URBAN LOW-COST WATER SUPPLY AS AN ALTERNATIVE TO OTHER SOURCES: THE CASE OF DUNKWA-OFFIN IN THE CENTRAL REGION, GHANA

BY

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OCTOBER 2012
CANDIDATE’S DECLARATION

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

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SUPERVISOR’S DECLARATION

I hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University for Development Studies:

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Name: Dr. Kanton I. Osumanu
The study investigated urban low-cost water supply as an alternative to existing sources in the Upper Denkyira Municipal Area of the Central Region of Ghana. Three zones of the capital of the municipality were purposively selected, namely Dunkwa-Kadadwen, Ayamfuri and Oponsu. The major objective was to determine how the adoption of low-cost water supply technology solves the problems of potable water in urban Upper Denkyira. The study adopted the descriptive research design with qualitative and quantitative approaches. The major tools of data collection were questionnaires, interviews and focus group discussions.

The results indicated that uneven spatial distribution, high tariff rates, bad water quality and fluctuations in the supply of potable water were the major factors that influenced the promotion of low-cost water supply approaches in the area. It was further revealed that low-cost water sources have low investment cost, low operational cost, affordable tariff rates, and also influenced human wellbeing in the municipality in several ways. It was therefore concluded that low-cost water supply technologies serve as better alternatives to other sources of potable water in the municipality.

The study recommended that there should be poverty reduction strategies to increase the ability of the urban poor to contribute to low-cost water supply projects for self-reliance. There should also be adequate subsidies on low-cost water supply material or on the budgets of community groups or households implementing low-cost water supply projects. Additionally, it was recommended that water quality should be improved through public education on the disinfection of water from low-cost water sources.
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DEDICATION

This work is dedicated to my parents: Mr. Kwaku Owusu and Mrs. Comfort Owusu, whose love and endurance remained my inspiration.
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CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

The issue of water supply problems dates back to the pre-historic times. The early man used rivers, stream, lake, lagoons and well etc. for domestic purposes. Today, water is used for agriculture, industry, transportation and energy. Even in those days when men had not settled permanently, but had to wonder about, there was the need for low cost sources of potable water supply, since potable water is a basic necessity.

Although numerous attempts have been made by the Government of Ghana to better the lives of its masses in all aspects including access to drinking water, little has been achieved due to budgetary constraints as a result of which the issue of achieving quality low cost water or decent living for all people remain a mirage (Daily graphic Wednesday, March 30 2005, page 6). The most reliable sources of water supply are also getting depleted due to the multiple uses of the water from rather limited sources by the ever increasing urban and peri-urban population. This means that increasing demand for water is not limited to domestic use only. Institutions like schools, hospitals and industries are affected by lack of water. The development and use of low-cost water supply outlets such as wells is one of the numerous ways of providing cheaper, quality, quantity, readily available, and sustainable water supply requirements (Owusu, 2007). Apart from being a substitute to high cost water supply, the use of low-cost water sources is adaptable in most parts of Ghana.

The ongoing debate over the relative merits of public and private sector performance in water provision has been a distraction from the inadequate performance of both public and private service providers in overcoming the global water problems (North Caroline Board of Health, 2005). The millennium development goals provide a bench mark for measuring progress towards the human right to water. But achieving the target is critical to the attainment of other goals. Ghana has adopted a Poverty Reduction Strategy (GPRS, 2002-2004) which presents comprehensive policies to support growth and poverty reduction in the country. Under the strategy the government intends to create wealth by transforming the structure of the national economy to achieve growth, poverty reduction and the protection of the vulnerable and excluded within a decentralized democratic environment.
The GPRS (2002-2004) is based on providing an enabling environment that will empower all Ghanaians to participate in wealth creation (Aryetey, 2007). One limiting factor to this dream is inadequate water supply, which tends to negatively impact on commerce and industry and so make investment unattractive. Therefore the situation of water supply in urban areas was perceived as a grave constraint to Ghana's vision of becoming a middle income country by the year 2020.

Some advances towards addressing the water problem, apart from the adoption of low cost technology, involve the promotion of private sector participation and strategies that combine equity with efficiency. This efficiency motive with emphasis on cost recovery, has brought about raising the price with the volume of water, how regressive this has been on urban poor has constituted sufficient reason for investigation. According to the WCL (2008) economic efficiency in the water sector remains below the regional average resulting from a lack of financial resources to extend the infrastructure to needy areas by the water supply sector in Ghana. However the problem is closely related to water quality, inadequate supply and lack of maintenance resulting into broken down hand pumps, the long distance women and children have to walk to fetch potable water, inability to pay for water because of lack of income generating activities and the existence of water borne diseases.

Inadequate access to water restricts opportunities for hygiene and has made backyard gardening and livestock production low which has affected the ability of low income urban dwellers to meet rising food needs to sustain their livelihood (Mandela, 2002). According to the UN General Comment Number Fifteen on the Right to Water (2002), this is a violation of the human right to water supply which is diminishing social welfare as vulnerable groups are being exposed to water-borne diseases. Conversely, capital investment in the urban water sector in Ghana is poor (World Bank, 2009).

The availability and quality of water is crucial to economic growth and development and to the survival of terrestrial systems. Global per capita water suppliers are declining and are now a third lower than they were 25 years ago. Further increase in population and economic activities are expected to boost demand for water exposing many countries to periods of water stress (Addo, 2007).

Despite these various expressions on potable water problems in developing countries and for that matter Ghana, mainstream literature has not adequately demonstrated an organized or
systematic way of classifying and diagnosing the situation on the basis of spatial variations in identified regional, district, urban, town and other smaller town service areas. This is due to the lack of the application of pure research approaches (Kumar, 1999), involving the development and testing of social science related theories in the realm of the distribution of socio-economic infrastructure in well-defined spatial units. A study of this nature, which oriented towards the examination of urban low-cost water supply as an alternative to other sources, by the use of urban settlement land use models such as the Central Place Theory and the Sector Model, does not only test the applicability of these models, but also provide a systematic way of describing the pattern of distribution of the nature and types of water supply infrastructure. This procedure also facilitates the opportunity to spell out clearly, areas that are constrained by potable water accessibility and where and why low-cost water supply strategies are appropriate.

1.2 Research Problem

Water is one of the most important things necessary for human existence. However, the efforts of governments of various countries to ensure that potable water is available in every settlement are being challenged by resource constraints and lack of guiding principles, such as appropriate urban development or resource allocation models for the effective use of the limited resources, through adaptations to alternative cheaper sources of water and for equity in the distribution of such sources. The situation is more critical in urban settlements differentiated by smaller suburban units with varying degrees of centrality from the Central Business District (CBD) of the larger whole (Getis, Getis and Fellmann, 2006). This often results into smaller zones of the urban settlements being left to cruel fate by public sector water service providers (such as the Ghana Water Company Ltd.), while in other settlements of the same urban town some people use treated water to keep their gardens evergreen, especially in the CBD.

Besides, in the CBD where there is concentration of services, there often arises the question of cost efficiency in public water services; many homes that abuse water use do not have meters to indicate how much water is consumed there and so pay the Ghana water company what a normal home consumption would cost, while the lack of effective consumer participatory arrangements for the management of the water system contribute to further losses in revenue due to higher levels of non-revenue water as a result of unreported system break-
down causing heavy leakages and illegal tapping of water from delivery mains (Nkrumah, 2004; SNV, 2009; Bukari, 2011). On the issue of unmetered water in urban towns, Obeng (1998) argued that this is not fair, and that the Ghana Water Company should inspect their connections to homes to ensure that consumption is rightly paid for. Otherwise it might mean their inspectors are indulging in corruption to deny the company of essential revenue.

Thus, the multiple problems of unavailability, poor consumer participation in facility management and maintenance, imbalance or lack of equity in distribution and ineffective mobilization of public sector water revenue erupt. These, according to Bukari (2011), are due to the lack of the application of models or theories to the management of local level potable water services by the public sector.

From observation, areas without access to the services of the GWCL depend on water vendors at a relatively higher cost. This thesis has examined how the high cost of investment in physical potable water infrastructure in higher order urban settlements is depriving some lower order urban residents of their rights to quality water services for a healthier life, and explored how the use of low cost technology such as mechanized wells, in the context of urban land-use and settlement theories such as the Central Place Theory and the Sector Model could serve as an alternative to the high-cost piped water system in use by the GWCL for sustainable and equitable urban water supply.

1.3 Research Questions
The study was aimed at finding answers to answer the main and specific research questions as stated below.

1.3.1 Main Research Question
How does the adoption of urban low-cost water supply serve as an alternative to other sources to solve the problems of access to potable water in urban Upper Denkyira?

1.3.2 Sub-Research Questions
I. What is the general condition of water supply in the Central Business District (CBD) and lower order residential areas in Dunkwa-Offin?
II. How does the provision of low cost water supply serve as an alternative to the existing sources in the CBD and other sectors of Dunkwa-Offin?
III. In what ways does low cost water supply contribute to improved access to potable water the CBD and other sectors of Dunkwa-Offin?
IV. What are the challenges in low cost water supply in the CBD and other sectors of Dunkwa-Offin?
V. What can be done in low cost water supply for a better way forward?

1.4 Objectives of the Study
This study sought to achieve the following objectives.

1.4.1 Main Objective
To determine how the adoption of low cost water supply technology solves the problems of access to potable water in urban Upper Denkyira.

1.4.2 Specific Objectives
I. To examine the general condition of water supply in the area.
II. examime the provision of low cost water supply as an alternative to existing sources
III. To ascertain how the provision of low cost water supply contributes to improved access to potable water in the area
IV. To identify the challenges of low cost water supply
V. To make recommendations for the way forward.

1.5 Significance of the Study
The issue of providing quality low cost water for the needs of people in Ghana has and continues to draw the attention of Government, families, municipal assemblies and individuals, especially farmers and other interest groups. However, all efforts made have been thwarted by rising cost of materials, labour and technical knowledge.

The findings of this study could draw the attention of the stakeholders to low cost water supply technology as an alternative to the existing high cost technology in use. It could also raise the interest of public water service beneficiaries who come across the findings of this study to adopt to services from low cost water supply technology such as mechanized wells. In other words, the findings could inspire both public water suppliers and consumers to make
comparative decisions between mechanized low cost water technology and other water sources with regard to cost and quality. Also, the outcome of this research could serve as a material of reference in related studies and inspire further research in urban water related studies.

1.6 Organization of the Study
This thesis is organized under five chapters. Chapter one is the introduction, which covers the background to the thesis, the statement of problem and the research questions and objectives and the justification for the study. Chapter two presents the reviewed literature, while chapter three looks at the research methodology adopted. The results and discussions were presented in chapter four, while chapter five completes work with the summary, conclusions and recommendations.
CHAPTER TWO
LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction
This chapter presents the relevant secondary data from textbooks, journals and other secondary sources that enabled the researcher to obtain existing information that served to support the validity of this study, or identify the gaps that exist in the literature and how this study sought to address them. The reviewed literature was therefore focused on major themes derived from the research objectives as provided in the subsequent sections.

2.2 Operational Definitions
This section considers some important terminologies explained in terms of their contextual relevance in this study, and which served as the pivot around which the study revolved.

Low cost water: Any water which is available, and is of quality and free from diseases, pollution and contamination with reasonable access to it and is affordable to low income people. Low cost water supply has been of central consideration in this study. In other words, the study examined the state of water supply under the usual public piped water system, and how low-cost water supply outlets such as wells served as alternatives to the existing means of water supply, and the associated benefits in terms of the maximization of water access and water-use as a result of the shift.

Access to water: This refers the percentage of people with reasonable access to an adequate amount of safe water in a dwelling or within a convenient distance of their dwellings. The focus of the study was to examine the state of accessibility to potable water before the adoption of the low-cost approaches and the situation afterwards, for the purpose of comparison. This aspect of the study was more descriptively inclined.

Urbanization: The process by which towns and cities grow bigger and more and more people go to live in them. In the context of this study, urbanization was taken into consideration by examining how urban population poses pressure on public sector potable water supply and how the adoption of low cost approaches served as alternatives to meeting urban water needs in urban
Upper Denkyira, with Dunkwa-Offin as a case study. Particularly, the need to be more systematic in this urban related study, called for the adoption of pure research approaches by the application of urban spatial models for the purpose of zoning and categorization the trend of distribution and effects of the variations in water supply services, and how alternative approaches using low-cost water systems are addressing the situations.

2.3 Theoretical Framework

According to Khan (1999), as cited in Bukari (2011), the theoretical framework of a study is a structure that can hold or support a theory of a research work. It presents the theory which explains why the problem under study exists. Thus, the theoretical framework is but a theory that serves as a basis for conducting research. This study therefore made use of the Sector Model and the Central Place Theory to guide the analysis of relevant thematic areas of the study. Figure 2.1 is an illustration of the adopted theoretical framework for this study.

Figure 2.1: The relevance of the Central Place Theory and the Sector Model to low-cost water service distribution

Source: Author’s construct

In Figure 2.1 the main theory, which is the Central Place Theory, is represented by the larger box. The Sector Model, which is represented by the oval sphere, is inserted in the main theory.
because its application in the study is subordinate to that of the Central Place Theory. The explanation of the components of the framework is given in the subsequent sections.

2.3.1 The Central Place Theory

The Central Place Theory (CPT) was idealized by the German Geographer Walter Christeller in 1933 as a framework to aid the explanation of the interrelationship between urban settlements and surrounding rural populations in agricultural areas. The theory maintains that urban settlements serve as central places or centers for the distribution of economic goods and services to surrounding rural populations, and that the degree of centrality depends on the location and sizes of the surrounding ones (Getis et al., 2006).

Though the CPT was originally used to explain the interrelationships between agricultural settlements, the basis of the interrelationship, namely for the distribution of economic goods and services is not different from the relationship between any other categories of settlements. The CPT is therefore very flexible in adaptation and applicability to other areas of spatial planning.

In this study, the CPT has been modified and adopted to explain how the sizes and locations of the study zones within the Dunkwa-Offin urban town influence the nature of low-cost water services and distribution to populations within and outside the settlements. The basic tenets developed out of the CPT for adoption in this study include the following:

There is one main central place or service center, which is Dunkwa-Offin, as the capital town of the Upper Denkyira Municipal area which provides higher order services including potable water within the municipality.

Each of the other three communities of the municipality sampled for this study (Dunkwa-Kadadwen, Ayamfuri, and Oponsu), were considered as low-cost water service points of varying degrees of centrality. In other words the size or level of centrality of each zone was considered to be proportional to the level of services offered.

The type of technology, number of facilities, level of distribution and accessibility were the basic indicators of the centrality of a study zone in the context of this study.
2.3.2 The Sector Model

The Sector Model of urban land use, maintains that residential areas are separated by transportation arterials, and with the Central Business District (CBD) at the centre, high rent residential areas expand outward along major transportation routs (roads, railways, etc.). Middle income housing cluster around the housing for the rich, and low income/working class housing (commuters’ zone) occupies land around areas of industry and associated transportation routes such as roads and railroad lines (Getis et al., 2006).

The mere arrangement of sectors as described in the sector model is of little importance without a discussion of the spatial development implications, especially in terms of the distribution of socio-economic goods and services. Thus, this study examined how issues of income stratification, location, the nature of socio-economic activities among others, constituted the basis of determining the nature and distribution of low-cost water infrastructure.

The framework of this study was operated in such a way that it employed the combined effects of the concepts of centrality and sector as premised by the CPT and the Sector Model respectively to account for the differences in the study communities, with emphasis on low-cost water supply.

2.4 Some Potable Water Related Policies in Ghana

Below are some identified policies in Ghana which seek to address problems related to potable water supply.

2.4.1 Drinking Water Policy

One of the objectives of the drinking water policy is to ensure accessibility to safe drinking water by low-income and peri-urban consumers. Two strategies are mentioned in the policy. One strategy is to adopt a tariff rate that provides an optional benefit to consumers including low-income consumers, such as the Increasing Block Tariff of IBT (Nkrumah, 2004). Another strategy is to escape cooperation between GWCL and small-scale independent providers rather than grant exclusively to either party the right to facilitate adequate and affordable provision of safe drinking water to un-served and under-served areas (PURC, 2009).

Thus, this thesis has examined how the issue of potable water scarcity is being addressed through the adoption of low-cost technology, by the GWCL and private sector stakeholders, as a
step towards the implementation of the Drinking water Policy in the Upper Denkyira District. Gaps in the implementation process through the identification of variations in the provision of water services to places of varying degrees of centrality, through the use of urban spatial models were also uncovered in the study.

2.4.2 National Constitution on Water
GWCL is required to supply water to all inhabitants in the supply areas (GOG, 1965). The constitution of Ghana, Article 35 (3) enjoins the state to promote just and reasonable access by all citizens to public facilities and services which naturally include water supply services (GOG, 1992). In article 17 of the same constitution, parliament is permitted to make different provisions for different communities having regard to their special circumstance. This provision allows for the service providers to have appropriate mechanisms to optimize social induction. This research work has therefore investigated into the special needs of urban population with considerations to locations and income stratification, and how the low cost water supply project serves as a fulfillment of this constitutional provision.

2.4.3 Public Utility Rights Commission (PURC) Act
The PURC was established by the PURC Act, 1997, Act 538 to regulate the water and electricity services in Ghana (GOG, 1997). For water supply, the mandate covers only urban water supply. PURC’s key tasks include the following:

- Provide guidelines for setting rates for the provision of utility services.
- Protect the interest of consumers and utility services providers
- Monitor and enforce standards of performance for provision of utility services
- Initiate and conduct investigations into standard of quality of services given to consumers.

Of central considerations in public water services are issues of water pricing, accessibility, service quality and technological choice according to the absorptive capacity of the target consumers. Hence, these functions of the PURC were examined, with emphasis on how low cost technology is meeting the needs of the urban poor in terms of the accessibility to water and the affordability of water tariff rates, and whether utility users are satisfied with the standard of performance, service quality and choice of technology in the study area.
2.5 Empirical Reviews

This section contains the major themes of the research obtained from the sub-objectives and the associated issues and debates raised in similar research works done earlier.

2.5.1 The General Condition of Water Supply

In Ghana as well as African countries such as Benin, Liberia, or Gabon, Water Companies aim to ensure that water of a good quality is produced and channeled to homes and industries in both urban and rural areas. They also monitor the network of distribution pipes to detect and remedy leaks that may waste fresh water (SNV, 2009). Illegal connection to water supply outlets and non-payment of water levies are also critical issues of concern (Bukari, 2011). The inability to address some problems of this nature has led to inadequate supply of potable water or the failure to sustain its supply by the water companies, due to the inability to meet operational cost of production.

In addition to this, the resource such as water supply materials to various areas, especially rural areas is a problem. In view of this, the Water Commission was set up in early 1990 and is mandated to manage all water bodies and grant concessions to users in Ghana (Bukari, 2011). The first priority of its function is to ensure that areas around major sources of water (such as rivers) are reforested to forestall excessive evaporation. Furthermore the commission also ensures the conservation of surplus water from natural water bodies such as rivers and lakes. For instance, surface water overflows the banks of rivers and lakes in the rainy season but evaporate, leaving most of the riverbeds dry during the dry season of the same year. To store the surplus water and prevent it from evaporating, the encouragement of the building dams or constructing wells along potential flood planes of rivers is among the functions of the Water Commission.

With the present state of privatization and increasing cost of providing quality potable water, alternative low cost water supply methods for the purpose of ensuring the affordability of services to low income groups is becoming an issue of concern in development thinking. Hence, there is the need to measure progress with a view to influence policy redirection if necessary.
2.5.2 Low Cost Water Supply as an Alternative to other Sources

Issues reviewed in this section include the determination and adoption of suitable approaches in the provision of low cost water supply technology, the types involved with a stress on mechanized wells, the properties of well water, the construction of mechanized wells and how well water is treated.

2.5.2.1 Approaches to Low Cost Water

Perhaps the main ideas that influenced the low cost water supply approaches of the 1980s was the strong advocacy role of a group of scholars in the post world war period, who came out with the earliest post world war approach to low cost water supply known as the Appropriate Technology Approach. The approach was championed by people like Schumbacher (1973). In his classical work “Small is Beautiful”, Schumbacher (1973) questioned some of the earlier approaches such as the Mainstream Resource Technology Injection Development Approach premised on the success of post world war plans.

The call for the Appropriate Technology Approach was based on the realization that there was a gross mismatch between the sophisticated and expensive technology being transferred to many parts of the developing world and the pre-industrial and semi-industrialized setting in which it was expected to function.

The alternative development mode had to be technologically, socially and economically more sensitive and less monolithic (Black, 1998). It was therefore community development oriented. Unlike urban water supply that benefits from the economies of scale, in community water supply programmes there are complex problems raging from technical feasibility, operational and management bottlenecks to cost effectiveness, in providing water for scattered people on continues basis. From the early forties until the promulgation of the United Nations International Drinking Water Supply and Sanitation Decade (1981 to 1990), water was considered by most Sub-Sahara African countries as a public good which should be provided by governments free of charge (Bacho, 2001). The central concern of this was to focus on the provision of water for the poor living in relatively inaccessible areas, through the adoption of low cost technologies (Black 1998; Waston et al., 1997).

Community potable water provision was, therefore a purely engineering fact, which was to be overcome by focusing on the most technically feasible approach. International donors and
UN bodies championed this view. UNICEF for instance, has been instrumental in the promotion of rural potable water rights from the 1940s, but the earlier approaches were usually accidental or ad hoc responses to large scale disasters. This study therefore examines the application of low cost water supply technology as an aspect of the alternative Appropriate Technology Approach, and how relevant it is in addressing the special needs of the urban poor in the Upper Denkyira District.

2.5.2.2 Forms of Low Cost Water Supply Technologies
The major sources of water to urban and rural areas in Ghana include dams and rivers, wells, boreholes, public standpipes, private household pipe connections and water vendors, including water tankers (Bukari, 2011). Since this study is focused on low cost potable water supply, dams and rivers as sources of water have not been contextually relevant in this study. Rather, the interest was in the availability and distribution of the other sources of potable water (water that is good for human health).

There are several categorizations of low-cost water supply technologies. For instance Evans (1984) the types of technology under the appropriate technology umbrella or low-cost water supply technologies to include:
Capital-saving technology
Labor-intensive technology
Alternate technology
Self-help technology
Village-level technology
Community technology
Progressive technology
Indigenous technology
People’s technology
Light-engineering technology
Adaptive technology
Light-capital technology
Soft technology
On the other hand, WHO (2006) also came out with some technologies associated with low-cost water supply as follows; Deep wells with submersible pumps in areas where the groundwater (aquifers) are located at depths >10 m.; Shallow wells with lined walls and covers; Rainwater harvesting systems with an appropriate method of storage, especially in areas with significant dry seasons; Fog collection, which is suitable for areas which experience fog even when there is little rain and Air well, a structure or device designed to promote the condensation of atmospheric moisture.

Handpumps and treadle pumps are generally only an option in areas located at a relatively shallow depth (e.g. 10 m). The Flexi-Pipe Pump is a notable exception to this (up to 25 meter). For deeper aquifers (<10 m), submersible pumps placed inside a well) are used. Treadle pumps for household irrigation are now being distributed on a widespread basis in developing countries. The principle of Village Level Operation and Maintenance is important with handpumps, but may be difficult in application.

Condensation bags and condensation pits can be an appropriate technology to get water, yet yields are low and are (for the amount of water obtained), labour intensive. Still, it may be a good (very cheap) solution for certain desperate communities. The hippo water roller and Q-drum allow more water to be carried, with less effort and could thus be a good alternative for ethnic communities who do not wish to give up water gathering from remote locations, assuming low topographic relief.

The roundabout playpump, developed and used in southern Africa, harnesses the energy of children at play to pump water.

Thus, while Evans (1984) based his classification on the intended purpose of the technology, WHO (2006) was interested in the physical construction of the technology, but both classifications could be linked to cost, beneficiary income levels and affordability variables. The long-run effect of which is to expose potential beneficiaries to a wide range of choices for the reduction of water poverty (Abrams, 2000).

This study examined how some selected low-cost sources are helping to overcome challenges in urban potable water supply.
2.5.2.2.1 Well Water

Well water is water obtained from a deep hole in the ground. The well is the oldest method of underground water supply and it must be deep, cemented and have raised sides to prevent contamination by waste liquid seeping through. The top of the well should have a concrete or stone surrounding wall and should be covered when not in use (Owusu, 2005).

Wells could be manually constructed or mechanized. According to (NKYE, 2006) using traditional well method to supply water is not usually ascribed to either neglect or ignorance but to inherent constraints associated with Traditional Well Water Supply (TWWS). There are however, mechanized wells of varying types. The successful development and the introduction of appropriate Solar Well Water Supply (SWWS) has brought about improvement in potable water supply, but sun energy is not reliable in nature.

Comparatively, the use of gas well water supply in modern technology cannot be over emphasized, but the cost of purchasing gas and refilling it periodically in low income areas is unbearable. In addition to this, experimental and technical evaluation carried out in London by the University of Bath has shown a modified version of electric well water supply to be quite suited for local conditions. The system operates like a reservoir in which an electric pump transmits the water from the well to the reservoir.

According to Gast (2003), all types of wells have some common characteristics in terms of material composition as illustrated in Figure 2.1. The humus horizon contains debris and particles and aeration is effective here, which is dangerous for human health. Although, clay retains water during the dry season it cannot stay for longer period. But it has a high argillaceous material with high carbonate and shale contents (Acquah, 2009). In the sandy horizon, there is little organic matter status such that it cannot retain water for longer periods especially during the dry season.
The horizon E, consisting of gravel is ideal for well construction since at any point in time water can flow. The water in this horizon is free from carbon and impurities. The hydrogen and Oxygen content is normal. It is better and often pure because it is filtered as it passes through the porous rocks. Since this study is focused on mechanized wells as a source of low cost water supply, it was considered necessary to look at how an average mechanized well is constructed. The sub-sections below present the stages involved.

- **Excavation**

All vegetation on the soil must be removed from the area to be occupied by the well. Well must not be excavated deeper than necessary to ensure firm well bottoms and preventing the collapse of the inner wall and free flow of water. The widths of wells need checking to ensure adequate spread of concrete (Obour, 2005).

Holes must be kept clear of water and back felting carried out uniformly and effectively on all sides of the walls in shallow layers. The safety of excavation is very important. Where the side of excavations requires temporary support to prevent the risk of earth or other material falling into the exaction with consequent dangers to work men and others on the site, adequate timbering or other support must be provided by suitably skilled persons. The supporting material must be free of projection nails which could be dangerous to persons on the site (Togarli, 2005).
According to Obeng (1998), materials must not be deposited or stored near the edges of the excavation, as they could cause the collapse of the side of the excavation with resultant dangers. Where the work may affect the stability of adjoining property, adequate precautionary measures must be taken. Any explosives used for excavation work must be under the control of competent and experienced persons. When a charge is fired, it is essential that no-one is exposed to the risk of injury.

- **Concrete Work**

The trench or hole of a well is generally considered to be the most important part of the construction and every possible area as well as the concrete used in holes or trenches must be carefully examined during work inspection. Where small quantities of concrete are mixed by hand the cement must be evenly distributed throughout the aggregate. Pulling a long pronged rake through the heap before mixing helps considerably (Seeley, 1974).

The wet mixing must be carried out on a platform or other hard, clean surface. The amount of water added is influenced by the temperature and abruptly of the receiving point. A good consistency is obtained when a handful of concrete press fight sticks together and does not crumble or flow. The cement and agreement must be checked and boxes kept clean and filled to the right level when in use. The sizes of gauge boxes are normally based on multiples of aggregates which relate to a 50kg bag of cement, but must not be excessively large and heavy (Adubondor, 1998).

When the laying of concrete in a well finishes part way along a trench at the end of a day’s work, the end of the concrete should be left rough and inclined as a key for the next day’s work. Before concrete is placed between formwork, the formwork should be checked in terms of dimensions, levels and strength. Formwork to holes should be so secured that they will not move under pressure from the concrete, and a sight camber of about 1/360 spam is customary. The side forms are usually removed after two or three days but a longer period is required for soffits of holes, depending upon such factors as the loading and the time of the year. If a fair face is required for the concrete, the form work must be treated so that the concrete comes away clean. All form work must be clean before use (Mackey, 1998).
Freshly laid exposed concrete must be adequately cured by covering with a tent of plastic sheeting or water proof paper to protect it from the sun and drying winds for seven to ten days. Concrete should be at least 4°C when placed and should not fall below 2°C until it has hardened. In cold weather special precautions should be taken such as keeping aggregates and mixing plant under cover, covering exposed concrete surfaces with insulating material, using a richer mix of concrete and or rapid hardening cement, heating water and aggregate, and placing concrete quickly. It is sometimes necessary to carry out site tests on materials to determine their stability (Obeng, 1998). The following tests relating to cement and sand serve to illustrate the approach.

**Cement**

Examine to determine whether it is free from lumps and of flour – like consistency (free from dampness and is reasonably fresh).

Place hand in cement and if of blood heat then it is in satisfactory condition.

Settle with water as paste in a closed jar to see whether it will expand or contract.

**Sand**

Handle the sand: It should not stain hands excessively, ball readily or be deficient in coarse or fine particles. Use a standard sieve test - if more than 20 percent is retained on a 1.25 min sieve, it is unsuitable for use. Apply a silt or organic test - a jar half filled with sand and made up to three-quarter mark with water; the amount of silt on top of the sand is then measured and this should not exceed six percent (Obeng, 1998).

Morris (1974) argued that coarse aggregates for concrete are normally required of BS882 and these require checking to ensure a well balanced mix. The maximum size of coarse aggregate is determined by the class of work; rarely exceeding 20mm for reinforced concrete but increasing strength are influenced by a number of factors:

Proportion and type of cement

**Plaster Work**

Plaster board ceilings must be securely fixed with suitable galvanized nails to give a true plane surface. Each board or lath should be nailed with not less than four nails to support it, and equally spaced across the width and driven no closer than 19mm from its edges.
Each joint should be staggered in alternative courses with cut ends located over the supports. Plasterboard ceilings are normally finished with one or two coats of plaster and angles at junction of wall and ceiling need checking to ensure that they are reinforced with a strip of jute scrim. Most internal wall surfaces are finished with two coats and the first coat should be ruled to an even surface and lightly scratched. Accrete screeds and gerunds are needed to produce a good finishing or floating coat. The finishing coat must be applied with an even amount of material and pressure. Irregular or wavy patches should be re-plastered.

Detective work should be identified at early stage so that irregularities can be felt even if not clearly visible. Good plasterwork requires skilled craftsmen, good materials and to be plastered, and there is no substitute for this Galvanized metal. Angle beads should ideally be used at all plaster external angles. Plaster should be stored in a dry place and be separated from concrete floors by wood bitterns (Adams, 2002).

The finished plaster work should be truly vertical, free from cracks, blister and other imperfections. Different plasters must not be mixed under any circumstances and the manufacturer's instruction should be closely followed. Plaster on the site should be checked to ensure that it is of the type specified (Clifford, 2002).

Brickwork

The brick should conform to the sample approved by the architect or other responsible persons. Rough checks for suitability on the site include striking two bricks together and the resultant impact should be hard and clear, and certainly not dull. Good bricks should be without sand and transportable to the site without too many breakages. Arrases should be true and dimensions within the generally accepted tolerance, otherwise the contraction may claim an extra sorting and gauging bricks (Mackey, 1998).

Lightness of colouring or a pink tinge indicates under burning and is a serious fault as the discoloured bricks are likely to disintegrate fairly rapidly if used externally and subjected to severe weather condition. Over burnt bricks may detract from the appearance of face work as they are likely to misshapen (Chudly, 2002).

In general the production and use of mortar on site is inadequately controlled. Very weak mortars can easily be produced and used, and if sulphates are present in the bricks or soil they dissolve in water and attack Portland cement forming calcium sulfoaluminate, resulting in expansion or mortar disintegration. The remedy in this situation is to use sulphate resisting
cement or stronger mortar -1.3 or 1.4, and to avoid bricks with high sulphate content' the composition of mortar should be carefully considered and should ideally have a density as close as possible to the density of the bricks. A good general purpose mortar is cement; time: sand (1:1:5-6) masonry-cement; sand (1:4/1/2) or cement; sand with plasticizer (1:1:5-6).

There are many matters to observe when supervising bricklaying. They must be laid to the specified bond and quoins. Piers and reveals should be checked, for plumb and bricks causes lay to gauge. It is unsatisfactory for brickwork to gain for one scaffold and internal walls should be carried up at approximately the same rate, leaving indents for half-brick walls and chases for block partitions. Quoins should be either racked back or partly racked and toothed (Meckey, 1998).

Bricks must be well wetted during hot weather and the top of newly constructed work suitably protected during frost or heavy rains. Defacement through scaffold splash must be avoided. Brickwork should be suspended during frosty weather, but where bricks and mortar are free from frost, work can commence at the beginning of the day if the temperature is not below 2°C. Special precautions may be taken to permit bricklaying to proceed during temporary frosts (Seeley, 1974).

- Plumbing
All materials and components need checking to ensure that they comply with the specification. Sanitary fitments deserve close examination to ensure that they are not misshapen, cracked crazed or pitted and that fittings such as water waste preventives are free from mechanical defects.

A constant check should be maintained while plumbing work is in progress to ensure that pipes are of the correct types with the prescribed provision of valves. All pipes should be properly jointed and graded where appropriate. Hole water pipes must be adequately fixed but at the same time permit movement for expansion and contraction 'care must be taken to ensure that floor joists are not weakened excessively through notches being cut to receive pipes (Idun, 1998).

Pipes should be located so as to be as inconspicuous as possible but nevertheless be readily accessible for repairs. Special precautions need to be taken with a single stack system to ensure satisfactory operations. For example, the stack must be of adequate size with air light
joints and branch pipes must fall gradually and continuously in the direction of flow abrupt changes of direction. The vertical distance between the lowest branch connection and the invert of the drain should not be less than 450mm (Aduboador, 2000).

The researcher’s background as a social scientist has very little to do with the technicalities involved in the construction of wells. However, the reviewed literature on well construction acquainted the researcher with some background knowledge that facilitated the observation processes, as the information served as a tachometer for measuring the quality of work done on existing wells constructed or under construction in the study area.

2.5.2.2.1 Properties of Well Water
According to Amevor (2005), for well water to be considered potable or good for human use, it must be a pure, clean, colorless and tasteless liquid. Generally, however, well water possesses the following characteristics:

Freezes at 0°C; Boils at 100°C; Has a maximum density of 1 gcm⁻³ at 4°C; is neutral to litmus; is a poor conductor of electricity but becomes a good conductor when a small amount of an ionic compound is dissolved in it; has high surface tension so that it appears to form a strong skin on its surface; lastly, it should expand between 4°C and 0°C and contracts (become less in volume) when melting from 0°C to 4°C so that unusually solid water (ice) floats on liquid water. (amevor, 2005).

This study is interested in how knowledge of these properties is essential for the determination of the deviation of any particular well water, and what treatment is necessary, for the purpose of ensuring that well water as a low cost water supply method is potable or good for human health.

2.5.2.2.4 Treatment of Well Water for Improved Water Quality
Well water can be soft or hard depending on the nature of the water. The water from most natural sources contains dissolved substances such as Calcium hydrogentrioxocarbonate (VI) and Calciumtetraoxosulphate (VI). These make the water hard and thus not lather easily with soap.
When this chemicals come into contact with soap they form an insoluble scum, until all of the ions forming the scum are removed, the hard water would not lather with soap. Amever, (2005) argue that, to activate this, first know the nature of hardness. This is either temporary or permanent. The temporary is the one caused by the presence of soluble Calcium hydrogentrioxidecarbonate (IV). Vis-à-vis permanent hard water is caused by dissolved calcium Ca$^{2+}$ and magnesium, Mg$^{2+}$ ions. Other impurities include suspended solid matter, dissolved salts, mud, minute organisms including bacteria, eggs, and larvae of some water organisms (Darkwa, 2004).

Raw well water must go through a series of physical and chemical treatments to change it into safe drinkable water for humans and for other purposes. The basic purpose of well water treatment is to remove all pollutants. Through the providers of treated water such as Ghana Water Company, primary health care, environmental protection agency and water research institute, the following two methods can be used: precipitation and chlorination.

The precipitation method involves adding calculated amounts of lime (Ca(OH)$_2$) or washing soda (Na$_2$CO$_3$) to the temporary or permanent hard well water to remove calcium ions as an insoluble element (trioxidecarbonate (IV) CaCO$_3$), as a quality control measure. (Amoakoh, 2009). Chlorination is also another way of treating well water. It is the process of adding chemicals to release chlorine gas in small amounts to kill any remaining germs in the well. This process is also called disinfection or sterilization. In some localities fluoride ions F$^-$ are added to promote dental health.

WHO (2006) also considered some practices as ideal for ensuring potable water quality, which include some of the methods indicated above. They include the following: Porous ceramic filtration, using either clay or diatomaceous earth, and oriented as either cylinder, pot, or disk, with gravity-fed or siphon-driven delivery systems; silver is frequently added to provide antimicrobial enhancement. intermittently operated slow-sand filtration, also known as biosand filtration chlorine disinfection; employing calcium hypochlorite powder, sodium hypochlorite solution, or sodium dichloroisocyanurate (nadcc) tablets; chemical flocculation, using either commercially produced iron or aluminum salts or the crushed seeds of certain plants, such as moringa oleifera; mixed flocculation/disinfection using commercially produced powdered mixtures; irradiation with ultraviolet light, whether using electric-powered lamps or direct solar exposure; membrane filtration, employing ultrafiltration or reverse osmosis filter elements.
preceded by pretreatment. This study investigated into what is being done in the upper denkyira district to ensure the quality of mechanized well water.

2.5.2.2.5 Maintenance of Well
To ensure to efficient functioning, durability and good quality of water from wells, the maintenance of the mechanized wells is very important. What goes into the maintenance activities may be determined by the prevailing conditions. Generally, however, maintenance may include weeding, cleaning, scrubbing, and plastering rendered in and around the well and nearby reservoirs, which help the well to last longer through the percolation of water from latter to the former. The study examined how the issue of maintenance of well water is handled by participatory arrangements.

2.6 The Influence of Low Cost water Supply on Access to Potable Water
Portable well water supply has always posed a serious challenge to all human societies at one time or the other during the course of their development. Periodic drought, cyclic seasonal shortage, socio-economic and political barriers and demographic process are only but a few causes. These larger contextual factors apart, the changing perception of potable well water supply over the years have also affected an important way in which the production and distribution has been organized. The perception of portable well has undergone dramatic changes from a free natural gift of Mother Nature to a scarce economic good (SNV, 2009).

Accompanying these changing perceptions has been also the dramatic change in the management of potable well water system. This provided an enhanced understanding and appreciation of the subsequent research issues that was developed in the specified case of Ghana, and which led to the problem statement. Throughout the over four decades of attempts to provide communities with mechanized well water, one pertinent problem has been how to provide this service on a cost – effective and sustainable basis. This led to several approaches which have been classified by Weston et al (1995 – 1999) as the Technological Approach and the Traditional Approach.

The development of the hand pump and the tube well technologies in India and Bangladesh for example, came as a result of disaster. UNICEF responded to the plight of the
drought stricken states of Utter Pradesh in India which affected 250 villages in 1967 and the victims of the cyclone in Bangladesh in 1948 and again in 1970 (Black, 1990). The UNDP and the World Bank on the other hand, initiated the Large-Scale Approach Technology Project such as the low cost water and sanitation project launched in 1976 by UNDP and the 1981 titanium tube well project undertaken by UNDP and World Bank.

The Technological Approach reached its height when the UNDP and World Bank undertook the first global project designed to increase investment in water and sanitation technology (UNDP 1995 to 1996). This led to the design of several alternative technological options in the provision of community potable water supply, such as rain harvesting and sand filtration, gravity piped water supply, several hand pump option and tube wells among others. Other bilateral agencies have also been instrumental in the developmental and promotion of rural potable water technologies. These include the German Agency for Technical Co-opiate (GTZ), Canadian International Development Agency (CIDA) Danish International Development Agency (DANIDA) among others. At the close of 1970s, the signs were clear on the wall that even with the simplest of technology community water supply systems could not be maintained (Black, 1990; World Bank, 1993; UNDP 1995; Weston et al 1995).

The obsession with “finding the right technology” (Weston, 1997) led to a neglect of other equally essential compound of community potable water supply. The issue of sustainability such as the operation and maintenance management (Moner, 1993), financial sustainability (World Bank, 1993) and the issue of who was ultimately responsible for the water supply system (Kyellerup et al., 1989) were not adequately addressed.

Commenting on the failures of the Technological Improvement Approach; nearly a decade after the massive support way of investment, the UNDP (1995: 58) had this to say: “We learned that technology and increased investment are not enough as projects were failing to sustain themselves; low-cost technology had been refined, but systems fell idle and into disrepair because not enough attention was paid to the capacities of institutions and communities that must manage and pay for them. Economic and financial analysis of the systems that were idle and in disrepair and the attention paid to the capacities of institutions and committees that were put in place were insufficient, and local communities and individual users were not appropriately consulted about the services they wanted and for which they were willing to pay.”

25
From the above literature, though low cost water supply technology aimed at increasing access to potable water to areas facing water crises, some technical and institutional rigidities posed limitations to this objective. Today, the challenges posed by rapid urbanization with population pressure on basic utilities like water, makes the re-adoption of low cost water supply technology unavoidable, as an alternative means of addressing problem of the high cost of pipe-borne water supply in urban and peri-urban areas by water supply companies.

An examination of the performance of the new advances in low cost water supply was therefore necessary, for the purpose of re-informing policy.

2.7 Challenges of Low Cost Water Supply

Groundwater use in most developing countries is not regulated. This has led to the over exploitation of the aquifers, causing the lowering of water tables, an increase in pumping cost and pollution of aquifers. Continued over exploitation of groundwater reduces the availability of freshwater for use and poses challenges to the health of people who are bound to live near these affected areas (Suman, 2006). Koppen (1999), noted that groundwater is the major source of drinking water for cities and urban area in the developing world and the demand is rising with unplanned expansion of urban and cities. Commercial agriculture and industries are other major users.

Groundwater over abstraction negatively impacts the urban and rural poor because they cannot afford to dig deeper wells. In water dependent societies, this particularly impacts on the lives of poor woman (Gautau, 2006). One of the greatest returns to improved access to water is in the time saving for women and girls and the expansion of their choices. Water collection is part of a gender division of labour that reinforces inequality within households, and contributes to poverty by retarding the human development prospects for a large section of the world’s people (women).

According to Bosiako (2009) social and cultural norms influence the household division of labour in developing countries, and generally roles involving looking after children, caring for the sick and elderly, preparing food and collecting water and fire wood are tasks dominated by women (Moser, 1993). Norms in this case translate into equal working hours between men and
women, however time surveys in the Dunkwa-Offin area point to weekly differences ranging from five to seven hours.

Fetching water is part of the gender inequality. In urban Ghana girls aged 6-14 spend an average of one hour a day collecting water compared with 25 minutes for their brothers. In Dunkwa-Offin, there are large variations in the amount of time allocated for water collection based on seasonal factors but women consistently spend four to five times more than men on this task (Acheampong, 2008).

Why does this matter for human development? Time is an important asset for the development of capabilities. Excessive time for essential labour leads to exhaustion, reduces the time available for rest and child care, limits choices of other activities, and reduces the substantive freedom that women enjoy. These create a situation where households are left to make a choice as to whether girls should be kept from school to collect water, freeing time for mothers to grow food or generate incomes, or should they be sent to school to gain the skills and assets to escape poverty. How the inadequacy of water supply facilities, with emphasis on low cost water supply systems contributes to this situation of time-poverty was of central consideration in this study.
CHAPTER THREE
RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction
Research methodology is an important component of any study and provides the framework upon which the research process is conducted (Brow, 1996). Hence, it is vital that the methodology is sound and conducted thoroughly to efficiently produce accurate and precise data in order to achieve the research goal and objectives. This section therefore, provides the framework that was adopted for the realization of the research goal and objectives.

Apusigah (2008) stressed that an in-depth explanation of the research approach and process, methods of data collection, sampling procedure, sample size, methods of data analysis and the scope of the study should be outlined in the methodology section. Accordingly, this has been the adopted guide in this thesis.

3.2 Selecting the Study Location
Any research undertaking requires the selection of a study location that exhibits the phenomenon to be investigated. In the Dunkwa-Offin area, low cost water supply technology was initiated in nine areas namely Oponso, Chichiwere, Foso, Mpeasem, Dunkwa-Kadadwen, Ayamfuri, Siskuma, Buadinso and Imbrahim. Plate 3.1 shows the locations of the study communities.

Upper-Denkyira Municipal, with its capital at Dunkwa-Offin has a land area occupying about 1.5% of the total land area of Ghana and has a population of about 120 thousand people. It is located between Ashanti Region to the north, Western Region the west, and the Greater Accra Region to the east. It can be found in the Central Region with about 120 villages and 10 districts. The major occupation is farming. In terms of infrastructural development the municipal is lacking.

Though the research covered all the nine communities, for the purpose of time and resource management, it was considered expedient to sample three out of the nine, using non-statistical methods as described in the sampling design section of this chapter. Apart from being among the nine communities considered for the study, the three communities also have evidences of public and private sector participation in low-cost water supply projects as the
Government of Ghana collaborates with the World Vision and other Non-Governmental Organizations (NGOs) in the implementation of potable water projects.
3.3 Research Design
For the success of the investigation, an appropriate research design should be selected aimed at achieving valid findings. A research design is a plan, structure and strategy of investigation conceived so as to obtain answers to research questions or problems (Kerlinger, 1986). Apusigah (2005) argued that the plan is the complete scheme or programme of the research. It includes an outline of what the investigator will do from writing the hypothesis and their operational implication to the final analysis of data.

Traditional research design is a blue print or detailed plan for how a research study is to be completed, the operationalization of variables so they can be measured, selecting a sample of interest to study, collecting data to be used as a basis for testing hypothesis and analyzing the result (Thyer, 1993). Another definition states that a research design is a procedural plan that is adopted by the researcher to answer questions validly, objectively, accurately, and economically (Adabugah, 2008).

In this study, the research design adopted was the descriptive method. This was considered appropriate due to the fact that the study involved a systematic collection and presentation of data to give a clear picture of the situation. However, both qualitative and quantitative approaches were applied because most authoritative sources in research methods admit that the two distinct processes (quantitative and qualitative) can be said to co-exist but the most important differences is the way in which each tradition treats data (Straus, 1990).
This design was facilitated by the use of participatory research approach tools, involving discussion with groups (men, women and mixed gender groups) and individuals on topical issues of the study.

3.4 Sampling Method and Sample Size
In order to make sound generalizations and draw inferences, there was the need to conduct sampling in the research process. Millar (1991) assets that the researcher needs to select only few interviewees from the universe for study.

According to Miller (1991), a study based on representative sample, is often better than a larger sample or on the whole population. This is collaborated by Karma (1990), who is explicit on the size of a sample and says that the use of a sample should neither be excessively large nor too small. It should be optimal and should be at the discretion of the researcher.
In this study, the chosen sample size was 210. This choice took into account an optimal sample that fulfilled the requirements of efficiency, representativeness, reliability and flexibility (Saunders et al., 1997).

Two main sample techniques were applied for the selection of the elements of the sample, namely probability sampling and non-probability sampling (Twumasi, 2001). According to Millar (1997), probability ensures the law of statistical regulation which states that if on an average the sample choice is a random one, the sample will have the same composition and characteristics as the universe.

In line with this, while the selection of the study communities was purposive (namely Dunkwa-Kadadwen, Ayamfuri and Oponsu) by virtue of the applicability of low cost water supply technology, the selection of houses from which respondents constituting the elements of the elements or respondents who made up the sample size were selected by the fish-bowl or lottery method (Kumar, 1999).

At the community level total enumeration of houses from cross-sections of the three communities was taken, and the total was 450. After the coding of the houses for each area, the codes were written on pieces of paper and put into a box. This was followed by the picking of 210 pieces (sample size) out of total of 450 (sample frame), shaking the box after each picking to ensure randomization or fair distribution of the sample elements across the communities. Table 3.1 shows that the sample size was distributed across the communities.

Table 3.1: Sample distribution among the study communities

<table>
<thead>
<tr>
<th>Community</th>
<th>No. of respondents</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dunkwa Kadadwen</td>
<td>98</td>
<td>47</td>
</tr>
<tr>
<td>Ayamfuri</td>
<td>68</td>
<td>32</td>
</tr>
<tr>
<td>Oponsu</td>
<td>44</td>
<td>21</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>210</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: This study, 2012.
Table 3.1 shows that the random sampling process ensured that respondents were proportionately distributed across the sample because the largest community of the three, Dunkwa-Kadadwen, had the greatest representation of 47% of the sample. This was followed by Ayamfuri as the second largest with 32%, and the smallest community, Oponsu, was represented by 21%.

3.5 Sources of Data
The study made use of primary and secondary sources of data. Primary sources from which data was collected included detailed interviews, observations and focus group discussions. These were specific tools that were used according to the various categories of respondent at a time (Apusigah, 2008).

It is significant to note that secondary sources of data also formed a major component of the study. The secondary sources included review of magazines, books, journals, internet and documentations on related researches. The purpose of using secondary sources was to ensure comparison of findings with those of earlier researchers (Stewart and Kamers, 1993, as cited in Saundres et al, 1997).

3.6 Tools of Primary Data Collection
- Interviews
Karma (1996) defined interview as any person-to-person interaction between two or more individuals with a specific purpose in mind. Interviews are classified into unstructured and structured. The two classifications would be used in the study.

In using the unstructured interview, a frame work was developed to guide the interview process (Yin 1993). The rational for using this approach is to ensure a collective engagement with the group of respondents within which questions will be formulated and asked spontaneously as the interview progressed.

This approach also allowed the respondent to freely express their opinion. This therefore, supports Yin (1993) view that a good interview is one in which the interviewer takes over the control of the interview situation and talked freely.

Hence, this approach sought to solicit in-depth information on construction of mechanized wells, conflict on access to water and maintenance of mechanized wells from policy makers, contractors and beneficiaries of mechanized well projects.
- **Questionnaire**

Questionnaires are a written list of questions and the answers to which are recorded by the respondent. The respondent’s also therefore read the question, interpreted what was expected and then wrote down the answers. The questionnaire approach was adopted and used on both formal and non-formal institutions. Saunders et al (1997) argued that the choice of using a questionnaire is influenced by a variety of factors such as: characteristics of respondents from which you wish to collect data, importance of reaching a particular person as respondents importance of respondent’s answers not being contaminated or distorted, size of sample you require for your analysis taking into account the likely response rate, type of questions you need to ask to obtain data, and number of questions you need to ask to collect your data.

Consequently, the questionnaire was based on the idea that the study locations being urban communities, most of the target respondents were literate and scattered over the geographical area. Hence, self administered questionnaires were used to elicit information from the communities/respondents.

On the other hand, interviewer administered questionnaires were conducted for the non-literate respondents. This was to ensure that the respondents understood the questions based on the best interpretations of the researcher and his assistants, and the write responses obtained and recorded.

- **Focus-Group Discussions**

Focus group discussions were held with small groups of people with similar background and knowledge such as household members, school children, women, students, workers and committee members, with participants ranging between 6-10 or 6-12 (Twumasi, 2001; Krueger, 1988) for 30 minutes to 1 hour discussion. Such joint discussions promoted cross fertilization of ideas and issues debated and looked at from different perspective by the group members. This also encouraged participation and generated further untapped information.

Some tools of Participatory Rural Appraisal (PRA) like matrix scoring and ranking were also used when appropriate to illicit active participation of interviewees and make them more analytical in their responses.
• Observations
The study applied both direct and indirect participant observation techniques cautiously in data collection (Strauss and Carbin, 1997). The purpose was to facilitate a deeper understanding of issues and cross checking of responses considered being inconsistent with what was observed. This process helped to improve the validity of the findings. A systematic observation of events, process and people’s behavior was undertaken and results were recorded.

3.7 Stages of Data Collection
Critical data needed for research was conducted in three phases, the recognizance survey, the main survey and in-depth survey (Millar, 1996). These are discussed in the ensuing sections.

• Reconnaissance Survey
Reconnaissance survey was carried out to build basic trust and confidence in the researcher. This yielded fruitful results as the researcher who is a social practitioner interacted freely with the opinion leaders, chiefs, school children and NGOs working in the research area. Throughout this phase the researcher was able to address the interests and concerns of the communities. The practical interaction during this stage made the people see value in the low cost water supply and this increased their sense of ownership and commitment to treat and maintain their water systems.

The rapport with some social and research networks in the study area proved useful during the in-depth field study.

• Main Survey Phase
Various groups in terms of occupation, age, education and other groups were identified to form the basis of the main survey stage. Emphasis was placed on the collection of data from households, students, and Ghana Water Company officials on expenditure on water, access to water, time and distance to get water, water quality and water borne disease.

With the assistance of local research assistants in the study areas, data gathering and analysis as well as interpretation within the study area was carried out.

The research assistant actively engaged the various community members and other research subjects in a process of action or participatory research (Reasons, 1988) such that the research was done “with” then but not “on” them or “about” them. Periodic visits were made...
with stakeholders who were consulted during the initial planning stages to ensure consensus building.

All changes at this point relating to what would be changed, why it would be changed and when it would be changed were documented to provide process evaluation. Preliminary finding of the study were discussed with community members and other stakeholders for them to validate the findings and possibly fill in some gaps before the final report was prepared.

- **In-Depth Study**
  One-on-one conversational interview as opposed to rigid formal questions and answers were held with key informants, purposefully identified (Adabugah, 2008). This facilitated the ability to see things from the perspectives of the respondents as well as captured their world views in the study, thereby minimizing personal biases in the information gathered. An interview guide structured around various themes of mutual interest was developed and used throughout this process. Related lines of questions and discussion during the interview also occurred. Further, supplementary information that was sourced on specific issues that arose in the earlier stages of the study were discussed.

3.8 **Data Analysis**
Data analysis is defined by Apusigah (2008) as the computation of certain measures along with searching for patterns of relationship that exist among data groups. In a related study, Yin (1993) also stipulated that a number of closely related operations are performed with the purpose of summarizing the data collected and organizing them in such a manner that may answer the research questions. Subsequent on this both quantitative (non-descriptive) and qualitative (descriptive) methods were used. This highlighted the assertion that data analysis should not be a separate step coming after data collection, but a continuous and simultaneous process (Yin, 1993). In carrying out this exercise, research personnel of the Ghana Water Company and municipal assembly and some data analysts were used to advantage in respect of the tabulation and cross checking of facts.

The researcher in conducting the qualitative research ensured that notes were carefully detailed in a notebook with the passing of each day. Information was captured on the problems
of water supply including high cost through discussions and interaction with individuals and groups.

According to Yin (1993), carefully planned interviews should be adequately extended to respondents of diverse backgrounds. Accordingly, officials of the District Assembly, Municipal Assembly, NGOs, as well as galamsey miners and palm wine tapers operating in the study areas were all involved. In all a total of twelve such groups were interviewed. The exercise involved the use of graph, chart, frequencies, and other statistical considerations using SPSS (Lech et al., 2005). After the tabulation the researcher then painstakingly analyzed the outcomes obtained.

3.9 Scope of the Research
In order to be able to streamline and regain urban people's knowledge on low cost water supply and make it available for use in domestic industry and agricultural development a clear focus was necessary. The study made use of a combination of methods. A decision was made for the actor-oriented approach and analytical tool (Long, 1984, 1989, 1990) and the field of study. The following were applied: general characteristics of low cost water supply, types and methods of low cost water supply systems, treatment of low cost water supply systems for improved water quality, the importance of low cost water supply systems in development, challenges of low-cost water supply.

3.10 Limitations of the Study
There were many challenges which may have impacted on the quality of this thesis. First, in a situation where language is a pathway to understanding local epistemological on low cost water supply, it brings to question the capacity of the researcher to do a more exhaustive content analysis of the data collected and arrive at conclusion without being able to speak and understand some of the language. In many of the situations the researcher had to rely on the benevolence of some local people he could lay hands on without having anything to do with any serious assessment on them.

A lot of researches have been done on low cost water-supply among others. All the water supply studies conducted earlier have focused largely on LCWS research concentrated on
Europe, North America and Asia, very few of the studies have focused on LCWS issues in Africa and none of the researches reviewed contained LCWS research conducted on Dunkwa-Offin (Upper Denkyira municipal). This made the study to be constrained by relevant literature for comparative purposes. However, with the careful operation of the scientific process the findings of this study could be relied upon as a step towards filling the literature gap.

About 60% of the Upper Denkyira population are farmers and galamsey miners, it was therefore very difficult getting community members for information since they are usually busy on their farms and work site. The preliminary survey however enabled the researcher to make good guesses of appropriate times of getting various categories of respondents.

The researcher has no car so car traveling in and out of the community for secondary data and other necessities was a problem.
CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Introduction
This chapter presents the analysis and discussion of the results of the study using both qualitative and quantitative approaches, involving the use of frequencies, percentages, tables and charts. Major areas of discussion centered on the socio-economic characteristics and analytical themes derived from the research questions and objectives.

4.2 Background of Respondents
This section begins the analysis of the data by looking at the relevant backgrounds of the respondents that influence or are influenced by the subject matter of this study; low-cost water supply. Thus any other aspects of the respondents’ background that the researcher could not relate well to the topic of the study have been ignored. Considered below are the sex, age, marital status, religion and occupational backgrounds of the respondents.

4.2.1 Sex Distribution
The research has shown that majority of the respondents were females (56%), while men constituted the remaining 44% out of the 210 respondents (Figure 4.1). Though the sample elements at the household level included all adults who were 18 years and above, the reasons for the dominance of women could be attributed to their productive roles in the home, for which reason most women were found at home during the data collection period. Since women’s productive activities are also linked to water use, their high participation contributed to the acquisition of adequate and relevant information in this study.

Figure 4.1: Sex distribution

---

44% male
56% female
The productive roles of men equally had a positive impact on this study through their participation. Men are responsible for community organization and politics. They influence the community decision making process using their modern or traditional political positions and as leaders or members of local pressure groups, such as youth movements that contribute to community development through the initiation of self help projects, including potable water provision, as well as their participation in multi-stakeholder projects in related fields (Apusigah, 2004; Bukari, 2009). As part of their productive roles, the burden of payment for water falls on them as part of the household budget. These reasons justified their inclusion and influenced their rich contributions.

4.2.2 Age Distribution

As captured in Table 4.1, the various age groups have been fairly represented. Out of the 210 respondents interviewed 25% were between 18-35; 32% were between 36-45; 20% were between 46-55 years; and 23% were above 56 years old. This shows that majority of the respondents are in the economically active working group (36 to 45 years of age). However there was a fair representation of the youth as well as the experienced ones.

Table 4.1: Age distribution of respondents

<table>
<thead>
<tr>
<th>Sex</th>
<th>18-35</th>
<th>36-45</th>
<th>46-55</th>
<th>56 and above</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>24</td>
<td>31</td>
<td>22</td>
<td>21</td>
<td>98</td>
</tr>
<tr>
<td>Female</td>
<td>29</td>
<td>36</td>
<td>21</td>
<td>26</td>
<td>112</td>
</tr>
<tr>
<td>Total</td>
<td>53 (25%)</td>
<td>67 (32%)</td>
<td>43 (20%)</td>
<td>47 (23%)</td>
<td>210 (100%)</td>
</tr>
</tbody>
</table>

Source: This study, 2012.

The various age groups, however, have their special roles to play in community water management issues, and as such were all beneficial in terms of contribution to data gathering in this study. Age groups between 46 and 56 and above play leadership roles, and as such form the focal points of community entry for research or development intervention (Twumasi, 2001). The youthful age groups (18-45) usually constitute the youth organizations for community mobilization for the implementation of community development projects that have received the
approval of the leading class. Most community self-initiated low-cost water projects were constructed through communal labour from such groups, who equally do not only make the highest proportionate contribution to water projects, but also provide additional labour when required by an external contractor, such as carrying water, building blocks and other materials at cheap cost or voluntarily.

4.2.3 Marital status

Table 4.2 presents the marital status of the 210 respondents. It shows that a greater proportion (75%) of them were married, while 23% were single or never married. The remaining 2% were widowed. There are several linkages between marital status and household demand and use of water. Generally, larger household sizes are associated with societies that have higher incidences of marriages (Ministry of Local Government and Rural Development (MLGRD), 2006). In such societies, therefore, there are higher household demands for utility services like water and other basic needs of life.

<table>
<thead>
<tr>
<th>Marital status</th>
<th>Sex of respondent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Married</td>
<td>64</td>
<td>93</td>
</tr>
<tr>
<td>Single</td>
<td>15</td>
<td>33</td>
</tr>
<tr>
<td>Widowhood</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>130</td>
</tr>
</tbody>
</table>

Source: Field survey 2012

The issue of marital status was considered necessary in this study because of the associated role of water acquisition and use, which is part of the reproductive roles of women. In other words, one of the primary responsibilities of the married women to look for water (Moser, 1993; Apusigah, 2004), but where such women are aged enough to have capable daughters and other dependents (mostly females and younger boys, see Plate 4.1), who are in the single group then the burden of fetching water is shifted onto such members of the household. Additional responsibilities include taking care of the needs of the very young and the aged as well.
Male singles who are culturally above water fetching age may engage in other related responsibilities such as being membership of youth committees for communal labour activities involving the voluntary construction of community wells, with the concern and support of the elderly males. All such people were well represented in the questionnaire administration and focus group discussions to express their views on low-cost water supply for adequate and reliable data collection through triangulation.

4.2.4 Religious Affiliation

The religious inclination of respondents makes an interesting reading. As captured in Table 4.3, 28% of the respondents indicated that they were loyal to the Traditional African Religion, 14% said they practiced Islam and a much greater proportion of 53% said they were Christians and the remaining 5% said they did not belong to any religion or denomination.

<table>
<thead>
<tr>
<th>Religion</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>58</td>
<td>28%</td>
</tr>
<tr>
<td>Islam</td>
<td>30</td>
<td>14%</td>
</tr>
<tr>
<td>Christianity</td>
<td>112</td>
<td>53%</td>
</tr>
<tr>
<td>Paganism</td>
<td>10</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>210</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Source: This study, 2012

The fact that all religious groups need potable water meant that the followers of these religions had similar interest in the subject matter of this study like.. Traditional, Christian and Islamic religious followers need water for everyday survival like any other person, yet during religious festivals and other forms of religious rites of passage (naming, wedding, funeral rites) one major utility that makes celebrations enjoyable, but hardly noticed (unless there is an acute shortage), is potable water. Besides, the Muslim needs clean water to pray five times a day, while the pagan or free thinker is not different from any other normal human being in terms of water use.

Religion or religiosity is therefore one of the subsystems of an integrated whole, which is the totality of the community, with common hopes and aspirations and dignity,
embodied in all that shape their collective wellbeing, among which is the availability of potable water and the associated infrastructure. Moreover, being a subsystem on its own, religion could be a potential avenue for the exploration of future institutional support for peri urban pro-poor potable water supply in the area.

4.2.5 Occupational Distribution

Table 4.4 shows the major occupations in the Dunkwa-Offin Municipality, and how the respondents were distributed among the various occupations.

<table>
<thead>
<tr>
<th>Main occupation</th>
<th>Sex of respondent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Farming</td>
<td>24</td>
<td>45</td>
</tr>
<tr>
<td>Trading</td>
<td>23</td>
<td>52</td>
</tr>
<tr>
<td>Salary work</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Others</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>92</td>
<td>108</td>
</tr>
</tbody>
</table>

Source: Field survey 2012.

As a major characteristic of urban settlements, trading employs the greatest proportion of the population, with 36% of the 210 respondents being engaged in trading activities. This was followed by farming with 33% responses, and then the salaried workers of public and private sector institutions with 19% responses. The others (12%) included housewives, students and the unemployed who were included in the sample. In the later sections of this work, we shall see how low-cost water supply was found useful to people engaged in all these categories of occupation.

4.3 The General Condition of Water Supply in the Study Area

To start a discussion on the adoption of low cost water supply technology in the study area, it is necessary to first examine the situation of water supply in general, so that the conditions that called for the need for the alternative sources can be known.
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<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
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<td>24</td>
<td>45</td>
</tr>
<tr>
<td>Trading</td>
<td>23</td>
<td>52</td>
</tr>
<tr>
<td>Salary work</td>
<td>30</td>
<td>10</td>
</tr>
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4.3.1 Sources of Water Supply

Table 4.5 shows the major sources of water supply for households in the Dunkwa-Offin area.

**Table 4.5: Major sources of water**

<table>
<thead>
<tr>
<th>Sources</th>
<th>Dunkwa-Kadadwen</th>
<th>Ayamfuri</th>
<th>Oponsu</th>
<th>Total Number of Responses</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe borne</td>
<td>40</td>
<td>17</td>
<td>5</td>
<td>62</td>
<td>29.5</td>
</tr>
<tr>
<td>Mechanized well</td>
<td>28</td>
<td>21</td>
<td>13</td>
<td>62</td>
<td>29.5</td>
</tr>
<tr>
<td>Hand dug well</td>
<td>21</td>
<td>9</td>
<td>14</td>
<td>44</td>
<td>21</td>
</tr>
<tr>
<td>River/dam/stream</td>
<td>9</td>
<td>21</td>
<td>12</td>
<td>42</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>98</strong></td>
<td><strong>68</strong></td>
<td><strong>44</strong></td>
<td><strong>210</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: This study, 2012

Table 4.5 shows that communities in the Upper Denkyira Municipality, namely Dunkwa-Offin, Ayamfuri and Oponsu have access to GWCL treated water either from pipes connected to their homes and/or desired points or through public stands pipes and/or tanker service. The degree of access to the services of the GWCL, however, depends on the level of centrality of the settlement; higher order service centres generally have more access to pipe borne water than low order service centres (Getis et al., 2006). This is because the GWCL is primarily aimed at serving urban towns (Bacho, 2001). This explains why Dankwa-Kadadwen as the largest of the three study communities experiences a greater response rate of 40, constituting 41% of its sample population of 98, compared to Ayamfuri and Oponso with absolute responses of 17 and 5, constituting 25% and 11% of their respective sample populations.

Plate 4.1 shows consumers of moderate income class and low income class drawing water from a public standpipe and a locally protected dug well respectively at Dunkwa-Kadadwen. Public standpipes are meant for low income households in urban towns, while the middle and high income groups are mostly connected to individual household pipes, but all based on the demand approach of water delivery services (Bacho, 2001). By this approach, public water services are provided upon the expressed demand of the prospective beneficiaries. The high level of patronage at the facility (standpipe as seen in the picture) reveals the affordable
nature of water tariffs compared to private connections, due to cost sharing (SNV, 2009; cited in Bukari, 2011).

Other sources of water indicated on Table 4.5 are mechanized wells of various kinds (such as those fitted with taps, lever systems and hand pumps). Table 4.5 shows that households in the study area have equal access to pipe borne water and mechanized wells, as the cumulative response rate for the source of household water was 29.5% for each of the two sources. Of the 98 sample households interviewed in Dunkwa-Kadadwen, 28 of them (constituting 25.5%) use mechanized wells. In the relatively smaller communities like Ayamfuri and Oponsu, 21 and 13 households, representing 30% each of their respective sample household populations of 68 and 44 also use mechanized wells.
The findings collaborates the interview results with both the Community Water and Sanitation Agency (CWSA) and the GWCL officials, which indicated that low cost water supply infrastructure is basically meant for suburban and rural settlements, with the level of technology used depending on affordability or degree of centrality of a settlement. Plate 4.2 shows a hand-pump mechanized well being operated in a vertical position by an eight year old boy at Ayamfuri.

Oponsu, being the smallest of the three communities, has a higher level of dependence on hand-dug wells without mechanized pumping systems, and about 14 households of the sample of 44 for this zone (constituting 32%) use this source. Households in both Ayamfuri and Oponsu have significant levels of usage of other untreated sources of water such as rivers, streams and dams.

Plate 4.3 shows a picture of women and children drawing water from a hand-dug unprotected concrete well at Oponsu.
The bushy background of the picture shows that Oponsu is more rural compared to Dunkwa-Kadadwen and Ayamfuri. Obviously, modern hand-dug wells with concrete constructions are mostly financed and owned by groups of households in communities in which they are found. The low level of technology involved does not require the use of external contractors for their construction. They are usually outcomes of communal labour, and the services are mostly free.

What is of concern in this study is the need to establish a comparative assessment of the level of consumer satisfaction on the basis of accessibility to services, water availability, nature of facility distribution, affordability and water quality, with a view to come out with the service type that suits the socio-economic threshold of consumers at different strata of the urban/suburban settlement (Abram, 2000).

4.3.2 Accessibility to the Water Sources

Knowledge of the type of potable water infrastructure at any given location would be inadequate for social services planning without an examination of the accessibility to these facilities. In other words, the issue of proximity of the facilities to the target beneficiaries is a major area for discussion. Table 4.6 shows how respondents view the proximity of the water sources to their homes in the three communities studied.
Table 4.6: Proximity of water sources to households in the Dunkwa-Offin Municipality

<table>
<thead>
<tr>
<th>Proximity</th>
<th>Dunkwa-Kadadwen</th>
<th>Ayamfuri</th>
<th>Oponsu</th>
<th>Total</th>
<th>Percen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very near</td>
<td>18</td>
<td>6</td>
<td>2</td>
<td>26</td>
<td>12%</td>
</tr>
<tr>
<td>Near</td>
<td>22</td>
<td>16</td>
<td>9</td>
<td>47</td>
<td>22%</td>
</tr>
<tr>
<td>Distant</td>
<td>46</td>
<td>25</td>
<td>17</td>
<td>88</td>
<td>42%</td>
</tr>
<tr>
<td>Very distant</td>
<td>12</td>
<td>21</td>
<td>16</td>
<td>49</td>
<td>24%</td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>68</td>
<td>44</td>
<td>210</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: This study, 2012

The data shows that proximity to the water sources varies according to the sizes of the communities. Dunkwa-Kadadwen being the largest had an absolute response rate of 18 for being very near to the water sources, which is about 18% of its sample population of 98. Comparatively, Ayamfuri and Oponsu had about 9% and 5% respectively for the same response. Generally, however, the water sources are distant, as this received the greatest cumulative response rate of 42%, compared to 12%, 22% and 24% for very near, near and very distant respectively, as seen in Table 4.6. This findings are consistent with the ideological basis of the Central Place Theory postulated by Walter Christaller, that higher order centres serve as central places where goods and services are concentrated, and provide such services to the hinterlands (Getis, Getis and Fellmann, 2006).

The generally distant nature of the potable water sources calls for the need to re-examine the types of infrastructure used in terms of technology and cost involved and how these impact on their distribution in the municipality. Table 4.5 illustrated that pipe-borne and mechanized well sources dominate in the municipality with 29.5% response rates each. JICA (1997) reported that the provision of piped water is generally more expensive both in terms of infrastructural outlay and operational cost, especially in developing countries. These factors contribute to the inability of governments in developing countries to make adequate provision of these facilities at convenient distances to households in rural areas. It is however worth examining whether the people of the Dunkwa-Offin Municipality are satisfied with the distribution of the potable water sources over space.
4.3.3 Distribution of Potable Water Infrastructure

Figure 4.2 shows the presentation of the data relating to the distribution of potable water infrastructure in the Dunkwa-Offin Municipality. The zoning system was designed after a careful study of the urban land use structure of the municipality in general (covering, but not exclusively, the three communities studied). The design followed the land use pattern stipulated in the Sector Model of urban land use, which maintains that residential areas are separated by transportation arterials, and with the Central Business District (CBD) at the centre, high rent residential areas expand outward along major transportation routes (roads, railways, etc.). Middle income housing cluster around the housing for the rich, and low income/working class housing (commuters’ zone) occupies land around areas of industry (Getis et al., 2006).

![Bar Chart]

**Figure 4.2: Distribution of potable water infrastructure at Dunkwa-Offin**

Source: This study, 2012

From Figure 4.2, it can be seen that there are differences in the distribution of potable water sources between the different sectors of land use in the Dunkwa-Offin Municipality. The
data labeled in percentages on the bars of Figure 4.2 indicate that the distribution favours the zones of middle/rich people’s homes, the CBD and the industrial/commercial areas and the responses indicate that they have more even distribution of water sources. The determinant of this pattern of distribution of water sources is basically effective demand. In order words, it is influenced by the Demand Approach in the first place, where the provision of services by the GWCL and other private sector operators give attention to areas whose residents or land users express interest in the extension of services to them (Bacho, 2001); the efficacy of this also depends on the willingness and ability to pay (Kendie, 1992). Expressed differently, a settlement area requesting for extension of the services of the GWCL should be able to cater for the cost of installation of service components, as well as the expressed ability to pay for services regularly. In the same way, a request for the construction of mechanized wells by settlement areas goes with the ability of the applicants to cover, at least, the 10% of the investment cost, provided the District Assembly and the Donors are prepared to cover their 10% and 80% quotas respectively (Bacho, 2001).

These conditions obviously mean that low income settlements would have unfavourable access to potable water sources. This explains why the zones of transition and commuters’ zones have high response rates for not satisfactory and uneven distribution of water sources in Figure 4.2. What this study purported to establish is the identification of the type of potable water supply facilities, and whether the criteria used in the selection of such facilities for the various zones incorporate adequate urban pro-poor rhetoric, and what alternative remedies are available for any short-comings (Bukari, 2011).

### 4.3.4 Availability of Potable Water

Figure 4.3 shows the factors that influence the availability of potable water in the three zones of the Dunkwa-Offin Municipality.
Figure 4.3 shows that more respondents at Dunkwa-Kadadwen (25%) perceive that there is regular supply of potable water in their area, compared to Ayamfuri (18%) and the smaller community of Oponso (9%). This also indicates that the regularity of water supply increases with the degree of centrality of a service area (Getis et al., 2006).

The supply of water is determined by both natural and human factors (Carla, 2003). Naturally, the hydrological cycle, basically involving evapo-transpiration, condensation and precipitation levels determines the natural availability of water at any given location on earth. Thus, from Figure 4.5 the most serious factor negatively impacting on the availability of potable water as indicated by the highest points of the curves is season fluctuation, with a cumulative percentage of 34% response rates, which is naturally determined. In other words it is caused by instabilities in underground aquifer water tables, which is determined in the first place, by the level of precipitation percolating into the ground after evaporation and channelization of runoff by man into reservoirs, and in the second place by the level of pumping of underground water to meet the needs of increasing populations due to high demand for water (Beaumont, 1993). The other human factors influencing water availability is pressure on the physical infrastructure without periodic maintenance, which results into irregular supply due to technical faults with a
cumulative response rate of 26%. This problem is often exacerbated by either delays in reporting the faults to service providers by the facility users, or failure of service providers to report promptly for the rectification and correction of the faults, or both (SNV, 2009).

Apart from the natural factors over which man has no immediate control, the researcher was interested in determining whether these causalities vary according to the type of water supply technology used, and whether there were variations in the extent to which the impacts were felt. In other words, is it low cost water sources that are most frequently breaking down without immediate solutions by the domestic users or the more expensive pipe-borne sources? How do these impacts vary according the centrality of a location and by income stratification? Finding solutions to these questions elsewhere in this study was contributory to addressing the situation by policy recommendations through the re-examination of low cost technology as an alternative.

### 4.3.5 Affordability of Potable Water

The affordability of potable water depends on the general price level relative to the income levels of the consumers. Interview with the GWCL officials revealed that the principal pricing method adopted at the various potable supply outlets that are metered is the Increasing Block Tariff (IBT). This simply means that higher consumption brackets attract higher tariff rates than lower brackets (Munasinghe, 1994; Nkrurnah, 2004). Generally, 28 liters of water is used as the standard measurement for potable water drawn from public standpipes, boreholes and protected wells. In 2011, the price of 28 liters of pipe-borne and tube well/borehole water was 10 Gp, while that of water from shallow protected hand dug well was 5Gp. In the same year, 750 liters of water from a water tanker was GH¢ 30. By 2012, the persistent increases in fuel prices and the resultant inflation among other factors stimulated an upward increase in utility tariff rates including water. Thus, 28 liters of water from public standpipe had a 100% increase in the price (from 10 Gp to 20Gp). There was a similar percentage increase in the price of the same quantity of water from dug well (from 5Gp to 10Gp), while that of borehole increased by 50% (10Gp to 15Gp) for the same quantity of water within 2012. Water tanker services for 750 liters of water also increased by 50%; from GH¢ 30 to GH¢ 45.
Table 4.7 shows the perceptions of respondents about the general price levels of potable water in the three zones of the Dunkwa-Offin Municipality studied, namely Dunkwa-Kadadwen, Ayamfuri and Oponso.

<table>
<thead>
<tr>
<th>Perception of water</th>
<th>Dunkwa</th>
<th>Ayamfuri</th>
<th>Oponso</th>
<th>Total</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kadadwen</td>
<td>Ayamfuri</td>
<td>Oponso</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>68</td>
<td>42</td>
<td>34</td>
<td>144</td>
<td>69</td>
</tr>
<tr>
<td>Moderate</td>
<td>18</td>
<td>16</td>
<td>6</td>
<td>40</td>
<td>19</td>
</tr>
<tr>
<td>Low</td>
<td>12</td>
<td>10</td>
<td>4</td>
<td>26</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>68</td>
<td>44</td>
<td>210</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: This study, 2012

Table 4.7 shows that generally, the potable water price level is high, since about 69% of the total sample population of 210 holds this view, while only 12% feel the price level is low. By an examination of the pattern of responses in the individual zones, it is apparent that there are similarities in the perception of water price level among the zones. Thus, 68 respondents (69% of its sample size of 98) in the larger Dunkwa-Kadadwen community see water price to be high. At Ayamfuri which is the second largest of the three communities, 42 respondents (62% of its sample size of 68) see water price to be high, while in the smaller community of Oponso 34 respondents (72% of its sample size of 44) consider water price to be high.

By recalling the types of potable water infrastructure in the various areas discussed earlier in this chapter, it was clear that Dunkwa-Kadadwen is dominated by piped water facilities while Oponso is dominated by hand dug wells. Focus group discussion and key informant interview results revealed that in the larger Dunkwa-Kadadwen settlement, the high cost of potable water is attributable to the high cost of technology and operational costs involved. Interview with the GWCL officials revealed that the pricing method used is the Increasing Block Tariff (IBT). By this method, there is a lifeline rate, which is a given level of consumption in liters free of charge. Any additional consumption above the lifeline rate is chargeable and taxable at rates determined by the GWCL (Munasinghe, 1992; cited in Bukari, 2011).
Though by nature the IBT is low income friendly, the pressure on water facilities in urban settlements like Dunkwa-Offin coupled with ignorance on the effects of wasting water at the pipes on tariff levels, pushes consumption levels far above the life line rate at the public standpipes meant for the urban poor. This causes the IBT rate to be more regressive as the poor rather begin to pay higher water tariffs than the rich with private home connections; some of who do remain below the life line rate for several months (Bukari, 2011). The high water tariff situation for the urban poor is often worsened by frequent increases in utility tariffs including water, ranging between 10% and 20% which further contributes to rapid increases in potable water prices.

In the smaller Oponso community, where the well water is almost free, the response is associated with the price paid for piped water brought by water tankers (in which the water vendors add additional cost of transportation and profit margin to the already high cost piped water), in the face of high level of poverty, which is characteristic of rural agrarian communities in Ghana and other parts of the world (Kendie, 1992; Seini, 2002).

Affordability of potable water is therefore a general problem to both the rich and the poor, high order and low order settlements. This explains why about 79% of households in the Dunkwa-Offin Municipality use less than 36 liters (60 buckets) a month, which is less than 50 liters of water recommended as essential for meeting the basic need or maximizing consumption for the promotion of good health or general social welfare (GWSC, 1969). It therefore became necessary to identify the common cause of this appalling situation, and attempting to find a common solution to it later in this work.

4.3.6 Water Quality

Table 4.8 shows the distribution of responses across the three zones of the Dunkwa-Offin Municipality that were studied, concerning the quality of potable water in the area.

Table 3.8: Perceptions of respondents about potable water quality

<table>
<thead>
<tr>
<th>Perception of water quality</th>
<th>Dunkwa-Kadadwen</th>
<th>Ayamfuri</th>
<th>Oponso</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>50</td>
<td>30</td>
<td>7</td>
<td>87</td>
<td>41</td>
</tr>
<tr>
<td>Bad</td>
<td>36</td>
<td>28</td>
<td>33</td>
<td>97</td>
<td>47</td>
</tr>
<tr>
<td>Don’t know</td>
<td>12</td>
<td>10</td>
<td>4</td>
<td>26</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>68</td>
<td>44</td>
<td>210</td>
<td>100</td>
</tr>
</tbody>
</table>
The data in Table 4.8 reveals that perceptions of water quality differ among the three communities, and that it tends to be favourable in higher order settlements than the lower ones. Thus, Dunkwa-Kadadwen had a higher response rate of 50% for good quality of water compared to Ayamfuri (30%) and Oponso (7%).

If one refers back to the sources of water discussed earlier in this chapter, it could be understood that the quality of potable water is associated with sources of dominant potable water infrastructure in the respective communities. Generally, 41% of the respondents felt that the quality of water was good, 47% felt it was bad while the remaining 12% do not know about water quality. Though the local people may not be able to describe water quality in terms of its analytical chemistry, focus group discussion results indicated that their judgment is based on the colour, taste and smell. They have the basic knowledge that good water should be colorless, tasteless and odorless.

To verify these responses in a more scientific way, water samples were collected and taken to the GWCL laboratory for testing. Table 4.9 shows details of the water sample collected from dug wells. Dug wells were considered because consumers stand a higher risk since most of the wells are unprotected shallow hand dug wells (Evans, 1984). This does not ensure water quality through the constructional set-up, nor were there any deliberate treatment schemes.

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Na (mg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12.5</td>
</tr>
<tr>
<td>2</td>
<td>18.8</td>
</tr>
<tr>
<td>3</td>
<td>23.5</td>
</tr>
<tr>
<td>4</td>
<td>30.2</td>
</tr>
<tr>
<td>Total</td>
<td>84.5</td>
</tr>
<tr>
<td>Mean</td>
<td>(\frac{\text{EX}}{N})</td>
</tr>
</tbody>
</table>

Source: This study, 2012

The Water was filtered using samples from each layer from horizon 1, 2, 3 and 4 with the purpose of determining the Iodine levels of samples in hand Dug wells. Iodine in the sample was
corrected with specific quantities of Na, \((\text{Na}^+)\) and \((\text{Na}^{+} \text{Ca})\) in mg\(^{-1}\) as indicated in the right column of Table 4.9, in the horizon of the study and the \(r^2\) values of 40 and 508 were obtained from Na and \(\text{Na}^{+} \text{K}\) respectively while the correlation with Ca and Mg were very low (<10%). Figure 4.4 shows regression line associated with the test.

\[
y = 0.5067x + 17.191
\]

\(r^2 = 0.4036\)

**Figure 4.6: Regression line showing the result from the sample and the correlation factor**

*Source: Field survey, 2012*

Where \(r^2\) is the standard deviation of the sodium content of the water sample; if this falls below 0.4036 there will be deficiency of hyponatremia disease in the water. Sodium content of water falls below this level as a result of leaching. \(Y\) is the total sodium content of the soil horizon of the well from which the water samples were collected, while \(x\) is the gradient.

Interviews with health officials at the Dunkwa-Offin Hospital indicated that this state of well water has some adverse health implications on regular uses. Obour (2000) observed that salt compounds like hexadrate \((\text{COCl}_2, 6\text{H}_2\text{O})\) and other salt compounds found in well water can affect dental health negatively, the health officials added. The officials also disclosed that in Oponsu, where well water serves as a major source of potable water, research findings indicated that the outbreak of Buruli Ulcer in this community in 2006 was due to contaminated
unprotected well water. This is because most wells were not covered and generally lacked hygienic surroundings.

How this state of water quality among other problems are influencing future policies as an indirect or direct form of preventive health service as well as social welfare maximization have been explored, and any identified gaps addressed through policy recommendations in later sections of this work.

4.4 Low Cost Water Supply as an Alternative to other Sources of Potable Water

Beginning from the year 2006 to date, the increasing population of the Dunkwa-Offin Municipality, and the associated high demand unmatched by the scarcity of quality potable water, exacerbated by wide-spread water-borne diseases drew the attention of the Upper Denkyira District Assembly policy makers to reconsider the situation of potable water supply in the area, with emphasis on improving low cost water supply sources as alternatives to the more expensive piped water services which many poorer settlements do not benefit from (Upper Denyira District Medium Term Development Plan, 2006). This section considers the factors that stimulated the need for developing low cost water supply sources, and how the interventions are meeting the anticipated outcomes.

4.4.1 Factors that Influenced the Re-adoption of Low Cost Water Supply Technology

Although low cost water supply technology existed in the study area, it is important to re-examine the factors that led to the placement of emphasis on the development of this component of the water sector in the study area. Figure 4.5 presents respondents’ views on the reasons why it was important to expand and develop low cost water supply sources as alternatives to other sources, such as piped water.
Figure 4.5: Reasons for low cost water supply

Source: This study, 2012

Figure 4.5 shows that 33% of the respondents were of the view that competition between piped water infrastructure and low cost water sources creates a situation where the location between prospective consumers and mechanized wells for the poorer urban settlers appear to be distant, while the available public standpipes which are equally distant, face much competition among consumers resulting into women and children spending long periods of time waiting to draw water. Additionally, the relatively expensive nature of better sources of potable water, such as pipes and mechanized boreholes (which received 17% response rate) creates a situation where they appear to be inadequate relative to the urban population size and demand, thus creating the problem of uneven distribution of the facilities in the area, which also accounted for the next highest responses of 29%.

It was therefore realized that the identification of cheaper forms of mechanized wells to suit the income levels of poorer urban settlers in all zones of the municipality, would facilitate more construction of such wells to reduce distance for accessibility and congestion at the facilities (Abrams, 2000/2001). Furthermore, the poor relationship between the GWCL officials and the lack of community ownership initiative in public water services, do not encourage reporting of detected faults such as leakages and breakdowns associated with delivery and service components of public water infrastructure, thus delaying repairs (Nkrumah, 2004). This,
in addition to natural factors such as inadequate rainfall to facilitate adequate seepage into the ground water aquifers to increase the water table (Beaumont, 1993), brings about irregularities of water supply, with a response rate of 19%.

These were the major contributory factors to the development of low-cost water supply infrastructure with the purpose of improving upon accessibility, distribution, affordability, regularity of supply and water quality among others (Michael, James and James, 2011).

4.4.2 Major Types of Low Cost Potable Water Supply Facilities in Focus for Development

Earlier in this chapter, we came across the general sources of water in the Dunkwa-Offin Municipality. This section is, however, focused on low-cost water supply infrastructural development as a way of overcoming some of the potable water supply constraints. The study revealed that there were some existing sources of water before the drive to low-cost water supply technology as an alternative. These are considered as the unimproved sources in this study (Michael et al., 2011), since the interventions in low-cost water supply beginning from 2006 did not tackle these. They include the under-listed:

- Unprotected surface water sources (dams, streams, rivers)
- Unprotected dug wells
- Tanker truck services
- Public tap/standpipes
- Private household tap systems

On the other hand, the failure of the above sources of water to adequately meet the special needs of low income water users in the study area in terms of affordability, water quality and accessibility among others led to the re-adoption and development of low-cost water supply technologies, which were people centered, and could properly be described as appropriate technologies (Evans, 1984). These include the following:

Shallow hand dug protected wells, with lined walls and covers, often for domestic household uses serving one or a few neighboring households. Field observation and interview results indicated that these are now being provided at the more rural Oponsu at lower costs. They fitted with very simple manual operation mechanisms such as rope and pulley system.
Tube wells/boreholes, which are constructed deep underground to reach water aquifers more than 10m of depth. These are often constructed for large scale uses with open public access in the locality in which they are found, except where restrictions are imposed on who qualifies to use the facility. They may also be constructed by private individuals for commercial operations. They are also constructed for schools, hospitals, and other organizations. The principle of Village Level Operation and Maintenance is important with hand pumps (Evans, 1984). This implies that the level of technology involved in the construction of hand pumps depends on how rural or urban a locality is: the more rural a beneficiary community, the less complex the operation and maintenance of the hand pump mechanized well. Thus, Oponso for instance has moved from the use of the unprotected hand dug operated by means of stringed containers (see Plate 3), to the protected hand dug wells with rope and pulley systems as well as boreholes with simple hand pumping mechanisms, while Dankwa-Kadadwen can now boast of gravity piped water supply making use of mechanized well water.

Rain water harvesting systems, with an appropriate method of storage including underground constructed reservoirs, as well as the use of plastic and metal tanks into which rain water is directed under hygienic conditions. The reservoirs may be fitted with hand pumps, taps or pulley system depending on the volume of water being served (JMP, 2011). They are constructed for housing structures (catchment areas) with corrugated roofing iron sheets to which a gutter/drainage system is attached, which guides the rainwater that falls onto the roof to a storage tank, and are designed for households, as well as schools, hospitals and other public and private sector institutions as primary or secondary sources of water (Mihelcic et al., 2009). They are found in all the three zones of the municipality studied, but dominated in the larger Dunkwa-Kadadwen community, especially in the homes of the wealthy people and public quarters occupants who can afford to buy poly-tanks for use as reservoirs.

The distribution of the various types of the low-cost water supply infrastructure varies among the three zones studied. Figure 4.6 is an illustration of the variation.
Figure 4.6: Types of improved low-cost water facilities

Of the three major types of low-cost water supply technologies, 48%, 34% and 25% of the respondents at Oponsu, Ayamfuri and Dunkwa-Kadadwen respectively use shallow hand dug protected wells. In terms of accessibility to tube wells/bore holes the corresponding response rates were 45%, 47% and 40%. Thus, apart from Oponsu which depends largely on protected hand dug wells, the rest of the communities use more tube wells/bore holes than the other sources. Though all other communities extract rain water for domestic uses in one way or another, which is about the cheapest and also the most seasonal source of water, the level of technology that determines the efficiency of the exploitation in terms of more economic quantities (Carla, 2003) is what attracted the attention of this study.

Figure 4.6 shows that rain water harvesting technology is more common in Dunkwa-Kadadwen, with a response rate of 35%, and lowest at the smallest zone of Oponsu, with 7% responses. This is because the effectiveness of rain water harvesting technology depends on the nature of the built environment, especially the type of roofing materials used. Dunkwa-Kadadwen with the majority of middle and high income households compared to the other two
communities, certainly has more housing structures roofed with materials that facilitate effective downward and concentrated running of rain water into constructed channels at the immediate edges of the roofs (such as corrugated aluminum sheets), thence into tubes directed into various forms of reservoirs, depending on the affordability of the water conserver or donor conditionality. It must however be noted that whatever technology prevailed in any community after the public and private sector interventions in low-cost water supply technology was a matter of choice, based on the contributory strength of the beneficiary community among others.

This study was not only interested in the unfolding of the type of technology used for improved low-cost water supply services, but also how the facilities were provided and whether they actually served as a better alternative to the existing methods of water supply in the area. Generally the technologies involved are labour intensive (manually operated), self-help oriented (largely depending on the people’s own initiatives and resource contributions) and people’s technology (where the people’s choice and interest is paramount even if external stakeholders are involved in the provision of the technology (Evans, 1984). The scale of services, investment capital requirement and level of beneficiary participation determines how the low-cost water supply infrastructure is provided, as discussed in the next section.

4.4.3 How Low-cost Water Supply Infrastructure is Provided
In the Dunkwa-Offin Municipality, the provision of low-cost water supply infrastructure as alternatives to the existing sources is facilitated by multiple approaches depending on whether they are community self-help initiated projects, in which case the investment capital and labour requirements are provided by the beneficiaries through the organizing abilities of local civil society groups (youth associations); or it is people centered technology, which does not exclude the participation of external stakeholders in the intervention, but the technology choice is by the people, such that it suits their local conditions. These included ability to meet their quota contribution, ability to operate the facility with ease and issues of sustainability (Evans, 1984; Abrams, 2000/2001).

Table 4.10 shows the various stakeholders of low-cost water supply technology in the municipality and their associated characteristics. With the understanding that the public sector piped water system among other sources were not considered as part of the low-cost water
supply systems as alternative sources of water in the study area, this automatically cuts out the dominant GWCL in the public water sector.

**Table 4.10: Stakeholders of low-cost water supply technology**

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Sector</th>
<th>Level of recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local civil society groups</td>
<td>Local community</td>
<td>30%</td>
</tr>
<tr>
<td>Municipal Assembly/CWSA</td>
<td>Local Government</td>
<td>30%</td>
</tr>
<tr>
<td>CIDA</td>
<td>International/Private</td>
<td>14%</td>
</tr>
<tr>
<td>World Vision</td>
<td>International/Private</td>
<td>12%</td>
</tr>
<tr>
<td>Others</td>
<td>Local/Private</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: This study, 2012

Both the local community civil society groups and the Municipal Assembly/CWSA were identified as the major stakeholders in the provision of low-cost potable water supply technology with a response rate of 30% each. This is because, being of the local community and the Local Government (which is represented by the Community Water and Sanitation Agency-CWSA) sector institutions, they are usually the initiators and intermediate funders of local level development projects jointly or independently, and constitute focal points for community entry for any externally influenced community development projects. For instance at Ayamfuri and Oponsu, most of the protected wells were constructed by the youth associations through communal labour and financial contributions for local material requirements.

The Canadian International Development Agency (CIDA), which is an international private sector development partner, is the next in rank in terms of respondents’ recognition with a response rate of 14% for its contribution in the design and construction of various forms of low-cost water supply technologies, especially tube wells/boreholes and gravity piped water facilities using the people centered approach (Evans, 1984). World Vision was also recognized with a response rate of 12% for its roles in the part funding of low-cost water supply projects. It also recommends technological designs that ensure water quality for the good health of low income beneficiaries, especially in the Ayamfuri and Oponsu communities, where it initiated and funded the rehabilitation of some local wells as well as the construction of new mechanized wells. Renovation of existing wells usually involves converting them into protected wells, while
new ones are usually of large scale uses serving more households, basic and senior high schools in the form of boreholes and rainwater harvesting systems.

The others, recognized with a response rate of 14% are made up of resident local private contractors engaged in the construction of low-cost water supply infrastructure. The notable ones are Offin Mechanized Wells Co. Ltd. and Champion Man Water Co. Ltd. They can be contracted to construct shallow protected wells, boreholes and rainwater harvesting systems by private individuals, civil society groups, donors like World Vision and the Local Authority through the CWSA.

The efficiency of these local contractors in this field of operation was not covered in the scope of this study, but Kathy (1999; as cited in Bukari, 2011), notes that the involvement of private sector local institutions in community projects is vital if good results are expected from project monitoring, evaluation and sustainability, due to the added advantages of their familiarity with the local conditions and proximity to project locations for easy communication for feedback and review by face-to-face approach, even long after the project implementation phase.

This institutional framework provided the structure within which the low-cost water supply strategy in the study area is being implemented. However, since no project can come to a perfect realization without the identification of the inputs and/or resources, it was considered necessary to examine the sources of funding the low-cost water supply projects in the study area as considered in the next section.

4.4.4 Sources of Funding Low-cost Water Supply Infrastructure

The study revealed that the funding of low-cost water supply projects depends on a number of factors as indicated in Figure 4.7.
Figure 4.7 shows that, the most important determinants of the sources of funding low-cost water supply projects known to the respondents are ownership of the facilities and intended scale of operation. These had 25% response rates each. By ownership of the facility, the study sought to determine whether the sources of funding depend on individual household ownership, community self-initiated project, public sector ownership, private sector ownership, or public-private sector ownership. Focus Group Discussion (FGD) with both men and women groups indicated that when the facility is to be constructed for an individual household, then irrespective of the nature and cost of the project, the entire cost is financed by such a household from its own resources, but does not exclude the ability to source personal loans and other financial assistance from sources known to that household.

Community owned or self-initiated projects are usually of medium scale in nature and are funded by contributions made by individual households considered to be prospective beneficiaries of such projects, and are usually organized by local civil society groups or traditional leaders. With the exception of requests for extension of piped water services of the GWCL, where the cost of provision of delivery components are borne by the service provider,
while the cost of service components is borne by the beneficiaries (Bukari, 2011), the community bears the total cost of constructing low-cost water supply infrastructure (such as mechanized wells) if it is a self-initiated project. For example in 2010, the youth of Mempeasem, a subsection of Dunkwa-Kadadwen successfully organized their community members to contribute for the construction of a borehole. Where such projects are of interest to the Municipal Assembly and other donors, then it becomes a tripartite project involving three sectors (community, Local Authority and the private sector) which has an element of cost-sharing involving a criterion discussed in the next section.

Public sector initiated projects in the area of low-cost water supply technology (excluding piped water services of the GWCL), usually by political initiatives are totally funded from parliamentary approved budgetary allocations. It is also possible for some private sector NGOs to provide low-cost water infrastructure to deprived sections of the urban population in the area. For instance World Vision and CIDA do provide mechanized wells and effective rainwater harvesting facilities to schools and deprived communities like Oponsu, with the beneficiaries contributing only communal labour when required, as well as other forms of expressing appreciation such as gifts for the workers at the project site. Generally, interventions in low-cost water supply projects by government agencies and the private sector are based on medium or large scale projects intended for larger groups of beneficiaries, and the associated costs are considered high compared to the income level of the potential beneficiaries. This explains why the type of technology and cost involved were recognized by the respondents with 24% and 15% response rates as factors influencing the funding sources.

The location of low-cost water supply projects as a factor influencing funding sources received the lowest response rate of 11%. As the theme implies, it should be low income rural communities that should be the target beneficiaries of such projects, since the GWCL caters for the needs of urban settlements in Ghana (Bacho, 2001; Nkrumah, 2004; Bukari, 2011). However, at Focus Group Discussion, a senior citizen exposed: “these days the distribution of every aspect of community development does not follow the objective order. It is influenced by political party affiliation, priority is given to population numbers, not the vulnerable few”. This therefore gives a greater advantage to the larger sections of the municipality in favour of the incumbent political party, to benefit more from projects rather intended for low-income sub-urban settlements, by
manipulating even the benevolent activities of the private sector to follow this pattern to the
detriment of the peri-urban poor.

4.4.5 The Distribution of Low-cost Water Project Costs

Having discussed the factors that influence the sources of funding, it is equally necessary to look
at how the estimated cost of any low-cost water supply project involving multiple stakeholders is
distributed or shared among them. Basically, where the Municipal Assembly, the community
people and a donor are in partnership for a low-cost water supply project, in which the initial
idea of the project identification was externally induced by the donor, or by need expression by
the beneficiaries and a donor accepts responsibility for funding as an external agency, then Table
4.11 presents the expected quota allocation of such a community development project in Ghana.

Table 4.11: Distribution of low-cost water supply project cost

<table>
<thead>
<tr>
<th>Sources of funding</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community contribution</td>
<td>10</td>
</tr>
<tr>
<td>District Assembly</td>
<td>10</td>
</tr>
<tr>
<td>Donors</td>
<td>80</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: This study, 2012

In line with the information in Table 4.11, an interview with the Coordinator of the Dunkwa-
Offin Municipal Assembly confirmed that the Municipality actually encourages private sector
participation in community development projects by making available to interested development
partners of private sector institutions, prioritized areas for interventions, as well as the conditions
for doing so. Where consensus has been established between the prospective community
beneficiaries, the Municipal Assembly and the external or local private sector agency, the
Municipal Assembly contributes 10% of the project cost from the Poverty Alleviation Fund; the
community people contribute another 10% in cash or kind, but usually in the form of communal
labour, provision of land or any other local environmental resource or material that the local beneficiaries are capable of providing. The remaining 80% of the project cost is borne by the donor agency that willingly expressed the desire to do so.

As indicated in the previous section, a community self-initiated project on low-cost water supply project usually has 100% of the budget funded by the groups and households to benefit from the project. For instance, the Parent/Teacher Association (PTA) of Boa-Amponsem Secondary School in the Dunkwa-Kadawen community, in view of serious potable water shortages they had been experiencing in previous years with adverse effects on academic progress, decided to construct a borehole by contributions from the students in 2010. Each student was to pay GH¢10 towards the project, which had an estimated total cost of GH¢2,500, 100% of which was to come from the specified source. Though some low income parents considered the GH¢10 to be too high, the project materialized.

Results also indicated that in the early 1990s, CIDA provided a mechanized well with 100% of the cost (which was undisclosed to the researcher) at the organization’s own expense to the residents of Ayamfuri. Major extensions of piped water delivery mains and mechanized boreholes of various types have been constructed at various zones of the municipality as part of the municipal water and sanitation development projects by the central government with 100% funding, without any contributions from the local people.

However, given the present situations of long distance to potable water facilities, their uneven distribution, seasonal fluctuations in supply, unsatisfactory water quality and generally high water tariff rates among others, it became necessary to determine the most effective way of solving these problems through low-cost water supply technology in terms of their types, investment costs and funding allocations, and how the net benefits contributes to the development of low income urban settlement areas.

4.5 The Contribution of Low-cost Water Supply to Improving Accessibility
The previous discussions on the situation of water supply, the factors that led to the promotion of low-cost water supply technology adoption, the funding sources and the distribution of investment costs would be meaningless if nothing is covered on the importance of these sources of water to the beneficiary communities. This section, therefore, looks at the major uses of the
low-cost potable water and how these promote the social wellbeing of the people and the development of the study area in general.

The study revealed that there are several uses of potable water obtained from low-cost sources to the residents of the study area. Basically, the respondents identified domestic, industrial, agricultural and commercial uses of water from such sources. Table 4.12 is a presentation of the major uses of water from low-cost sources.

Table 4.12: Major uses of water

<table>
<thead>
<tr>
<th>Uses of low water supply</th>
<th>Dunkwa- Kedadwen</th>
<th>Ayamfuri</th>
<th>Oponso</th>
<th>Total</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic uses</td>
<td>43</td>
<td>23</td>
<td>17</td>
<td>83</td>
<td>40</td>
</tr>
<tr>
<td>Industrial uses</td>
<td>25</td>
<td>15</td>
<td>9</td>
<td>49</td>
<td>23</td>
</tr>
<tr>
<td>Commercial uses</td>
<td>21</td>
<td>9</td>
<td>2</td>
<td>32</td>
<td>15</td>
</tr>
<tr>
<td>Agricultural uses</td>
<td>9</td>
<td>21</td>
<td>21</td>
<td>46</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>68</td>
<td>44</td>
<td>210</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: This study, 2012

The data in Table 4.12 supports the view of Miller (1996) that the uses of water vary among localities, regions or countries. In the Dunkwa-Offin Municipality, however, the major use of potable water in the three zones studied is for domestic purposes, including drinking, cooking, washing and bathing. The domestic use of water received the highest response rates across the three zones, with 44%, 39% and 34% for Dunkwa-Kadawen, Oponsu and Ayamfuri respectively, and 40% of the total responses. The second most important use of water from low-cost sources is for industrial uses with response rates of 26%, 20% and 34% for the same communities respectively. The overall percentage of 23% for industrial use in Table 4.12, marvelously consists with the findings of Miller (1996: 258), that “worldwide, about 23% of the water withdrawn is used for energy production and industrial processing”. Agricultural use of potable water from low-cost sources accounted for 22% as the third in importance in absolute terms, while commercial uses received the lowest of 15% responses.
Though in the industrialized countries the agricultural sector is the highest consumer of water withdrawn from groundwater sources (Miller, 1996), this has not been the priority in the study area because agriculture is predominantly rain-fed. Few households, however, use water from low-cost water sources for back-yard or dry season gardening, basically for the cultivation of vegetables. Commercial uses, though received the lowest cumulative response rate of 15%, the degree of importance attached to this use of water was observed to vary with the centrality of the study zones. In the largest of the three zones (Dunkwa-Kadadwen), 21% of the respondents compared to 13% and 5% for Ayamfuri and Oponsu respectively realized the commercial significance of water from low-cost sources. This is because in the larger settlements, apart from water vending, the demand for water for hospitality services (hotels and restaurants), chop bar operators among other is higher than the smaller communities. The next section looks at how these uses of low-cost water influence development in the study area.

Table 4.13 is a presentation of the distinguishing features of low-cost water services that make them suitable for urban pro-poor water services, as identified by the respondents.

Table 4.13: Characteristics of low-cost technology as urban pro-poor water supply

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low investment capital</td>
<td>48</td>
<td>23%</td>
</tr>
<tr>
<td>Incorporates indigenous technology</td>
<td>47</td>
<td>22%</td>
</tr>
<tr>
<td>Affordable tariff rates</td>
<td>40</td>
<td>19%</td>
</tr>
<tr>
<td>Freedom of technology choice</td>
<td>40</td>
<td>19%</td>
</tr>
<tr>
<td>No or very low operational cost</td>
<td>35</td>
<td>17%</td>
</tr>
<tr>
<td>Total</td>
<td>210</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: This study, 2012

Table 4.14 shows that the major characteristic of low-cost water supply technology is low investment capital requirement, with a response rate of 23%. This is because such technologies are small-scale, labour intensive and energy efficient, which are features of the Appropriate Technology originally idealized by Schumacher (1973). This was followed by the recognition that low-cost water supply technology incorporates indigenous technology in their design and not
entirely foreign, with 22% response rate. In other words low-cost water supply methods are people centered (Schumacher, 1973; Jequier, 1976). The people centered nature of this type of technology means that service providers have the ultimate objective of satisfying the interests of the beneficiaries, and so allowing for freedom of technology choice according to their ability to absorb their part of the investment cost and also the affordability of the resulting services, both of which had 19% response rates. In view of the fact that such technologies do not require complex institutional set-ups with salaried employees, as well as varied and expensive inputs, operational costs tend to be low, and this received a response rate of 17%.

These features of low-cost water supply technology are therefore pro-poor in nature as they helped to overcome the problems of dependence on foreign technology, heavy investment capital, high operational cost and limited technology choice options, which are associated with public sector water services as discussed earlier. The next section looks at how these benefits of low-cost water supply technology are influencing development in the study area.

### 4.5.6 How Low-cost Water Supply Contributes to Development

From the previous discussions on the uses of water from low-cost sources as well as their characteristics, one could see that there obviously exists a positive relationship between low-cost water supply and the socio-economic development of low income rural and urban dwellers in developing countries. Table 4.14 presents respondents’ views on how low-cost water supply contributes to their wellbeing.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction of water poverty</td>
<td>52</td>
<td>25%</td>
</tr>
<tr>
<td>Contributes to employment</td>
<td>35</td>
<td>17%</td>
</tr>
<tr>
<td>Reduces urban migration</td>
<td>45</td>
<td>21%</td>
</tr>
<tr>
<td>Ensures water quality for good health</td>
<td>35</td>
<td>17%</td>
</tr>
<tr>
<td>Reduces cost of living</td>
<td>43</td>
<td>20%</td>
</tr>
<tr>
<td>Total</td>
<td>210</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: This study, 2012
Majority of the respondents were of the view that low-cost water supply reduces water poverty (a situation inadequate access to potable water) with response rate of 25%. Water poverty is an issue of universal concern, and its reduction is contributory to meeting the first of the Millennium Development Goals (MDGs), (Castro, 2005). This is made possible by making potable water not only available on sustainable basis, but also affordable to low income urban dwellers. This maximizes their utility satisfaction and promotes their living conditions or social welfare.

Secondly, the use of low-cost water supply sources was observed to be providing employment opportunities with 17% responses. This is evident by the fact the incorporation of indigenous knowledge or technology in the construction low-cost water infrastructure allows the participation of local contractors as covered in the interpretation of Table 4.10. These apart, the dealers of low-cost water technology materials and components, the tariff collectors at the facility sites, the head porter water vendors, and all other entrepreneurs whose activities depend largely on such sources of water, owe their employments partly or wholly, to low-cost water sources. Since these sources of water do not only reduce unemployment, but also social inequality in the distribution of social amenities and enhanced ability to meet other basic needs from the income so generated, then development is said to be taking place (Schumacher, 1973; Todaro, 2006).

It has also been observed that population out-migration to the urban towns from rural and peri-urban settlements is stimulated by pull factor effects such as the availability quality basic utility services such as safe drinking water among others. The adoption and expansion of low-cost water supply facilities in the study area was observed to have reduced the migration of the youth from the previously guinea worm endemic peri-urban areas to the centre of the municipality (Dunkwa-Offin). This received the second highest responses of 21% in Table 4.15. This brings about development as pressure on urban infrastructure is reduced due to over population control, while economically active labour is attracted to stay back in the peri-urban areas for agricultural and other primary and secondary economic activities for themselves and the urban population (Schumacher, 1973).

The basic aim of promoting the provision of potable water is to ensure the good health of the people who depend on such water, by protecting them from water-borne diseases (GWSC, 1969). Accordingly, 17% of the respondents expressed the perception that the promotion of low-cost water supply technology does not only ensure increased supply of water, but also improved water quality that goes a long way to ensure the good health of the people.
This is because the tendency to use untreated water from sources like rivers, streams and unprotected hand dug wells as drinking water is reduced.

Further to this, interview results with the CWSA officials at Dunkwa-Offin indicated that the agency also embarks on water quality improvement projects periodically, with a focus on low-cost water sources. This basically involves chlorine disinfection, through the application of calcium hypochlorite powder and sodium hypochlorite solution into the mechanized and protected wells (Jequier, 1976). The agency also educates and encourages low-income areas with unprotected hand dug wells to seek their services for the disinfection of such wells. These water quality improvement projects led to the reduction of the incidences of water-borne diseases such as guinea worm and Buruli Ulcer, especially in the Oponsu community, where there is too much dependence on unwholesome water sources as discussed earlier.

The positive development implications of improved water quality in the area are that, apart from good health, productivity continues with increased output per unit labour force since there is no interruption on the grounds of ill-health.

Finally, the affordable nature of water from low-cost sources means that there is a reduction in the net expenditure on utility services, thus, allowing households to save money for other life goods, as a good proportion of the respondents (20%) recognized the potential of low-cost water supply to reduce their cost of living. Generally therefore, the emphasis on low-cost water supply technology in the area was aimed at shifting the development of potable water infrastructure from a bias towards the central place to, to a focus on the hinterlands (Schumacher, 1973). There are, however, some challenges associated with low-cost water supply in the area, that are worth identifying in order to establish a foundation for a better future for this branch of community potable water supply. The next section looks at some of these challenges.

4.6 Challenges of Low-cost Water Supply

The efforts being made to provide affordable potable water in the Dunkwa-Offin Municipality through the promotion of low-cost technology are never without some constraints or challenges. These challenges however vary from one study community to another. Figure 4.8 is a pictorial presentation of ideas of the respondents on some of the challenges.

The study revealed that despite efforts aimed at reducing urban bias in the allocation of Municipal Assembly resources for infrastructural provision, the tendency still exists as development projects in the areas of water and sanitation still tend to be in favour of the
Dunkwa-Offin township as the central place. However, Figure 4.10 shows that comparatively, this challenge received the lowest response rate across the three zones studied, with a cumulative lowest response rate of 16% or 34 out of the 210 responses, signifying some positive impact of the low-cost water projects on this aspect of urban planning (Schumature, 1973).

Since the low-cost or Appropriate Technology Approach does not imply absolute governmental or donor funding of the related projects, but which are meant for the poor, then certainly, one could predict facing the challenge of low participation when it comes to the issue of cost-sharing in multi-stakeholder projects such as a tri-sector partnership project in terms of beneficiary willingness and ability to pay (Bukari, 2011). This opinion did not only receive the second highest cumulative response rate of 28% (59 out of 210 responses), but the pattern of the responses among the three zones in Figure 4.8, seem to reflect that the lower order zones which are more agrarian and as such of lower income status (Kendie, 1992), tended to have higher responses to this question. Thus, in an ascending order of centrality, Oponsu, Ayamfuri and Dunkwa-Kadadwen had 32%, 30% and 26% responses respectively.

This situation explains why a PTA rule of GH¢10 contribution per student for a mechanized well at Boa-Amponsem Senior High School was met by the wrath of some low income parents who considered the amount to be too high.
Figure 4.8: Challenges of low-cost water supply in the Dunkwa-Offin Municipality

Further to the above challenges, the issue of water quality received serious respondent reaction as a majority of them (highest cumulative frequency of 68 out of 210 constituting 32% response rates), expressed the view that water quality was still a problem in the area. Figure 4.10 shows that among the three zones, Dunkwa-Kadadwen had the highest response level of 39% concerning water quality as a problem. This is very interesting since it has the best potable water infrastructure, dominated by public standpipes and household connections, as well as the best of the low-cost water supply technology, mainly boreholes or tube wells (Mihelcic et al., 2009).
This study found explanation to this in a focus group discussion with both men and women groups at Dunkwa-Kadadwen, and the reasons were that physically, grayish sediments were found to settle at the bottom of a container after drawing and keeping pipe-borne water for some time; water from boreholes are usually either salty or not very clean in colour, while water from protected wells could be observed to contain sandy particles from the bottom of the well apart from their milky appearance.

In the case of wells, the quality of water depends on the type of aquifer on which they are constructed. Soft and shallow aquifers usually have little water and of poor quality (Beaumont, 1993). Such wells run short of water after the rainy season leaving very little water, such that when disturbed in the process of drawing the water, it easily mixes with the soil sediments beneath the well, thus negatively impacting on the water quality. The GWCL on their part explained that there are various treatment methods, and that particles found in water does not necessarily mean that the water is polluted. That some of their treatment plants depend on the intermittently operated slow-sand filtration, also known as biosand filtration. Under such circumstances it is possible for much smaller sandy particulates to escape, but remain harmless to health in view of the additional disinfection processes that are carried out, including chlorine disinfection and chemical flocculation (WHO, 2006).

In the case of Ayamfuri and Oponsu, the concern of the 26% and 27% respondents of such communities were that, a majority of the people (about 41%, see Table 3.5) still depend on unprotected hand dug wells and other natural sources such as streams, and that such water is very bad to health. So if low-cost water projects are pro-poor oriented, then considerations should be given to ensuring water quality for such classes of people as well, they argued.

On the issue of sustainability, about 23% of the total of 210 respondents was not certain about the sustainability of low-cost water supply technology. Ayamfuri and Oponsu had higher response rates of 26% and 25% respectively to that question. The explanation was that though such technologies are people centered and incorporates indigenous knowledge; very few local people are interested in acquiring technical skills for the maintenance of the facilities during break-downs. Some private sector partners do offer training for some members of the youth including women on the repair and maintenance of mechanized wells, but after a short period, the trained youth migrate out of the peri-urban areas to the town center and other larger towns in search of better jobs. Additionally, it was revealed in a focus group discussion that the interest to comprehensive answers to the research questions and to contribute to identified gaps in the existing body of knowledge in practice in urban pro-poor low-cost water supply. The final chapter considers these issues as the summary, conclusions and recommendations.
5.1 Introduction

This chapter winds up the study by presenting summaries of the discussion on the various themes covered. The emphasis is on addressing the research questions and objectives, as such the subtitles herein, reflect the analytical themes derived from the objectives, and the associated questions recalled and how the study addressed each one. A conclusion was drawn on how low-cost water supply sources serve as alternatives to other sources in urban areas, with the study location as a case study. Recommendations are also made for addressing any remaining gaps or challenges as the researcher’s contribution to existing body of knowledge and practice in urban pro-poor water supply.

5.2 Summary of Major Findings

The ensuing sections and subsections present the summaries of the major findings from the pre-analysis and analytical chapters.

5.2.1 Background and Theoretical Orientation

The subject matter of the study was Urban low-cost water supply as an alternative to other sources: the case of Dunkwa-Offin in the Central Region, Ghana. The research problem was focused on investigating into the approaches used in meeting the needs of deprived urban populations through low-cost water supply as alternatives to the more expensive public and private sector water services. This was to be addressed by finding answers to the following research questions: What is the general condition of water supply in the area? How does the provision of low cost water supply serve as an alternative to other sources? What are the challenges in low cost water supply? What can be done in low cost water supply for a better way forward?

In terms of justification, the findings of the study could inspire both public water suppliers and consumers to make comparative decision between mechanized low cost water technology and other water sources with regard to cost and quality. It could also serve as a means
of partial measurement of the achievement of the MDGs.

Theoretically, The central Place Theory (CPT) and the Sector Model constituted the major theories that shaped the analysis of applicable themes. The theories helped to establish the relationship between settlement types, functions and distribution of potable water infrastructure, and the significance of low-cost technologies in bridging identified spatial gaps.

5.2.2 The Research Methodology
The study location was in the Upper Denkyira Municipal area in the Central Region of Ghana. Dunkwa-Kadadwen, Ayamfuri and Oponsu, are sub-sections or communities selected by simple random sampling methods from the capital of the Municipality: Dunkwa-Offin for the purpose of the study.

The study adopted the descriptive study design, aided by both qualitative and quantitative approaches, and a sample size of 210 was chosen using the non-statistical method. Both primary and secondary sources of data were resorted to, and data was obtained mainly from questionnaires, interviews, discussions and available literature. These among other aspects of the methodology helped to address the research problem on meeting the needs of deprived urban populations through low-cost water supply as alternatives to the more expensive public and private sector water services.

5.2.3 Addressing the Research Questions
At this stage, the individual research questions were recalled and how the results answered the questions were indicated, thus, providing the basis for the achievement of the research objectives as well.

5.2.3.1 The General Condition of Water Supply in the Area
This section answers the first research question: *What is the general condition of water supply in the area?* The variables identified for solving this question included the sources of potable water, the spatial distribution of these sources, as well as the availability, affordability and quality of the potable water. It was revealed that the major sources of household water were public standpipes, mechanized wells, hand dug wells and streams, dams and rivers. The most popular sources were found to be public standpipes and mechanized wells.
The distribution of potable water infrastructure was found to vary according to the functions and population sizes of the various sectors of each study zone. Generally, facilities were found to be more concentrated at the zones of transition due to population concentration and the zone of rich/middle income people’s residences, which did not only fall second in terms of population numbers, but also, the concentration of facilities was influenced by the willingness and ability to pay in this area. The Central Business District (CBD) in each community ranked third in terms of water infrastructure distribution. Though this constitutes the busiest sector, the fact remains that such areas do not have much permanent inhabitants. They are mostly zones of business locations where people come to work and return home, such as popular shops and administrative offices. Industrial areas and commuters’ zones (working class residences near zones of industry) with relatively fewer populations recorded the lowest proportions in terms of water facility distributions.

In terms of availability of potable water, though respondents acknowledged the availability of appreciable water supply, this was negatively impacted by seasonal fluctuations, technical breakdowns and the excess of demand over supply.

Another basis of examining the condition of potable water was by the affordability of the water in terms of pricing. Cumulatively, about 69% of the respondents considered the price of potable water to be high, 19% saw it to be moderate, while only 12% thought it was low. This consideration was based on the general view of potable water pricing without a focus on low-cost water sources only.

Finally, on the issue of water quality about 41% of the respondents were satisfied, 47% said the water quality was bad while 12% could not judge the quality of the water. This shows the extent to which the objective of determining the general condition of water supply in the area was achieved.

5.2.3.2 Low Cost Water Supply as an Alternative to other Sources of Potable Water
This section is also committed to providing a solution to the second research question: How does the provision of low cost water supply serve as an alternative to other sources? The variables that were measured to facilitate the answering of this question included the following: The factors that influenced the re-adoption of low-cost water supply technology, the type of low-cost water supply facilities in focus for development, how low-cost water supply infrastructure is
provided, the sources of funding low-cost water infrastructure, and the distribution of low-cost water supply projects.

To begin with, the study revealed that the major factor that induced the re-adoption of low-cost water supply technology in the area beginning from 2006 was to reduce the long distance between users and the existing public sector piped water facilities, such as standpipes. The second inducing factor was the need to bridge the gap between the excess of demand over the supply or distribution of the already existing public sector water infrastructure. Third in importance was also the need to remedy the irregularity in the supply of potable water due to power failures, technical breakdowns and seasonal fluctuations. Additionally, the high cost of potable water from the existing sources, made the need to provide cheaper alternatives to the urban poor through low-cost water supply technology. Bad water quality, though received an insignificant response rate, was also identified as a reason for the promotion of low-cost water supply, especially in areas where the use of river or dam water and the risk of water-borne diseases were high, such as Oponsu.

The study also showed that, to achieve the above aims for the promotion of low-cost water supply in the area, various technological options were identified, and beneficiaries were to choose from these based on the absorptive capacity of the threshold of each study zone on the basis of investment cost and affordability of the resulting water services. The adopted technologies in order of importance were tube well/borehole, shallow hand dug protected wells and rain water harvesting.

The determination of the type of low-cost water supply technology to be adopted was related to the source(s) of provision as well as funding. The study indicated that a number of organizations play active roles in the provision of low-cost water supply technology. Some of these institutions in order of importance were Local civil society groups, Municipal Assembly/CWSA, the Canadian International Development Agency, the World Vision Ghana and local private contractors engaged in the construction of low-cost water supply technological facilities. These institutions educate beneficiaries on available technological options and aided, encouraged the independent choice of options by beneficiaries and aided the implementation of chosen options through physical constructions. Where the initiating agency is different from the funding agency, a number of sources of funding low-cost water supply projects were uncovered in this study, the most important ones being by community contributions, Municipal Assembly
Poverty Alleviation Fund, and aid from donor agencies.

The above unfolding mark how the achievement of the second objective of examining the provision of low-cost water supply technology as an alternative to other sources was reached.

5.2.3.3 The Contribution of Low-cost Water Supply to Improving Accessibility

This section answers the third research question stated as: In what ways does low cost water supply technology contribute to improving access to potable water supply in the area? In approaching this question the key variables whose analysis contributed to the development of the answer were the uses of water from low-cost sources, achieving development through low-cost water supply, perceptions of public sector water supply and development that necessitate alternative sources, low-cost water supply as a solution to the problems of public water services and how low-cost water supply contributes to development.

The study revealed that the major uses of low-cost potable water in the area are domestic, industrial, agricultural and commercial uses. Of these, the three most important uses were found to be domestic, industrial and agricultural. It was observed that some undesirable characteristics of public sector water services called for the need to promote low-cost water supply. Some of these were heavy investment capital, high operational cost, lack of technological choice options and relatively higher water prices.

On the other hand, low-cost water sources were considered to be urban pro-poor because they involve low investment capital, incorporate indigenous technology, provides freedom of technology choice to potential beneficiaries, have no or very low operational cost and according water tariff rates are very affordable.

Given the above characteristics, low-cost water supply was seen as contributing to development through its potentials to reduce poverty, contribute to employment at the local level, reduce urban migration, ensures water quality for good health and reduces cost of living.

Thus, the third research objective which purported to ascertain how the provision of low cost water supply technology contributes to the development of the area was achieved, by the answer to the associated research question as summarized above.
5.2.3.4 Challenges of Low-cost Water Supply

To climax the summary of the major findings of this study, the fourth research question which was framed as: *What are the challenges of low cost water supply?* was answered, and the results indicated that the major challenges were the problem of controlling water quality, low level of community contribution due to low household incomes, the problem of ensuring the sustainability of low-cost water infrastructure, and finally urban bias in funding allocations to low-cost water supply projects. This therefore enabled the researcher to achieve the fourth research objective of identifying the challenges of low cost water supply.

5.3 Conclusions

The scientific character of social science research calls for a systematic approach to every aspect of the research design. Accordingly, just like the summary of findings followed the direction of the specific research questions, the purpose of the major research question is also to provide a concluding or an over-arching answer, to determine whether the major objective was achieved and/or serve as a brief explanation to how the research problem was addressed.

Thus, to approach the major research question: *How does the adoption of low cost water supply technology solve the problems of potable water in urban Upper Denkyira?* One could recall that before the efforts aimed at promoting low-cost water supply in the area, also known as Appropriate Technology Approach, other unwholesome sources of water such as dams and rivers dominated in the deprived parts of the urban town resulting into water-borne diseases, in addition to general potable water scarcity and higher tariff rates. The low investment cost, the flexibility and freedom of technological choice, wide distribution, water quality control initiatives and affordability of water from low-cost sources helped to overcome some of these problems.

The promotion of the Appropriate Technology Approach in the study area did not only increase the supply of safe and affordable drinking water, but also contributed in its own small way to the development of the area, as it increased the supply of water for domestic, industrial, agricultural and commercial uses. Improved water supply in these spheres directly or indirectly led to improved health, poverty and/or water poverty reduction, local employment generation and reduced cost of living. However, the fact that some challenges like low household contribution to low-cost water projects as a result of poverty, sustainability problems, water quality problem...
and urban bias in funding allocations still persisted, necessitate the need for policy recommendations for improved low-cost water services in the future of the area.

5.4 Recommendations
To answer the last of the research question, this section provides some recommendations to overcome the identified challenges for a better future of low-cost water supply in the area. In other words, a thesis of this nature would be incomplete without the researcher’s own contribution to the available knowledge on the phenomena investigated. The sub-sections below indicate how the various challenges should be tackled as they relate to the research objectives, in the view point of the researcher, but not excluding what was ever tried and found workable by other researchers.

5.4.1 Improving the General Condition of Water Supply through Household Contributions to Low-cost Water Projects
The problem of low household contribution resulting from the low incomes of households or poverty in general is a major impediment to the implementation of community self-initiated water projects. As a result, it became necessary to re-examine the nature of the interventions in low-cost water supply and the gaps that remained to be filled.

It could be recalled that though the scarcity of potable water and water-borne diseases that hit the urban poor in 2006 stimulated the attention of the Upper Denkyira Municipal Assembly to explore alternative sources of potable water for increased supply, it was not clear what model was followed for the interventions. Was it by Public Sector Operation? Private Sector Participation? or Public-private Partnership? It is only when a clear answer existed for this question that actual roles and shortfalls of households in terms of contributions could have been better assessed. In other words though the stakeholders of the low-cost water supply projects included all the sectors listed above, there was no formal structure that bound them together, such that each operated almost independently, to the extent that the beneficiaries of the low-cost water supply projects were largely the dominant funders of such projects. This explains why the low-income nature of households and the associated negative impacts on projects was felt.

To address this problem, the formal establishment of a tri-sector partnership would have been more appropriate, since there would have been clear definition of the roles of partners
according to capabilities. More specifically, the strength of tri-sector partnerships to overcome the problem of low household incomes and the effects on contributions to projects or payment for services is clearly expressed in the Multi-factorial Pro-poor Community Water Service Model postulated by Bukari (2011), which integrates capacity building and economic empowerment projects into pro-poor community water supply projects. The writer's argument is that, no project in which sustainability depends on cash payments by the beneficiaries could be described as pro-poor without any component that addresses the root causes of poverty. As such, there is the need to re-examine and define an appropriate model for interventions in low-cost water projects with emphasis on reducing the root causes of poverty as well, for increased household income.

5.4.2 Ensuring the Sustainability of Low-cost Water Supply Infrastructure as Alternatives to other Sources

On the issue of sustainability of low-cost water supply infrastructure as alternatives to other sources of potable water, it was realized that the major problems were the lack of incentives to be trained for repairs of technical faults and the out-migration of the few who might have acquired the maintenance skills. A close look at the nature of local level structures involved in the management of low-cost water supply facilities in the area could inform one that they were usually ad hoc youth committees established to mobilize the people for contribution towards a low-cost water supply project, such as a borehole, after which they seize to function for the same reasons expressed in the previous subsection. Members of such committees simply return to see to their individual and family needs.

It was therefore obvious that the composition of the membership of such committees in terms of diversity of skills and role definitions was not prioritized. To address this problem, the formation of permanent Community Water Boards should be encouraged. Such boards should have a well defined organizational structure with hierarchies of authority and associated responsibilities; such as president, secretary, treasurer, tariff collectors, repairer and other relevant positions, with gender sensitivity. There should also be a deed or written constitution that establishes the boards and serves as the document of reference or provide the code of ethics among members, such as methods of election and exit of members.

Better Community Water Boards are found in tri-sector partnerships, where the task of training and retraining of members with essential responsibilities such as fault detection,
maintenance and repairs, revenue collection and non-revenue water control are often taken up by the private or public sector partners or both, and where issues of expected returns and conditions for the sharing of benefits are also be covered (SNV, 2009; Bukari, 2011).

The above strategies together with freedom of technology choice among other methods of localizing the approaches of low-cost water supply contribute to the sustainability of the Appropriate Technology Approach or low-cost technologies in rural and peri-urban areas.

5.4.3 Reducing Urban Bias in Funding Allocations as a Way of Improving Accessibility to Low-cost Water Supply

Though this study revealed that the problems of potable water accessibility are more prevalent in the smaller settlements of the urban town, it was rather surprising that Municipal Assembly funding of low-cost water projects which are theoretically meant for low-income rural and peri-urban settlers, tend to favour Dunkwa-Offin which is the capital of the municipality, and other larger suburban settlements such as Dunkwa-Kadadwen, compared to the smaller settlements like Oponsu. The cause of this situation has been attributed to the influence of the interests of politicians who want to promote support for their political parties, hence development projects tend to be concentrated in populous areas where majority could witness them for the assessment of the ruling party’s performance.

Here again, the active involvement of local Civil Society groups and private sector organizations, does not only lead to effective mobilization of local resources for community self-initiated development projects with self-reliance in the area of water supply, but also constitutes a stronger union for advocacy and lobbying to secure political will for the funding of low-cost water projects for deprived suburban settlements, and the long-run effects would be that, the deprived communities would benefit, the private sector would make profit and the government would serve better (Bukari, 2011).

Additionally, instead of the Municipal Assembly having to decide on where and when it is to intervene in low-cost water projects, it could rather provide subsidies on materials for low-cost water supply technologies, or better still encourage individual households seeking to construct household low-cost water pumps to provide their budgets for subsidies to be paid to them to facilitate speedy implementation. This makes municipal intervention in low-cost water supply demand driven with the potential to create a net increase in good drinking water facilities.
at the household level. The success of this however depends on parliamentary readiness to approve Municipal Assembly budgets on low-cost water supply, which could lead to an increase in the allocation of common funds to the assembly.

5.4.4 Addressing the Challenge of Poor Water Quality

Though this study revealed the efforts made to improve water quality through the various methods of low-cost water supply and treatment procedures, such approaches did not guarantee the elimination of previous unwholesome sources of water, such as surface sources including rivers, streams and dams. Also the dependence on the CWSA and the GWCL for the disinfection of potable water sources were not very sustainable, since uncovered areas remained vulnerable to water-borne diseases.

To address these causes of poor water quality, the CWSA, the GWCL and the Municipal branch of the National Commission for Civic Education should collaborate to intensify education on the dangers of drinking bad water, and then introduce some potable water treatment methods to the public that are easier for adoption by households, through community forums, radio and other media accessible to the urban poor. For instance WHO (2006) identified the following methods as household adoptable methods of improving water quality, namely using the crushed seeds of moringa oleifera and porous ceramic filters made of clay or diatomaceous earth fixed into pots or cylindrical containers with gravity-fed delivery systems. These methods are not only easy to adopt, but also the materials involved are cheap and readily available locally. Besides, they can be applied to water from any of the sources: pipe-borne, well, dam and rain water among others.


Japan International Cooperation Agency (JICA) (1997). *Progress with Public-private*


Washington D.C: The World Bank
APPENDICES

Appendix I: HOUSEHOLD QUESTIONNAIRE ON THE TOPIC: URBAN LOW-COST WATER SUPPLY AS AN ALTERNATIVE TO OTHER SOURCES: THE CASE OF DUNKWA-OFFIN IN THE CENTRAL REGION, GHANA.

To the prospective respondent: This questionnaire is being administered for a purely academic purpose. Your household has been selected to provide information which can contribute immensely to the understanding of the situation of urban low-cost water supply as an alternative to other sources in your locality. I should be grateful if you could kindly respond to the under listed questions as objectively as possible for the success of the study. Confidentiality of all responses is assured.

SECTION A: BACKGROUND OF RESPONDENTS

Instructions: For each section there are a set of close and open-ended questions. With close-ended questions respondents may choose an option by ticking thus [✓]. With open-ended questions the appropriate responses should be written in the blank spaces provided.

1. Sex:
   Male [ 01 ]
   Female [ 02 ]

2. Which of the following groups include your age?
   18-44 [ 01 ]
   45-64 [ 02 ]
   65+ [ 03 ]

3. Are you .................?
   Married [ 01 ]
   Single [ 02 ]
   Divorced [ 03 ]
   Widowed [ 04 ]
4. What is your religious domination?
   - Traditional religion 01[  ]
   - Christianity 02[  ]
   - Islam 03[  ]
   - Paganism 04[  ]
   - Others 05[  ]

5. What is your major occupation?
   - Farming 01[  ]
   - Trading 02[  ]
   - Salary work 03[  ]
   - Others 04[  ]

SECTION B: GENERAL CONDITION OF WATER SUPPLY

1. What are the main sources of water in your community?
   - Pipe-borne 01[  ]
   - Mechanized well 02[  ]
   - Hand dug well 03[  ]
   - River/stream/dam 04[  ]

2. What is your observation about the proximity of the water sources to your household?
   - Very Near 01[  ]
   - Near 02[  ]
   - Distant 03[  ]
   - Very distant 04[  ]

3. Indicate the nature of distribution of potable water sources in your locality
   - Evenly distributed 01[  ]
   - Unevenly distributed 02[  ]
   - Generally not satisfactory 03[  ]
4. What is the general nature of water supply at the various sources in terms of availability?

- There is regular supply
- Irregular supply due to technical faults
- Seasonal fluctuation in supply
- Inadequate supply relative to population
- Moderate availability

5. What is your general perception of potable water price level in your area?

- High
- Moderate
- Low

6. What do you think about the quality of potable water in your area?

- Good
- Bad
- Don’t know

SECTION C: LOW COST WATER SUPPLY AS AN ALTERNATIVE TO OTHER SOURCES

1. What condition(s) of potable water sources influenced the promotion of low-cost water supply in your area?

- Long distance
- Inadequate distribution
- Irregular supply
- Bad water quality
- High water price

2. What are the major types of low-cost water technology adopted in your area?

- Tube well/Borehole
- Hand dug protected well
- Rain water harvesting
3. Who are the stakeholders of low-cost water supply projects in your area?

- The community people
- The Municipal Assembly
- International Private sector institutions
- Local private sector institutions

4. What factors influence the sources of funding low-cost water projects in your area?

- The nature of ownership
- Intended scale of operation
- Level of technology involved
- Service location
- Cost involved

SECTION D: THE CONTRIBUTION OF LOW-COST WATER SUPPLY TO DEVELOPMENT

1. What are the uses of potable water from low-cost sources?

- Domestic/household uses
- Industrial uses
- Commercial uses
- Agricultural uses

2. What are the undesirable characteristics of public sector water services that necessitate the need to switch to low-cost water supply as an alternative development strategy?

- Dependence on foreign technology
- Heavy investment cost
- High operational cost
- Limited technology choice options
- Demand driven/ability to pay
3. What characteristics of low-cost water supply technologies make them suitable for addressing the special needs of the urban poor?

- Low investment cost
- Incorporates indigenous technology
- Affordable tariff rates
- Freedom of technology choice
- No or very low operational cost

4. What are the immediate effects of the urban pro-poor nature of low-cost water technology on the development of the municipality?

- Reduction of water poverty
- Contribute to local employment generation
- Reduces urban migration
- Ensures water quality for good health
- Reduces cost of living for the urban poor

SECTION E: CHALLENGES OF LOW-COST WATER PROJECTS

1. What challenges impede the promotion of low-cost water supply as an alternative to other sources?

- Urban bias in funding allocations
- Low level of community contributions due to low incomes
- Problem of water quality
- Inadequate strategies for sustainability
- No or very low operational cost

SECTION F: RECOMMENDATIONS

1. What contribution would you make for the future improvement of low-cost water supply projects in your area? 
Appendix II: INTERVIEW GUIDE FOR MUNICIPAL ASSEMBLY/PRIVATE SECTOR OFFICIALS ON LOW-COST WATER SUPPLY AS AN ALTERNATIVE TO OTHER SOURCES IN THE UPPER DENKYIRA MUNICIPAL AREA

To the prospective respondent: This interview is being administered for a purely academic purpose. Your institution has been selected to provide information which could contribute immensely to the understanding of the situation of urban low-cost water supply as an alternative to other sources in your municipality. It would be very much appreciated if you could kindly respond to the under listed questions as objectively as possible for the success of the study. Confidentiality of all responses is assured.

Part I: Personal Information on Respondent
Name of institution..........................................................
Post/status of respondent..................................................
Community of residence..................................................

Part II: General Condition of Water Supply in the Municipality
Kindly give a brief description of the aspects of potable water supply in this municipality that attracts the interest of your institution (e.g. issues of sources, distribution, affordability, water quality, etc.)
Have there been some interventions over the years in low-cost water supply by your organization? (Specify the year(s) of such interventions)
If 'yes' to question 5, what factors resulting from the previous potable water situation accounted for the interventions through low-cost water supply approaches?

Part III: Low-cost Water Supply as an Alternative to other sources
What are some examples of low-cost water supply technologies being adopted in the municipality through interventions by your institution or other institutions?
Could you identify the stakeholders for the promotion of low-cost water supply technology in the municipality? (Name them if applicable).
How are low-cost water supply projects funded (if any)?

What can you say about the spatial distribution, affordability and water quality associated with the period of low-cost water supply promotion, compared to the period before?

Part IV: The Contribution Of Low-Cost Water Supply to Development

What are the important uses of water from low-cost sources, for which reason your organization is much concerned about the promotion of low-cost water supply projects?

To what extent could you say that your organization’s involvement in the promotion of low-cost water supply has contributed to the development of the municipality?

Part V: Challenges of Low-Cost Water Supply

Briefly Comment on any challenges that your organization is exposed to, in the process of initiating and/or implementing low-cost water projects.

Part VI: Recommendations for the Improvement of Low-Cost Water Supply

What recommendations do you have for the future improvement of low-cost water projects for your organization and other stakeholders?

Thank you!
Appendix III: INTERVIEW GUIDE FOR OFFICIALS OF GHANA WATER COMPANY LTD. AND THE COMMUNITY WATER AND SANITATION AGENCY ON LOW-COST WATER SUPPLY AS AN ALTERNATIVE TO OTHER SOURCES IN THE UPPER DENKYIRA MUNICIPAL AREA

To the prospective respondent: This interview is being administered for a purely academic purpose. Your institution has been selected to provide information which could contribute immensely to the understanding of the situation of urban low-cost water supply as an alternative to other sources in your municipality. It would be very much appreciated if you could kindly respond to the under listed questions as objectively as possible for the success of the study. Confidentiality of all responses is assured.

Part I: Personal Information on Respondent
Name of institution
Post/status of respondent
Community of residence

Part II: General Condition of Water Supply in the Municipality
Kindly give a brief description of the roles of your institution in terms of urban potable water supply
Since when did this municipality begin to give attention to low-cost water supply projects?
What conditions of public water supply might have stimulated the need to promote low-cost water supply?

Part III: Low-cost Water Supply as an Alternative to other sources
What are some examples of low-cost water supply technologies being adopted in the municipality?
What is the estimated project cost for each of the low-cost water technologies you have identified?
Could you identify the stakeholders for the promotion of low-cost water supply technology in the municipality? (Name them if applicable).

How are low-cost water supply projects funded (if any)?

What are the units of measurement of water from low-cost water supply sources and the associated tariff rates?

How would you compare the units and rates given to low-cost water sources, to other sources of urban potable water, such as pipe-borne and water tanker services in the municipality?

What can you say about the spatial distribution, affordability and water quality associated with the period of low-cost water supply promotion, compared to the period before?

Part IV: The Contribution of Low-Cost Water Supply to Development

What are the important uses of water from low-cost sources?

To what extent could you say that the promotion of low-cost water supply has contributed to the development of the municipality?

Part V: Challenges of Low-Cost Water Supply

Briefly Comment on any challenges of low-cost water projects.

Part VI: Recommendations for the Improvement of Low-Cost Water Supply

What recommendations do you have for the future improvement of low-cost water projects?

Thank you!
Appendix IV: INTERVIEW GUIDE FOR HEALTH OFFICIALS ON HOW LOW-COST WATER SUPPLY AS AN ALTERNATIVE TO OTHER SOURCES AFFECTS WATER QUALITY AND HEALTH IN THE UPPER DENKYIRA MUNICIPAL AREA

To the prospective respondent: This interview is being administered for a purely academic purpose. Your institution has been selected to provide information which could contribute immensely to the understanding of the situation of urban low-cost water supply as an alternative to other sources in your municipality. It would be very much appreciated if you could kindly respond to the under listed questions as objectively as possible for the success of the study. Confidentiality of all responses is assured.

Part I: Personal Information on Respondent
Name of institution........................................
Post/status of respondent..............................
Community of residence................................

Part II: Effects of Low-cost Water Sources on Water Quality and Health

What is your observation on the changing patterns in potable water infrastructural provision (with especial consideration to low-cost water supply projects)?
Could you identify any period within the last decade, in which water-borne diseases was a major health problem?
What were some of the diseases (if any in question 5)?
How are water-borne diseases related to low-cost water sources?
Could you identify specific types of low-cost water sources that are potential sources of water-borne diseases?
What is the role of your institution in the control and prevention of water-borne diseases, especially from low-cost water sources?
Which other organizations do you think they have the responsibility to prevent water-borne diseases from low-cost water sources?
Are such institutions (in question 10, if any) performing their roles well?
Are there other low-cost water supply sources designed to improve water quality or prevent water-borne diseases? (Give examples)
What challenges do you think are still associated with low-cost water supply technologies in terms of water quality promotion, disease prevention and control?
What recommendation would you make for ensuring water quality for the prevention of water-borne diseases through low-cost water supply technologies in the municipality?
Appendix V: FOCUS GROUP DISCUSSION GUIDE FOR MEN AND WOMEN’S GROUPS ON LOW-COST WATER SUPPLY AS AN ALTERNATIVE TO OTHER SOURCES IN THE UPPER DENKYIRA MUNICIPAL AREA.

Part I: General Condition of Water Supply in the Municipality
Perceptions of public and private sector water services conditions, in terms of spatial distribution, availability of water, affordability and water quality
Identification of period of low-cost water supply promotion and the specific problems the associated projects were to solve

Part II: Low-cost Water Supply as an Alternative to other sources
Examples of low-cost water supply technologies being adopted in the municipality
Estimated project cost for each of the low-cost water technologies, and the beneficiary share of the cost
Identification of the stakeholders for the promotion of low-cost water supply technology in the municipality
How low-cost water supply projects funded
The units of measurement of water from low-cost water supply sources and the associated tariff rates
Comparing the units and rates given to low-cost water sources, to other sources of urban potable water, such as pipe-borne and water tanker services in the municipality
Observations about the spatial distribution, affordability and water quality associated with the period of low-cost water supply promotion, compared to the period before
Part III: The Contribution of Low-Cost Water Supply to Development

The important uses of water from low-cost sources
How the promotion of low-cost water supply has contributed to the development of the municipality

Part IV: Challenges of Low-Cost Water Supply
Identification of the challenges of low-cost water projects.

Part V: Recommendations for the Improvement of Low-Cost Water Supply

Thank you!