.

4.5.2 Supply, uses and perception of desalinated water by the community

4.5.2.1 Days for receiving water

Table 4.7: Days of receiving water during desalination period

Days of desalinated water	Estate	Old Town	Teshie Camp	North Teshie	Total
Everyday	6 (11.3)	9 (9.2)	3 (7.9)	15 (10.7)	33 (10.0)
2 days	29 (54.7)	60 (61.2)	18 (47.4)	76 (54.3)	183 (55.6)
3 days	16 (30.2)	26 (26.5)	16 (42.1)	43 (30.7)	101 (30.7)
4 days	2 (3.8)	2 (2.0)	0 (0.0)	5 (3.6)	9 (2.7)
No idea	0 (0.0)	1 (2.6)	1 (2.6)	1 (0.7)	3 (0.9)
Hours of flow (hours)					
<8	1 (1.9)	0 (0.0)	1 (2.6)	1 (0.7)	3 (0.9)
8-16	18 (34.0)	4 (4.1)	12 (31.6)	25 (17.9)	59 (17.9)
16-24	30 (56.6)	91 (92.9)	20 (52.6)	103 (73.6)	244 (74.2)
No idea	4 (7.5)	3 (3.1)	5 (13.2)	11 (7.9)	23 (7.0)

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field Survey, 2019.

It has been established that water supply was frequent during the desalination period as compared to the period before desalination (Table 4.4). However, Table 4.7 provides further details on the frequency of water using days respondents received water per week. The data reveals that more than half of the respondents (55.6%) received water two days a week. Within this figure were more than half of the residents— Estate (54.7%), Old Town (61.2%) and North Teshie (54.3%). The rest of the days are in this wise: 10.0% of the respondents received water every day, 30.7% received water three days, 2.7% received water for four days and 0.9% did not know. The table further shows the majority of respondents (74.2%) received water between 16-24 hours (*spatially, all the four communities had more than half of their residents receiving water within this period*), 0.9% of the respondents received less than 8 hours of flow, 17.9% received water between 8-16 hours. The district manager of GWCL had this to say concerning water flow:

> *"We supply Teshie three times a week that is Wednesdays, Saturdays and Sundays. Most people have storage capacities, so anytime we deliver, they store. So, you store, two days later you get water again" (Interview with the District Manager, GWCL)*

4.5.2.2 Volume of water used in a day

The volume of water was determined using the number of gallons (*size of a gallon was 20-25 litre*) respondents used in a day during the desalination period. The days of desalination was compared to the period after the desalination was shut down. Figure 4.2 showed that more than half of the respondents (66.3%) used approximately 4 to 6 gallons of water per day. However, there was a marginal decrease in the volume of water from 66.3% in the desalination period to 65.0% after the plant was shut down (1.3% decreased). Interestingly, whiles household's usage of water slightly drops between 4-6 per day, usage of water between 1-3 per day increased from 18.2% to 24.3% (6.1% increase in that category) indicating that after the desalination plant was shut down, the use of one to three gallons of water a day marginally increased.

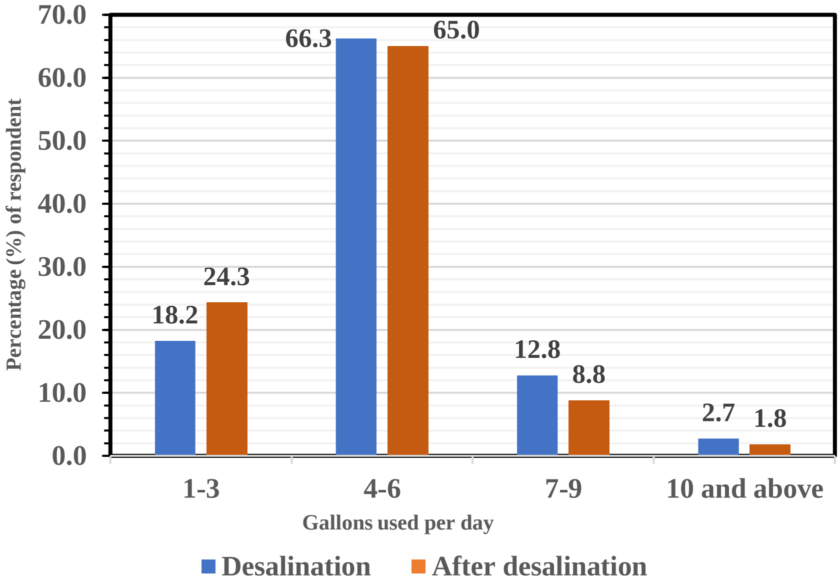

Figure 4.2: Number of gallons used per day (n=329)

Source: Field survey, 2019.

4.5.2.3 Usage of desalinated water

Table 4.8: Uses of desalinated water

Variable	Communities				
Uses of desalinated water	**Estate**	**Old Town**	**Teshie Camp**	**North Teshie**	**Total**
Drinking					
Regularly	1 (1.9)	4 (4.1)	0 (0.0)	1 (0.7)	6 (1.8)
Not regularly	14 (26.4)	19 (19.4)	6 (15.8)	27 (19.3)	66 (20.1)
No	38 (71.7)	75 (76.5)	32 (84.2)	112 (80.0)	257 (78.1)
Cooking					
Regularly	28 (52.8)	28 (28.6)	11 (28.9)	44 (31.4)	111 (33.7)
Not regularly	20 (37.7)	38 (38.8)	21 (55.3)	60 (42.9)	139 (42.2)
No	5 (9.5)	32 (32.7)	6 (15.8)	36 (25.7)	79 (24.0)
Bathing					
Regularly	41 (77.4)	89 (90.8)	31 (81.6)	121 (86.4)	282 (85.7)
Not regularly	12 (22.6)	7 (7.1)	7 (18.4)	16 (11.4)	42 (12.8)
No	0 (0.0)	2 (2.0)	0 (0.0)	3 (2.1)	5 (1.5)
Washing					
Regularly	47 (88.7)	85 (86.7)	31 (81.6)	107 (76.4)	270 (82.1)
Not regularly	3 (5.7)	10 (10.2)	5 (13.2)	21 (15.0)	39 (11.9)
No	3 (5.7)	3 (3.1)	2 (5.3)	12 (8.6)	20 (6.1)
Flushing					
Regularly	24 (45.3)	25 (25.5)	28 (73.7)	54 (38.6)	131 (39.8)
Not regularly	7 (13.2)	13 (13.3)	0 (0.0)	18 (12.9)	38 (11.6)
No	10 (18.9)	40 (40.8)	7 (18.4)	47 (33.6)	104 (31.6)
No response	12 (22.6)	20 (20.4)	3 (7.9)	21 (15.0)	56 (17.0)
Cleaning					
Regularly	42 (79.2)	75 (76.5)	35 (92.1)	116 (82.9)	268 (81.5)
Not regularly	9 (17.0)	22 (22.4)	2 (5.3)	21 (15.0)	54 (16.4)
No	2 (3.8)	1 (1.0)	1 (2.6)	3 (2.1)	7 (2.1)
Total	**53 (100)**	**98 (100)**	**38 (100)**	**140 (100)**	**329 (100)**

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019.

The uses of desalinated water across four communities is presented in Table 4.8 based on six categories of application. All the four communities revealed that they could not drink desalinated water but aggregately about 78.1% of the total respondents disregarded drinking desalination. Only 20.1% of households drank it but not often, and 1.8% regularly drank the desalinated water. For cooking purposes, 33.7% of households used desalinated water frequently, and 42.2% did not cook with desalinated water regularly. However, to sum it, the majority of respondents (75.9%) prepared food with the desalinated water. Almost of them used the desalinated water for bathing (98.5%). In contrast to drinking, the majority of respondents from the four communities bathed with the desalinated water. Also, uses such as washing with desalinated water were high. For flushing, more than half of the households (51.4%) used the water, and about 31.6% did not flush with the water. However, specifically, residents of Teshie camp highly used the water for flushing purposes (73.7%). Aside from these five-essential uses of the desalinated water, all other domestic use such as cleaning was high (81.5%). Apart from the obvious reason why drinking desalinated water was low, other reasons have been noted through interviews and focus group discussions;

> *"The question of the water being chemically good, for that we did not know. All we knew was that we have water flowing through our pipes. We used desalinated water for washing cassava, fish and other domestic things. People waited for freshwater from Kpong at the weekends so that they would store it for drinking." (Interview with the TCCA)*

> *"I used the water for everything, just that it does not lather well when used for washing. More soap was needed for effective washing. You realise the difference when you try to drink. So, if the water company intend to start the supply again, then we want it clear." (Respondent, FDG 1*)

> *"For me, since we have been told that it's treated, sometimes I drink because I don't have an option. If I cook with it, I get some running stomach and also it came at a cost because I used a lot of soap when bathing and washing. I bought soap for almost every time." (Respondent 2, FDG 2)*

> *"The water was very salty, so it was difficult to drink, but I do not agree with my friend. I believe the water is good for cooking; I use the water for cooking and I don't have any problem." (Respondent 3, FDG 2)*

4.5.2.4 Perception of water quality by the community of residents

The data in Table 4.9 shows respondents' concerns about the quality of desalinated water. Majority of the respondents (69.0%) were concerned about desalinated water. Considering the spatial variation, all the four community's respondents were more than half who were concerned about the use of desalinated water. A follow up multiple-choice question was asked to ascertain specific concerns. Four (4) factors were enumerated—salt content, smell, colour, and particles. The table further demonstrates that water salinity was a primary concern of respondents. Apart from the majority— Estate (62.3%), Old Town (72.4%), Teshie camp (52.6%) and Teshie north (58.6%) who had issues with the salt content, aggregately, 29.2% of the respondents found that the desalinated water contained particles. Also, about 9.7% indicated bad smell and 9.1% of the respondents showed that the water was coloured. The interview below present what the GWCL had this to say concerning the salt content of the desalinated water:

> *"Treating seawater is different from freshwater. There are differences in water salinity, but WHO has their standards that we follow, so whatever is treated here, must follow the same standards. After treatment, seawater will not taste like freshwater. The taste is different, and the processing is also different so the outcomes cannot be the same because the raw materials are also different" (Interview with the District Manager, GWCL)*

Table 4.9: Quality of desalinated water

Variables		**Communities**			
Concerns with quality of desalinated water	**Estate**	**Old Town**	**Teshie Camp**	**North Teshie**	**Total**
Yes	35 (66.0)	76 (77.6)	22 (57.9)	94 (67.1)	227 (69.0)
No	18 (34.0)	22 (22.4)	16 (42.1)	46 (32.9)	102 (31.0)
Total	**53 (100)**	**98 (100)**	**38 (100)**	**140 (100)**	**329 (100)**
Quality of desalinated water					
Salty	33 (62.3)	71 (72.4)	20 (52.6)	82 (58.6)	206 (62.6)
Bad smell	3 (5.7)	9 (9.2)	4 (10.5)	16 (11.4)	32 (9.7)
colored	8 (15.1)	8 (8.2)	1 (2.6)	13 (9.3)	30 (9.1)
Particles	7 (13.2)	41 (41.8)	9 (23.7)	39 (27.9)	96 (29.2)

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019.

4.5.3 Use of desalinated water and community support

Table 4.10: Chi-square analysis of uses of desalinated water and support for desalination

Uses of desalinated water	Community support					
	Supportive	Unsupportive	Total	df	χ^2	p-value
Drinking				2	1.001	0.606
Regularly	4 (2.5)	2 (1.2)	6 (1.8)			
Not regularly	30 (19.1)	36 (20.9)	66 (20.1)			
No	123 (78.3)	134 (77.9)	267 (78.1)			
Cooking				2	3.631	0.163
Regularly	61 (38.9)	50 (29.1)	111 (33.7)			
Not regularly	60 (38.2)	79 (45.9)	139 (42.2)			
No	36 (22.9)	43 (25.0)	79 (24.0)			
Bathing				2	0.729	0.694
Regularly	136 (86.6)	146 (84.9)	282 (85.7)			
Not regularly	18 (11.5)	24 (14.0)	42 (12.8)			
No	3 (1.9)	2 (1.2)	5 (1.5)			
Washing				2	6.452	**0.040***
Regularly	125 (79.6)	145 (84.3)	270 (82.1)			
Not regularly	17 (10.8)	22 (12.8)	39 (11.9)			
No	15 (9.6)	5 (2.9)	20 (6.1)			
Flushing				3	4.310	0.230
Regularly	71 (45.2)	60 (34.9)	131 (39.8)			
Not regularly	18 (11.5)	20 (11.6)	38 (11.6)			
No	46 (29.3)	58 (33.7)	104 (31.6)			
No response	22 (14.0)	34 (19.8)	56 (17.0)			
Cleaning				2	1.406	0.495
Regularly	131 (83.4)	137 (79.7)	268 (81.5)			
Not regularly	24 (15.3)	30 (17.4)	54 (16.4)			
No	2 (1.3)	5 (2.9)	7 (2.1)			
Total	**157 (100)**	**172 (100)**	**329 (100)**			

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019.

Analysing support for desalination was key to the study. The study revealed that 52.3% of the respondents were not in support of desalination, and 47.7% of the respondents were in support of desalination (*see appendix D*). However, specifically, amongst the four communities, the respondents of the Old town (60.2%) and the Estate (50.9%) who were unsupportive of desalination were more than half. More than half of the respondents from Teshie camp (55.3%) and North Teshie (50.7%) were in support of desalination (*see appendix D*). Table 4.10 further establishes a χ^2 analysis on uses of desalinated water and the community/public support of the plant. The table showed that there was no significant relationship (**p=0.606>0.05**) between drinking desalinated water and support for desalination. However, majority of the respondents who did not drink desalinated water (77.9%) were unsupportive of the operation of desalination. Also, from Table 4.10, there was a statistically significant relationship between using desalinated water for washing and the support for the desalination (**p=0.040<0.05**). This implies that respondents using desalinated water to wash were in support of the desalination.

Table 4.11: Willingness to pay for the service concerning support for desalination

Variable	Support for desalination		Total
Willing to pay for service	**Supportive**	**Unsupportive**	
Yes	33 (21.0%)	9 (5.2%)	42 (12.8%)
No	96 (61.8%)	129 (75.0%)	225 (68.4%)
Undecided	28 (17.8%)	34 (19.8%)	62 (18.8%)
Total	**157 (100%)**	**172 (100%)**	**329 (100%)**

χ^2=18.489, df=2 p-value = 0.000 $\alpha = 0.050$

Source: Field survey, 2019.

A chi-square (χ^2) analysis of the association of respondents who are willing to pay for the service of desalination to support desalination is illustrated in Table 4.11. The relationship was statistically significant (**p=0.00**). From the outcome, the study rejects the null hypothesis (H_o: There is no statistically significant relationship between willingness to pay for desalination and support for desalination) and accepts the alternate hypothesis (H_a: There is a statistically significant relationship between willingness to pay for desalination and support for desalination). In terms of respondents who were willing to pay, 21.0% were supportive of desalination, and only 5.2% were unsupportive. Respondents who were not willing to pay, 61.8% were supportive, and the majority (75.0%) were unsupportive. The Concerned Citizens of Teshie gave this account concerning support for desalination;

> *"In 2016, we wrote to the minister of water resources, that we don't want the desalination. The water company were angry at us, but we didn't care because the lives of our people are paramount than what the government will say. Then in 2017, a different government came to power and continued with the project. We told them we don't want it. When the plant was shut down, we wrote a petition to the President and also visited most of the media houses. The project comes with a lot of issues for the community like cost, so we don't support desalination." (Interview with the chairman of TCCA)*

Table 4.12 shows a multivariate binary logistic regression on other predictive variables including the willingness to pay to determine support for desalination. From Table 4.12, the variables explain low variance in support for desalination plant (R^2=0.195), indicating that 19.5% variation in support for desalination is explained by 80.5% in the covariates namely: gender, age, the regularity of water, years lived in the community, quality of desalinated water, willingness to pay for desalination service and type of community.

All the predictor variables were not significant to the model except gender and willingness to pay for desalination. The model shows age as a demographic variable was not significant. However, gender was significant in the model—males (**p=0.005<0.05**). This indicates that males were two (2) times less likely (OR=0.502, 95% CI= 0.309–0.816) to support desalination than their female counterpart. Additionally, willingness to pay was a significant predictor of the model (**p=0.004<0.05**). This means households who were willing to pay for the desalination were four (4) times less likely (OR=0.246, 95% CI= 0.096–0.631) to support desalination than respondents who were indifferent on their willingness to pay for the services of the desalination.

Table 4.12: Summary of binary logistic regression (Estimating the effect of predictors on support for desalination)

Independent variable	B	SE	Sig.	Odds	95% C.I. for EXP (B)	
					Lower	Upper
Gender						
Male	-.689	.248	**.005***	.502	.309	.816
Female (*reference category*)				1.00		
Age						
18-27	.190	.860	.825	1.210	.224	6.532
28-37	-.221	.837	.792	.802	.155	4.134
38-47	-.327	.827	.693	.721	.142	3.650
48-57	-.233	.841	.782	.792	.153	4.115
58-67	.135	.889	.879	1.144	.201	6.531
68 and > (*reference category*)				1.00		
The regularity of water						
Every day (*reference category*)	.003	1.473	.998	1.003	.056	17.989
2 days	-.870	1.435	.544	.419	.025	6.978
3 days	-.625	1.438	.664	.535	.032	8.968
4 days	.450	1.598	.778	1.568	.068	35.928
No idea (*reference category*)				1.00		
Years in the community						
Below five years	.251	.853	.768	1.285	.241	6.845
6-10	-.490	.382	.200	.613	.290	1.295
11-15	.092	.278	.742	1.096	.636	1.890
Above 15 (*reference category*)				1.00		
Quality of desalinated water as good						
Agree	-1.494	1.284	.245	.225	.018	2.780
Disagree	-1.094	1.282	.393	.335	.027	4.131
Indifferent (*reference category*)				1.00		
Willingness to pay for desalination						
Yes	-1.403	.481	**.004***	.246	.096	.631
No	.097	.311	.754	1.102	.599	2.028
Undecided (*reference category*)				1.00		
Community						
Estate	-.085	.350	.808	.918	.463	1.823
Old Town	.296	.293	.312	1.345	.757	2.388
Teshie camp	.035	.410	.933	1.035	.463	2.314
North Teshie (*reference category*)				1.00		

Note: support for desalination is the outcome variable (supportive =0, unsupportive =1)
** means significant difference at* ***p < 0.050 (5% level of significance)***

Source: Field survey, 2019.

4.6 Coping strategies adopted after the desalination plant was shutdown

4.6.1 Water situation before, during and after desalination

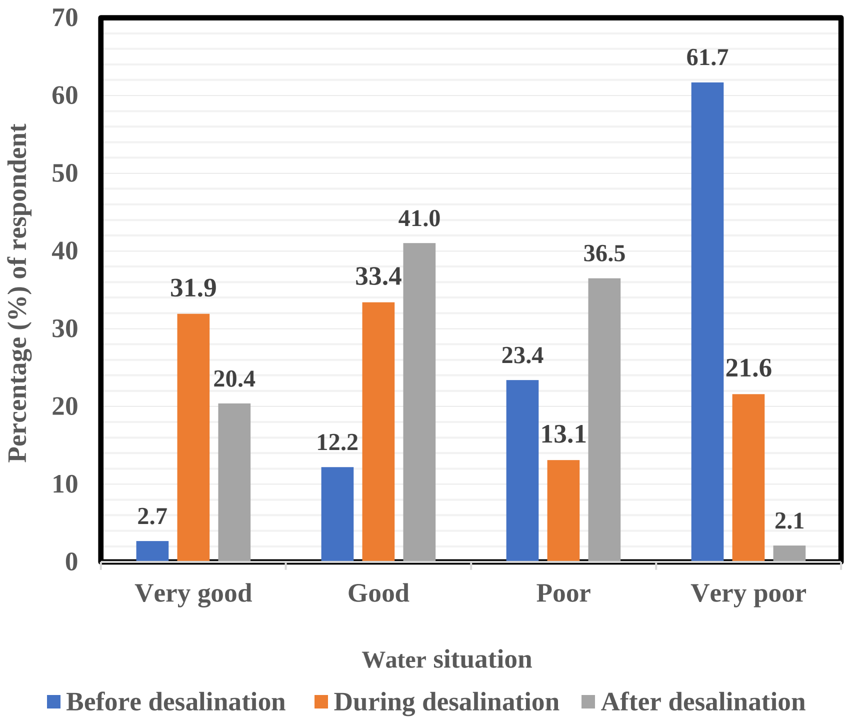

Figure 4.3: Water situation before, during and after desalination (n=329)

Source: Field survey, 2019.

The above figure (4.3) presents the water situation before, during and after the desalination operational period. However, the analysis focused on the situation after the desalination was curtailed. Comparatively, the state of water supply after the shut down had improved compared to the period preceding the desalination implementation. Reclassifying four categories of response (very good, good, poor, very poor) into dichotomous categories (good and poor); the majority of the respondents (61.4%) noted that the water situation was good. On the other hand, about 38.6% of the respondents responded that the water situation was not good.

Table 4.13: **Relationship between water issue and satisfaction of the water scenario**

Variables	**Existing water challenge after desalination**		
Satisfaction with current water scenarios	**Yes**	**No**	**Total**
Yes	127 (46.2%)	46 (85.2%)	173 (52.6%)
No	148 (53.8%)	8 (14.8%)	156 (47.4%)
Total	**275 (100.0%)**	**54 (100.0%)**	**329 (100.0%)**

χ^2 =27.539, df=1, p-value < 0.000 **$\alpha = 0.050$**

Source: Field survey, 2019.

If the water situation has improved, then why is there the need to cope? Although the general water situation had improved after the plant was shut down, water issues persisted. Communities like the Estate (67.9%), Teshie camp (65.8%) and North Teshie (50.7%) were satisfied with the water scenario after the plant was shut down. However, more than half of the respondents (58.2%) in the Old town were not satisfied with the current water scenario (*see appendix D*). Although three communities were content with water situation after desalination, they agreed that the challenge persisted—Estate (71.7%), Old Town (92.9%), Teshie camp (76.3%) and North Teshie (83.6%) (*see appendix D*).

It can be observed from Table 4.13 that, majority of the respondents were satisfied with the current water situation and acknowledged water challenges did not persist (85.2%). Additionally, more than half of the respondents (53.8%) were not satisfied with the water situation but also acknowledged that water challenges persisted after the desalination plant was closed to supply.

A Chi-square (χ^2) test used to demonstrate the relationship between variables (Table 4.13) indicated a statistically significant relationship (**χ^2 =27.539, p-value=0.000<0.050**). The result confirms that after desalination, the water issues had not been entirely mitigated, although some residents were satisfied with the current situation.

4.6.2 Coping methods adopted after desalination was shutdown

4.6.2.1 Institutional method (Rationing of water)

Ghana water company resorted to water rationing to help relieve the community after the desalination plant was closed. The mode of water rationing adopted in Teshie replicates the service outage model delineated by Lund and Reed (1995). With this model, sections of the city are allowed specific hours of water in a day. Water was supplied on Wednesdays, Saturday, and Sunday. The statement below presents what GWCL had to say concerning water rationing:

> *"Currently the best alternative for supplying water is through rationing water from Weija and Kpong interconnections. The situation has been controlled well. Expansion of treatment plants is underway to directly inject more water from Kpong to Teshie through new pipelines." (Interview with the Distribution officer, GWCL)*

4.6.2.2 Household method

Table 4.14: Household coping methods

Variable	**Community**				
Household coping methods	**Estate**	**Old Town**	**Teshie Camp**	**North Teshie**	**Total**
Tanker services	18 (34.0)	17 (17.3)	15 (39.5)	43 (30.7)	93 (28.3)
Water vendors	3 (5.7)	6 (6.1)	3 (7.9)	17 (12.0)	29 (8.8)
Rain water	12 (22.6)	20 (20.4)	2 (5.3)	28 (20.0)	62 (18.8)
Sachet water	32 (60.4)	78 (79.6)	33 (86.8)	118 (84.3)	261 (79.3)
Neighbour support	8 (15.1)	12 (12.2)	2 (5.3)	20 (14.3)	42 (12.8)

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019.

Multiple response format was used to illustrate coping strategies after the desalination plant was shut down. Table 4.14 shows that about 28.3% of the households relied on the services of water tankers. Households which relied on water vendors were 8.8%. About 18.2% of the households depended on rainwater. Majority of the households (79.3%) relied on sachet water, possibly for drinking purposes. However, amongst the four communities, respondents from the Teshie camp used more sachet water (86.8%) than the rest of the areas understudied. Households which relied on their neighbour's support for water were 12.8% of the sampled population.

A Chi-square (χ^2) test of the relationship between seven variables and household coping method

Table 4.15: Relationship between demographic variables and of coping method

Variables	Tanker	Water vendor	Rainwater harvesting	Sachet water	Neighbour
Age	0.266	0.130	0.464	0.388	0.332
Gender	**0.032***	0.078	0.540	0.865	0.860
Education	0.451	0.666	0.845	0.694	0.294
Income	0.117	0.744	0.504	**0.002***	0.524
Household size	0.513	0.569	0.758	0.187	0.657
House type	0.707	0.868	0.568	0.062	0.379
Distance to water	0.895	**0.046***	0.086	0.211	0.705

*Figures with * connotes significant difference at* ***p < 0.050 (5% level of significance)***

Source: Field survey, 2019.

Table 4.15 demonstrates a Chi-square (χ^2) analysis between seven (7) variables of demographic characteristics and household coping methods. There was a significant association between gender and coping with water tanker (**p=0.032**), but all other variables were statistically insignificant. Distance to a water vendor was significant (**p=0.046**); meaning the probability that water vendors were in proximity was high. Average household income was significant with using sachet water—the level of significance (**p=0.002**) indicated a high probability of using sachet water to cope in terms of drinking (*consumption*). The significant relationship of some of the demographic variables and coping methods resonates with some aspects of the conceptual framework (Figure 2.1) which illustrates that demographic variables influence coping strategies.

4.6.2.3 Other strategies of coping (water storage and relocation)

Table 4.16: Water storage and relocation as a coping strategy

Variable	**Community**				
Other coping methods	**Estate**	**Old Town**	**Teshie Camp**	**North Teshie**	**Total**
Water storage					
Tanks	27 (50.9)	8 (8.2)	17 (44.7)	35 (25.0)	87 (26.4)
Jerrycan	42 (79.2)	72 (73.5)	31 (81.6)	108 (77.1)	253 (76.9)
Buckets	8 (15.1)	38 (38.8)	5 (13.2)	42 (30.0)	93 (28.3)
Pots	0 (0.0)	8 (8.2)	1 (2.6)	2 (1.4)	11 (3.3)
Gallons	23 (43.4)	64 (65.3)	18 (47.4)	81 (57.9)	186 (56.5)
Relocation					
Yes	7 (13.2)	15 (15.3)	5 (13.2)	29 (20.7)	56 (17.0)
No	46 (86.8)	83 (84.7)	33 (86.8)	111 (79.3)	273 (83.0)
Total	**53 (100)**	**98 (100)**	**38 (100)**	**140 (100)**	**329 (100)**

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019.

Table 4.16 demonstrates that most households (83%) in the study area would not relocate to escape irregular water stress. This cuts across all the four communities. Only a few respondents (17.0%) would relocate as a way to cope with the stressful water situation.

Aside from coping methods stated in Table 4.14, about 26.4% of households store water in tanks: specifically, 50% of residents in Teshie estate used tanks to store water. Majority of the respondents (76.9%) stored water in jerrycans, indicating that the jerrycan water storage is predominant amongst water storage method in the four communities. Also, more than half of the households (56.6%) used gallons to stock water. With the use of gallons, the majority of the residents in Teshie old town (65.3%) and more than half of the respondents in north Teshie (57.9%) who stored water in gallons. Storing water was predominant for almost all the respondents (98.2%) (*appendix D*). The data also show that timing of the "water days" aided respondents ability to store water. The focus group captured some responses;

> *"I have conditioned my mind to store water at least till the next time it flows. The rationing created awareness, especially in storing water. Before you know the tap is flowing so anytime I take a bucket; I go to the tap" (Respondent, FDG 1)*

> *"We have containers and "Adom" rubber bowl that we fetch water; it comes in sizes 7 and 10. We can store water for at least more than three days." (Respondent, FDG 2)*

4.6.2.4 Storage equipment

Plate 4.1: Storage equipment

Source: Field survey, 2019.

Plate 4.1 presents some storage equipment used by households. These storages are poly-tanks (black and white) that come in different sizes, jerrycans (blue) and a block/cement tanks. The extreme right image shows gallons commonly referred to as to "Kufour gallon."

A Chi-square (χ^2) test of the relationship between seven (7) variables and water storage

Table 4.17: Relationship between demographic variables and storage

Variables	Tanks	Jerrycan	Bucket	Pot	Gallons
Age	0.096	**0.000***	0.842	0.657	0.766
Gender	0.255	0.078	**0.006***	0.587	0.094
Education	0.096	0.174	0.119	0.396	0.522
Income	**0.001***	**0.000***	**0.038***	0.914	**0.041***
Household size	0.852	**0.001***	0.344	0.360	0.814
House type	**0.003***	0.680	**0.038***	0.255	0.989
Distance to water	**0.000***	0.184	0.089	0.770	0.373

*Figures with * connotes significant difference at **p < 0.050 (5% level of significance)***

Source: Field survey, 2019.

Table 4.17 depicts that the income of household (**p=0.001**), house type (**p=0.003**) and distance to the water outside the house (**p=0.000**) were significant with tank water storage (e.g. Poly-tank: Plat 4.1). With jerrycan water storage—age (**p=0.000**), income (**p=0.000**) and household size (**p=0.001**) were significant. Also, there was a significant association with buckets used as storage—gender (**p=0.006**), income (**p=0.038**) and house type (**p=0.038**). Only income (**p=0.041**) was significant, with gallon water storage. Again, the above results corroborate with the conceptual framework (Water Intervention and Access Framework; Figure 2.1). It directs the interaction between some demographic variables such as age, gender (sex), income, household size and distance to a water source within the locality.

4.6.2.5 Factor analysis of coping strategy

Eleven (11) variables or factors were used to conceptualise the effectiveness of coping methods. The study outlined three classes of household possibility to adopt one or more coping method. Exploratory Factor Analysis (EFA) was used as a data reduction method to simplify the correlations between the coping variables. The variables that were considered for factor analysis are outlined in Table 4.18.

Table 4.18: Factor analysis on coping methods

Counts	Factors		
	Coping	**Storage**	**Spatial location**
1	Tankers		
2	Water vendors		
3	Rainwater harvesting		
4	Sachet water		
5	Neighbour		
6		Tanks	
7		Jerrycan	
8		Buckets	
9		Pots	
10		Gallons	
11			Relocation

Source: Field survey, 2019.

Table 4.19: KMO and Bartlett's Test (11 variables)

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		**0.557**
Bartlett's Test of Sphericity		
	Approx. Chi-Square	**235.325**
	Df	**55**
	Sig.	**0.000**

Source: Field survey, 2019.

Under the EFA, common variables are accumulated into descriptive categories (Yong and Pearce, 2013). Table 4.19 shows the results of the test for compatibility by illustrating KMO sampling adequacy of 0.557, Bartlett's Test of Sphericity Difference of $\chi^2 = 235.325$ and significance value 0.000 (< 0.05) signifying a data or model fit for EFA base on Principal Component Analysis (PCA) extraction method. Five components were redacted (Table 4.20).

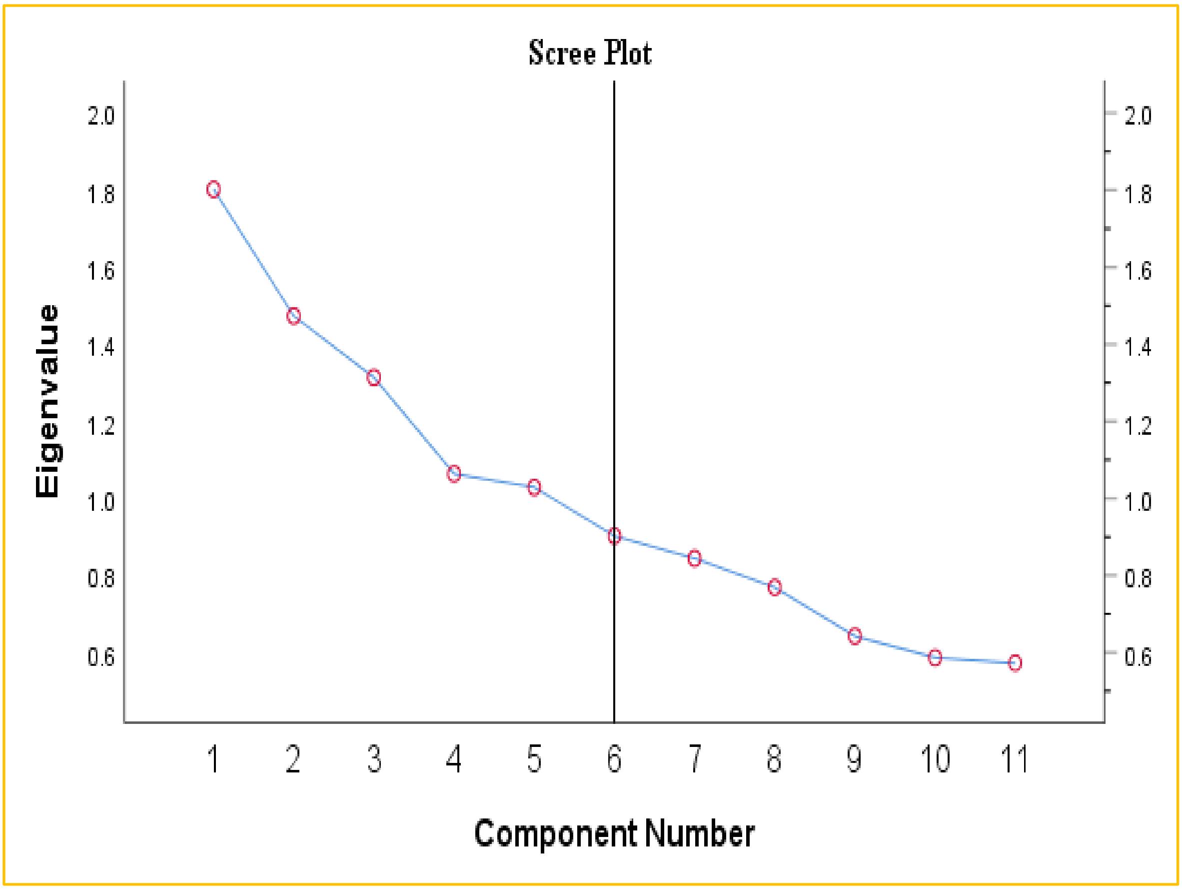

Figure 4.4: Scree plot depicting the number of primary components retained (Eigenvalue > 1, variance 60.748)

Source: Field survey, 2019.

Figure 4.4 is a graphical representation of five (5) intercepted factors found to have a total variance of 60.7 in the components or factors based on Eigenvalue greater than one (1). The breakpoint indicates the point where components that could not redact plummets. From this point, varimax rotated Principal Component Analysis (PCA) was carried out for all the elements (Table 4.18). All enumerated components were 0.4 and above, which is suitable for interpretation (Tabachnick and Fidell, 2007). All the coping factors outlined were retained, meaning there was no deleted factor. Outcomes ranged from low to high positive and negative correlation (-0.776-0.971).

Table 4.20: Rotated component matrix of factors

Variables	Components				
	1	2	3	4	5
Jerrycan	**.761**				
Relocation	**-.620**				
Sachet water	**.580**	**-.412***			
Water vendors		**.763**			
Tankers		**.690**			
Neighbours			**.791**		
Rainwater			**.741**		
Tanks				**-.776**	
Gallons				**.734**	
Buckets					**.755**
Pots					**.694**

Extraction Method: PCA
Rotation Method: Varimax with Kaiser Normalization
*****Low factor loading*

Source: Field survey, 2019.

The rotated varimax component matrix used in this scenario is to understand if factors loaded well under different coping method. Giving explanations to components from table 4.20, one of the factors had less loading (-.412). A single or one-factor loading may not adequately depict any component within acceptable levels but much suitable when two or more variable with relatively high loadings are used to explains a factor better (Yong and Pearce, 2013).

As illustrated in the table (4.20), component one (Jerrycans, Relocation, Sachet water) loaded together very well, which reflects as “High-Effective Coping Method”. From the analysis in Table 4.14, Table 4.16, Table 4.15 and Table 4.17 it can be concluded that these coping method specifically the use of jerrycans and sachet water is spatial (across the four communities) and “income-dependent” for various households.

Component two (Water vendors, Tankers) loaded fairly well, which is conceptualise as “Low Coping Method”. It can be observed from Table 4.14, Table 4.16, Table 4.15 and

Table 4.17 that under the combination conceptualised as a low coping method is not ideal in the four communities. This is because the households from the study area rarely used these options as a coping method.

Component three (Neighbours, Rainwater) factors highly loaded. Component three is conceptualised as "Moderate Coping Method". Again, the reliance of these combinations was not extensive. From data in Table 4.14, Table 4.16, Table 4.15 and Table 4.17 the four communities under study scarcely relied on neighbours support and the use of rainwater.

Component 4 (Tanks, Gallons) had a high factor loading; this component is conceptualised as "Effective Coping Method". The use of tanks and gallons to store water as a way of coping with water stress was income-dependent (see Table 4.17). From Table 4.16, tanks were accessed largely in the Estate community and gallons were highly accessible in the old town and north Teshie. This corroborates with the conceptual framework (Figure 2.1) where coping with water challenge is income dependent.

Component five (Buckets, Pots) factors loaded highly well, which is conceptualised as "Unstainable Coping Method". Buckets and pots were rarely used to store water even though from Table 4.17 the use of buckets was associated significantly with income. However spatially, households preferred other storage alternatives to the usage of buckets and pots (see Table 4.17).

4.7 Discussions of the results

Water challenges have engulfed Teshie for decades in both the supply and demand side (Doe, 2007; Fiasorgbor, 2013). This state of affairs has been prolonged due to inadequate infrastructure and fast-paced development, particularly in the Teshie north (Doe, 2007). Even with the prospect of micro water interventions, poor water supply appeared protracted. As noted earlier, before the desalination implementation the state of water supply and access was poor. This outcome converged somewhat with Fiasorgbor (2013), who opined that the water situation in Teshie was unsatisfactory. Fiasorgbor's work further cited increased industrial (Coca Cola and Printexe) use of water as the cause of the inadequate water supply in Teshie.

One interesting outcome of the study was the quality of the desalinated water. The quality of water before desalination was satisfactory. However, during the operational period of the desalination plant, the quality of water was reported to be poor. A possible explanation for the perception of poor water quality is attributed to inadequate education and awareness creation on this novel "non-traditional" form of water supply (*likely to taste salty*)—which concur with a previous study by Shaffer *et al*. (2012) who reasoned that most clients of desalinated water are likely to associate the quality of desalinated water to the amount of salt concentration. What is surprising is that before and during desalination, the distance travelled to access water outside the house was short, yet, during the desalination period, much time was spent to access water.

Following the analysis of the study, women spent more time in fetching water before the desalination intervention. This finding agrees with studies by Sorenson *et al.* (2011) in forty-four countries and Gambe (2019) in Chitungwiza (Zimbabwe) who noted that women and children were burdened with spending more hours to fetch water for the entire household in water-scarce or stress areas. After the desalination was implemented, women spent less time to fetch water. This finding is in line with the findings of Sijbesma *et al.* (2009) who reported that a substantial number of women in India with adequate access to water saves time on fetching water which increases their livelihood income by 14 per cent.

Concerns about the truancy of school-going pupils caused by the prevailing water issues were curtailed because the desalination intervention improved the water supply, and therefore, mitigating the lateness of school pupils. This finding indeed confirms Rathika and Mohanasundaram, (n.d.) finding in India that easy access to water truncates the absenteeism of school-going pupils. One important discussion that mostly intertwines with water issues is sanitation. Although desalination improved water supply, the poor state of sanitation was marginally changed. Fiasorgbor (2013) suggested that sanitation in Teshie is poor as a result of inadequate sanitation facilities but not the case of water challenges. Her suggestions appear to be the case in this study because the desalination intervention only improved water supply and access.

As suggested by Saurman (2015:2), awareness "through effective communication and information strategies with relevant users" sensitise users to embrace services installed by institutions (services or intervention). Awareness creation satisfied the recommendations of Cipollina *et al.* (2009), who noted that the means of providing alternative desalination schemes in countries globally should involve vital information to users or beneficiaries. A study conducted by Heck *et al.* (2016b) in California found that males were not aware of desalination and level of educational achievement did not guarantee or increase awareness of desalination. The outcome of the studies of Heck *et al.* (2016b) is similar to the findings of this study which showed that gender and level of education did not influence the awareness of desalination.

Since an appreciable number of people were sensitised on the treatment and supply of seawater, the study further showed that most people received desalinated water two days per week. To a degree, the finding is dissimilar to the study of Nyarko *et al.* (2008). Nyarko *et al.* (2008) mentioned that regularity of water supply in Accra was 1-2 (33 per cent) and 3-4 days (16 per cent) per week, 5-6 days per week (6 per cent) and 17 per cent received water every day, and the rest without water. However, most people received water between 6-24 hours. In terms of hours of water flow, the findings converged with one study, yet, varied from another research finding. The outcome of this study does not appear to echo the findings of Kumpel and Nelson (2016) who suggested that most countries in Sub-Saharan Africa receive less than

12 hours of water flow in a day. Again, this same finding agrees with WaterAid (2008) estimates that about 25 per cent of people in Accra received uninterrupted water supply and about 30 per cent received more than 12 hours of water daily each day. The study assumes that the convergence of this study to WaterAid (2008) and its divergence to Kumpel and Nelson (2016) was based on the difference in geographical or regional settings of the two studies.

Desalination improved the volume of water used in a day by households. Nevertheless, after the plant was shut down, households use of water decreased which is consistent with Veerkamp *et al.* (2018) findings on the shutdown of the Staleen water treatment plant in Ireland which reduced their use of water in a day. The quality of desalinated water affects domestic uses (Shaffer *et al*., 2012). It is already established that the quality of water was good before the desalination than during the desalination. Specifically, four characteristics of treated or desalinated water determined the quality. Water treated and distributed from the desalinated plant was of poor quality based on the salt concentration. Werner and Schäfer (2007) noted that trust and quality of water produced are determinants of the suitability for the smooth operation of desalination to meet the demands of the local community. As Haddad *et al*. (2018) suggested, the measure of the quality of desalinated water based on a characteristic such as salt concentration extremely influence public attitudes towards accepting and supporting alternative desalination.

Although WHO has standardised and approved the quality of desalinated water (WHO, 2004), the study found diverse uses of desalinated water. The outcome of this research is divergent and corroborative to previous studies. For instance, on drinking desalinated water, Marks *et al.* (2008) found that 91 per cent of people drank desalinated water. Another study by Dolnicar and Hurlimann (2010) found that 53 per cent of Australians drank desalinated water. Likewise, on uses such as bathing, Dolnicar and Schäfer (2009), concluded that 80 per cent of people would bath with desalinated water, which is consistent with this study. Again, Dolnicar *et al*. (2010) found that the likelihood for all uses of desalinated water was high, except for toilet flushing and gardening. Here, the outcome of the study is divergent since, in this study, more than half of the households who had toilets used the desalinated water for flushing.

There is enough evidence from some studies that public acceptance and support of desalination changes over time often influenced by its potential benefits to the community (Gibson *et al.*, 2015). In this study, the support for the desalination was inadequate, which is divergent with several previous studies on support for desalination. For instance, Gibson *et al*. (2015) reported that 73 per cent and 74 per cent of the sampled population in Perth (Australia), supported the use of desalination plants in 2007 and 2012. Also, Heck, *et al.* (2016a) found strong support for desalination in San Diego, California. Recently, Ben Brahim-Neji *et al.* (2019) found strong support for desalination to escape the fast-paced development and limiting factors such as water scarcity in Djerba Island in Tunisia.

Gender and willingness to pay for desalination were not consistent with studies such as Heck *et al.* (2016b) who found that age was significant with support for desalination whiles gender was not a statistically significant predictor of support for desalination. Willingness to pay for the desalination was significant meaning, people who were not willing to pay, are less likely to support desalination. Again, the outcome of the regression model is consistent with Ben Brahim-Neji *et al.* (2019) and Gibson *et al.* (2015) who found that acceptance and support of desalination may be critical to people because of its benefits, yet these people are unwilling to for pay for the services or future installation of desalination.

Treatment protocols for seawater or brackish water have been standardised by WHO of which every country complies, including Ghana. The perception of water quality by the Teshie community created a conflicting idea between the locals of the community and government stakeholders in the water sector. Falling on the water politics and contentions of renegotiating and restoring desalination, key actors and social groups in the Teshie community who mediate in water issues revoked their support for the desalination plant citing, water quality, cost and environmental concerns (brine waste discharge) as their primary reason. The situation is comparable to findings by Dolnicar and Schäfer (2009), who indicated that environmental concerns fuelled Australians opposition to desalination. This corroborates actions in the conceptual framework (Water Intervention and Access Framework), that social groups in the community may influence the decisions of the traditional or local authorities and water institutions concerning an intervention (*the desalination plant in this scenario*)

Unfortunately, without addressing the issues raised on the desalination plant, the interest of GWCL was to expedite the BOOT contract renegotiation to restore the desalination plant (Daily Graphic, 2019:3). Since key members who partake in water-related discussions in the community feel exempted by the water company, they could not reach consensus. Additionally, the TCCA petitioned the government to restrict the operation of the desalination plant (The Publisher, 2019:3). King *et al.* (2012) study present evidence to demonstrate community resistance to desalination schemes and stresses on the importance of education or knowledge sharing on issues concerning desalination. It also resonates with the theory of Political economy which argues that institutions may act alone based on their discursive power in matters of institutional interest.

Out of different coping strategies used by households; sachet water was prominent. Majority of households preferred this strategy as a primary source for drinking purposes. This finding converges with two previous studies. Beck *et al.* (2016), noted that 70.6 per cent of people in Accra rely on sachet water for drinking. Again, it corroborates Amankwaa (2016), who suggested that sachet water use is the most convenient means of coping in Ghana. Household income influenced coping strategies in using sachet water and also the use of gallons to store water. The result is consistent with Peloso and Morinville (2014) study in Ashaiman, Ghana, which found residents flexibility to purchase sachet water on a day to day basis based on their income level. The fact remains that sachet water has become a quick way to access water in both low-income or high-income households in Ghana and West Africa (Stoler *et al.*, 2013; Stoler, 2017).

Through an assemblage of coping strategies, water storage was predominant through diverse means. This finding agrees to a study in Nigeria by Abubakar (2018). Abubakar found that in Abuja, 90 per cent of households stored water as a coping mechanism. Individuals in the study area utilised diverse methods for storing water which is consistent with Kumwenda (2009) assertion that households in developing countries tend to use several storage containers for complementarity purpose. It was a realisation that coping with water stress is socio-economically determined. This echoes the claim that a household's ability to store water is socio-economically determined according to Vásquez (2016).

Since there were numerous means of coping with water stress, the study delineated a combination of coping methods to illustrate the different levels of coping. An appreciable level of combined coping factors was through the High-effective coping method and the Effective coping methods which connotes a combination of two or more methods of coping in the study. The use of jerrycans, sachet water, gallons and tanks were considered as the best form of coping in the study area whiles the use of buckets and pots were designated as unstainable means of coping.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter draws all the findings and discussions related to water supply and access, the effect of desalination usage on support for desalination and the coping methods adopted after curtailing the desalination plant. Further in the chapter presents the conclusions and recommendations of the study.

5.2 General overview of the study

The study assessed the role of desalination on water supply and access, support for the desalination and the coping strategies employed after the project was shut down. Specifically, the objective was to examine the nature of the water supply and access in the study area before and during the desalination, ascertain the uses of desalinated water and its effect on local support for the plant and the coping strategies used after shut down. The study adopted a cross-sectional descriptive design, where a multistage sampling method was used to select 329 research participants for the survey. Questionnaires, in-depth interviews and focus group discussions were used to collect data on the field. The quantitative data was organised, tabulated and graphed with the aid of SPSS version 25 and Microsoft excel 2016. The qualitative data were transcribed and themed to support discussions from the quantitative data. Data analysis techniques—descriptive statistics (frequencies and percentages), Chi-square analysis, binary logistic regression and EFA was used to analyse and present the data.

5.3 Summary of findings

5.3.1 Need for alternative water (desalination)

Utilising desalination as an alternative to augment conventional water supply generally produced positive results. The motive for relying on desalination mainly was to increase water supply and water access. The days of water flow increased from just about once or twice a week to five days per week during the desalination period which further lessened the burden of women and children in the time spent to fetch water. Unfortunately, the quality of the desalinated water was poor due to the high salt concentration in the water.

5.3.2 Uses of desalinated water

The study revealed that the quantity or volume of water used per day improved during the desalination period. Thus more than half of the respondents (66.3%) used between 4-6 gallons of water in a day during the desalination period. Desalinated water was used in various ways domestically, except for drinking. Majority of respondents used the water for cooking (75.7%), bathing (98.5%), washing/laundry (94.0%), and cleaning (97.9%). However, using desalinated water for drinking or consumption purpose was very low (29.9%) due to perceived poor water quality.

5.3.3 Support for desalination

Aside from the fact that the water was of poor quality which hampered drinking, more than half of the respondents (52.3%) were unsupportive of desalination. Also, about 57.3% of respondents were not willing to support the desalination plant to be restored. Consequently, these resulted in unparallel interest from social groups within the community and the Ghana water company’s decision to renegotiate the BOOT contract to reinstate the desalination plant.

5.3.4 Coping with desalination shut down

The study found that after the desalination plant was shut down, about 61.4% of the respondents indicated that the water situation improved than the period preceding the desalination project. Although the desalination plant was shut down, Ghana water company rationed water (between one to three days per week) to mitigate the situation. Since the challenge persisted, diverse household coping strategies became inevitable. Amongst these diverse coping methods, the use of sachet water (79.3%) was high. Also, respondents use of jerrycans for storing water was prominent. A combination of coping strategies was conceptualised as “High effective coping method” if the combination involved the use of sachet water and jerrycan for water storage.

5.4 Conclusions

Utilising large-scale alternative desalination to augment water supply proved to be substantial; thus, the decision to use desalination increased water supply and improved water access. The study reflects earlier studies suggestions that desalination may be viable in augmenting urban water supply, and completely overcoming water stress (Fragkou and McEvoy, 2016; Teusner *et al.*, 2017). Despite the improvement in the community’s water situation during the operational period of the desalination, the water quality was poorly perceived compared to the days the community was supplied with fresh water. The perception of the quality of desalinated water affected vital domestic use, such as drinking. These responses or findings suggest that wrong perception of water quality may hamper the future introduction of alternative water irrespective of the scale.

The citizens of Teshie put desalinated water into diverse uses excluding drinking. Their inability to use desalinated water for consumptive purposes coupled with their unwillingness to pay for the services of desalination could not influence the needed support for the re-opening of the plant. Consequently, diminished trust in the desalination alternative caused some social groups to oppose the GWCL effort to restart the operations of the plant. Compared to a similar situation in Australia, it can be deduced that this form of technological innovation in alternative water supply could potentially provoke contentions between locals and institutions (Dolnicar and Schäfer, 2009).

Indeed, the current state of desalination cast doubts on its feasibility in augmenting urban water supply aside conventional means. Although the service outage-model of water rationing regulated water supply after the desalination was shutdown, respondents were not satisfied with this arrangement. The access model may enhance understanding of water access, yet, this study utilised the model by incorporating the subject of coping. Sachet water continues to be the most prominent coping method. A coping method was considered as "High effective" in cases where jerrycans and use of sachet water were effectively combined. Also, a coping method was considered unstainable when residents used only buckets and pots. Beyond these conceptualise ways of coping, residents of Teshie rarely supported their neighbours in coping with water stress.

5.5 Recommendations

The study demonstrated that drinking desalinated water was a challenge. The study recommends that if the desalination plant is re-established, its water treatment should be systematically re-designed to improve the water quality (salinity) to meet the consumption level.

Since respondents perceived the quality of desalination largely based on salt content, there should be constant stakeholder educational forums by GWCL to change the perception of the community about the treatment of the seawater.

A social group (TCCA) in the community were in opposition to the decision of the water company to reopen the plant for water treatment. The study recommends that GWCL should involve the Traditional Council and other opinion leaders in the community in decisions concerning renegotiating and restoration of the desalination plant. Taking this step would help residents better understand the issues concerning the plant to enable them to rescind their agitations and channel their support for the operation of the plant.

Moreover, people in the Teshie community could not rely on their neighbours or other households to support their way of coping. The study recommends that households in the community should embrace self-help water initiatives through resource pooling to store water for their common benefit.

5.6 Suggestion for future research

In a situation where the operation of the desalination plant recommences, future research should consider the cost of operation and its environmental impact. Future research should be able to include Befesa Desalination Development Ghana Limited (BDDG) as part of the study.

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APPENDIX A

SURVEY QUESTIONNAIRE FOR HOUSEHOLDS

University of Ghana (Legon)

School of Social Science

Department of Geography and Resource Development

QUESTIONNAIRE

This questionnaire seeks information on the topic: ***Water Thirst in Teshie and The Desalination Intervention.*** You are assured of strict confidentiality and that any information/comment given will be treated with respect. This research is purely for academic purposes. You are therefore not required to provide your name under any circumstance. I do hope that you will offer the researcher the required information. Thank you for your consideration.

INSTRUCTION: Please respond as you deem fit with a tick [√] unless otherwise told to specify. [Questionnaire No. ………]

MODULE 1: SOCIO-DEMOGRAPHIC BACKGROUND OF RESPONDENTS

1. Sex
   a. Male [] b. Female []
2. Age
   a. <18 [] b. 18-27 [] c. 28-37 [] d. 38-47 [] e. 48-57 []
   f. 58-67 [] g. 68 and > []
3. Religion
   a. Christian [] b. Islam [] c. Traditional [] d. No religion [] e. Others []
4. Marital status
   a. Never married [] b. Married [] c. Divorced [] d. Others specify____________
5. Educational status
   a. Basic/ middle [] b. Secondary/Voc/tech/ [] c. Tertiary [] f. No education []
6. Occupation/Job/Profession
   a. Civil servant [] b. Petty trade [] c. Artisan [] d. Commercial driver []
   e. Farmer [] f. Fisherman [] h. Unemployed [] h. Others________________
7. Do you engage in other income earning activities?

a. Yes [] b. No []

8. If yes to **question 7,** what activity do you engage yourself ___________________

9. What kind/type/form of house do you stay in?

a. Compound [] b. Non-compound []

10. Household size of respondent?

a. 1 – 3 [] b. 4-6 [] c. 7 – 9 [] d. 10 and above []

11. The total number of males within the household?

a. 18years and below___ b. Above 18years___

12. The total number of females within the household?

a. 18 years and below___ b. Above 18years___

13. Total number of rooms shared by household ___

14. How many years have you lived here?

a. Below 5 years [] b. 6-10 years [] c. 11-15 years [] d. Above 15 years []

15. Which part of Teshie is your dwelling ____________________________

16. What is your average monthly spending?

a. < Gh¢ 200 [] b. Gh¢ 200- 500 [] c. Gh¢ 500-800 [] d. Gh¢ 900 > []

e. Undisclosed []

MODULE 2: WATER SUPPLY/ ACCESS /USAGE

17. Do you have connected piped water to your house?

a. Yes [] b. No []

18. If Yes, how many times in the week does the tap flow?

a.1-2 days [] b. 3-4 days [] c. 5-6 days [] d. Once a week []

19. How many hours do you receive water during periods of flow? [**In hours**]

a. Less than 8 [] b. Between 8-16 [] c. Between 16-24 [] e. No idea []

20. Do you have water measuring meter?

a. Yes [] b. No []

21. If Yes to **question 20**, do you receive your water bills regularly?

a. Yes [] b. No []

22. If you have connected pipe water, how much do you pay in a month? **Gh¢** _____

23. If no to question **17,** how do you get water?

a. Stand pipe [] b. Borehole/well [] c. Water kiosk [] d. Tanker []

e. Others specify_________________

24. How many gallons/buckets of water does the household use in a day?

a. 1-3 [] b. 4-6 [] c. 7-9 [] d. 10 > []

25. Does the number of gallons/buckets of water used by the household sufficient?

a. Yes [] b. No []

26. What is your opinion about the quality of water you receive from GWCL?

a. Good [] b. Coloured [] c. Particles [] d. Salty [] e. Odour []

27. If pipe water does not flow, do you spend much money on water from different sources?

a. Yes [] b. No []

28. If Yes to **question 27**, how much do you spend on other water sources? **Gh¢**______

29. Which of these categories of water do you prefer/drink? **(Multiple responses)**

a. Piped water [] b. Bottled water [] c. Sachet water [] d. Borehole/well []

e. Other specify______________

30. Are you satisfied with the supply current water scenario?

a. Yes [] b. No []

31. Do you think there are problems with water delivery in your area?

a. Yes [] b. No []

32. Form an opinion on the following

Water Challenge	**Minor challenge**	**Major challenge**	**Not a problem**
High water prices from water vendors			
Long-distance travelled in search of water			
A lot of time spent on fetching water			
Slowing the pace of commercial activities/businesses			
Children late for school because of fetching water			
Price of other things such as food increases			
Risk of drinking untreated or unwholly water			
Domestic chores of women and children increases			
Water rationing by GWCL			
Late for work due to water			

33. What opinion will you form on the water situation in the community **before desalination**

SA= Strongly Agree, A= Agree, SD= Strongly Disagree, D= Disagree, N= Neutral

Situation	**SA**	**A**	**SD**	**D**	**N**
There was pipe connected to your house					
Water supply from GWCL was frequent					
The quality of water was good					
Distance to a water source outside the house was short					
Less time spent to fetch water					
Household stored large volumes of water					

34. What is your opinion on water access **before desalination (April, 2015)** water supply**?**

Level of accessing water	**SA**	**A**	**SD**	**D**	**N**
Food prices increased					
Commercial activities slowed down					
High charges on water from vendors					
Women wasted more working hours in search of water					
Lives of children were risked					
Children were late for school					
No proper sanitation					

35. What is your overall opinion on the water situation **before** the desalinated water?

a. Very good [] b. Good [] c. Poor [] d. Very poor [] e. Severe []

MODULE 3: AWARENESS AND RESPONSES TO DESALINATION

36. Did you have any knowledge about desalination before its implementation?

a. Yes [] b. No []

37. If yes to **question 36**, how did you know?

a. Internet [] b. Radio [] c. Newspapers [] d. Friends [] e. Others specify_____

38. Did you hear any announcement concerning the supply of desalinated water?

a. Yes [] b. No []

39. If yes to **question 38**, how did you get the information?

a. GWCL [] b. Media [] c. Neighbour [] e. Other specify__________________

40. What was your reaction to hearing the supply of desalinated water?

a. Positive [] b. Negative []

41. How regular was the flow of desalinated water supplied by GWCL?

a. Everyday [] b. Every 2 days [] c. Every 3 days [] d. Every 4 days []

42. How many gallons/buckets of **desalinated water** did the household use in a day? ***(4 Gallons=34cm size)***

a. 1-3 [] b. 4-6 [] c. 7-9 [] d. 10 > []

43. Were there concerns/issues about the desalinated water?

a. Yes [] b. No []

44. If yes to question **43**, what specific issues? **(Multiple response)**

a. Salty [] b. Bad smell []c. Coloured [] d. Contains particles []

e. Other specify____________________

45. State your preference for the use of desalinated water

Use of desalinated tap-water	**High**	**Low**	**No idea**
Drinking			
Cooking			
Bathing			
Washing clothes or laundry			
Other domestic uses (cleaning, watering garden, etc)			
Flushing toilet			

46. In your opinion, how was the quality of desalinated water?

a. High quality [] b. Medium quality [] c. Low quality []

47. How supportive are you of desalination to respond to water stress in this area?

a. Very supportive [] b. Supportive [] c. Not supportive [] d. Indifferent []

48. What opinion will you form on water supply **during the period of desalination**?

Water Situation	**SA**	**A**	**SD**	**D**	**N**
Water supply from was frequent					
The water is not salty					
The water was not containing particles					
The water was colourless					
The water had no bad odour					
Distance to water source outside the house was short					
Less time for fetching water					
Household stored large volumes of water					
Usage of other alternative water sources reduced					

There was no rationing of water					

49. What is your opinion on the impact of **desalination** period on water access?

Impact on accessing water	**SA**	**A**	**SD**	**D**	**N**
Food prices increased					
Commercial activities slowed down					
High charges on water from vendors					
Women wasted more working hours in search for water					
Lives of children were risked					
Children were late for school					
No proper sanitation					

50. Give a brief description of the water situation **during desalination** water supply?

a. Very good [] b. Good [] c. Poor [] d. Very poor [] e. Severe []

51. Would you like/accept that desalination should be restored?

a. Yes [] b. No [] c. Maybe [] d. Neutral []

52. Are you willing to pay more for desalinated water if the services are restored?

a. Yes [] b. No [] c. May be [] d. Neutral []

MODULE 4: COPING WITH IRREGULAR WATER SUPPLY

53**.** What is the state of the water situation **after desalination**?

a. Very good [] b. Good [] c. Poor [] d. Very poor [] e. Severe []

54. Apart from desalinated water and tap water, what other sources of water did you rely on? **(Multiple responses)**

a. Tankers [] b. Borehole [] c. Rainwater [] d. Sachet water [] e. Seawater [] f. Neighbour []

55. What is the approximate distance you travel to acquire other sources of water you rely on? **m: meters**

a. < 100 m [] b. 100-400 m [] c. 500 m and above []

56. How much does it cost you to access alternative sources of water? **State in Gh¢**_____

57. Are other water sources costly than desalinated water or tap water?

a. Yes [] b. No []

58. How often do you access to water from other sources?

a. Daily [] b. Once a week [] c. Once a Month [] d. Occasionally []

59. Do you store water in the house?

a. Yes [] b. No []

60. If yes to question **59,** what kind of equipment do you use to store water?

a. Poly Tanks [] b. Jerrycan [] c. Bucket [] d. Pots [] e. Others specify__________

61. Which activity in your household consume water the most? **NB. Rank from 1-8**

Use of Water	**Rank**
Drinking	
Cooking	
Bathing	
Washing clothes or laundry	
Washing cars	
Watering garden	
Flushing toilet	
Other uses (cleaning)	

62. Are you likely to relocate because of inadequate access to water?

a. Yes [] b. No []

63. Aside desalination as a current alternative, will you prefer any other?

a. Yes [] b. No []

64. If yes to question 63, which of the alternatives are you willing to use?

a. Recycled water [] b. Treated rainwater [] c. Greywater reuse []

65. Do you think it is important to pay for water?

a. Yes [] b. No []

66. Any other comment for the way forward? ____________________________________

THANK YOU FOR YOUR TIME

APPENDIX B

IN-DEPTH INTERVIEW

University of Ghana (Legon)
School of Social Science
Department of Geography and Resource Development

This In-depth interview seeks to gather information on the topic: ***Water Thirst in Teshie and The Desalination Intervention.*** You are assured of strict confidentiality and that any information/comment given will be treated with respect. This research is purely for academic purposes. I do hope that you will offer me the required information. Thank you for your consideration.

Data for identification

1. Interview location/place/community ....
2. Date of interview..
3. Mode of communication..
4. Language used for communication..
5. Pseudonym for key informant/focus group................................
6. Time of interview [start-end] ....

Data for demographics of the respondent

7. Sex
8. Age
9. Education status
10. Occupation
11. Number of years lived in the community*

Water Access and Supply (Ghana Water Company)

12. How did you supply water to the community before the operation of desalination?
    Probe: a. *Was it solely from traditional methods or other alternatives were considered?*

13. How much has the water sector improved since 2015?
    Probe: a. *To what extent has pipelines been extended?*
    b *Have as there been reports on illegal connections, broken pipes?*
14. How often do you conduct water quality testing?
15. What amount/volume of water is supplied to Teshie?
16. What are some of the challenges you confront to the volume of water supply?
    Probe: a. Do you record loses in the transmission/supply of water?
17. What do you think are the possible cause of water problems in Teshie?

Desalination

18. Was desalination as a technical response to water shortages in Teshie?
    Probe: *Was there a pilot project before the implementation of the Teshie/Nungua desalination project?*

19. Was desalination a feasible alternative to water supply in Accra?
20. Did you receive any complaints from the population about the operation of desalination?
    Probe: *What were these complains?*
    How were you able to resolve these complaints?
    Did the population accept these innovations?

21. Did desalination meet the proposed demand per day?
22. How much has the introduction of desalination helped the population?
23. How did women and children cope with the water situation in terms of household duties and schools?**
24. Was there any economic activity that was affected as a result of the desalination?**

Coping Strategies to Water Challenges

25. Did you have the arrangement to help the community when there was a water shortage before (2015) the supply of desalinated water?
26. Was the desalination able to meet the water demand for the population designed for?
27. How long has rationing been used to regulate water supply in Accra?
    Probe: *How effective is the rationing schedules in Teshie and other parts of Accra?*
28. Aside rationing, what other arrangement has been put in place to increase water supply?
29. What is the way forward on providing and sustaining water levels in Accra?

Way forward

30. Do you think Ghana will benefit from increasing desalination?
31. How feasible is desalination as an alternative source to the traditional ways of supplying water by GWCL?
32. How supportive are you on prioritising desalination as an alternative water supply for Accra and Ghana in general?
33. What other alternative source of water will be feasible for beefing up the capacity to supply water in Accra?
34. Do you have other strategies of water supply that you can recommend?

35. What ways do you think can make desalination more sustainable and to be accepted by the population?

- **Secondary information from GWCL**
    - ***a.*** Rationing schedules
    - ***b.*** Water coverages
    - ***c.*** Pipeline expansion [Rate of Increase]

d. Metered homes
e. Rate of payment of bills [population based]

Section for Teshie Concerned Citizens

36. Was there a community-stakeholder engagement?

Probe: did the government communicate the desalination project to the community?

Probe: was the community willing to use alternative water sources?

35. Do you think it is the government responsibility to provide water for?

Probe: Will the community be willing to pay a higher fee if the desalination is restored?

Probe: Was desalination designed to target the pro-poor neighbourhoods in Teshie?

Probe: Was there any community engagement before the desalination water supply?

Probe: Why have they not been targeted, is it because of the income status of these neighbourhoods or because of the site or situational difficulty?

36. What is the general customer perception of water delivery?
Probe: From private and individual perspective

APPENDIX C

FOCUS GROUP DISCUSSION

University of Ghana (Legon)
School of Social Science
Department of Geography and Resource Development

This Focus Group Discussion seeks to gather information on the topic: ***Water Thirst in Teshie and The Desalination Intervention.*** You are assured of strict confidentiality and that any information/comment given will be treated with respect. This research is purely for academic purposes. I do hope that you will offer me the required information. Thank you for your consideration.

Data for identification

1. Interview location/place/community ....
2. Date of interview..
3. Mode of communication...
4. Language used for communication..
5. Pseudonym for key informant/focus group................................
6. Time of interview [start-end] ....

Data for demographics of the participants in the each group

7. Sex
8. Age
9. Occupation
10. Number of years lived in the community*

Water Access

11. How did you access water before and after desalination?
12. How much was the cost of water comparatively?
13. Did you walk or travel far to fetch water from the house?
14. How did you store water before the desalination was instituted?
15. What can you say about women and children during the water crisis?
16. Was can you say about the general sanitation situation before the desalination?
17. How was the pricing of water like when there was no desalination

Desalination

18. Was there any information given or awareness creation before and during the operation of the desalination?
19. What can you say about the quality of the desalinated water?
20. What ways were you putting the desalination into use?
21. Did you drink desalinated water?
    Probe: What motivated or demotivated you?
22. How was the water pricing from especially the water vendors?

23. What will motivate you to support desalination or not?

Coping Strategies to water challenges

24. How did you cope with the water situation after desalination was shut down?
25. Was the desalination able to meet your water demand?
26. What kind of ways were you coping with the water situation after the desalination was shut down?
27. Were you able to store enough water?
28. What equipment or containers did you prefer to use in storing your water?
29. Did you spend on coping (cost of coping)?

Way forward

30. Was there a community-stakeholder engagement?
    a. ***Probe:*** did the government communicate the desalination project to the community?
    b. ***Probe:*** was the community willing to use alternative water sources?
31. Do you think it is the government responsibility to provide water for?
    a. ***Probe:*** Will you be willing to pay a higher fee if the desalination is restored?
    b. ***Probe:*** Was there any community engagement before the desalination water supply?
32. What is the general perception of water delivery?

APPENDIX D

Support for desalination in the community

Variable	Communities				
Support for desalination	**Estate**	**Old Town**	**Teshie Camp**	**North Teshie**	**Total**
Supportive	26 (49.1)	39 (39.8)	21 (55.3)	71 (50.7)	157 (47.7)
Unsupportive	27 (50.9)	59 (60.2)	17 (44.7)	69 (49.3)	172 (52.3)

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019.

Household water storage

Household water storage	Estate	Old Town	Teshie Camp	North Teshie	Total
Yes	53 (100.0)	98 (100.0)	35 (92.1)	137 (97.9)	323 (98.2)
No	0 (0.0)	0 (0.0)	3 (7.9)	3 (2.1)	6 (1.8)

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019.

Satisfaction with current water scenarios

Variables	Communities				
Satisfaction with current water scenarios	**Estate**	**Old Town**	**Teshie Camp**	**North Teshie**	**Total**
Yes	36 (67.9)	41 (41.8)	25 (65.8)	71 (50.7)	173 (52.6)
No	17 (32.1)	57 (58.2)	13 (34.2)	69 (49.3)	156 (47.4)
Total	**53 (100)**	**98 (100)**	**38 (100)**	**140 (100)**	**329 (100)**

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019.

Existing water challenge after desalination

Variables		**Communities**			
Existing water challenge after desalination	**Estate**	**Old Town**	**Teshie Camp**	**North Teshie**	**Total**
Yes	38 (71.7)	91 (92.9)	29 (76.3)	117 (83.6)	275 (83.6)
No	15 (28.3)	7 (7.1)	9 (23.7)	23 (16.4)	54 (16.4)
Total	**53 (100)**	**98 (100)**	**38 (100)**	**140 (100)**	**329 (100)**

Figures in parentheses are percentages (%) while those not in brackets are the respondent counts

Source: Field survey, 2019.