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Thesis title: A City with limited access to water: The use of rainwater harvesting as an alternative water supply source in Vittin-Tamale, Ghana

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Summary

Access to water is a necessity to almost every living entity on earth. The quantity of fresh water accessible in the planet is projected to be 3% of the total available water of about 1,386 million cubic kilometres on earth (Cassardo, Jones, et al., 2011). However, the global population is growing faster than the increase in water resources as such the per capita water available will eventually decrease in the next years (Pandey, Gupta, et al., 2003). As such, Ghana is one of the fast-growing economies in West Africa with a current population of about 29,923,747 with 54.8% (16,507,512) of the inhabitants located in urban areas (Worldometers, 2019). Further, Tamale is the fourth fastest growing city in Ghana (UN-Habitat, 2009) with a total population of about 269,227. The region has one rainy season from May to October, as such the level of water supply is mostly affected when the amount of water in the water sources fluctuates especially during the dry season and periods of low rainfall. This situation mostly leads to irregular water supply by GWCL in providing water to urban settlements leading to the adoption of alternative water supply measures by households such as rainwater harvesting.

The study investigated how socio-economic, technical and reliability factors influences the adoption of RWH by households as an alternative water supply measure.

The researcher employed a case study survey method in gathering relevant information on RWH from households.

The main findings of the study revealed as part of the socio-economic factors that people who leave in their own houses have a high tendency to adopt RWH. Affordability (initial and maintenance cost) of the system was also seen as a key contributory factor to the adoption of RWH by households. With regards to the technical factors, the size of the system and access to space influences the ability of households to adopt RWH. Further, the capacity, the functionality and ability of the system to meet households critical water needs were key reliability factors influencing households to either adopt or not adopt to RWH. Indeed, the socio-economic, technical and reliability have an interdependent influence on RWH. As such should to be viewed holistically towards enhancing an effective and efficient rainwater harvesting among households.

The study recommends that, political/governmental or NGOs should give some form of support to households in the quest to adopting RWH in large scale. Nonetheless governmental and non-governmental institutions should introduce awareness programs on RWH to effectively promote the practice among the citizenry as a measure to meeting household water needs in the face of limited water supply by responsible institutions.

Keywords

Rainwater harvesting, alternative water supply, socio-economic, technical and reliability factor

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Abbreviations

IHS	Institute for Housing and Urban Development
RWH	Rainwater Harvesting
RWHS	Rainwater Harvesting System
FGD	Focus Group Discussion
GWCL	Ghana Water Company Limited
GWC	Ghana Water Company

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Chapter 1: Introduction

1.1 Background

Access to water is a necessity to almost every living entity on earth. Water is recognized globally as a human right and requirement for a healthy live (Rashid, Manzoor, et al., 2018). As such the need for adequate measures to be taken towards meeting the water needs humans.

Globally, over one billion people are unable to access potable water(Pandey, Gupta, et al., 2003). Indeed, the global records on water resource accessibility depicts that, about 844 million individuals are unable to obtain clean water while 263 million and 159 million people devote more than 30 minutes of their time per round to access portable water as well as resort to surface water as drinking sources respectively (WHO, 2017). This situation certainly implies an equal number of people waking up every single day without access to potable water which in turn may translate a critical impact on the health of humans and their socio-economic growth (WHO, 2017).

The quantity of fresh water accessible in the planet is projected to be 3% of the overall available water of about 1,386 million cubic kilometres on earth (Cassardo, Jones, et al., 2011). However, the global population is growing faster than the increase in water resources as such the per capita water available will eventually decrease in the next years (Pandey, Gupta, et al., 2003). The rapid growth in population would therefore imply a mismatch between available water resource and demand by the population. Furthermore, Urban population growth over the time have indicated an increase from 28.3% to 50% in 1950 and 2010 respectively (Rashid, Manzoor, et al., 2018). With the current trends, the urban population has been estimated to rise from 3.4 million to 6.3 million, with 90% increase in Africa and Asia by 2050 (United Nations, 2010). Certainly, the fast-growing regions in developing countries would experience a higher demand of water from its inhabitant's thereby exacting excessive pressure on the existing water sources and or structures.

Additionally, climate change events emanating from anthropogenic activities stances as a major challenge threatening rainfall pattern and impacting significantly on the existing water sources. The continuous increase of negative human activities such as deforestation (to create room for the built environment), individual consumption lifestyle, high energy consumption and industrial pollution constitute mainly 70% of greenhouse gases (UNEP/UN-HABITAT, 2005). Certainly, this contributes greatly to climatic events and consequently affecting the hydrological cycle. This further causes a gradual reduction on the renewable surface water as well as ground water resources thereby creating competition among various water users (Döll, Jiménez-Cisneros, et al., 2015). The decrease in water resource does not only affect water users but also create challenges for water system managements in designing a fair water distribution system towards meeting the growing water needs from the increasing population. The dynamics of water supply through any means is related to rainfall pattern. As such water remain the main avenue through which climatic events impacts the ecosystems and consequently people's wellbeing (Giupponi and Gain, 2017).

Ghana is among the fast-developing economies in West Africa with a current population of about 29,923,747 with 54.8% (16,507,512) of the inhabitants located in urban areas (Worldometers, 2019). Additionally, close to 22% of the population rely mainly on surface water sources in meeting their basic water needs which not only makes them vulnerable to diseases but also exposes them to water scarcity especially during the dry season (water.org). For instance, (the World Water Assessment Programme, 2018; UN-Water, 2015) indicated that, the rapid population increase, urbanization as well as the rising water consumption(per person) could lead to 40% global water shortage by 2030 (Staddon, Rogers, et al., 2018).

Further, Ghana is among the fast urbanizing developing countries in Africa. This implies that, the growing number of urban dwellers will increase the demand of water which in turn will leave a great number of urban dwellers with inadequacies in water supply (McDonald, Green, et al., 2011).

Additionally, Tamale is the fourth fast developing city in the country and the capital town of the Northern Region and (UN-Habitat, 2009) with a total population of about 269,227. The region has only one rainy season from May to October, as such the level of water provision to the residents is mostly affected when the amount of water in the water sources fluctuates especially during low rainfall and or dry periods of the year.

With regards to the delivery of potable water for urban residents in the country, Ghana water company limited (state own utility company) has been the main overseer for the supply of clean water to urban set up throughout the country (gwcl.com.gh). This water company primarily relies on surface water sources towards providing water to residents. Most often than not, the effective delivery of portable water become unstable especially in the dry periods, compelling Ghana Water Company to adopt rationing of water as their only option to distribute water. Indeed, this situation has often led to unequal water distribution in Tamale and its environs and one of as such affected neighbourhoods is Vitin.

Vittin is in the Tamale South Constituency of Tamale Metropolis with an estimated population of 5000 people. Bounded to the South by Dabokpa, Vitin-Dabogse to the East, Dohinayili to the West and Jakarayili to North. The community is about 2km from the central business district. This neighbourhood among others is faced with serious water crisis especially within the dry periods. Indeed, Inadequate access to clean water has become one major problem faced by most urban residents' despites leaving with most of these facilities (Rashid, Manzoor, et al., 2018).

To overcome the water inadequacies, rainwater harvesting (RWH) has been adopted by some households and institutions as an alternative measure to meeting their water needs. Even though this measure may not be an ultimate solution to meeting households water needs as its full potentials is dependent on the rainfall pattern which mostly is irregularly distributed over each year Hardy et al. (2015), some Ghanaian policy makers on the contrary perceives the concept as a potential solution to increasing water availability as well as reducing the demand on pipe-borne water from both institutions and households (AHK, 2018).The system according to Pandey et al.(2003) has been used in the past to store water especially during the rainy season. RWH is known to have substantial impact to the water supply system for both domestic and production purpose. This system indeed serves as an alternative measure to overcoming urban water deficiencies resulting from the increase in water demand and socio-economic expansion(Amos, Rahman, et al., 2016). As such the concept of RWH in the context of this study is expressed as an another or alternative means through which households water needs may be met in the face of inadequate water supply from Ghana Water Company. The purpose of this research is therefore based on assessing how socio-economic, technical and reliability factors influencing households to either adopt or not adopt RWH as an alternative water source under the current urban water supply system (conventional water supply system) in Vitin-Tamale, Ghana.

1.2 Problem statement

Inadequate level of water supply to urban households in Vitin-Tamale, from Ghana Water Company, leading to RWH as an alternative water supply. Indeed, inadequate water supply has remained a challenge, affecting the lives of many especially in developing countries.

More than 1 billion humans across the globe still lack basic access to potable drinking water (Pandey, Gupta, et al., 2003). Most of these people are located in the poorer regions in the world, including most parts of Northern Ghana of which Tamale is no exception.

Over the years, Ghana Water Company Limited has remained the main water provider to urban areas. The water supply system depends mainly on surface water sources in providing potable water to the inhabitants. Tamale has one rainy season from May to October, as such, when the amount of water in the water sources fluctuates especially within the dry periods and periods of low rainfall, the level of water supply by the water company is mostly affected following the variation in climatic conditions (Grey and Sadoff, 2007). For instance, the water company in Tamale observed serious water inadequacies in 2018 resulting in the rationing of water to the inhabitants on daily basis.

With the current trend, this situation may worsen in future when the amount of surface water sources starts to deplete due to increasing water pollution, industrialization, rapid population growth and urbanization, coupled with climate related impacts (Şen, Al Alsheikh, et al., 2013). Even though water is said to be a merit good and therefore non-excludable (Batley, 1996), shortage of potable water from the water company may tend to create competition among various water users which may result in exclusion of the vulnerable groups as well as socially weak sections. Furthermore, an increase in demand of water will eventually threaten the environmental sustainability in terms of insufficiency, since availability of water is significant to achieving sustainable environment and socio-economic development (Lambi and Kometa, 2009) .

In the quest to overcome the deficiencies in the supply and demand of water, whilst reducing the pressure from the water company, rainwater harvesting (RWH) has been adopted as an alternative water source. However, this concept is not prevalent among households in urban Ghana even though it is recognize to have potentials in overcoming urban water deficiencies (Amos, Rahman, et al., 2016). As such, its impact to urban water supply deficits especially among household as an alternative water supply measure cannot be overemphasis without taking into account the socio-economic, technical and reliability factors underpinning its adoption. This research therefore aims at assessing how socio-economic, technical and reliability factors influences households to either adopt or not adopt RWH as an alternative measure to household water supply under the current urban water supply system in Vitin-Tamale, Ghana. This study may therefore support in planning and or integrating rainwater harvesting system into Urban Water Management system at different scales towards meeting urban water demand amidst urbanization and climate change events.

1.3 Research objective

The main objective of the research is to assess the socio-economic, technical and reliability factors that influences the potential adoption of RWH by households as an alternative water supply system in Vitin-Tamale.

1.4 Research question

How does socio-economic, technical and reliability factors influence the adoption of RWH by households as an alternative water supply system in Vitin-Tamale, Ghana?

1.4.1 Sub-questions

1. What is the current deficit of the water supply system in Vitin?
2. How does socio-economic factors influence the adoption of RWH by households as an alternative water supply system in Vitin-Tamale, Ghana?

3. How does technical factors influence the adoption of RWH by households as an alternative water supply system in Vitin-Tamale, Ghana?
4. How reliable is RWH in meeting the current deficits in household water supply system?

1.5 Significance of the study

Undertaking this research is relevant in two main dimensions. Thus, adding knowledge to the scientific world as well as finding solutions to identified societal gap or problems in relation to inadequate water supply within the water sector.

1.5.1 Scientific significance

The scientific relevance of this study is expected to provide empirical evidence of how socio-economic, technical and reliability factors influences the adoption of RWH as an alternative measure to household water supply system. The findings from this study is expected to build on existing knowledge while serving as reference point for further studies in related field. Additionally, it could influence policy decisions on RWH as an alternative water supply measure. The results could also lead to further interesting research on areas that this study could not explore such as the impact of irregular rainfall pattern to the adoption of RWH, the impact of cultural and behavioural influence on RWH.

1.5.2 Societal relevance

The irregular provision of water by the Ghana water company especially during dry periods of the year necessitates looking in to recognized alternative water supply measures like rainwater harvesting while taking in to account critical influence of socio-economic, technical and reliability factors that enable or disenable household's adoption to the concept. At the end of this study, the outcome is expected to serve as a turning point for community members to understand and take the necessary measures towards alleviating the numerous challenges in attaining adequate access to water supply. Further, the result could be used as a source document for Ghana Water Company Limited towards planning and or integrating rainwater harvesting system in to urban water management system at different scales towards meeting urban water demand especially during dry periods.

Additionally, the document could also serve as bases for support from non-governmental organizations within the water sector to scale- up rainwater harvesting in Vittin and other communities within Tamale as a measure to overcoming water related insecurity among the population.

1.6 Scope and limitation of the research

This research is focused on one study area though with an intention geared at creating a larger perspective on how socio-economic, technical and reliability factors influences households to either adopt or not adopt rainwater harvesting in Tamale, Ghana as an alternative water source in the face of limited water supply from Ghana Water Company Limited. Even though, other factors such as behaviour and culture may also stand as influencers to the adoption of RWH, the main focus of this study is geared at accessing household's adoption to RWH based on the influence of socio-economic, technical and reliability factors. Further other institutions (schools, hospitals) which might also be affected by inadequate water supply from the water company and might be triggered to adopt RWH as an alternative water supply system are not also considered in the research due to limited resources and time allocation for the study.

However, to create a clear picture on the need for RWH within the area of concerned, the researcher will source information on the current pipe-borne water supply as well as current water deficit from Ghana Water Company on the area of studies.

Chapter 2: Theory review

The key purpose of this study is to determine how socio-economic, technical and reliability factors enable or disenable households to adopt RWH as an alternative water supply system in the urban set up. To ascertain this, the review of theories under this study is presented in five sections. The first section looks in to the main concepts of the study. The second section of the literature will review the potentials of rainwater harvesting to urban household water supply. The third section of the literature brings to light some critical discussion on the socio-economic, technical and reliability factors influencing the adoption of RWHS in urban areas. The fourth section investigates the possible risks condition(s) associated to the adoption of RWH and lastly the relationships between the concepts.

2.1 Review of concepts

2.1.1 Conventional water supply system

The conventional water system is a method of water supply generally used for providing clean and adequate quantity of water to people in both developed and less developed countries (Totsuka, Trifunovic, et al., 2004). The conventional water supply system is mostly a partially or fully owned state institution in-charge of water provision (Liddle, Mager, et al., 2016). Nonetheless, the services under this system in most developing nations is not regular, resulting from threatened water resources and poor maintenance practices(Totsuka, Trifunovic, et al., 2004).

In Ghana, the conventional water supply system is a state own decentralized system which depends mainly on surface water sources in providing clean water to the urban inhabitants. The Ghana Water Company Limited (GWCL) formally known as the Ghana Water and Sewerage Corporation was established in 1965 and later incorporated early 1999 into full state company with new name GWCL. The company is mainly in-charge of supplying urban set-up with portable water for industrial, domestic, as well as other socio-economic uses. In total, the company operates 88 water distribution systems in the entire country and operates under the Ministry of Water Resources, Works and Housing (GWCL, 2013). Also, the Public Utility Regulatory Commission (PURC) regulates the performance of GWCL as well as monitoring and approval of water rates (PURC, 2008).

The nationwide potable water coverage by GWCL to the urban set-up as at 2012 was estimated at 63.15% indicating an unserved population of about 36.85% (AHK, 2018). Thus, out of a current demand of 1,13Mm3 per day, the company only supplied 0.708Mm3 (62.65%) daily with about 25% coverage in Tamale (gwcl.com.gh). Additionally, with the increasing population in the country, more people are likely to be underserved or unserved even though water is seen as a merit good and non-excludable (Batley, 1996).

In the Northern Region of Ghana, close to 800,000 people still access drinking water from unclean sources water.org (2018). According to water.org (2018), most Out-patient records indicate that about 70% of sickness in the northern region is due to poor water and sanitation situation.

In Tamale, the GWCL get water from a river, White Volta in Nawuni, Dalun. The production capacity of GWCL is 45,000Mm^3/day (gwcl.com.gh). The water distribution system in Tamale has seven (7) distribution networks which receives water from the main treatment plant in Dalun. The distribution network is 125km with 25% coverage (gwcl.com.gh). Significantly, about 75% of the people living in Tamale still lack basic accessibility to clean water under the current coverage of 24 hours per day.

The inadequacies in water provision by the formal sector to the entire urban population among third world countries has led to alternative urban water supply measures in many cities (Smiley, 2013). Certainly, alternative measures play a critical role towards meeting household water requirement in the face of insufficient water provision from the conventional water sources. To adequately access water, will therefore require, water to be captured in various forms and or distributed to people for their respective uses. However, there is huge investment requirement and governments in developing countries mostly are not able to provide the required funding to match the service needs of the people (Macdonal et al.2011). Consequently, private organizations most often tend to be at the rescue of government resulting into partnerships towards adequate water deliveries within countries (Fuest and Haffner, 2007). Thus, the involvement of Aqua VitRa Limited and GWCL in early 2006 for improve service provision Ghana.

2.1.2 The need for water and household water requirement /use

Water is an important natural resource for the survival of every life on earth. Indeed, it is the most vital commodity for every living life (Barron, 2009). According to Grey and Sadoff (2007) water is a very vital component in humanity, indicating that it is so essential for human life, their livelihood activities as well as their prosperity .The inability to change the role of water makes it crucial in taking drastic measures towards its sustenance. From the period when primeval species tried to migrate from the oceans to the land, prevention of dehydration has been a major key to survive Nicolaidis (1998). Without any water, human beings can only survive for days.

According to Nicolaidis (1998) water constitute about 75% and 55% body weight in infants and elderly respectively and it is vital for cellular homeostasis and life. Indeed, to survive, human beings need at least 1 to 2 liters of clean drinking water per person per day (Jéquier and Constant, 2010). Furthermore, water acts as the means through which nutrients are transported, regulates the human temperature, offers structure to cells and tissues as well as help preserve cardiovascular function(Otten, Hellwig, et al., 2006). Accordingly, human health requires a minimum of 50 liters per person per day (Arouna and Dabbert, 2010).Additionally, the (UN-Habitat, 1989) indicated that, at least 20 to 50 liters of water is required in a household for the purpose of cooking, bathing and general hygiene. Indeed, this implies a more sustainable way to water supply towards efficient human consumption (Hardy, Cubillo, et al., 2015)

Even though adequate water supply is critical for the wellbeing of every human, yet the global supply of this resource is gradually decreasing(MacDonald, 2007). Eventually, with the growing population and decreasing water resources, many lives may be affected due to the mismatch between the growing population and the depleting water resources thereby creating the likely incidence of water insecurity and related impact.

2.1.3 Water security

The consumption of unclean water has often resulted in millions of deaths among humans. Globally, about 3 to 4 million lives are lost every year resulting from waterborne diseases including 2 million children dying from diarrhoea (Nnaji, Edeh, et al., 2018). Certainly, when there is inadequate water provision, it does not only affect social and economic activities but the general wellbeing of the human system, causing poverty, devastation and death in the society Grey and Sadoff (2007), as such the need for a water secured society taking into account how to attain it.

Over the years, the notion of water security has been defined differently in literatures (See: Grey and Sadoff, 2007; Bakker, 2012; Jepson et al., 2017, for review). According to Webb and Iskandarani (1998) water security is defined as the access to sufficient potable water at all time for every individual. Emphasizing that, access to water denotes household's control of the water resource. Jepson et al.(2017) were of the view that, water security is a process that takes into account the physical increase in water towards satisfying the demand while recognizing the broader relations between people and water. Indeed, water security denotes efficient access to portable water by all persons.

Further, it is noted that, the amount of rainfall influences the availability of all water resources (Piyush, 2015). However, the amount of freshwater is unequally distributed within geographical sphere which mostly result in excesses for some people while threatening the water security for others (Webb and Iskandarani, 1998). Consequently, leaving close to 1,200 million people without access to portable water supply especially in Sub-Saharan Africa (UNEP, 2003). Even though the concept of water security is mostly geared at effective water management, it is essential to have a broad thinking of relating water security to other water related concepts such as water harvesting, as a step to overcoming water related risks while moving towards sustainable adaptive measures to attaining water security at individual household level and the community as a whole. Indeed, attaining a water secured society requires a swift response to climate adaptative measure towards reducing vulnerability as well as taking progressive actions to achieving the millennium development goals (Sadoff and Muller, 2009). Hence, the struggle by developing countries towards improving water accessibility and security requires a ponder on effective adaptive measures as such the need for water harvesting in the challenging face of climatic events, population increase and growing water demand.

2.1.4 The notion of alternative water harvesting measures

According to Domen et al.(2014), Water security is a global issue that the world leaders urgently need to identify new ways to water supply and resources options to supply increasing demand and uncertainties of climatic events. The impact of population growth, urbanization, globalization and socio-economic development pose as great threat to water security Hardy et al. (2015). Consequently, countries, cities and households undergo various structures, procedures and reforms that aims at improving water supply management. The concept of water harvesting is defined by Mekdaschi and Liniger (2013, p.4) as "the collection and management of floodwater or rainwater runoff to increase water availability for domestic and agricultural use as well as ecosystem sustenance". There are several forms of alternative water harvesting measures that are practiced by people at different scale and levels as part of efforts to meeting their water needs. The alternative water supply measures being practiced among people include, rainwater harvesting, stormwater harvesting/retention basin and greywater/waste/re-use water and desalination (IWA, 2015). However, this study will largely focus on RWH as an alternative water supply measure towards augmenting the water deficit created by conventional water supply system.

According to Ward (2014), the adoption and practice of alternative water supply measures has become a norm and daily routine in most water stressed cities and countries. A classical case is Saudi Arabia, which depends entirely on desalination sea water as alternative measure for their water supply needs Loáiciga, H. A. (2015). Alternative measures to water supply according to (Bichai, Ryan, et al., 2015) are considered towards making water users augment their water needs and create diversity in conventional water systems. Adding that, the adoption and practice of alternative water sources are mostly specific in context and often associated to local and regional priorities.

2.2 An overview of rainwater harvesting system

In the face of growing water resource demand, RWH is seen as adequate water provision for different users in a sustainable way (Fuentes-Galván, Ortiz Medel, et al., 2018). Indeed, the system of RWH decreases the demand of water from the convention water supply among various water users.

The concept of RWH has been used within the field to express different ways of collecting and saving water from rooftop catchments, through runoff from different catchment surfaces for different purposes such as domestic, agriculture and industrial (Che-Ani, Shaari, et al., 2009) . The concept of RWH is mostly focused on catching water from the hydrological cycle and safeguarding it for various uses. Within the context of this study, the concept is focused on the rooftop rainwater harvesting.

The rooftop RWH system is described as a traditional system of collecting and storing harvested rainwater typically through the rooftop for future use (Mooyoung, 2004). It is perhaps the greatest ancient practice used in the world today with regards to meeting the water supply needs of people (Campisano, Butler, et al., 2017). The concept of rainwater harvesting is currently used in supplying diverse water needs for people across the globe (Fuentes-Galván, Ortiz Medel, et al., 2018).

Rainwater harvesting lingers around adequate water supply for various water users. This has made the design phase and the tank(type) selection for water storage most essential in constructing the system (Campisano, Butler, et al., 2017). It is therefore relevant for potential adapters to consider their demand before selecting the tank type in order to store and attain adequate water supply.

Similarly, the better management of water resource implies great resilience among people and effective measure to adaptation which will further aid in managing the current climate variability and shocks which presently is a key developmental issue in developing countries (Sadoff and Muller, 2009).

2.3 Why rainwater harvesting system / rainwater harvesting system as a potential solution to urban household water supply

Adequate water supply is critical for the wellbeing of every human, yet the global supply of this resource is gradually decreasing (Macdonald,2007). Global water crisis estimation indicates that, about 34 to 76 million lives will be lost by 2020 (Cain, 2014a). As such RWH has been proven as an alternative measure to overcoming water deficiencies resulting from increasing water demand as well as socio-economic growth(Christian Amos, Rahman, et al., 2016).Certainly, the construction of RWHS is geared towards augmenting water supply while enhancing water security for users (Campisano, Butler, et al., 2017). As such, the system does not only provide supplementary water for domestic use but also serve as a time saving mechanism for households away from the long hours search of water during dry periods.

Further, rainwater harvesting provides household’s water right while suppressing their burden of walking long distances in search of water (Kahinda, Taigbenu, et al., 2007). Piyush (2015) opined that, the system provides self-reliance to water supply and serve as a supplement to domestic water demand during dry seasons and drought conditions, which Che-Ani et al.(2009) described as independent with relatively clean water supply system. Certainly, installing rainwater harvesting system within a household turns to create an additional water supply system away from the conventional system.

Additionally, rainwater harvesting is used as a strategy to reducing incidence of water related conflict among inhabitants (Hardy, Cubillo, et al., 2015). Certainly, RWH decreases the demand of water from the conventional water system as such reducing potential competition as well as conflict among water users at communal water point during periods of inadequate supply.

The use of RWH as a scheme of collecting water tends to create opportunities for low-cost decentralized water system for the population away from the centralized large-scale distribution systems (Gwenzi, Dunjana, et al., 2015). Certainly, decentralized rainwater harvesting system has greater potentials in building resilience of urban water schemes.

According to Handia et al. (2003), the concept of RWH is adopted as an alternative measure where urban water supply schemes are unable to meet the demand of water users in some countries. Additionally, Che-Ani et al. (2009) emphasized that RWH has a great potential for the future as a major water resource since it has become an effective tool for water conservation. Likewise, Cain (2014) viewed the system as a sustainable approach to providing water in both advanced and developing countries and for that matter should be given attention from both governmental and non-governmental agencies.

At the global front, this system tends to contribute towards attaining the sixth goal of the SDGs when it is used to supply potable water in less developed countries(Hardy, Cubillo, et al., 2015).

2.4 Factors determining the adoption of rainwater harvesting

Despite the growing recognition on the benefits of rainwater harvesting from literatures and some successful projects, yet the concept of rainwater harvesting is not widely adopted in many developing countries Hardy et al. (2015) as such Ghana is not an exception. According to Baguma and Loiskandl (2010), appropriate financial means, some level of education and or technical knowledge may stand as a means to a broader relation determining households' access to water. For Mankad and Tapsuwan (2011), determining the technical viability, economic and social drivers is of key relevance to the adoption of alternative water supply measures within an urban context.Indeed looking into how socio-economic, technical and reliability factors influences the adoption of RWH amidst to water pollution and changing climatic events which continuously affect the growing demand of the water resources cannot be underestimated .

2.4.1 Socio-economic factors

In recent times, the inadequacies of the conventional water system in providing portable water has created attention towards the adoption of alternative water supply measures in the quest to meeting the water needs among people. According to Mankad and Tapsuwan (2011), having a wider understanding of the overall position of the social drivers is crucial for public and household acceptance to alternative water supply measures.

2.4.1.1 Affordability

Constructing a RWHS involves financial investment and commitment from households. Hardy et al. (2015) and Ahmed et al. (2013) asserted that, the slow promotion of rainwater harvesting system is due to high initial cost when equated to the charges or bills of tap water which is often too low. Likewise, Cristina et al.(2015) opined that, the economic feasibility of RWHS should have a balance between the initial cost of investment of the system and that of the operations and maintenance costs especially when compared to the cost of the conventional water system. Emphasizing that, the affordability with installation of the system should take into account the estimated payback period of the facility. Certainly, the lower the pay back periods, the more interested households maybe towards investing in RWH facilities. However, Ishaku et al (2012) on the other hand opined that, apart from the fact that rainwater harvesting requires minimal maintenance cost, it provides households with a free source of water as well as conveys water to the point of need.

2.4.1.2 Concerns of political support

The promotion of RWH by political actors and or NGOs towards ensuring the effective adoption of the practice by citizens especially among households is essential to meeting household water supply.

To ensure an effective transition to a more decentralized water resource management Chelleri et al (2015) asserts that, the main challenge towards ensuring a successful transition away from a centralized water control system is more of a political issue rather than a technical barrier. Likewise, Cain (2014) opined that inadequate governmental support may stand as a major barrier to RWH while indicating that, one major challenge to the extensive adoption and use of RWHS among the population in sub-Saharan Africa countries appears to be limited funding from international NGOs and financial establishments. Stating that, though the situation is beginning to change, majority of aid and financing still lingers around large and centralized projects. Certainly, effective financial aid on rainwater harvesting will enhance a swift adoption of the concept among water users as such contributing effectively to household water supply system. Furthermore Kahinda et al (2007) indicated that, government-led RWH programme can enhance the successful promotion and adoption of rainwater harvesting technology to a wider scale. Indeed, organising widespread campaigns, extending support as well as lobbying households into adopting rainwater harvesting may enhance household water availability while reducing pressure on the conventional water system.

2.4.1.3 Household awareness

Awareness creation plays an essential role in disseminating information on the relevance of RWH for household adoption especially through successful projects. According to Handy et al. (2015) inadequate awareness still stands as a limiting factor towards the effective adoption of rainwater harvesting. Indicating that, more sensitization is required in the form of tangible incentives towards promoting the installation of RWHS. Baguma and Loiskandl (2010 ,P.356) emphasize that "a knowledge gap exists on why some people may adopt or reject domestic rainwater harvesting (DRWH) technologies and adoption trends may continue to be inadequately understood at a household level". As such the more knowledge is acquired through public sensitization on the importance of rainwater harvesting, the more likely people would resort to the practice, especially when governmental institutions and or NGOs begin to render financial and or technical support to households on the adoption of RWH.

2.4.1.4 Status on house ownership

In most developing countries such as Ghana, land is owned by both state and individuals. According to Staddon et al. (2018) house ownership is of significant importance to the installation of rainwater harvesting system while indicating that, tenancy security appears to be the bases for investment on fix asserts like rainwater harvesting system. Indeed, people living in rented houses without tenancy security may be sceptical to invest in the system where as those with adequate tenancy security and free from unnecessary eviction may likely investment in rainwater harvesting facilities.

2.4.1.5 Level of income

The economic or financial feasibility of RWH largely rest on the income of households as such should be prioritise while promoting the concept to households. According to Kahinda et al. (2007), poor financial conditions of people may tend to limit their cost capacity to adopt to this practice as such some may resort to small scale and labour-intensive methods of collecting water. On the other hand, Christian et al. (2016) argued that, the economic analysis of the system is key in the pursuit for gainful solutions to adequate water provision especially in less developed countries. Indicating that, the amount of money spends on water in sub-Saharan African is mostly high as compared to the developed countries especially, when measure against the wage. This may imply that, people living under poor conditions may be challenged to adopt rainwater harvesting.

2.4.2 Technical factors

Understanding the technical effectiveness of RWH is key to addressing water insecurity at the household level Staddon et al. (2018). Indeed, research into the technical factors on the adoption of rainwater harvesting system especially among developing countries is essential for adequate water supply.

2.4.2.1 Integration of systems

Proper integration of RWHS with the existing water supply scheme stances as a great contributor to effective implementation of the concept of rainwater harvesting as well as a proper regulatory measure for efficient management of the systems, which according to Che-Ani et al. (2009) will support in meeting the water demand as such contributing effectively to the sustainable supply of water among users. Owing to this, Ahmed et al.(2013) indicated that, improper integration of these systems has remained a major challenge in the urban setup affecting significantly the effective adoption of RWH as an alternative water supply measure. Further, Campisano et al.(2017) opined that, setting up regulations for effective system management should be approached in a contextual manner, which may require a combinations of support actions to enhance successful adoption. On the contrary, Mitchell et al. (2007) argued that, integrating and diversifying systems may tend to increase their complexity, creating new attributes which will significantly impact its adoption. However, a well-integrated system may lead to effective promotion of the concept which intend may contribute greatly towards attaining a common goal of sustainable water provision for all.

2.4.2.2 Design, location and size of system

The design, location and size of a water harvesting facility is a major operating factor influencing the reliability and efficiency in water collection. Kahinda et al.(2007) opined that, the size and location of RWH systems regulates the amount of water to be harvested while emphasising that, the size can also be influenced by socio-economic constraints. Owing to this, Campisano et al. (2017) indicated that, the adoption of RWH is not about the physical scarcity of the water resource. Thus, there is usually enough water but issues regarding adequate storage of water as well as transportation to the required location remains a challenge. This implies that the mere harvesting of rainwater is not a means to solving household water problems, but the quantity of water harvested plays a critical role in determining the magnitude of household's water security especially during the dry periods. As such various water users need to pay key attention to their consumption while selecting the tank as a measure to overcoming water deficits.

2.4.2.3 Concern of water quality

Moreover, rainwater is mostly thought to supply potable drinking water because of the limited contact with the ground. However, according to Piyush (2015) the issue of contamination from the rooftop hinders the quality of rainwater. Detecting that, the distance the rainwater has to travel, determines the level of contamination it will drive. Kahinda et al. (2007) reiterated that, RWH contamination can be traced to dust from the soil, insects, leaves, chemical deposits, as well as bird droppings from the rooftop. Based on this, White (2009) stated that, the conveyance system should be selected taking key consideration of the first rain as it usually carry depositors such as debris and dirt from the roof from going into the down-pipe. In fact, issues regarding water contamination may deter majority of people from adopting the concept especially if the cost involve in purification is too high.

2.4.2.4 Technical resource

Extensive training and innovation are essential tool in the construction field. According to Islam et al.(2011), the technical viability of RWHS depends largely on available human skills, labour as well as the availability of materials and equipment. Stressing that, the technical practicability of RWHS is central to the system implementation and should be taken into account towards enhancing efficient work output while avoiding previous mistakes in the system setup. Indeed, having the right human skills to undertake proper survey of the site, masonry, plumbing, carpentry and metal works can easily facilitate the installation of a rainwater facility.

2.4.2.5 Ease/ Complexity of implementation

Despite the fact that, RWHS is viewed as a sustainable approach to providing water in both advanced and developing countries Cain (2014), the ease/complexity of implementation is essential for the potential adoption of a RWHS. According to Cristina et al. (2015), the complexity of RWHS are usually different between the developed and less developed countries indicating that , the common elements in both cases is with the system components(the collection stage, the conveyance or transporting system and the storage and delivery system).White (2009) on the other hand opined that, diversity in the use of harvested water by various end users plays a role in the system setup leading to diversity of rainwater harvesting system technology among adopters as such no single-handed standard in rainwater harvesting system is applied during system installation. This may support the argumentation of Cain (2014),which suggested that, social weak groups can engage in rainwater harvesting by resorting to the construction of simple rainwater system which are relatively inexpensive and easy to manage. Definitely, the ease or complexity of the system will depend on the individual or household's preference of system type.

2.4.3 Reliability factors

The reliability of RWHS is essential to households' water supply system. According to Huang et al (2005) a reliable water system basically focuses on the probability of the system to function effectively over a specified period. According to them, there is no single universally accepted measurement for a reliable system. For this study, the reliability of RWHS will focus on the ability of the system to operate successfully as an alternative source of water towards meeting households water needs under the conventional water supply system.

2.4.3.1 Potential to meet critical water needs

The concept of RWH is currently used in supplying water for diverse needs for people across the globe (Fuentes-Galván, Ortiz Medel, et al., 2018). According to Piyush (2015), rainwater harvesting provides self-reliance in water supply system to households, serving as a supplement to domestic water demand during periods of dry seasons and drought conditions. Che-Ani et al. (2009) retreated that, the system is independent with relatively clean water supply system. Owing to this, Ishaku et al. (2012) indicated that, harvested rainwater can be used in meeting households needs (potable and non-potable) Indeed, installing rainwater harvesting facility can give households control over their water supply system but with critical dependence on the capacity of the system and main purpose or use of the water

2.4.3.2 Capacity of supply

The concept of RWH is geared towards adequate water supply for various water users. Campisano et al (2017) indicated that, the size(tank) of the system is the most essential to determining the availability and duration of water supply. Certainly, for a household to have a guarantee water supply using a RWH facility, it is essential to consider their water demand before selecting the tank size. A larger tank will most likely ensure adequate storage of water for a longer duration. Further, it is noted that, the amount of rainfall influences the availability of all water resources (Piyush, 2015) .As such the duration of rainfall also regulates the supply of water within a given period. Based on this, Ishaku et al. (2012) added that, the water collected under the system mostly lasts for a few days because of prevailing climatic events. Emphasising that, there is the need for rainwater harvesting to be done in a systematic manner towards ensuring sustainable potable water supply to communities. Similarly, Sadoff and Muller, (2009) indicated that, the better management of water resource would enhance the resilience among people. Indeed, effective adaptation measures such as rainwater harvesting will aid in managing the current water challenges especially in developing countries towards attaining a frequent and sustained water supply.

2.4.3.3 Functionality of system

According Ward (2014), the adoption and practice of alternative water supply measure has become a norm and daily routine in most water stressed cities. Indeed, alternative measures are considered to make water users resilient in periods of water scarcity, to augment and create diversity in conventional supply systems(Bichai, Ryan, et al., 2015).Thomas (1998) opined that, rainwater harvesting offers households a means of improving their water supply needs on daily bases without waiting several years for the conventional water supply to upgrade their system. Accordingly, Che-Ani et al. (2009) indicated that, RWH has a great potential for the future as a major water resource as it has become an effective tool for water conservation. Handia et al. (2003), asserts that, the concept of RWH is adopted as an alternative measure where the conventional water schemes have been ineffective in satisfying the demand of water users. Further, Cain (2014) viewed the system as a sustainable approach to providing water in both advanced and developing countries and for that matter should be given attention from governmental and non-governmental agencies.

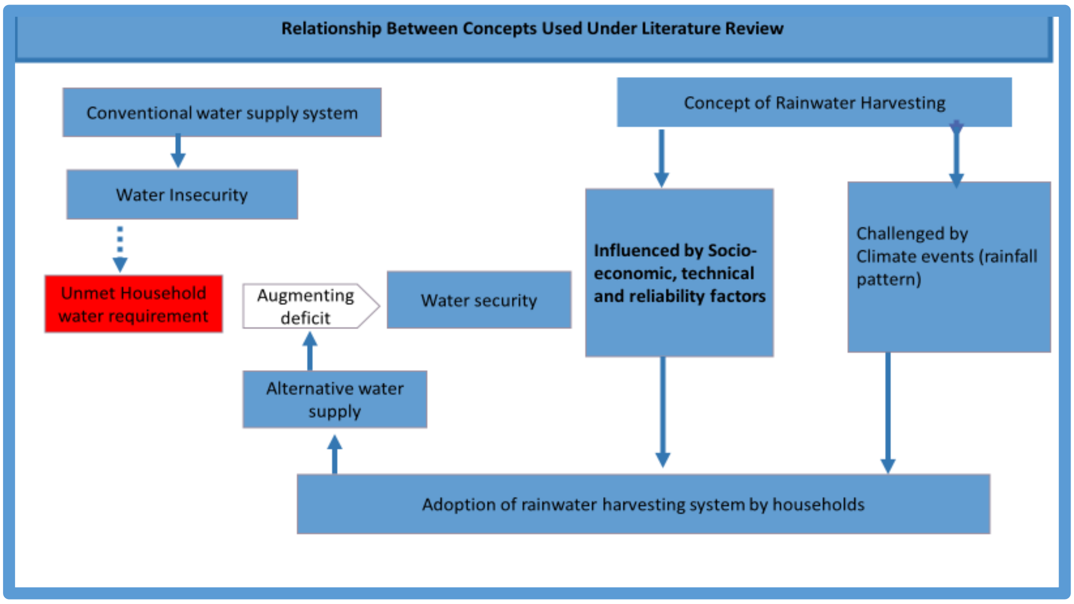
2.5 Potential risks to rainwater harvesting

Globally, the general influences of climatic events on freshwater sources is anticipated to have negative impact (Sadoff and Muller, 2009). Climatic events actually appear as the most threatening risks to rainwater harvesting due to its significant impact on rainfall pattern. The full potential of the rainwater harvesting system is viewed as rainfall dependent which is mostly irregularly distributed over each year (Hardy, Cubillo, et al., 2015). In fact, the system is considered as an unreliable water source due to deficiency of rainwater during the dry season and also during instances of incorrect estimation of rainfall, thereby making the system appear as impractical (Kahinda, Taigbenu, et al., 2007b). This indeed, may stand as a huge barrier since climate change will continue to impact rainfall patterns as such may influence the quantity of water harvested. Therefore, governments and citizens may hesitate to invest money in promoting and adopting the system respectively.

2.6 Relationship between concepts used under literature review

The diagram as depicted below describes the relationship between concepts used in the literature review as driven from the bigger research problem or statement. The literature review was analysed connecting concepts based on their relationship and importance. For instance, the inadequate water provision from the conventional water system leads to unmet household water requirement which intend leads to water insecurity thereby requesting the need for alternative water supply (rainwater harvesting) while taking into account how socio-economic, technical and reliability factors which enable or disenables household's adoption to the concept of RWH as an alternative water supply to augment the deficit in water supply created by the conventional water system or GWCL. Below is the theoretical based explanation on the relationship between concepts.

Figure 1: Relationship between concepts

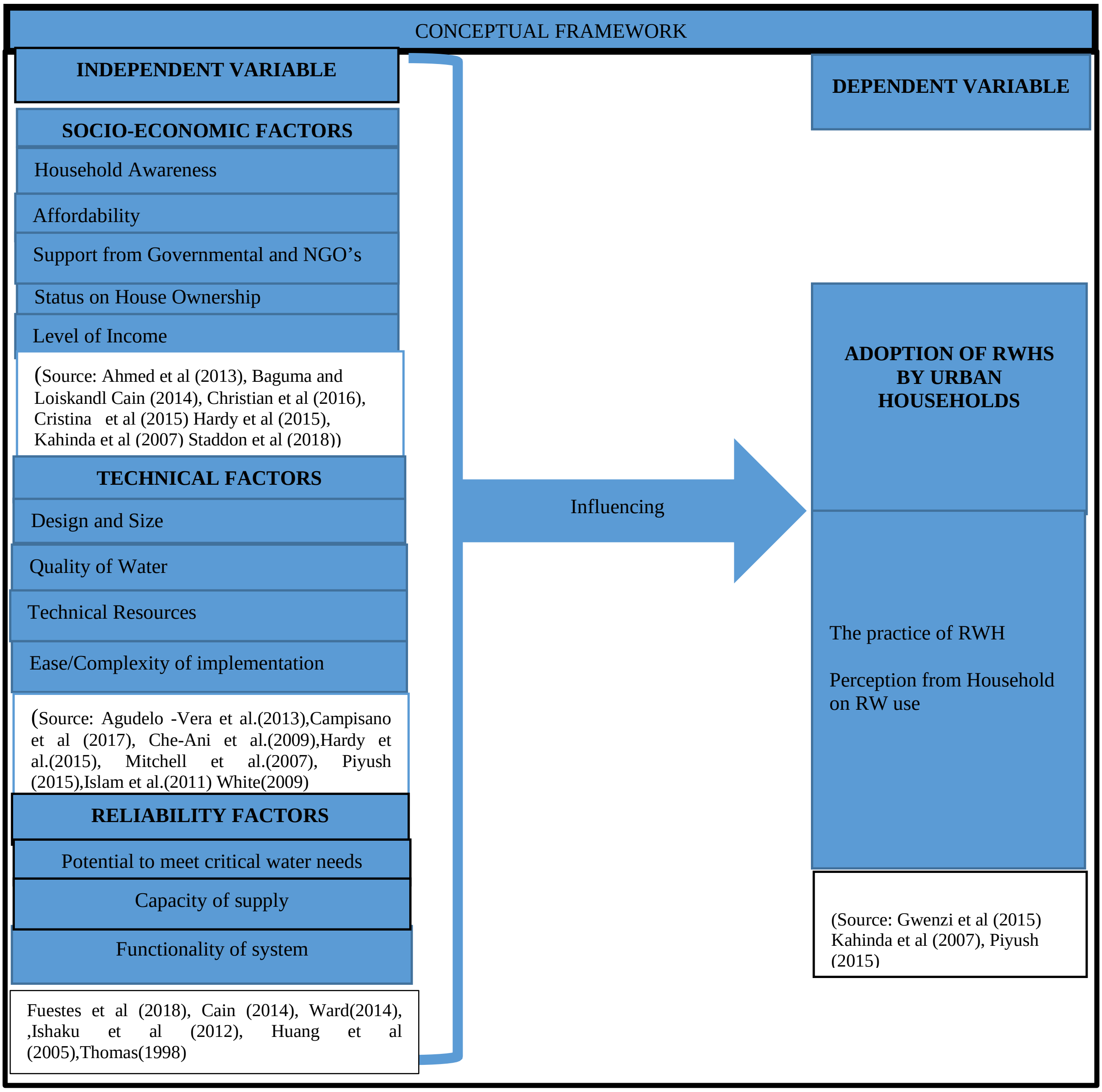


Source: Author's elaboration (2019)

The conventional water supply system is mostly a partially or fully owned state institution in-charge of water provision (Liddle, Mager, et al., 2016). However, in most developing countries, the system is often threatened by inadequate water supply to the large population. For instance, in Ghana the nationwide coverage on the conventional water supply system as at 2012 was estimated at 63.15% indicating an unserved population of about 36.85% (AHK, 2018). As such leading to unmet household water requirement. Consequently, inadequate water supply leads to water insecurity. For example, according to global records, about 3 to 4 million lives are lost annually from waterborne diseases (Nnaji, Edeh, et al., 2018).

Further RWH is introduced as an alternative water supply measure. According to Handia et al. (2003), the concept of RWH is adopted as an alternative water supply measure where urban water supply schemes are unable to satisfy the demand of water users in some countries. However, the concept is hindered by certain factors and as such the concept is not widely adopted in many developing countries Hardy et al. (2015). If these factors (socio-economic, technical and reliability) are determined and analysed, there is a likelihood for effective adoption as such creating alternative water supply to argument the deficit created by the conventional water system such as the GWCL.

Figure 2: Conceptual Framework



Source: Author's elaboration (2019)

The conceptual framework is developed based on the influence of socio-economic, technical and reliability factors on the adoption of RWH by urban households. Despite the growing recognition of successful implementation of the concept of rainwater harvesting in literatures, yet gaps have been identified in some literatures regarding the low adaptation of the concept, thus establishing critical socio-economic, technical and reliability factors influencing the wide adoption of rainwater RWH among people.

The adoption of rainwater harvesting according to literatures is dependent on several factors. On the aspect of socio-economic factors, Inadequate household awareness appears as a limiting factor to the concept. According to Cain (2014), consumers needs be educated through rainwater harvesting programs on the relevance of the system to the demand side efficiency to enhance effective adoption of the concept. Hardy et al. (2015) opined that, the spread of information on RWH can be enhanced through education in schools as well as in the form of tangible incentives towards promoting adoption. Also, the system is associated with concerns of high Initial cost as compared to the cost of tap water. Kahinda et al.(2007) opined that, people with poor financial conditions may have limited capacity to adopt to this practice as such may resort to small scale and labour-intensive methods of collecting water. Cain (2014) argued that, social weak groups can resort to constructing simple rainwater system which are relatively inexpensive and easy to manage, further stating that, rainwater harvesting is receiving limited funding from international NGOs and financial establishments while emphasizing that, governmental agencies and NGOs can play a supportive role to expand user coverage.

Additionally, Staddon et al. (2018), was of the opinion that, house ownership is a significant contributory factor hindering the adoption of rainwater harvesting especially among tenants. In fact, the tenancy agreement as well as security might dictate the willingness of tenants to invest in such a system.

Furthermore, technical factors such as the quality of water harvested under the system is questioned due to likely contamination from rooftop in to tanks. According to Piyush (2015) the issue of contamination from the rooftop hinders the quality of water harvested from the rains. Hardy et al.(2015) emphasised that, the contamination of this water source is linked to dust from the soil, insects, leaves, chemical deposits as well as bird droppings which may require some level of treatment while indicating that, the essential purpose or use of the water counts. Additionally, the concept is also challenged on grounds of improper integration to formal water management system. According to Che-Ani et al.(2009) ensuring proper integration of the concept to existing water supply system will help in meeting the demand for users while enhancing the sustainable supply of the water resource. However, Mitchell et al.(2007) opined that, integrating and diversifying systems may tend to increase their complexity, creating new attributes which will significantly impact its adoption. On the aspect of technical resources, Islam et al.(2011) indicated that, the technical viability of rainwater harvesting system depends largely on availability of human skills, labour as well as the materials and equipment. In line with the ease/complexity of system the implementation,White (2009) opined that, diversity in the harvested water usage by various end users plays a role in the system setup leading to diversity of rainwater harvesting system technology among adopters as such no single-handed standard in rainwater harvesting system is applied by all during system installation.Additionally, the design, size and location of RWHS is a major operating strategy for the installation of a system. Agudelo-Vera, et al., (2013) indicated that studying the type of designs (size and location) is important while emphasizing that, size and location will allow easy access and collection of rainwater, which may intend limit the impact of irregular rainfall pattern when the facility is large to store more water. Furthermore, the reliability of RWHS is essential to household water supply system. According to Huang et al. (2005) a reliable water system focuses on the probability of the system to function effectively over a specified period while indicating that, there is no single universally accepted measurement for a reliable system. In line with the functionality of the system, Thomas (1998) opined that, rainwater harvesting offers households a means of improving their water supply needs on daily bases without waiting several years for the conventional water supply to upgrade the system. Also, with the capacity of supply, Campisano et al (2017) indicated that, the tank size of the system is the most essential to determining the availability and duration of water supply. However, Piyush (2015) noted that, the amount of rainfall influences the accessibility of all water sources as such the duration of rainfall determines the supply of water within a given period. Owing to this, Ishaku et al. (2012) emphasised that, the water collected under the system sometimes lasts for few days because of prevailing climatic events. With regards to the reliability of the system towards meeting critical water needs, Fuentes-Galván (2018) indicated that, the concept of RWH is currently used in supplying diverse water needs for people across the globe. Accordingly, Piyush (2015) opined that, rainwater harvesting provides self-reliance on water supply system for households, as such serving as a supplement to domestic water demand during periods of dry seasons and drought conditions.

Driven from literatures, the concept of rainwater harvesting as an alternative measure may therefore be widely implemented based how the socio-economic, technical and reliability factors such as household awareness, contamination of water(quality), affordability of system, design and size of system, income level of household, house ownership, technical resources, ease/complexity of system, integration of concept with existing systems, capacity of supply, potential to meet critical water needs and functionality of system are been influenced within a context.

Chapter 3: Research design and methods

This chapter took a critical view of relevant existing data and or materials from Ghana Water Company while indicating a detailed description of the fieldwork strategies with key consideration of relevant data collection tools for capturing data from households in Vitin. The main issues discussed included; the review of research questions, operationalization of variables and concepts driven from the conceptual framework, methodology and or strategies selected for the research as well as other relevant information required in response to the research objective and questions formulated in Chapter1.

3.1 Revised research question(s)

3.1.1 Main research question

How does socio-economic, technical and reliability factors influence the adoption of RWH by households as an alternative water supply system in Vitin-Tamale, Ghana?

3.1.2 Sub-research question

1. What is the current deficit of the water supply system in Vitin?
2. How does socio-economic factors influence the adoption of RWH by households as an alternative water supply system in Vitin-Tamale, Ghana?
3. How does technical factors influence the adoption of RWH by households as an alternative water supply system in Vitin-Tamale, Ghana?
4. How reliable is rainwater harvesting in meeting the current deficits in household water supply system?

3.2 Operationalization: Variables, Indicators

The conceptual framework is developed considering how socio-economic, technical and reliability factors influences the adoption of RWH by households as indicated in literatures in previous chapter. With the detailed presentation of the concepts in the preceding Chapter 2, the operationalization of socio-economic, technical and reliability factors influencing the adoption of RWH are contextualized in Vitin-Tamale. Further, the variables and indicators for the independent variables are clearly illustrated depicting a relationship with the dependent variable (adoption of rainwater harvesting by urban households in Vitin) as shown in the table below.

3.2.1 Explanation of Variables (Dependent and Independent)

This study accessed the relationship or association of socio-economic, technical and reliability factors and the adoption of RWH by households in Vitin-Tamale.

- **Independent Variable**: In this research, 'how socio-economic, technical and reliability factors influences the adoption of RWH ' represents the independent variables defining the conditions which enable or disenables a household to adopt or not adopt RWH as an alternative water source in Tamale, thus socio-economic factors (Household awareness, Initial cost, house ownership, income level),Technical factors (water quality, integration of system, Design and size of system, Technical know -how, ease/complexity of implementation) and Reliability factors (Potential to meet critical water needs, functionality of system and Capacity of supply)
- **Dependent Variable:** The dependent variable for this research 'Adoption of rainwater harvesting by urban households' is expressed as the ability of households to adopt or practice RWH as an alternative household water supply measure while considering their

perception on the use of rainwater in the face of inadequate water supply by Ghana Water Company Limited

Table 1: Operationalization of variables and indicators

Sub-Questions	Concepts	Variables	Sub-variables	Indicators	Data	Data Collection Instruments	Respondents
	Independent Variable						
How does socio-economic factors influence the adoption of RWH by households as an alternative water supply system in Vitin-Tamale, Ghana?	Socio-economic, technical and reliability factors influencing the adoption of RWH	Socio-economic					Households In Vitin- Tamale
		Household Awareness	Households knowledge and or access to information on RWH.	Source of information Available awareness creation programs on RWH	Nominal Binary	Questionnaire	
		Affordability	Type of cost	Initial cost Maintenance cost	Numerical Numerical	Questionnaire FGD	
		Concern of Political support.	Type of governmental and NGOs support. Lobby from governmental and NGOs	Technical support Financial support Education/capacity building Material	Nominal Binary	Questionnaire	
		House Ownership	Tenancy agreement		Binary	Questionnaire FGD	
			Existence of tenancy security		Binary	Questionnaire FGD	
		Level of income		Monthly income	Numerical	Questionnaire FGD	

		Technical					**Households**
How does technical factors influence the adoption of RWH by households as an alternative water supply system in Vitin-Tamale, Ghana?		Water Quality	Type of use (Domestic water uses)	Cooking, Gardening, Drinking, Sanitation and Hygiene	Nominal	Questionnaire FGD	.
			Treatment technique	Chlorine Filtration Biosand Others	Nominal		
			Level of water contamination	High Average Low	Ordinal	Questionnaire FGD	
		Technical Resource	Type of resource	Available human resource (Technical Know-How) Availability of materials	Binary	Questionnaire	Households
		Ease/Complexity of Implementation		Procedure for implementation	Binary	Questionnaire FGD	Households
		Location, design and size of system.		Amount/Quantity of water	Numerical	Questionnaire FGD	Households
				Availability of space	Binary	Questionnaire FGD	
How reliable is RWH in meeting the current deficits in household water supply system?		Reliability					
		Potential to meet critical water needs	Type of need	Domestic needs Drinking needs Availability of water	Nominal Interval	Questionnaire FGD	
		Functionality of system	Frequency	Number of days	Interval	Questionnaire FGD	
		Capacity of supply		Quantity of water	Numerical	Questionnaire	
	Dependent Variable						
		Perception of Households on rainwater use	Household Perception	Potable water source Non-potable water source	Binary	Questionnaire FGD	
		Practice of RWH		Adopters Non-adopters	Binary	Questionnaire FGD	

Source: author's elaboration

Table 2: Research questions and data sources

Research Question	Required Data	Data Source
What is the current deficit of the water supply system in Vitin?	Amount/Volume of water supplied to residents.	Secondary data from GWCL
How does socio-economic factors influence/determine the adoption of RWH by households as an alternative water supply system in Vitin-Tamale, Ghana?	Data and or information on: Household awareness level Households' income level Tenancy agreement Tenancy security	Households
How does technical factors influence/ determine the adoption of RWH by households as an alternative water supply system in Vitin-Tamale, Ghana?	Domestic water use Level of water contamination Level of knowledge Treatment technique Water collection technique Availability of space	Households
How reliable is RWH in meeting the current deficits in household water supply system?	Amount of rainwater harvested by households Type of water need(domestic/commercial) Duration of available water use Frequency	Households

3.3 Research strategy

In undertaking a research, various strategies can be employed by researchers such as the use of a survey, experiment, case study and desk study taking into account the focus of the study(Van Thiel, 2014).

In the context of this study, the researcher undertook an explanatory case study, which assessed how socio-economic, technical and reliability factors influences household's adoption to RWH as an alternative water supply system in Vitin,Tamale-Ghana. An explanatory case study usually examines a contemporary phenomenon and explain how/why a phenomenon occurs(Yin, 2003).Van Theil (2014), further emphasized that, the strategy (case study) aims at gathering new data thereby allowing researchers to collect data on attitudes towards a certain subject matter. Adding that, the case study strategy is aimed at studying a commonly observed incident using a single or multiple case that can be seen as representative of the subject of study. Further, it examines the applicability of variables or concepts in validating empirical reasons as such contributing concrete solutions to societal issues. In the context of this study, a single case study is used to obtain data from households with RWHS and households without rainwater system.

The study employed a mixed method using both quantitative and qualitative research methods. The researcher collected both secondary and primary data. With the secondary data, the data was obtained on the quantity or amount of water supply from the conventional water system. As such establishing the current deficit in water supply from Ghana Water Company Limited. With regards to primary data using quantitative method, the researcher employed the use of a survey questionnaire in assessing data on how socio-economic, technical and reliability factors influence the adoption of rainwater harvesting by households as an alternative water supply system as well as the amount of water supplied by the RWHS. Qualitative method on the other hand employed the use of focus group discussion in getting in-depth data on how socio-economic, technical and reliability factors influence the adoption of rainwater harvesting system by households while taking in to account other key reasons why the concept is not adopted by some households as an alternative water supply source.

3.4 Sample size and selection

Purposive sampling technique was employed to select respondents from120 households. Out of the total number, 60 respondents were selected from households with RWH facilities and the remaining 60 from households without rainwater harvesting facilities. Also, 2 focus group discussion were organized separately (women group and household heads) with a minimum of 8 people each. The relevance of the purposive sampling technique was to select respondents who can provide the relevant information or have knowledge on the subject matter as such it aids in providing new knowledge and insight on the subject under study (Van Theil,2014). Additionally, snowballing was used, where the first respondent aided in the identification of the next respondent and so on within the chain of actors in the study area. To ensure anonymity of all respondents and privacy in the data collection process, different codes were created in response to the questionnaire to ensure confidentiality while ensuring easy verification and identification of information generated. Furthermore, to test the strength of respondents' opinions, the Likert scale was used to answer some questions.

3.5 Data collection methods

The following procedures were applied in collecting data towards answering the research question of the study. The researcher collected secondary and primary data from Ghana Water Company Limited (GWCL) and the respondents(household) respectively. A mixed data collection method was employed in collecting both qualitative and quantitative data. Further, the methods of primary data collection envisaged for the study included; the use of semi-structured questionnaire (quantitative data) for the households as well as focus group discussion (qualitative data) in obtaining relevant information from two different groups (women and household heads) with different roles and level of knowledge on rainwater harvesting.

- Literature Review/ Secondary Data

Extensive review of literatures relevant to the study were obtain through academic journals on related studies as well as reports on related fields. By this, second hand information was obtained on the contributions of rainwater harvesting as well as key secondary data from Ghana Water Company especially on the water supply deficits towards attaining a sustain body of knowledge on why the subject under study is relevant.

- Design and use of questionnaire survey

Questionnaires are usually designed to aid researchers in collecting primary data from respondents in the field**.** The researcher administered questionnaires to householders towards obtaining relevant information on how socio-economic, technical and reliability factors influences households to adopt or not adopt to RWH as an alternative water supply system. Also, with the help of a check list, the researcher was able to crosscheck the number of questionnaires administered to respondents.

- Focus group discussion (FGD)

The Researcher used focus group discussion to engage with two separate groups consisting of a women group and a group of household heads taking into consideration the availability or non-availability of RWHS in their household. The women group were targeted based on the fact that, they are mostly in-charge of collecting water as well as their direct involvement in water related issues especially during periods of water scarcity. On the part of the household heads, the researcher sourced first-hand information on how socio-economic, technical and reliability factors influencing the adoption of RWH by households, the major challenges with the system as well as its contributions towards augmenting the water deficit with the conventional water supply system.

- Observation

The researcher also employed observation as a guide to verifying or confirming some information provided by respondents such as facial expressions, availability and nature of rainwater harvesting facilities within households.

3.6 Types of data to be collected

In undertaking this research, both primary and secondary data sources were essential to attaining the objective of this research. In line with secondary data collection, data was obtained from Ghana Water Company Limited on the current water supply as well as water deficit. Further, the researcher employed the use of questionnaire to obtain primary data from different respondents on how socio-economic, technical and reliability factors influencing the adoption of RWH by households as well as using focus group discussion (with women and household head) to source detailed information on the above-mentioned factors towards household's adoption to the concept while meeting their water needs.

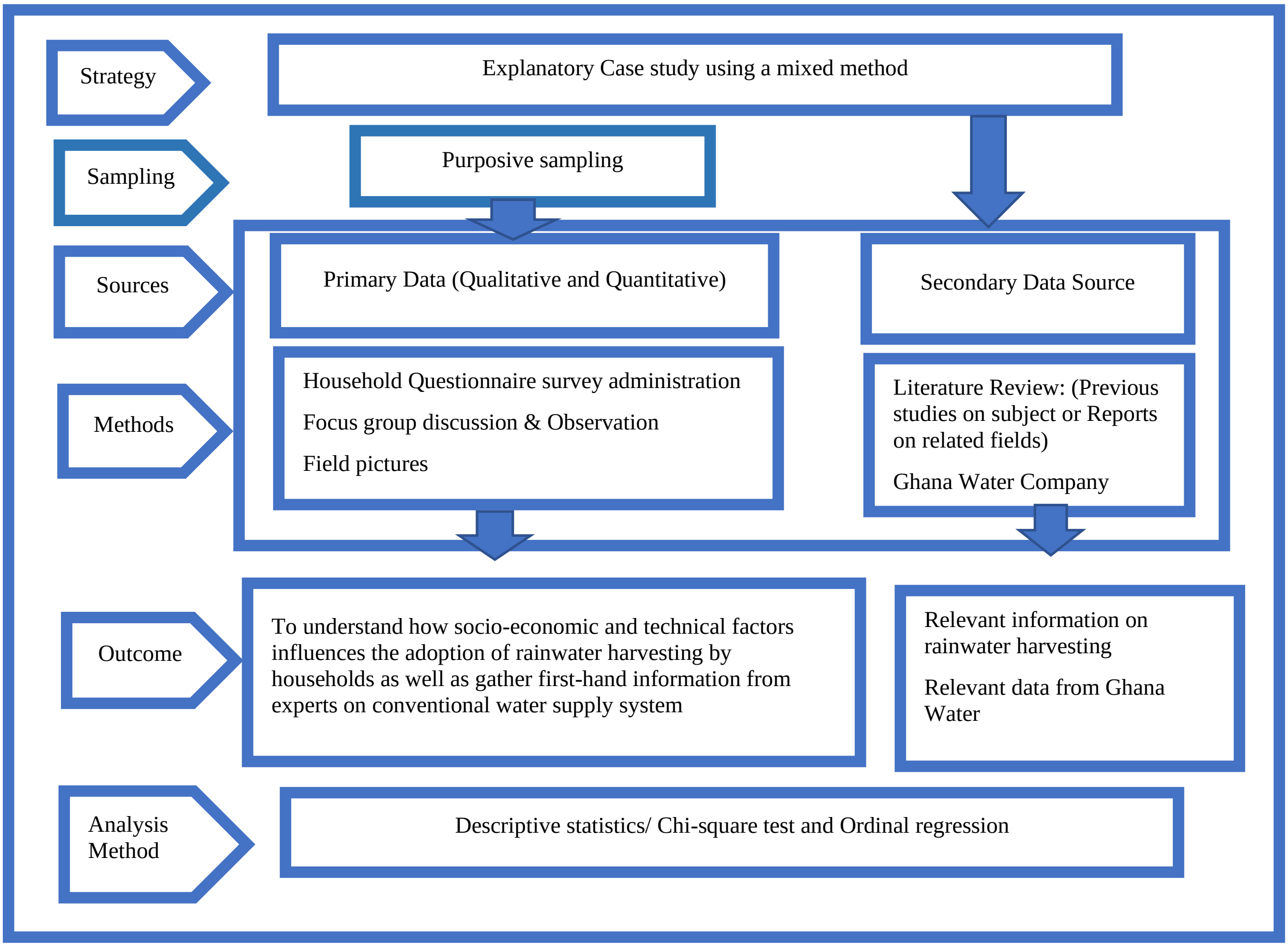
3.7 Data analysis methods

Different data analysis tools were employed for the different data collection methods. The researcher used different tools such as Excel and SPSS for qualitative and quantitative data respectively. Further, data collected from individual households through different data collection methods were analysed using descriptive statistics. Chi-square test was used to establish the association between the independent and dependent variable of the study. Again, Ordinal regression was used to establish the relationship between the independent variables and the perception of harvested water use.

3.8 Procedure for data collection and analysis

The diagram below illustrates the kind of data collection techniques employed as well as data analysis conducted towards attaining the research findings. Further, the findings obtained are used in answering the overall question of the research under study

Figure 3: Procedure for Data Collection and Analysis



Source: author's elaboration

3.9 Validity and reliability

To attain reliability in data collection, the researcher ensured that, the variables are accurately and consistently measured according to the objective of the research. Also, the researcher retrieves relevant data of interest for the study using triangulation to double check data collected as well as results reach. According to Van Theil (2014), a reliable data revolves around repetition of the same ideas under comparable circumstances to attaining similar results. For instance, this research employed the use of questionnaire and sfocused group discussion method to obtain data on the availability of RWHS in households, the reliability of rainwater harvesting to household's water needs while employing observation to confirm responses through facial expression and the physical availability and size of rainwater facilities. As such the repeatability of same questions within the study enabled the researcher to compare results from respondents towards reaching a conclusion which indeed can be proven to be right (Van Thiel, 2014).
Further, the validity focuses at ensuring that the research measures its intended purpose(Van Thiel, 2014). To attain this, the research questions were tested via consultation with experts (supervisor) within the field of study towards assessing the content and completeness of the questionnaire. Further, the researcher undertook a Pilot study towards assessing first-hand information on the practicability of the research questions. As such the feasibility of the questionnaire were measured. Certainly, providing clearer instructions, easy-to-read and

unambiguous questions, appropriate questions with the required variables enhanced the internal validity of the findings.

3.10 Challenges/ limitations in data collection

- Language barrier was one of the challenges encountered by the researcher. As such research assistance were employed to administer the questionnaires as well as help in data transcription.
- Difficulties in accessing secondary data direct from Ghana Water Company due to administrative bureaucracies. As such the researcher resorted to reports from the company towards obtaining relevant information on water supply to urban set-up in Ghana which was used for further analysis in the context of Tamale and Vittin precisely.
- Some major observations and responses obtained during the study were proven to have no statistical significance with regards to the adoption of RWH. However, households viewed them as a good foundation for the effective adoption of RWH by households. For instance, the lack of public awareness programs on RWH as well as support from political/governmental or NGOs is seen as a great limitation to the effective promotion of the concept.

Chapter 4: Research findings

This chapter presents the results of the study through data collected from secondary sources, household survey, focus group discussion and observation. The findings gathered are geared towards answering the research question "How does socio-economic, technical and reliability factors influence the adoption of rainwater harvesting by households as an alternative water supply system in Vitin-Tamale, Ghana".

4.0 Presentation and analysis of research findings

A total of one hundred and twenty-one (121) respondents were engaged for the study of which a hundred and fifteen (115) respondents completed their questionnaire. Thus 61 responses came from households with RWH facilities and 54 responses from households without RWH facilities. Also, 2 separate focus group discussions were held (10-member women group and 9 household heads (men)). In effective, the study had 95% respondents' rate.

With regards to the presentation of the study findings, the results are presented in three sections; the first part (**Section A**) presents findings of the socio-economic factors associated with rainwater harvesting, the second part (**Section B**) presents the results of the technical factors and the third part (**Section C**) present the results of the reliability factors influencing the adoption of RWH by the household.

Further, this chapter also looks into the existing relationship between the socio-economic, technical and reliability factors while taking keynotes of the findings.

4.1 Section A: Socio-economic factors

The socio-economic factors influencing the adoption of RWH includes; households' awareness level, status on house ownership, affordability of system (initial and maintenance cost), Political/government or NGO Support as well as their income levels as presumed from previous studies (Ahmed et al 2013, Baguma and Loiskandl(2010), Cain 2014, Hardy et al 2015, Kahinda et al 2007, Staddon et al 2018 etc.). However, the socio-economic characteristics of households such as their income levels, employment status, educational status and households' size were presumed necessary to household's decision making.

Discussion on socio economic characteristics

From the results in (Annex 1, Table 10), it is noted that within the sample population, there is a high educational attainment with most people been employed. However, it can be deduced that though majority are employed, they have low monthly earnings of less than GhC500 and between GhC500 to GhC999. Also, most households within the study area have family size of 4 to7 people. This may also imply that most households are likely to have high demand for water. Thus, following from Arouna and Dabbert (2010) studies which indicated human health requires a minimum of 50% liters per person per day. As such, large families may require more water towards meeting their water needs.

4.1.1 Inferential statistics

Chi Square test for association between socio-economic factors and the practice of rainwater harvesting (adoption)

In accessing the how socio-economic factors influence the adoption of rainwater harvesting by households, Pearson's chi2 ($\chi 2$) statistical test was used to test the association between the practice of RWH (Adoption) and socio-economic factors (Level of income, household awareness, Affordability [cost of installation of RWHS and cost of maintenance of RWHS], political/government support and house ownership) at a significance level of $p < 0.05$.

From the χ^2 test in Table 3 below, it was observed that Affordability [initial cost and Cost of maintenance were significantly associated (p value = 0.016) and (p-value = 0.000) respectively with the practice of RWH (Adoption). Also, house ownership was significantly associated with practicing RWH (p value = 0.045). On the other hand, there was no observed association between level of income (0.067), awareness creation (0.349) as well as political/governmental and or NGO support (0.286) and the practice of RWH (Adoption).

Even though level of education was not significantly associated, most respondents (24.35%) had attained tertiary education. Also, employment status was not associated with practicing RWH, even though most respondents (51.3%) practicing RWH were employed. Interestingly respondents with income level more than GhC2000 practiced RWH less (3.48%) compared with other levels of income earners. Largely, respondents who practiced RWH rather strongly disagreed or disagreed that there is high awareness on RWH. Th association between initial cost and adoption was observed to have a higher proportion of respondents who practice RWH strongly agreeing (20.87%) or agreeing (26.09%) that there is high initial cost for RWHS. Even though there is an association between maintenance cost and the practice of RWH, it was realised that most respondents (60.66%) stayed neutral regarding the high cost of maintenance. Furthermore, almost all respondents (who practice or do not practice RWH) indicated that there is no support from the government for the installation of RWHS. It was also observed that 7 respondents (6.09%) practiced RWH though they did not own a house, but most of the respondents who practiced RWH owned houses (46.96%).

Discussion on the relationships between socioeconomic and adoption of RWH

From the results, it was clear that some socio-economic factors have significant influence on the practice of RWH (Adoption) such as the affordability of system (initial cost and Cost of maintenance) and house ownership.

With regards to the initial cost of the system most respondents acknowledged that the installation cost is high. 19 non-adopters cited high installation cost as their reason for non-adoption. It was also revealed during the FGD session that, most households resorted to smaller facilities due to high initial cost of the system. As such one household head said, "***It is difficult to install a system because a lot of cash is required***". This indeed might limit the adoption of RWH to many households who can afford the initial cost of the system.

Additionally, though there was an ironic response outcome as most respondents (60.66%) rather stayed neutral regarding the high cost of maintenance while depicting an association between maintenance cost and the practice of RWH. Direct observation and engagement sessions confirmed that most systems were new and had not gone through serious maintenance process.

It was also clearly ascertained during the survey with households that, most adopters (RWH) were leaving in their own houses. However, those who did not own a house but had tenancy agreement which permitted them to put up an additional structure (RWH) were able to install their systems as depicted in (**Figure 9**). Also, it was revealed during the focus group discussion session that, people leaving in rented houses without any formal tenancy agreement had no interest to install a system since they can be evicted at any point time. As such RWH is not formally practiced by them but done with small containers based on their availability to collect the water whenever it rains. On the contrary, people leaving in their own houses had a high tendency to adopt (RWH) since their decision does not depend on a third-party's action. Indeed, this follows the path of Staddon et al. (2018) as they stated that, house ownership is a great contributory factor to the installation of RWHS.

Interestingly, as the results on the level of awareness creation revealed no association with the practice of RWH, most respondents (66.9%) held the view that there were no awareness creation programs on RWH. It was further revealed during the FGD session that, awareness creation through social media will enhance the uptake of the practice among households. As such one participant said, "***It has never occurred to me to collect rainwater in large quantity until I moved to this neighbourhood and saw people collecting rainwater in big storage containers due to limited access to tap water supply, I saw it was good then I also started***". Even though there was no formal platform for formation sharing regarding RWH within the study area, it was indicated that, information on RWH was communicated down through informal or local mechanisms to most adopters as shown in(Figure 7). Indigenous knowledge (through parents) appeared to be the main medium of information sharing on RWH. Also, neighbours were noted to be another important channel through which information on RWH was disseminated. Even though formal structures (awareness) have not really contributed to information dissemination towards the adoption of RWH within the study area, households see it as the fastest means to disseminate information on RWH as revealed by Handy et al. (2015) as they viewed inadequate awareness as a limiting factor towards the effective adoption of rainwater harvesting

Similarly, political/governmental and or NGO support revealed no association with the practice of RWH(Adoption) in the study even though majority of respondents (99.3%) indicated that there is no support from both political/governmental and NGOs on RWH. Furthermore, both adopters and non-adopters disclosed in the focus group session that, support from governmental and non-governmental bodies, either in kind or cash will encourage more people to adopt as well as aid people with smaller facilities to upscale.

Ironically, respondents with high income level of more than GhC2000 practiced RWH less (3.48%) compared with other levels of income earners. Those with high income but were not practicing RWH revealed that the water is mostly associated with contamination. As such a participant had this to say, '***the process is time consuming, one has to first harvest the water, treat it and then test to be sure of its state before consumption'.***

Table 3: Chi2 test of association between dependent variable (adoption of RWH) and socio-economic factors

	Do you practice RWH				
	No (n = 54)	**Percent (%)**	**Yes (n = 61)**	**Percent (%)**	**p - value**
Level of Education					0.872
No formal education	17	14.78	17	14.78	
Primary education	9	7.83	10	8.7	
Senior secondary/O'level	7	6.09	6	5.22	
Tertiary	21	18.26	28	24.35	
Employed?					0.901
No	2	1.74	52	45.22	
Yes	2	1.74	59	51.3	
Level of Income					0.067
Less GhC500	20	17.39	19	16.52	
GhC500 - GhC999	11	9.57	25	21.74	
GhC1000 - GhC1500	10	8.7	5	4.35	
GhC1501 - GhC2000	5	4.35	8	6.96	
More than GhC2000	8	6.96	4	3.48	
There is high awareness creation					0.349
Strongly disagree	23	20	26	22.61	
Disagree	15	13.04	13	11.30	
Neutral	10	8.7	7	6.09	
Agree	3	2.61	9	7.83	
Strongly agree	3	2.61	6	5.22	
There is high initial cost for RWHS					0.016*
Strongly disagree	1	0.81	0	0	
Disagree	4	3.48	0	0	
Neutral	5	4.35	7	6.09	
Agree	19	16.52	24	20.87	
Strongly agree	25	21.74	30	26.09	
There is high maintenance cost RWHS					0.000*
Strongly disagree	0	0	0	0	
Disagree	0	0	4	6.56	
Neutral	0	0	37	60.66	
Agree	0	0	16	26.23	
Strongly agree	0	0	4	6.56	
Is there political/government support?					0.286
No	53	46.08	61	53.04	
Yes	1	0	0	0	
Do you own a house					0.045*
No	14	12.17	7	6.09	
Yes	40	34.78	54	46.96	

*. Statistically significant (p-value < 0.05)

Ordinal regression analysis to determine the relationship between socio-economic factors and perception of households on rainwater use

Ordinal regression was used to determine which of the socio-economic factors (Level of income, household awareness, Affordability [cost of installation of RWHS and cost of maintenance of RWHS], political/government support and house ownership) have effect on the perception of household water use.

From the analysis, level of education was found to be significantly related (p = 0.006) with the perception of household on the use of harvested water. Largely, 66.7% of respondents who had tertiary education level had perception that harvested water is non-potable (bad), whilst 30.9% of respondents with no formal education had perceived the use of harvested water as potable. Employment status was seen to an association (p = 0.001) with the perception of household use of harvested water. 16.2% of the respondents who were employed held the perception that harvested water was non-potable (good), whilst 95.9% of the employed respondent said harvested water was good. Also, high initial cost for RWHS and house ownership were both found to be significantly associated with the perception of harvested water (p = 0.000).80 respondents who have their own houses perceive RW use as potable as presented in Table 4 below.

Discussion on socioeconomic factors and households' perceptions

From the result, level of income appears to be the only socio-economic factors that did not have any relationship with the perception of households on the use of harvested water. However, from Table 4 below, it can be observed that most people with low monthly earnings perceive rainwater use as potable than people with high monthly earnings. In fact, from the FGD some household heads with high monthly earnings who were not practicing rainwater harvesting indicated that they prefer buying from the commercial water tanker because rainwater is non-potable and therefore requires some level of treatment to make it wholesome. On the hand, households with low income preferred to harvest rainwater as a way of saving cost in buying water especially during the rainy season. Adding that "***we use rainwater in performing so many household chores such as washing, cooking, bathing and flushing toilet***"

With regards to household awareness creation, it was detected that people who strongly disagree or disagree that there is high awareness creation on RWH perceives harvested water use as potable than those who strongly agree or agree that there is awareness creation. During the FGD session, a woman indicated that she used to perceive rainwater as a very potable water source because it is natural while adding that ***"I never knew it was associated with some level of contamination, so I used to consume the water without treating it until I fell sick and the doctor advised me to always boil my water before drinking, so having awareness creation programs can enhance water related hygiene".***

Also, majority of people who leave in their own houses perceived the use of harvested water as potable. Some of the uses of harvested as indicated by households include; washing, cooking, drinking, bathing as depicted in Table 22 (Annex 14)

All 4 unemployed respondents perceive the use of RW as potable. Perhaps, this might be because they do not have much income to purchase from the commercial water tanker or might also see it as a way of saving cost just like the low-income earners.

Table 4: **Ordinal regression analysis to determine the relationship between socio-economic factors and perception of household on use of harvested water**

Socio-economic Factors	Perception of Household on use of harvested water					
	Bad (n = 18)	Percent (%)	Good (n = 97)	Percent (%)	p - value
Level of Education					0.006*
No formal education	4	22.2	30	30.9	
Primary education	1	5.6	18	18.6	
Senior secondary/O'level	1	5.6	12	12.4	
Tertiary	12	66.7	37	38.1	
Employed?					0.001*
No	0	0.0	4	4.1	
Yes	18	100.0	93	95.9	
Level of Income					0.128
Less GhC500	2	11.1	37	38.1	
GhC500 - GhC999	4	22.2	32	33.0	
GhC1000 - GhC1500	4	22.2	11	11.3	
GhC1501 - GhC2000	5	27.8	8	8.2	
More than GhC2000	3	16.7	9	9.3	
There is high awareness creation					0.000
Strongly disagree	5	27.8	44	45.4	
Disagree	6	33.3	22	22.7	
Neutral	6	33.3	11	11.3	
Agree	1	5.6	11	11.3	
Strongly agree	0	0.0	9	9.3	
There is high initial cost for RWHS					0.000
Strongly disagree	0	0.0	1	1	
Disagree	3	16.7	1	1	
Neutral	5	27.8	7	7.2	
Agree	6	33.3	37	38.1	
Strongly agree	4	22.2	51	52.6	
Do you own a house					0.000
No	4	22.2	17	17.5	
Yes	14	77.8	80	82.5	

4.1.2 Descriptive analysis of the socio-economic factors

Households income level

Findings: As depicted in Table 10 (Annex 1), Majority of the respondents (33.9%) reported earning less than GhC500, 31.3% of respondents indicated earning between GhC500 to GhC999, 13% of the respondents reported earning between GhC1000 - GhC1500,11.3% and 10.4% of respondents stated earning between GhC1510 - GhC2000 more than GhC2000 respectively.

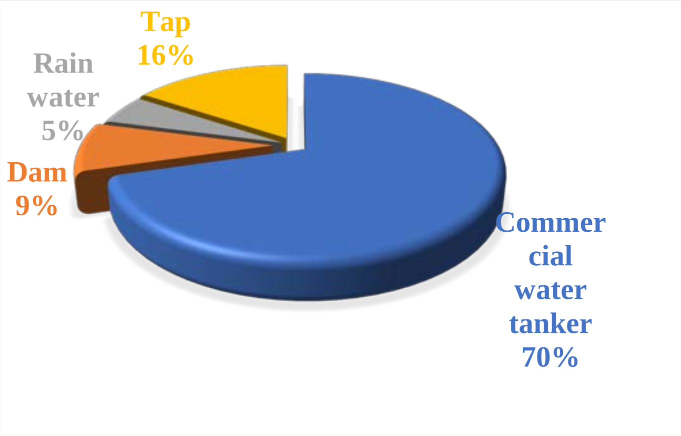
Discussion: From the results provided, it is realised that majority have low monthly earnings of less than GhC500 and between GhC500 to GhC999 and a small proportion of the population having high monthly earnings. As such the majority with low monthly income might resort to small scale rainwater harvesting (using small tanks or drums).

Households main source of water

Findings: From Figure 4 below, it is observed that, 70% of the respondents get water from the commercial water tankers, 16% of the respondents get water from the tap (Ghana Water Company), 9% of the respondents get water from the dam and 5% of the respondents get water from the rains.

Discussions: From the result, it is obvious that, majority of households rely on the commercial water tankers as their main water source with only few households relying on rainwater as their main source. Also, few households depend on Tap (Ghana Water Company) in meeting their water needs.

Figure 4: **Main sources of water**

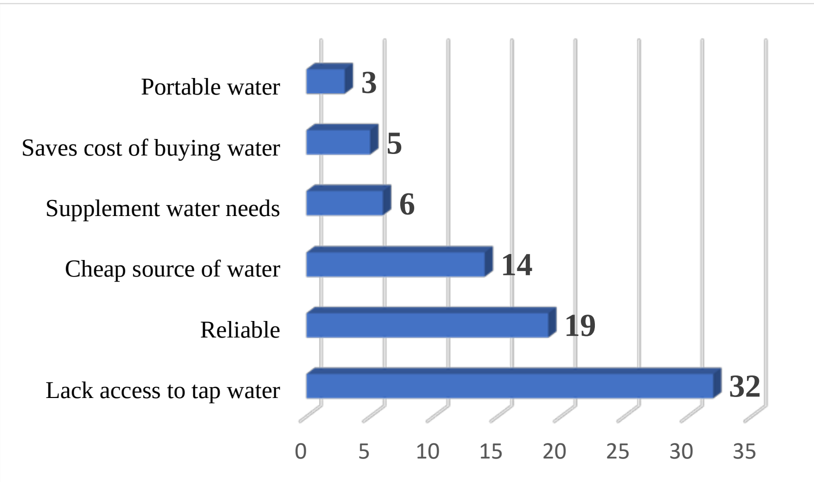


Reasons for adopting RWH

Findings: As presented in Figure 5 below, the 61 respondents currently practicing rainwater harvesting in their homes gave the following reasons for their adoption. 32 respondents (52.5%) reported lack of access to tap water (from Ghana Water Company), 19 respondents (31%) indicated it is a reliable source of water, 14 respondents (23%) indicated it is a cheap source of water and 3 respondents (8.2%) indicated that it is a portable source of water.

Discussion: This therefore implies that, majority of households who adopted RWH was as a result of lack of access to tape water (from Ghana Water Company). The remaining households associated their adoption to rainwater harvesting due to some characterises or benefits o associated with the system such as reliable, cheap source of water, supplement water needs, saves cost of buying water and provides potable water.

Figure 5: Reasons for adoption of RWH



Reasons for not practicing RWH

Findings: From Table 16 (Annex 7), respondents who indicated they were not practicing RWH gave various responses. 35.2% of the respondents reported high installation cost for their non-adoption, 27.8% reported association with contamination,18.5% respondents cited no storage facility,9.3 reported storing tape water, 7.4% of the respondents stated seasonal nature of system and 1.9% of the respondent said their roof was not conducive to install a RWHS.

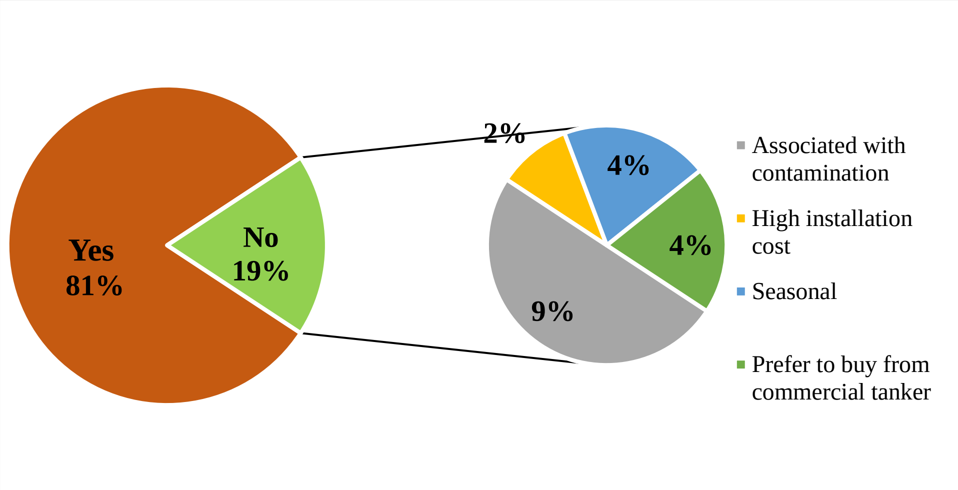
Discussion: Largely, it is noted that, majority of the people who did not practice RWH was as a result of high installation cost. It is also obvious that, a good number of people who did not practice RWH is due to issues related to contamination and storage facility.

Reasons for not having interest to adopt RWH (No interest in RWH)

Findings: Among the 54 respondents who did not practice RWH, 81% however indicated interest in practice but 19% remained indifferent. As illustrated in Figure 6 below, the 19% respondents who maintained having no interest in RWH, 9% indicated that rainwater is associated with contamination,4% indicated the p refer to buy from the commercial tanker and 2% cited high installation cost.

Discussion: Largely, it can be deduced that, the main issue to non-interest in adoption of RWH is contamination though seasonal nature of system and high installation cost are also cited.

Figure 6: **Responses on whether respondents were interested in practicing RWH**



Reasons why RWH is a good practice

Findings: As shown in Table 11(Annex 2), with the majority (92%) who indicated RWH was a good practice, 40 respondents (38.5%) were of the view that RWH saves cost in buying water,30 respondents (28.8%) reported that it supplements water needs with only 5 respondents(4.8%) reporting that it was good for only domestic activities respectively .

Discussion: From the result, it can be deduced that majority of people who indicated that RWH is a good practice, sees it as a means to save cost in buying water and also a supplement to their water needs.

Problems associated with rainwater harvesting

Findings: As shown in Table 12(Annex 3) on the problems associated with RWH, 40.9% of the respondents indicated that, the system is associated with contamination, 22.6% reported inadequate storage facility, 13.9% of the respondents stated high installation cost and 1.7% of the respondents stated difficulty in cleaning the RWHS as the problems associated with RWH.

Discussion: At large, the main problems with RWH is more of contamination, high installation cost and seasonality of system rather difficulties associated with cleaning.

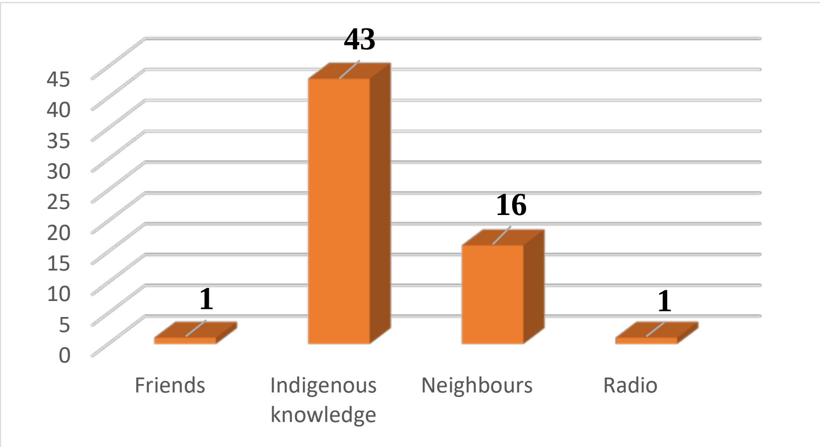
Household awareness on RWH:

Source of information on rainwater harvesting

Findings : As illustrated in (Figure 7) below, From the 61 respondents who reported practicing RWH, 43 respondents revealed they had information regarding rainwater harvesting through indigenous knowledge,16 respondents reported getting information on RWH from their neighbours and the remaining 2 respondents indicated getting information from friends and radio.

Discussion: From the results, it is revealed that there is no formal platform for formation sharing regarding RWH within the study area. However, it is observed that, people have access to information on RWH through informal or local mechanisms. Indigenous knowledge (through parents) appears to be the main medium of information regarding RWH. Also, neighbours are seen as another important channel through which information on RWH is disseminated. This may also imply that formal structures have not really contributed to information dissemination on RWH in the study area.

Figure 7: Information of RWH



Awareness creation on RWH

Findings : As shown in Table 13(Annex 4), most respondents (42.6%) strongly disagree that there is high awareness creation on household RWHS, 24.6% disagree that there is high awareness creation on household RWHS while fewer respondents 7.8% and10.4% strongly agree and agree that there is high awareness creation on household's RWHS.

Discussion: From the results, it is obvious that are there no awareness creation programs on RWH towards promoting the uptake of the practice.

House ownership

Findings: As shown in Figure 8 below, the survey on house ownership revealed that 82% of the respondents who practice RWH owned a house while 18% of the respondents indicating they did not own a house. Among the 18% of the respondents who did not own a house, 52% indicated that their tenancy agreement permitted them to install a RWHS as depicted in Figure 9 below.

Discussion: From the findings, it was discovered that, most of the adopters (RWH) were leaving in their own houses. Also, those who did not own a house but had tenancy agreement which permitted them to put up an additional structure (RWH. However, through the FGD was revealed that people who rented houses without any formal tenancy agreement did not have any interest to install a proper system since they can be evicted at any point. As such these people turn to harvest water with small containers depending on their availability at home whenever it rains.one of the women said ***" I am a tenant and works with the government, I can be transferred at any time, so I don't want to spend money on a system that is difficult to carry from one place to another ".*** Indeed, people leaving in their own houses have a high tendency to adopt RWH since it is their permanent resident.

Figure 8: Do you own a house?

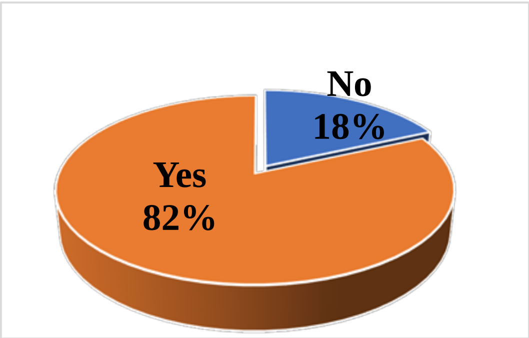
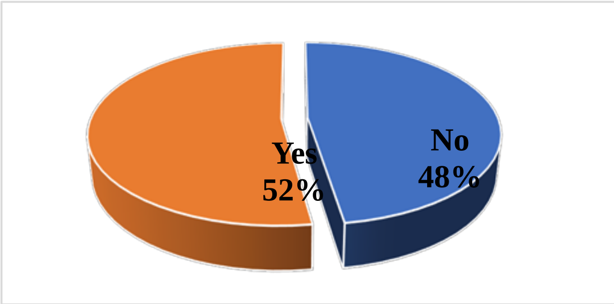


Figure 9: Does tenancy agreement allow installation of RWHS?



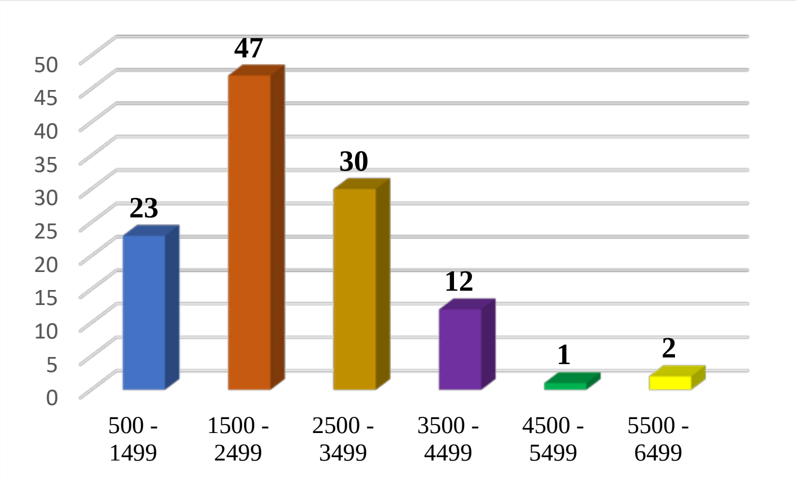
Affordability of system (initial and maintenance cost)

Initial cost for rainwater harvesting system

Respondents largely strongly agree (47.8%) that there is high initial cost for RWHS and a proportion of 0.9% strongly disagree that there is high initial cost of RWHS as shown in Table 14 (Annex 5).

On the average, an amount of GhC2318.70 (SD ± GhC968.845) is required to install a RWHS. Most of the respondents (40.9%) indicated that an amount ranging from GhC1500 to GhC2499 as required to install a RWHS. Also, an amount ranging from GhC2500 - GhC3499 was indicated by 26.1% of the respondents as installation cost and only one respondent (0.9%) indicated that an amount from GhC4500 – GhC5499 is required for installing a RWHS as shown in Figure 10 below

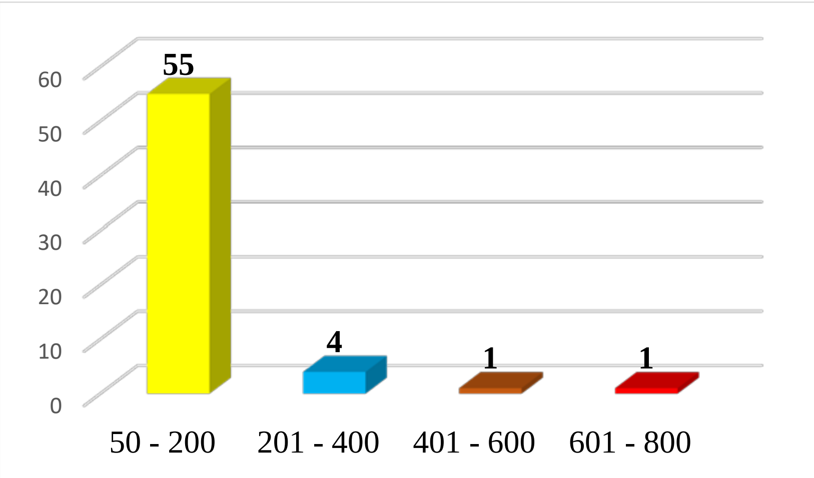
Figure 10: Amount required to install RWHS



Maintenance cost for rainwater harvesting system:
The 61 respondents who practiced RWH were asked a Likert scale question if there is high maintenance cost for RWHS. Majority (60.7%) neither agreed nor disagree that there is high maintenance cost for RWHS and 6.6% strongly agree that there is high maintenance cost for RWHS as shown in Table 15(Annex 6).

Further, the mean cost of maintenance as reported by respondents who practiced RWH was GHC132.4 (SD ± GhC116.2). Majority of these respondents (90.2%) stated an amount ranging between GhC50 – GhC200 as the annual cost of maintenance of a RWHS as illustrated in **Figure 11** below

Figure 11: Cost of maintenance of RWHS per year



Support from Political/Governmental and NGOs

Findings: As depicted in the Table 17(Annex 8), almost all the respondents reported that there was no support from any governmental organisation or NGO towards adoption of RWH by households.114 out of 115respondents indicated that there was no support while only 1 respondent reported that there was support.

Discussion: From the result, it is clear that no support is rendered to households from neither the government nor NGOs towards the adoption of RWH.

4.2 Section B: Technical factors

The technical factors influencing the adoption of RWH as assumed from previous studies (Agudelo -Vera et al.(2013), Campisano et al (2017), Che-Ani et al.(2009),Hardy et al.(2015), Mitchell et al.(2007), Piyush (2015),Islam et al.(2011) White(2009)) include; water quality, design, size and location of system, access to technical resources and, ease and complexity of system

4.2.1 Inferential statistics

Chi square test for association between technical factors and the practice of rainwater harvesting (adoption)

As depicted in Table 5 below, the size of a RWHS and access to space for the installation of a RWHS were found to be the only technical factors having significant association with the practice of RWH (p value = 0.000 and 0.031 respectively). Although the location and size of RWHS was found not to be significantly (p value = 0.470) associated with the practice of RWH, it was observed that 93.4% respondents who practiced RWH indicated that the location and size of the RWHS was important. Likewise, quality of water relative to contamination was found not to be associated (P value = 0.683) with the practice of RWH even though 93.4% of respondents who practiced RWH stated that RW is associated with contamination. Also, most respondents (those who practice (83.6%) and those who did not practiced RWH (64.8%)) indicated that they could easily acquire a space within their house or neighbourhood to install RWHS if they wanted to. Majority of respondents (74.1%) who did not practice RWH indicated that the procedure for installation was difficult, although procedure for installation was found not to be associated with adoption of RWH (p-value = 0.066).

Discussion on association between technical factors and adoption of RWH

From the result and through field observations, it was noted that majority of households had small sized RWHS. The reason for the choice of system type was associated to the cost component as revealed during the FGD. A participant said, "***The size of the system is important because it helps me to collect more water but acquiring a big system is costly***".

Also, access to space for the installation of a RWHS was found to have a significant association with the practice of RWH. As such 51 respondents who were practicing RWH clearly indicated that one can easily access space once they want to install a system. However, it was disclosed in the FGD session that, the number of people staying in a 'compound house' also determines the accessibility of space. This was more directed to people leaving in a rented 'compound house', indicating that if all tenants have interest to installing a system then access to space may stand as a challenge.

Interestingly, even though the location and size of RWHS was found not have association with the practice of RWH, it was observed that all respondents (61) who practiced RWH reported that the location and size of the RWHS was important. On the contrary, it was discovered during the FGD session that, some people practice RWH manually using drums and other local containers. A participant said, "***It is good to consider the location and size when installing a system, but this is mostly not the case when collecting rainwater manually***". As such people harvesting water on small scale might not focus on the location and size of the system.

Similarly, quality of water which indicated no association with the practice of RWH had majority of respondents indicating that the system is associated with contamination. Even though most people indicated that the system is associated with contamination, it was further revealed to be low while indicating some known water treatment techniques used by households as shown in (Figure 12 and Figure 13 respectively) below.

Furthermore, the procedure for installation was found not to be associated with practice of RWH. 25 respondents who practiced RWHS indicated that the procedure for installation was easy while 36 respondents indicated that it was difficulty. Most respondents who indicated that the procedure was easy had the RWHS plan incorporated their building plan while those who had to install a system with no initial plans saw it to be difficult.

Table 5: Chi2 test of association between technical factors and adoption of RWH

Technical Factors	Do you practice RWH				p - value
	No (n = 54)	Percent (%)	Yes (n = 61)	Percent (%)	
Size of RWHS					0.000*
Small	0	0	28	24.3	
Medium	0	0	23	20.0	
Large	0	0	10	8.7	
Is location and size of system important in the construction RWHS					0.470
No	1	1.9	0	0.0	
Yes	53	98.1	61	100.0	
RW Associated with Contamination					0.683
No	2	3.7	4	6.6	
Yes	52	96.3	57	93.4	
Can you easily access a technical person to install RWHS within Tamale					0.470
No	1	1.9	0	0	
Yes	53	98.1	61	100	
Can you easily access materials for construction of RWHS					0.470
No	1	1.9	0	0	
Yes	53	98.1	61	100	
Can you easily acquire a space within your house or neighbourhood if you want to install RWHS for household?					0.031*
No	19	35.2	10	16.4	
Yes	35	64.8	51	83.6	
Procedure for installation					0.066
Difficult	40	74.1	36	59.0	
Easy	14	25.9	25	41.0	

* Significant (p-value < 0.05)

Ordinal regression analysis to determine the relationship between technical factors and perception of households on rainwater use

From Table 6 below, location and size of RWHS was found to be significantly associated (p value = 0.021) with perception of household on RW use (potable or non-potable). Also, access to a technical person as well as RW association with contamination was found to have relationship (p = 0.000) with the perception of household on use of harvested water. However, the size of a RWHS and the procedure for installing a RWHS was found to no association (p value = 0.203 and 0.066 respectively) with the perception of households on use of harvested water. 97 out of the 114 respondents who indicated that location and size of system is important in the construction of the RWHS perceives RW as potable(good) while 17 respondents perceive it as non-potable(bad). Even though majority of respondents indicated that RW is associated with contamination yet only 16 of them perceive the usage as bad. Additionally, only 18 out of the 114 respondents who indicated that one can easily access a technical person to install RWHS perceive rainwater as non-potable.

Discussion on the relationship between technical factors and perceptions

From the results, it is observed that location and size of RWHS was found to have a significant relationship with perception of household on RW use (potable or non-potable). Only 17 respondents who indicated that location and size of system is important in the construction of the RWHS perceive the use of harvested water as non-potable(bad) while 97 respondents perceive RW use as potable(good). Indeed, a participate revealed this during an FGD session, '***I rear fouls in an open system and these birds sometimes find their way to the kitchen roof top so when I wanted to construct a RWHS I was very mindful of connecting it to the side that was high"***

Also, access to a technical person was found to have relationship with the perception of household on use of harvested water. Only 18 respondents who indicated that there is easy access a technical person perceive rainwater as non-potable while remining respondents perceive the use of harvested water as potable.

Further, Rainwater association with contamination was found to have relationship with the perception of household on use of harvested water. Interestingly, though majority of respondents indicated that the practice of harvesting rainwater is associated with contamination yet only 16 respondents perceives the use of harvested water as bad. Perhaps, this might be because respondents are previewed to treatment techniques as illustrated in (Figure 13) and or the intended use of the water in Figure 18(Annex 9).

The size of a RWHS was found to have no relationship with the perception of households on use of harvested water. However, it was observed that 8 respondents who reported using large systems perceived the use of rainwater as potable as well as 27 and 22 respondents who indicated using small and medium sized systems respectively perceived harvested water use as potable.

The procedure for installing a RWHS was also found to have no relation with the perception of households on use of harvested water. From the survey, it was observed that most respondents who indicated the procedure was difficult perceive the use of harvested water as non-potable compared to those who saw it to be easy.

Table 6: Ordinal regression analysis to determine the relationship between technical factors and perception of household on use of harvested water value

	Perception of Household on use of harvested water				
Technical Factors	**Bad (n = 18)**	**Percent (%)**	**Good (n = 97)**	**Percent (%)**	**p - value**
Size of RWHS					0.203
Small	1	5.6	27	27.8	
Medium	1	5.6	22	22.7	
Large	2	11.1	8	8.2	
Is location and size of system important in the construction RWHS					0.021*
No	1	5.6	0	0.0	
Yes	17	94.4	97	100.0	
RW Associated with Contamination					0.000*
No	2	11.1	4	4.1	
Yes	16	88.9	93	95.9	
Can you easily access a technical person to install RWHS within Tamale					0.000*
No	0	0	1	1	
Yes	18	100	96	99	
Procedure for installation of RWHS					0.066
Difficult	40	74.1	36	59.0	
Easy	14	25.9	25	41.0	

4.2.2 Descriptive analysis of technical factors

Quality of water

Types of rainwater Uses: Largely (98.4%), respondents who practiced RWH used the rainwater for bathing, washing utensils and laundry as depicted in Figure 18 (Annex 9).

Level of contamination and treatment techniques

Findings: From the household survey as illustrated in (Figure 12) below, 95% of the respondents were of the view that RWH is associated with contamination with only 5% of the respondents reporting that the water is not associated with contamination. However, from the number who indicated that RW is associated with contamination, 58% of them reported that the level of contamination was low,21% reported medium and 16% reported high level of contamination association with RWH.

With regards to water, majority (94%) of respondents indicated that they knew water treatment technique. The proportion of respondents who knew water treatment technique indicated filtration (47%) as shown in Figure 13 below.

Discussion: From the result, can be deduced that, though people indicated much concerns regarding rainwater association with contamination, it is observed to be at the low level. It is also detected that majority of people have knowledge on water treatment techniques such as filtration, boiling and use of chlorine.

Figure 12: RWH associated with contamination

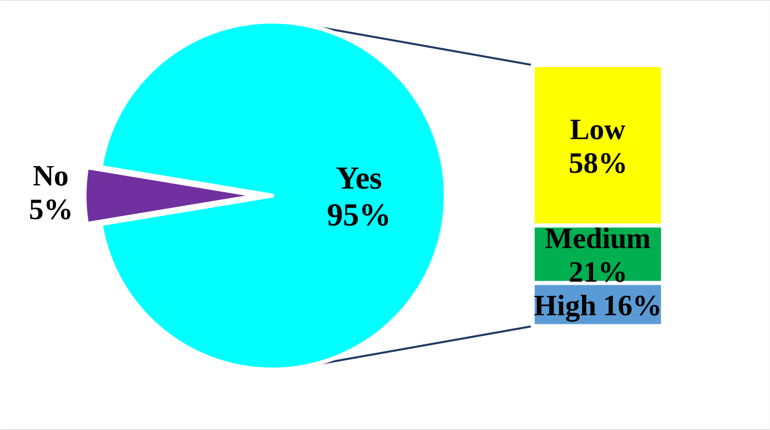
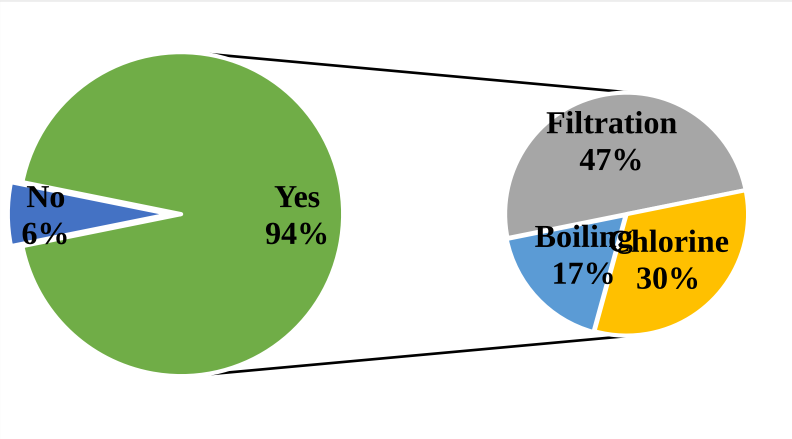


Figure 13: Water treatment technique



Cleaning of RWHS:

Findings: As presented in Table 18 (Annex 10), all respondents (100%) who practiced RWH indicated that they clean the system periodically. Whilst, 14.8% respondents reported that they cleaned their system when the water is finished in the storage facility, 4.9% indicated that they cleaned the system every month.

Discussion: From the findings, it is realized that all households practicing RWH sees the need to keeping the system clean on periodic bases. This was seen as a way of getting rid of accumulated dirt from the system which will translate to reducing contaminations as revealed during the FGD.

Design, size and location

Almost all the respondents (99.3%) held the view that location and size of the system was important for its construction.

Type/ Size of storage tank/container

Findings: With regards to the type and size of storage tank or container used for harvesting rainwater as shown in Table 7 below, 28 respondents reported using small sized poly tank,18 respondents used medium sized poly tank, 7 respondents used underground tank, 6 used local pots and drums, whilst 2 respondents reported using large sized poly tanks.

Discussion: From the results it can be deduced that most households who practice RWH used small sized poly tank while only few households used lager sized poly tank. Even though RWH is adopted by most households yet it is observed to be on a low scale considering the type or capacity of most systems (Small sized poly tank) in placed.

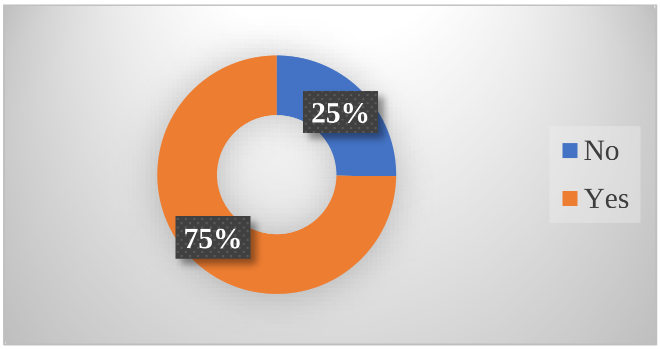
Table 7: Responses on type of storage tank/container

Storage tank/container	Frequency (n = 61)	Percent (%)
Large sized poly tank	2	3.3
Local pots and drums	6	9.8
Small sized poly tank	28	45.9
Underground tank	7	11.5
Medium sized poly tank	18	29.5

Access to space for installing a RWHS

As depicted in Figure 14 below, 75% of respondents reported that they could easily acquire space in their house or neighbourhood once they were ready to install a RWHS while 25% indicated that they cannot easily acquire space in their house or neighbourhood if they want to install a RWHS.

Figure 14: Access to space for installation of RWHS



Technical resources

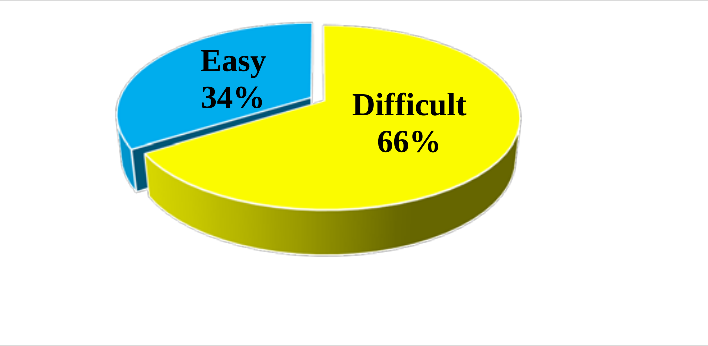
From the survey, almost all respondents reported easy access to materials and technical person when installing a RWHS in Tamale.

Ease/Complexity of implementation

In describing the procedure for installing a RWHS, most respondents (66%) described the installation as difficult while 34% described it as easy as illustrated in **Figure 15** below.

This means that majority of people view the installation procedure as difficult.

Figure 15: Description of procedure for installation of RWHS



4.3 Section C: Reliability factors

The reliability factors influencing the adoption of RWH as assumed from previous studies (Fuestes et al (2018), Cain (2014), Ward(2014), Ishaku et al (2012), Huang et al (2005),Thomas(1998)) include; functionality of system, capacity and potential to meet critical water needs.

4.3.1 Inferential statistics

Chi square test of association between reliability factors and the practice of rainwater harvesting (adoption)

From the chi square test, it was detected that all the reliability factors (Capacity of system [**Estimated amount of water harvest during rainy season],** Functionality of system [**How long do you have access to RW**] and potential to meet critical water needs [**How long does harvested water available for use**]) were significantly associated (p value = 0.000) with the practice of RWH. With regards to the capacity of the system, majority of the respondents (70.5%) indicated that they can harvest between 3000-10000 litres during the rainy season. In terms of the functionality of the system, most respondents (52.4%) indicated that they mostly have access to rainwater for four months. In line with meeting critical water needs, majority of respondents (57.4%) who indicated practicing RWH use the water within 1-3months as indicated as presented in Table 8 below.

Discussion on association between reliability factors and adoption of RWH

From the result, it is detected that all the reliability factors are found to have significant association with the practice of RWH. This implies that the capacity of the system, the functionality as well as its ability to meet potential critical water needs plays an important role to practicing RWH.

With regards to the capacity of the system, it is observed from the survey that majority people can harvest between 3000-10000 litres with only few people harvesting between 16001 - 22000 during the rainy season. It was detected from personal observation that majority of system were small to medium size. During the FGD, most women indicated that their system could harvest about 10 drums on the maximum. Which indicates that any excess water cannot be stored. Following Campisano et al (Campisano, Butler, et al., 2017), they asserted that, the size(tank) of the system is the most essential to determining the availability and duration of water supply

In line with the functionality of the system, it was indicated that the rains are mostly accessed for a period of four to five months annually. Indeed, participant revealed in the FGD that, the short nature of the rain season mostly makes the system to appear seasonal in nature especially for households with smaller facilities which cannot store more water and or households with large membership. As such this remains consistent with previous studies (Hardy, Cubillo, et al., 2015) depicting the system as rainfall dependent which is mostly irregularly distributed over each year.

In line with meeting critical water needs, majority of respondents (57.4%) who indicated practicing RWH use the water within 1-3months as indicated. Indeed, this goes in line with Ishaku et al. (2012) findings which indicated that, the water collected under the system does not last long. Additionally, harvested water as presented in Table 22 (Annex 14) is used for various purposes within the household such as cooking, laundry, bathing washing and drinking.

Table 8: Chi2 test of association between reliability factors and adoption of RWH

Reliability Factors	Do you practice RWH				p - value
	No (n = 54)	Percent (%)	Yes (n = 61)	Percent (%)	
Estimated amount of water harvest during rainy season					0.000*
3000 - 10000 litres	0	0	43	70.5	
10001 - 16000	0	0	11	18.0	
16001 - 22000	0	0	5	8.2	
22001 - 28000	0	0	1	1.6	
34001 - 40000	0	0	1	1.6	
How long do you have access to RW					0.000*
4 months	0	0.0	32	52.4	
5 months	0	0.0	29	47.5	
How long does harvested water available for use					0.000*
1 - 3 weeks	0	0.0	17	27.9	
1 - 3 months	0	0.0	35	57.4	
4 - 6 months	0	0.0	9	14.8	

Ordinal regression analysis to determine the relationship between reliability factors and perception of households on rainwater use

Estimated amount of water harvested during rainy season and the period harvested water is available for use had no influence on the perception of household on the use of harvested water (p = 0.998 and 0.206 respectively). Access to rain water was however found to be significant with perception of harvested rain water (p = 0.035). From the respondents who reported harvesting between 3000- 10000 litres of rainwater during the rainy season, only one person perceives RW use as bad (non-potable) whereas 42 of them perceive it as good(potable). 29 and 28 respondents who reported having access to RW for a duration of 4 and 5months respectively perceive rainwater as potable. is shown in Table 9 below.

Discussion on reliability factors and perception of household on use of harvested water

From the result, it was observed that estimated amount of water harvested during rainy season did not have any significant relationship with the perception of household on the use of harvested water. However, majority respondents who reported harvesting between 3000-10000 litres of rainwater during the rainy season, perceive the use of rainwater as good(potable) with only one person perceiving RW use as bad (non-potable). This group of people happen to be those with low income and small facilities.

Access to rain water was found to have a significant relationship with perception of harvested water use. It was realized that people who mostly have access to RW for a period of 4 months perceive rainwater as potable.

In line with meeting critical water needs, all respondents (35) who indicated the availability of their harvested to be within the period of 1-3months perceive rainwater use as potable. Additionally, the perceived uses of harvested water by households as shown in Table 22 (Annex 14) includes; cooking, laundry, bathing washing and drinking.

Table 9: Ordinal regression analysis for reliability factors and perception of household on use of harvested water

	Perception of Household on use of harvested water				
Reliability Factors	**Bad (n = 18)**	**Percent (%)**	**Good (n = 97)**	**Percent (%)**	**p - value**
Estimated amount of water harvest during rainy season					0.998
3000 - 10000 litres	1	5.6	42	43.3	
10001 - 16000	3	16.7	8	8.2	
16001 - 22000	0	0.0	5	5.2	
22001 - 28000	0	0.0	1	1.0	
34001 - 40000	0	0.0	1	1.0	
How long do you have access to RW					0.035*
4 months	3	16.7	29	29.9	
5 months	1	5.6	28	28.9	
How long does harvested water available for use					0.206
1 - 3 weeks	2	11.1	15	15.5	
1 - 3 months	0	0.0	35	36.1	
4 - 6 months	2	11.1	7	7.2	

4.3.2 Descriptive analysis of reliability factors

Capacity of supply

Findings : From the survey,70.49% of the respondents reported that they harvest between 3000 – 10000 litres of water during the rainy season and only one respondent (1.64%) indicated harvesting between 34001 to 40000 litres of water as depicted in Table 19 (Annex 11). It is observed that only few people harvest more water during the rainy season due to the system size.

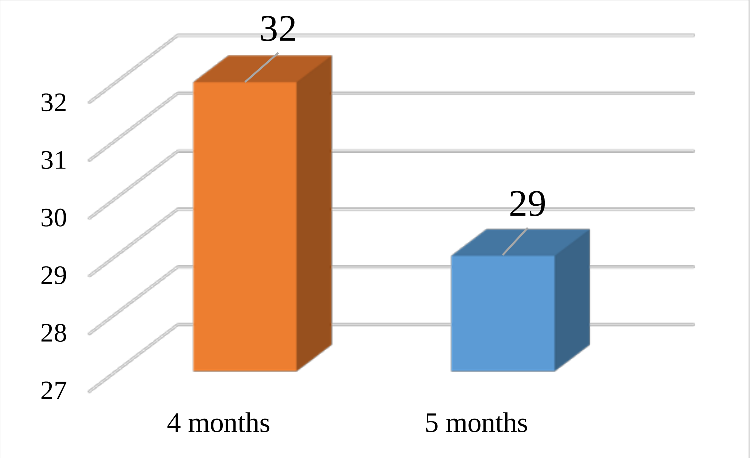
Functionality of system

With regards to the functionality of the system, 57.4% of the respondents who practiced RWH indicated that harvested water is available for a period of 1-3 months for use as shown in Table 20(Annex 13).

From the result, majority of households are able to use their harvested water for a period of 1-3 months. This might partly be link to the system size and or household size.

Figure 16 shows the access to RW in a year among respondents who practiced RWH. A large proportion of these respondents (52.5%) have access to rainwater for 4 months in a year.

Figure 16: Period of Rainfall in a year



Potential to meet critical water needs

With the level of harvested water meeting respondents demand, majority of respondents practicing RW (55.7%) indicated medium level as indicated in Table 21(Annex 13).

Also, the major uses of RW among household as reported by all the respondents using RW include; laundry (100%), drinking (85.2%), cooking (96.7%) as shown in the Table 22 (Annex 14).

From the result, it is clear that rainwater is used for different purposes within the household. It can also be observed that most households see it as a means to meeting their water needs to some extent.

4.4 Relationship between socio-economic, technical and reliability factors

From the analysis, there appear to be a logic relationship between all the factors that are significantly associated with the practice of RWH. Thus, the initial cost, house ownership, the size of system, access to space for the installation, the capacity of system (**Estimated amount of water harvest during rainy season),** the functionality of system (**How long do you have access to RW**) and potential to meet critical water needs (**How long does harvested water available for use**)

From the observations made, house ownership which is significantly associated with practicing RWH is also directly linked to access to space. It was detected that, most adopters (RWH) were leaving in their own houses as such having easy access to space. However, those who did not own a house but had tenancy agreement which permitted them to put up a RWHS were able to adopt. Further, it was revealed during the focus group discussion session that, people leaving in rented houses without any formal tenancy agreement had no interest to install a system since they can be evicted at any point in time. Also, it was revealed that people staying in rented 'compound houses' may not have access to space if majority of tenants are interested in installing separate systems.

The initial cost of the system was indicated as a reason for non-adoption by 19 respondents. The size of the system is mostly driven by the income of the households as well as the cost of the system. It was revealed during the FGD session that, most households resort to smaller facilities due to cost related reasons. As one household head said, "***It is difficult to install a system because a lot of cash is required***". Indeed, people who cannot afford a big system because of the initial cost resort to installing small sized system.

Furthermore, it is noted that, the system size is directly related to the capacity of the system. It is observed that majority of people can harvest between 3000-10000 litres during the rainy season. It was further disclosed in the FGD session that, some of the systems can harvest about10 drums of water indicating that any excess water cannot be stored.

More so, the functionality of the system has a direct influence on the system ability to meet households critical water needs. From the result, it is observed that households can access the rains for a period of four to five months annually. The short nature of the rainy season mostly affects households with smaller facilities since they cannot store more water for future use. Indeed, this goes to affect the ability of the system to meeting critical water needs. As such majority of households can only use their harvested water within 1-3months duration. In effect, house ownership have a direct influence on access to space, the initial cost have an influence on the size which further influences the capacity as well as ability to meet critical water needs.

4.5 Key notes

This chapter has revealed the various ways through which socio-economic, technical and reliability factors influences the adoption of rainwater harvesting by households. It has also unveiled the realities behind people's decisions (to adopt or not to adopt).

- The zeal to meet household water needs was a key driving force to rainwater harvesting by households.
- Low income earners viewed RWH as a way of saving money from routine water purchase especially during the rainy seasons
- Informal structures such as indigenous knowledge transfer was the main medium of information sharing on RWH.

Chapter 5: Conclusions and recommendations

5.1 Introduction

This chapter comprise of three sections. The first part provides the conclusion by answering the questions of the study based on the findings in five sub sections, the second part looks into some reflection from literature review in line with findings as well as Outlook of RWH and finally some recommendations emanating from the findings.

5.2 Discussion

The irregular water supply by the GWCL especially during dry periods of the year necessitates looking in to recognized alternative water supply measures like rainwater harvesting while taking in to account critical influencing factors that enable or disenable household's adoption to the practice. As such, this study assessed how socio-economic, technical and reliability factors influence households to adopt or not adopt RWH as an alternative measure to household water supply under the current urban water supply system in Vitin-Tamale, Ghana. The study therefore attempted to answer the main research question; **How does socio-economic, technical and reliability factors influence the adoption of rainwater harvesting by households as an alternative water supply system in Vitin-Tamale, Ghana?** The main question of the study was supported with four sub-questions with the first sub-question providing baseline information on the water supply situation in the area of study from GWCL. As such the need to study alternative water supply systems (RWH).

5.2.1 Sub-section one

What is the current deficit of the water supply system in Vitin?

Ghana Water Company Limited has remained the main water provider to urban areas of which Tamale is no exception. According to the GWCL charter (2015), the urban water supply coverage is about 63% with an average water production of about 709,090.91m per day. However, the estimated amount of water demand is about 1,131,818.18m per day thereby depicting a water deficit of 422,727.27m daily.

With a total household number of 219,971 in Tamale and an average urban water production at 709,090.91m daily, the estimated amount of water supply per household will stand at 3.22m per day.

Vittin has a population of about 5000 and an average household size of 6, therefore, reflecting an estimated number of households at 833.33. This suggest an estimated water supply of 2683.32 m per day to the neighborhood (vittin). However, this is not the case as majority of households only get access to tap water thrice a month.

Additionally, with a total water deficit of 422727.27m, an estimated water deficit per household will be 1.92m per day. As such Vittin will further experience 1599.99m water deficit daily. Indeed, this situation has kept majority of households in an everlasting state of water scarcity leading to the adoption of alternative water supply measures by households such as RWH.

5.2.2 Sub-section two

How does socio-economic factors influence the adoption of rainwater harvesting by households as an alternative water supply system in Vitin-Tamale, Ghana?

In line with how the socio-economic factors influences the practice of RWH, the study assessed how these factors (level of income, house ownership, affordability [initial and maintenance cost], level of awareness and political/NGO support) could influence household's adoption to

RWH. Based on this, indicators such as monthly earnings, source of information, awareness creation programs, tenancy agreement and type of support from government or NGO were used.

A key highlight of the results revealed that affordability (initial and maintenance cost) of the system and house ownership had a significant influence on the adoption of rainwater harvesting by households while indicating no direct association with the other factors such as income level, political/NGO support as well as level of awareness.

The study showed that, people leaving in their own houses have a higher possibility of adopting RWH as compare to those leaving in rented houses. Interestingly, those leaving in rented houses but with some form of tenancy agreement have the potential to install RWH facilities while those without any form of formal tenancy agreement sees it as unwise to adopt RWH since they can be evicted at any point in time. The latter group may only engage in RWH based on their availability at home during rainfall, collecting water manually with smaller containers that can barely last for a week.

Furthermore, most non-adopters cited high installation cost as the reason for their failure to adopt RW as an alternative source of water supply to their household. The initial cost of a RWHS appears to be high for many households, as such, majority of people are unable to adopt to the practice. Indeed, this leads majority of people with low monthly earnings who cannot afford a big system to resort to the installation of small sized RWHS.

The study however revealed that there was no significant association between the practice of RWH and awareness creation. Information sharing on RWH is communicated through informal structures. As such indigenous knowledge is seen as the main medium for knowledge transfer on the adoption of RWH by households. Nevertheless, respondents view awareness creation through the radio and television as an effective way to easily promote the practice of RWH. Similarly, no significant association was found between political or NGO support and the adoption of RWH. However, respondents viewed it as a medium of support to scaling-up the practice among households and or promoting the practice to a large extent.

Furthermore, it was ascertained that all socio-economic factors except level of income had a relationship with the perception of households on the use of harvested water. Majority of people perceived the use of harvested water as potable within the household.

5.2.3 Sub-section three

How does technical factors influence the adoption of rainwater harvesting by households as an alternative water supply system in Vitin-Tamale, Ghana?

The technical factors were accessed to ascertain their influence on the adoption of RWH by households. The findings revealed a significant association between the practice of RWH with the size of RWHS as well as access to space for installation.

It was noticed that, the size of the system has an influence on the adoption of RWH by households. The size of a RWHS influenced households' adoption in two different ways. Some households considered the size with regards to the amount of water that can be harvested, whilst others related the choice of the system size to the cost element (initial cost). Households who do not have a storage facility do not consider adopting RWH while those with smaller tanks only access rainwater during the rainy season and return to the former state of water scarcity during the dry periods since the system cannot harvest enough water. As such inadequate storage facility is acknowledged as a challenge to adopting rainwater harvesting.

In furtherance, this study uncovered that access to space for installation of RWHS is significantly associated with the practice of RWH. It was also discovered that people who practiced RWH had easy access to space for the installation of their system. It also depicted that, people who cannot easily access space would mostly not install a system. Interestingly, access to space was somehow connected to house ownership. People who leave in their own houses have a higher tendency to acquire space as compare people leaving in rented apartment especially when a great number of tenants are interested in installing their individual rainwater harvesting system. As such, the availability and accessibility of space may limit their ability to adopt of RWH.

This study also presents that there is no association between the practice of rainwater harvesting and quality of rainwater, although majority of the people indicated that rainwater was associated with contamination. It was also observed that the level of contamination as indicated was low and almost all households had some level of knowledge on water treatment techniques. These techniques included boiling, filtration and use of chlorine. As such the quality of water do not influence the adoption of rainwater by households.

Furthermore, the procedure for installation was also found to have no significant association with the practice of RWH. People who incorporated their RWHS installation plans into their building plans indicated that the procedure was easy while those who had to install a completely new system described the procedure as difficult. However, revelations from the FGD session indicated that there is no standard procedure for installing a system. As such does not influence the adoption by households.

Also, majority of people perceived the use of harvested water as potable within the household.

5.2.4 Sub-section four

How reliable is rainwater harvesting in meeting the current deficits in household water supply system?

It is interesting to note that, all the reliability factors have significant association with the practice of RWH. In terms of the functionality of the system, the adoption of RWH depends on the duration of rainfall in a year. In the case of Vittin, people mostly access rainwater between a duration of four to five months annually. As such the practice is viewed as seasonal in nature especially by non-adopters and households with smaller facilities who cannot harvest water in large quantities. Indeed, the duration of access to rainfall influences households to adopt or not to adopt to the practice of RWH.

Further, the capacity of the system is seen as key to the adoption of RWH by households. This is observed to be in connection with the size of the system. Households who do not have storage facilities cannot practice RWH while those with small sized tanks will be unable to store excess water during continuous rainfall. As such this may limit them to effectively practice RWH.

In line with meeting critical water needs, households mostly consider the various uses of harvested water such as cooking, laundry, bathing washing and drinking while adopting to the practice. Households also considers the duration within which harvested water would be used. Majority of people also perceived the use of harvested water as potable within the household

In effective, the capacity of the system, the functionality as well as its ability to meet potential critical water needs plays key role to practicing RWH.

5.2.5 Sub-section five

How does socio-economic, technical and reliability factors influence the adoption of rainwater harvesting by households as an alternative water supply system in Vitin-Tamale, Ghana?

It is interesting to note that socio-economic, technical and reliability factors influence household's adoption to RWH under different circumstances but in an interconnected manner. House ownership is seen as one key socio-economic factor influencing the adoption of RWH by households. People leaving in their own houses have a higher tendency to adopting RWH as compared to those in leaving rented houses. This is for the fact people leaving in their own houses do not require permission from a third party in taking decisions regarding RWH. Also, people leaving in rented houses with a tenancy agreement are more likely to adopt than those without any formal tenancy agreement as they can evicted at any point in time. Similarly, access to space is a key influencing factor to the adoption of RWH by households. People who can easily acquire space within their premises have a greater possibility of adopting RWH as a source of household water supply as compare to people leaving in houses or neighbourhoods with limited or no space.

Further, affordability of the system is also seen as a crucial factor to the adoption of RWH by households. The high cost of installation is delimiting the adoption of RWH by majority of households. However, some households have resorted to adopting the practice of RWH but in a small scale which does not allow harvested water to stay for long. Indeed, the size of a RWHS have an influence on the adoption of the practice by households. Inadequate storage facility is acknowledged as a limitation to the adaptation of RWH by households. As such, households with smaller facilities only enjoy the practice (RWH) during the rainy season as they cannot store enough water for future use.

More so, the functionality of the system plays a critical role to the adoption of RWH by households. The duration within which households can actively engage in RWH influences their adoptability. The short nature of the rainy season turns to discourage most households from adopting RWH. Additionally, the capacity of the system is essential to the adoption of RWH by households. Indeed, the amount of water to be harvested under the system is key to determining the adoption of RWH by households. Also, the ability to meet critical households water needs such as cooking, drinking, washing and bathing is vital to household's adoption to RWH. Generally, majority of people perceived the use of harvested water as potable within the household

5.3 Reflections from literature review

The literature review served as the foundation upon which the conceptual framework was established and subsequently the design of the questionnaire. From the research findings, some reflections are made in line with the literature review.

As asserted by Hardy et al. (2015) and Ahmed et al. (2013), the slow adoption of RWH is due to high initial cost. This indeed, was discovered as a concern in the study area. As such making most households to resort to small scale rainwater harvesting.

Also, house ownership was noted as a key contributory factor to RWH. People leaving in rented houses without tenancy agreement or security did not have interest in RWH since they can be evicted at any point in time. As such, this follows the path of Staddon et al. (2018) as they stated that, house ownership is essential to the adoption rainwater harvesting by households.

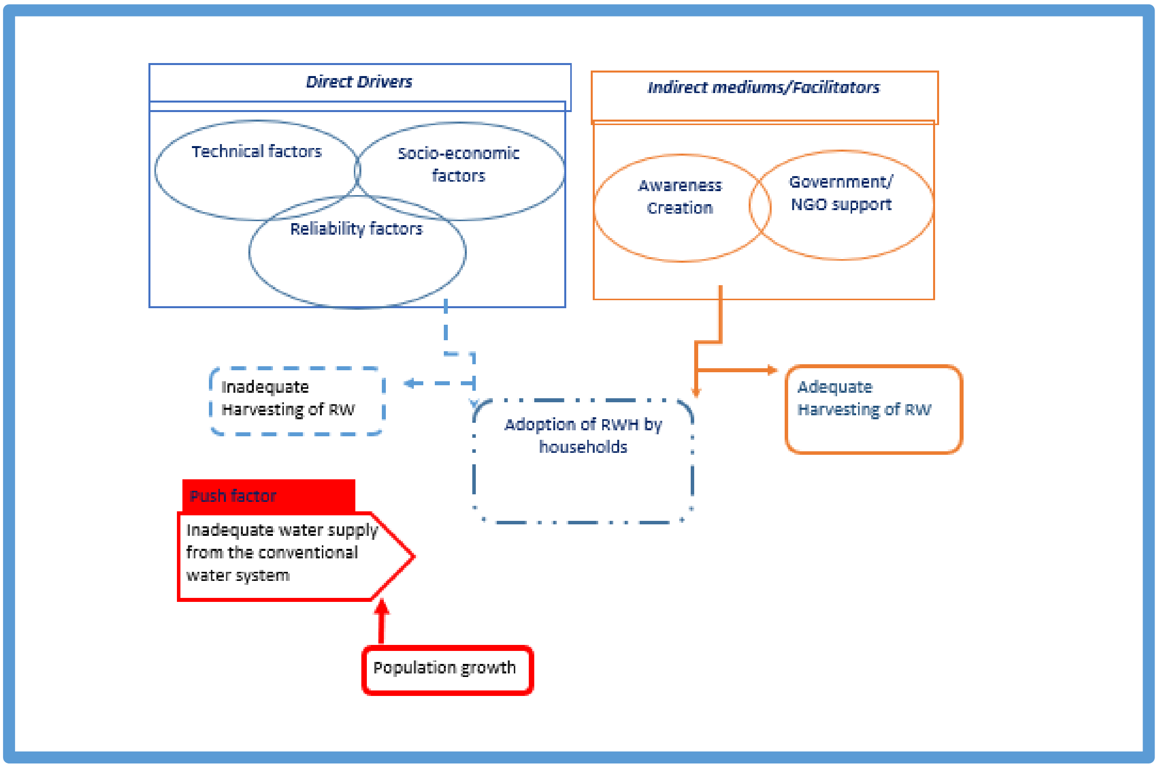
In line with the functionality of the system, most respondents indicated that they can access rains within a duration of 4 to 5 months in a year. As such staying constant with (Hardy, Cubillo, et al., 2015) findings which depicted the system as rainfall dependent which is mostly irregularly distributed over each year.

Following Campisano et al (Campisano, Butler, et al., 2017), they asserted that, the size(tank) of the system is the most essential to determining the availability and duration of water supply. Indeed, most households had small sized tanks which turns to limit their ability to harvest enough water.

With regards to meeting critical water needs, households are able to use their harvested water within 1-3 months duration. Indeed, this goes in line with Ishaku et al. (2012) findings which indicated that, the water collected under the system does not last long.

5.4 The Outlook of RWH

Figure 17: Framework on the outlook of RWH



Source: author's elaboration

This study has revealed an interconnectivity of influence between socio-economic, technical and reliability factors with regards to the adoption of RWH by households as depicted in Figure 17 above. It also unveiled the realities behind people's decisions (to adopt or not to adopt).

Meeting household water needs is seen as a key driving force to rainwater harvesting. Indeed, limited water supply from GWCL led many households to adopt RWH.

Also, informal structures such as indigenous knowledge transfer and learnings through neighbours are revealed as the main medium of information sharing on RWH. Indeed, there are no formal platforms sensitizing communities and or households on the importance of RWH. As such RWH is seen as a household's self-initiative to accessing water.

Further, there are no support mechanism (government/ NGOs) facilitating the adoption of RWH by households in their quest to meeting their water needs. As such the practice is adopted based on the individual's household capacity.

With the current trend of adoption (RWH), the practice may only stay as seasonal due to the inadequate storage facilities and or quantity of water most system can harvest (small sized system). As such rising issues of concern considering the fact that there is continue population increase, inadequate water supply from GWCL and worse of it the lack of support to effectively promote the adoption of alternative water supply (RWH) towards augmenting households water deficit.

Indeed, the lack of support from political /governmental and non-governmental towards household's adoption to rainwater harvesting remains an issue of concern. As such understanding the underlying factors influencing the adoption trend of households might give a clearer insight for governmental and non-governmental bodies to determine a focus of support. Nevertheless, people with low income and smaller systems raised concerns of their inability to store enough water for future use which they anticipate support from government or NGOs in up-scaling their water harvesting capacity.

Additionally, enabling policy environment could also serve as a good foundation to the effective adoption of the practice (RWH).

More so, public or household awareness on RWH through social media is acknowledged as an effective means to promoting the adoption of RWH and its hygiene related issues.

Certainly, the future of RWH could be brighter, if the adoption (RWH) decision is not left solely in the hands of households. As such government and or NGO support may facilitate the adoption of RWH in a larger scale thereby leading to the adequate harvesting rainwater.

5.5 Recommendations

This section is divided into three parts. The first and second part looks at the contributions of the study for local action and literature while third part suggest areas for future research.

5.5.1 Contribution for local action

The study recommends that, political/governmental or NGOs should give some form of support (technical, financial, logistics) to households in the quest to adopting RWH especially on large scale. Nonetheless governmental and non-governmental institutions should introduce awareness programs on television and radio to effectively promote the practice among the citizenry as a measure to meeting their water needs in the face of limited water supply by responsible institutions.

Aside RWH, some households resorted to dam and commercial water tankers (private water service) as a way of meeting their household's water needs. As such there is the need for GWCL and or NGOs in the water sector to sensitize households on how to properly treat water to avoid possible contraction of water borne diseases through the use of dam water (non-potable) while meeting their water needs.

5.5.2 Contribution to academic literature

- There is an interconnectivity of influence between all the three factors with regards to the adoption of RWH by households. For instance, the initial cost of the system may influence the size of the system which determines the capacity of the system and in effect its potentials to meeting household water needs. As such all three factors should be viewed holistically towards ensuring effective and efficient rainwater harvesting among households.
- Indigenous knowledge is acknowledged as the main medium through which information on rainwater harvesting is disseminated among households. Indeed, indigenous knowledge should be seen as a key player in RWH

- The reliability of the system except (functionality component) depends directly on the influence of both socio-economic and technical factors. For instance, the initial cost (socio economic) influence the size of the system(technical) which in effect determines the capacity of system (quantity of water to be harvested)
- Political or NGO support as well as awareness creation are recognised as channels for support and the effective promotion of the practice respectively.

5.5.3 Areas of future research

Following the learnings from this research and other interesting works that were cited, the researcher would like to recommend the following research areas for the future generations;

Further studies could investigate;

- How policy environment influences the adoption of RWH in urban areas.
- How behavioural and cultural factors influences the adoption of RWH in peri urban communities.
- How political and behavioural factors influences the adoption of RWH by urban households

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Annex 1: Socio-economic characteristics

Table 10: **Socio-economic characteristics**

Socio-Economic Characteristics	Frequency (n = 115)	Percent (%)
Level of Education		
No formal education	34	29.6
Primary school	19	16.5
Senior secondary School/O'level	13	11.3
Tertiary	49	42.3
Employed?		
No	4	3.5
Yes	111	96.5
Level of income per month		
less than GhC500	39	33.9
GhC500 - GhC999	36	31.3
GhC1000 - GhC1500	15	13
GhC1510 - GhC2000	13	11.3
More than GhC2000	12	10.4
Household Size		
1 - 3	18	15.7
4 - 7	52	45.2
8 or more	45	39.1

Annex 2: Reasons why RWH is a good practice

Table 11: Reasons why RWH is a good practice

Reasons why rainwater is a good practice	Frequency (n = 106)	Percent (%)
Cheap source of water	9	8.7
Saves cost in buying water	40	38.5
Supplements water needs	30	28.8
Reliable	17	16.3
Accessible	14	13.5
Natural and potable source of water	8	7.7
Good for only domestic activities	5	4.8

Annex 3: Problem associated with RWH

Table 12: Problem associated with RWH

Problems associated with RWH	Frequency (n = 115)	Percent (%)
Associated with contamination	47	40.9
Difficulty in cleaning system	2	1.7
Destruction from strong winds	7	6.1
High cost of maintenance	4	3.5
High installation cost	16	13.9
Improper system installation	4	3.5
Inadequate storage facility	26	22.6
Rainfall is seasonal	15	13.0

Annex 4: Responses on likert scale questions

Table 13: Responses on likert scale questions

There is high awareness creation on household's RWHS	Frequency (n = 115)	Percent (%)
Strongly disagree	49	42.6
Disagree	28	24.3
Neutral	17	14.8
Agree	12	10.4
Strongly agree	9	7.8

Annex 5: Responses on likert scale questions on initial costs of RWHS

Table 14: Responses on likert scale questions on initial costs of RWHS

There is high initial cost for RWHS	Frequency (n = 115)	Percent (%)
Strongly disagree	1	0.9
Disagree	4	3.5
Neutral	12	10.4
Agree	43	37.4
Strongly agree	55	47.8

Annex 6: Response on Likert scale question on maintenance cost of RWHS

Table 15: **Response on Likert scale question on maintenance cost of RWHS**

There is high maintenance cost for RWHS	Frequency (n = 61)	Percent (%)
Disagree	4	6.6
Neutral	37	60.7
Agree	16	26.2
Strongly agree	4	6.6

Annex 7: Responses for not practicing RWH

Table 16: Responses for not practicing RWH

Reasons for not practicing RWH	Frequency (n = 54)	Percent (%)
Associated with contamination	15	27.8
High installation cost	19	35.2
No storage facility	10	18.5
Roof not conducive for the system	1	1.9
Seasonal	4	7.4
Store tap water for use	5	9.3

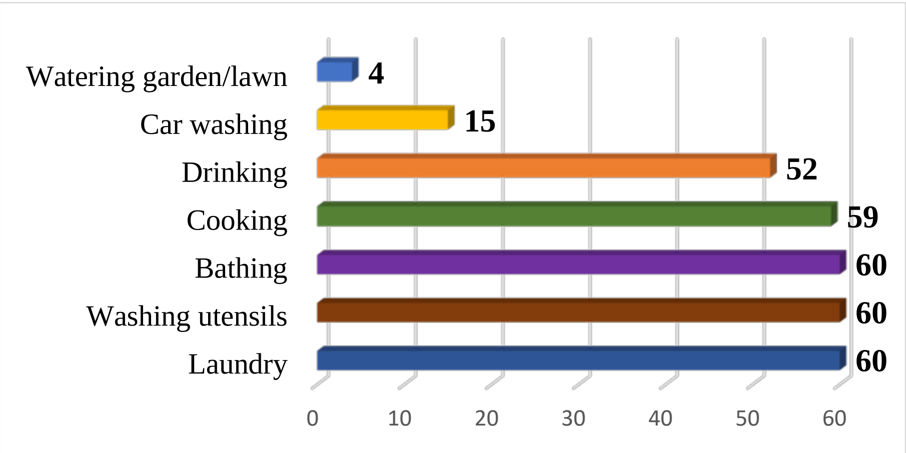
Annex 8: Political government or NGO support

Table 17: Political government or NGO support

	Do you practice RWH	
	No (n =114)	Yes (n = 1)
Is there political/government support?		
No	114	
Yes	1	

Annex 9: Major use of RW in the household

Figure 18: Major use of RW in the household



Annex 10: How often RWHS is cleaned

Table 18: How often RWHS is cleaned

How often RWHS is cleaned	Frequency (n = 61)	Percent (%)
Every month	3	4.9
Every 3 months	17	27.9
Once a year	17	27.9
Twice a year	15	24.6
When water is finished in the storage facility	9	14.8

Annex 11: Quantity of RW harvested during rainy season

Table 19: Quantity of RW harvested during rainy season

Quantity of RW Harvested during rainy season (Litres)	**Frequency (n = 61)**	**Percent (%)**
3000 - 10000	43	70.49
10001 - 16000	11	18.03
16001 - 22000	5	8.20
22001 - 28000	1	1.64
34001 - 40000	1	1.64

Annex 12: Period harvested water available for use

Table 20: Period harvested water available for use

Period Harvested water available for use	**Frequency (n = 61)**	**Percent (%)**
1 - 3 weeks	17	27.9
1 - 3 months	35	57.4
4 - 6 months	9	14.8

Annex 13: Level harvested water meet demand

Table 21: Level harvested water meet demand

Level Harvested water meet demand	Frequency (n = 61)	Percent (%)
Low	19	31.1
Medium	34	55.7
High	8	13.1

Annex 14: Major uses of RW in household

Table 22: Major uses of RW in household

Major uses of RW in Household	Frequency (n = 61)	Percent (%)
Drinking	52	85.2
Bathing	60	98.4
Cooking	59	96.7
Laundry	61	100.0
Washing	60	98.4
Car washing	14	23.0
Watering garden/lawn	5	8.2

Annex 15: Research Instruments and Time schedule

FGD guide for residence to share their experience/perception on how socio-economic, technical and reliability factors influencing the potential adoption of rainwater harvesting as alternative water supply system in Vitin-Tamale.

Purpose: To explain how socio-economic, technical and reliability factors influences the potential adoption of rainwater harvesting by households as an alternative water supply system in Vitin-Tamale.

Group Identifier:

Date

Why do you practice RWH as an alternative water source?

What is the perception on the use of harvested water?

Do you own a house?

How long do you have access to rainwater in a year?

What quantity of water can most of your systems harvest?

What are the challenges with regards to RWH?

How would you describe the procedure for installing of a rainwater harvesting system?

Do you think rainwater harvesting is a good practice?

Where or how do you access information on rainwater harvesting /Are there awareness creation programs on RWH?

What do you think about the initial and maintenance cost of a RWHS?

Do you think the location and size of the system is important in the construction face of the RWHS?

Is there any form of support from the government or NGO on RWH?

Questionnaire guide for residence to share their experience/perception on how socio-economic, technical and reliability factors influencing the potential adoption of rainwater harvesting (RWH) as alternative water supply system in Vitin-Tamale.

Purpose: To explain how socio-economic, technical and reliability factors influences the potential adoption of rainwater harvesting by households as an alternative water supply system in Vitin-Tamale.

Group Identifier:

Gender:

Interviewer:

Date:

SOCIO-ECONOMIC FACTORS

1. What is your level of education?

No formal education

Primary school

Senior Secondary School/ O'level education

Tertiary

2. Are you employed?

No

Yes

3. What is your level of income per month?

Less than Gh₵500

Gh₵500 - Gh₵999

Gh₵1000 - Gh₵1500

Gh₵1510 - Gh₵2000

More than Gh₵2000

4. How many dependents do you have/ household size?

1 – 3

4 – 7

8 or more

5. What is your main source of water? ....

6. Do you practice rain water harvesting?

Yes

No (please skip to question 12)

7. Why do you practice rain water harvesting as an alternative water source?

………………………………………………………………………………………………

10. How do you harvest the water (with what type of tank)?

…………………………………………………………………………………………………

11. Where did you get information on rainwater harvesting?

....……………………………………………………………

12. If no to question 6, why are you not practicing rainwater harvesting?

…………………………………………………………………………………………………

13. If you are not currently practicing RWH, are you interested in rainwater harvesting?

If no. why?

……………………………………………………………………………………………………….

14. Do you think rainwater harvesting is a good practice?

Yes, why? ....………………………………………………………………………………………….

No, why? …………………………………………………………………………………………………

15. What are some of the problems faced here in rainwater harvesting?

………………………………………………………………………………………………

16. There is high awareness creation on household's rainwater harvesting system (RWHS)?

1=Strongly disagree

2=Disagree

3=Neutral

4=Agree

5=Strongly agree

17. There is high initial cost for RWHS?

1=Strongly disagree

2=Disagree

3=Neutral

4=Agree

5=Strongly agree

18. How much money is required in the installation of a RWHS? ……………………

19. There is high maintenance cost for RWHS?

1=Strongly disagree

2=Disagree

3=Neutral

4=Agree

5=Strongly agree

20. How much money is spent on the maintenance of a RWHS per year? ……………

21.Does your monthly income influence your decision to adopt RWHS?

Yes

No

22. Do you own a house?

Yes (Skip 23 and 24)

No

23. If no, does your tenancy agreement allow you to set-up a RWHS?

Yes

No

24. If no, do you think there is a possibility for tenancy security to enhance the installation of RWHS?

Yes

No

25. Does government or NGOs offer any kind of support with regards to rainwater system installation?

Yes (please indicate if government and/or NGO) ....

No (please skip question 26)

26. If yes, what type of support does the government or NGOs offer?

Technical support

Financial support

Education/capacity building

Logistics (Building materials)

Others

TECHNICAL FACTORS

27. What is the major use of the rain water within the household? Please tick all applicable answers

Drinking

Bathing

Cooking

Laundry

Washing utensils

Washing of cars

Watering of garden/lawn

28. Do you clean your RWH system?

Yes

No, why not?...

29. If yes, how often do you clean your RWH system?

Once a year

Twice a year

Every three months

Others, please specify ....

30. Do you think rainwater harvesting is associated with contamination?

Yes

No

31. If yes, what is the level of contamination?

Small

Medium

Large

32. If no,whynot? …………………………………………………………………………………….

33. Do you treat or know of any treatment technique?

Yes

No, skip question 34

34. If yes, what type of treatment technique do you know and or is frequently used by households?

Chlorine

Filtration

Biosand

Others, please specify ....

35. Do you think the location and size of the system is important in the construction phase of the RWHS?

Yes

No

36. Can you easily access a technical person to install a RWHS within Tamale?

Yes

No

37. If no, what are the available options? ..………………

38. Can you easily access the materials for the construction of a RWHS within Tamale?

Yes

No

39. If no, where can you get the materials from?

40. Can you easily acquire space within your house or neighborhood once you want to install a RWHS for household water use?

Yes

No

41. How would you describe the procedure for the installation of a rainwater harvesting system?

Difficult

Easy

42. What is the size of your system?

Small

Medium

Large

43. What is the estimated quantity of water your system can harvest?

RELIABILITY/SUSTAINABLE FACTORS

44. What are the various uses of water in the household? Please cycle the various types

1. Drinking
2. Bathing
3. Cooking
4. Laundry
5. Washing utensils
6. Washing of cars
7. Watering of garden/lawn
8. Other

45. How long do you have access to rainwater in a year?

3weeks

3months

4months

5months

Others

46. Can you please tell me the estimated amount of water you can harvest during the rainy season?

47. How long is the harvested water available for use?

1-3weeks

1-3months

4-6months

7-8 months

9-12 months

Others

48. To what level does the harvested water meet your household water needs?

Low

Medium

High

49. If the level is low, do you resort to other alternative sources of water?

Yes

No

50. If yes to the question above, please indicate the source(s)……………

ADOPTION OF RAINWATER HARVESTING AT THE HOUSEHOLD

51. What is the perception of households on the use of harvested water?

Good (potable water source)

Bad (non- potable water source)

53. What is the level of use(rainwater) by your household?

Low

Medium

ACTIVITIES	TIME FRAME					
	March	April	May	June	July	August	September
Proposal Writing							
Consutations with supervisor							
Design of Questionnaire							
Pilot of Questionnaire							
Data collection							
Sorting Cleaning of data							
Data Analysis							
Thesis Report Writing							
Finalisation and presentation of Thesis							

High

Annex 16: IHS copyright form

IHS
Making cities work
Erasmus

Institute for Housing and
Urban Development Studies of
Erasmus University Rotterdam