KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, GHANA

Access to water and financial implications of groundwater development in Dodowa, Ghana.

By
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DECLARATION

I hereby declare that this submission is my own work towards the M.Sc. degree in Water Supply and Environmental Sanitation and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

Global urban population growth has led to an increase in the difficulties in urban water provision. This population growth and urbanization which is rampant in the Sub- Saharan Africa has led to the rapid expansion of slums and informal settlements in the urban centers. Access to drinking water in these urban informal settlements of developing countries has being a challenge. The use of groundwater has hence evolved as a major source of urban water supply. In Ghana, Dodowa is one of the peri-urban communities where groundwater is widely used in addition to utility supplies and hence the research in Dodowa gives a true picture of water supply situation and domestic groundwater use within the urban poor. This study therefore focused on determining access to water supply, its cost implication to consumers and also to assess the financial implications of groundwater development in Dodowa. The methodology adopted was household surveys where a total of 300 households were interviewed to access all the necessary data such as socio-economic status of the consumers, access to water, cost and consumption. In addition, water point inventory was conducted where financial data such as capital cost, operation and maintenance cost and replacement costs of various water points was obtained. The results revealed a variety of water points in Dodowa which include utility pipe public taps, utility piped into buildings, motorized boreholes, hand/foot pump boreholes, hand-dug wells, water tankers and vendors. It was found that groundwater is widely used than all other sources of water supply in Dodowa. As much as 78% of all households use groundwater; only that most consumers of the groundwater sources find the water to be salty and hence they do not patronize it as a main source of supply. The financial analysis revealed that managing a utility public tap as well as motorized borehole fetches good returns with short payback periods (1 year 9 months and 2 years, 3 months respectively) and hence was found to be a profitable business for private water point operators. It was also found that the lowest income group rather pays more for water (0.84 Ghana Cedis/Capita/Day) while the highest income earning group pays less (0.36 Ghana Cedis/Capita/Day). Sachet water was also found to be in high demand (96.3% of all households purchase and use it) and a major contributor to high household water expenditure (it forms 72% of the average household water expenditure).

DEDICATION

To the Almighty God, My Family and Friends.

LIST OF ABBREVIATIONS AND SYMBOLS

GWCL	Ghana Water Company Limited
DA	District Assembly
CUA	Community Unit Assembly
VIP	Ventilated Improved Pit
PWB	Present Worth of Benefits
PWC	Present Worth of Costs
NPW	Net Present Worth
IRR	Internal Rate of Return
A	Annual Uniform Cost
D	Depreciation

S Salvage Value

N Useful Life C

Capital Cost i Interest

Rate

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CHAPTER 1: INTRODUCTION

1.1 Background

Water is vital for human survival, health and dignity and a fundamental resource for human development. The world's freshwater resources are under increasing pressure yet many still lack access to adequate water supply for basic needs. Growth in population, increased economic activity and improved standards of living lead to increased competition for, and conflicts over, the limited freshwater resource.

Freshwater sources that are exploited for water supply may be classified as surface water source and groundwater source. Surface water resources include rivers, streams, lakes, irrigation canals, impounding reservoirs etc. Groundwater is the freshwater that lies in aquifers (a geologic formation that transmits and yields significant amount of water) beneath the earth surface.

More often, groundwater has been developed in response to water shortage and/or service deficiency and often through private initiative but in a few cases, the use of groundwater has evolved as part of planned urban water supply development. Other freshwater sources such as surface water from rivers and ponds or rainwater collection, are less reliable and readily contaminated, whereas aquifers and water wells have a substantial degree of natural protection from contamination and drought (Foster *et al*., 2006).

Groundwater is developed with alternative applications, which come at a cost and fetch a return.

The economics of ground water use seeks to ask the question: what are the costs to put a ground water abstraction system in operation (however simple the system could be) and to operate and maintain it. The determinants driving the costs and benefits will also determine access to water supply (Nkrumah *et al*., 2011).The hypothesis is that access to water supply is influenced by the costs and benefits of ground water. The cost of ground water use may change the choice between the available options for drinking water for the poor.

There are two dimensions of analysis which are carried out separately from the perspective of private sector and from the perspective of public sector. The financial analysis takes the point of view of private sector whereas the economic analysis takes the point of view of government (Liang, 2011). The financial analysis focuses on viability of water projects, while the economic analysis aims to determine the contribution of a proposed project to the development of the total economy. Both financial analysis and economic analysis are complementary, and the integrated financial and economic analysis can systematically and completely assess the groundwater economy. In financial analysis, the market value is used directly for the value determination of financial cost and benefits.

1.2 Problem Statement

Global urban population growth has led to an increase in the difficulties in urban water provision. This population growth and urbanization which is very rampant in the Sub- Saharan Africa has led to the rapid expansion of slums and informal settlements in the urban centers. Access to drinking water in these urban informal settlements of developing countries has being a challenge for the poor and depends on technology selected (Isoke&van Dijk, 2013).

Furthermore, Franceys(2005), asserted that inadequate access to water and high cost of water to urban poor communities are major problem in developing countries.In Ghana, the access to water in poor communities is also confronted with the same problem.

As a result of these problems with water, groundwater has become a vital resource for domestic water supply and yet there is not reliable, comprehensive statistics on groundwater use in SubSaharan Africa (Foster *et al*., 2006). In Ghana, Dodowa is one of the peri-urban communities where groundwater widely used and hence the need for a comprehensive research on access to water and groundwater development in such an area.

1.3 Research Questions

This study therefore seeks to answer the following questions relating to the study area:

- RQ1- What are the water supply systems and groundwater development technologies in the study area?
- RQ2- What are the extent of access, consumption and cost of various water sources to the consumers in the area?
- RQ3- How affordable to the people is the water price of the supply systems?
- RQ4- How much does it cost to develop and maintain groundwater supply systems, and its return on investment?
- RQ5- Is access to water supply influenced by the cost and returns on groundwater development technologies (or financial implications on access to water)?

1.4 Objectives of the Research

The main objective of the study is to determine access to water supply and assess the financial implications of groundwater development in Dodowa.

1.4.1 Specific Objectives

The specific objectives are:

- To determine access to water supply and its cost to consumers in the area.
- To assess the implications ofcost of water supply in the area
- To map and take inventory of groundwater source development options in the area.
- To analyze the financial costs and rate of returns of groundwater development in the area.

1.5 Justification

Groundwater plays a critical role in the water-supply security of many African cities; even in those cases where most of its development has been under private rather than municipal initiative. There is therefore an urgent need for strategic (hydrogeologic and socioeconomic) assessment of its current utilization for water-supply provision and the management actions needed to ensure future availability and greater integration with surface water-supply. (Foster *et al*., 2006)

It is imperative to undertake a full economic assessment of the water supply, including both direct and indirect costs associated with the current situation and available resources, to facilitate effective comparison of alternatives (Kumar *et al*., 2012).

This researchwill reveal the economic viability of the various technologies of groundwater supply and its impact on water supply to the urban poor. It will also serve as a guide for stakeholders in decision making towards sustainable and improved access to water supply to the urban poor and peri-urban communities.

CHAPTER 2: LITERATURE REVIEW

2.1 Global Urban Water Supply

The increase in urban growth has resulted in higher demand for freshwater resources, yet surprisingly the water sources of the world's large cities have never been globally assessed, hindering efforts to assess the distribution and causes of urban water stress. About 78.3% of the water supply to large cities is obtained from surface sources, some of which are far away. Cumulatively, large cities moved 504 billion liters a day (184 km3 per year) through a distance of 27,000 to3800 km. One in four cities, containing $4.8 to0.7 trillion in economic activities, remain water stressed due to geographical and financial limitations. The strategic management of these cities' water sources is therefore important for the future of the global economy.(McDonald *et al*., 2014)

2.1.1 Water Supply in Sub-Saharan Africa

With only 56 percent of the population enjoying access to safe water, Sub-Saharan Africa lags behind other regions in terms of access to improved water sources (Banerjee *et al*., 2008). Only 35% of the urban population in sub-Saharan Africa has access to a piped water connection on their premises. Hence majority of households obtain water from public standpipes or from neighbors who are connected to the municipal network (Zuin*et al*., 2011). This leads to water resale and in effect raises concerns about affordability and risks to public health.

Hopewell and Graham (2014) observed that though cities appeared to be making the most progress in gaining access to water supply and sanitation along metrics which reflect specified targets of the Millennium Development Goals, nearly half of these cities did not make progress in reducing the amount of time spent collecting water. This may imply that the Millennium

Development Goals have led to a focus on "improved" services while other measures, potentially more relevant to the extreme poor are being neglected.

Rapid population growth and rampant urbanization have put enormous pressure on utilities. Most of the population growth has occurred in peri urban slum neighborhoods, and utilities have not been able to extend their networks fast enough.

Most city dwellers who do not obtain their water from a utility get it from wells and boreholes, which are the primary source of water for 24 percent of Africa's urban population. Each year, the share of the urban population that gets its water through wells and boreholes rises by 1.5 percent, compared to 0.6 percent for public standposts and a mere 0.1 percent for piped water (Banerjee *et al*., 2008).

2.1.2 Water Supply in Urban Ghana

In Ghana, the water demand from the urban population outstrips current levels of urban water supply. The Ghana Water Company Limited (GWCL) currently operates 82 urban systems with an average daily output of 572,012 m^3/day as against a daily demand of 1,049,306 m^3/day (Addo, 2010).

Water is rationed to many consumers with only a few customers able to get 24-hour supply. In the peri-urban areas and the densely populated poor urban areas customers are mostly faced with the challenge of irregular water supply. Addo (2010) observed that all the respondents canvassed agreed that uncontrolled urbanization makes it difficult for Ghana Water Company to map out strategy for service delivery and to wean bloc consumers.

Increasing and improving existing water sources; improving access to water; financing urban water supply; hygiene education and environmental sanitation; public private partnerships; capacity; good governance; research and development; monitoring and evaluation; emergency and extreme events; and pro-poor issues are issues of concern with the urban water supply that the government of Ghana seeks to address.

2.2 Accessibility, Cost and Affordability of Water Supply to the Urban Poor

In Sub-Saharan Africa, access to water and its cost has been a major challenge to the urban poor. Kosoe and Osumanu (2015) observed and rated the challenges of accessing potable water in the Wa Municipality (an urban centre in northern Ghana) as follows: "long queues" rate 35.7%, follow by "high cost" which rated 24%. The next challenge was time of repair of broken down water facilities (15.6%), followed by "irregular flow" rating 10.4%, then the challenge of distance (7.8%) and finally, "high chemical input" (6.5%).

Whilst government believes that the subsidies reach the people who deserve it, the question remains whether a non-targeted subvention like lower water price does reach the right people (the poor), under the present conditions of inadequate water supply (poor reliability and accessibility).

In the city of Accra (Ghana), only 45% of the population has direct access to tap water (i.e household connection) and these mainly in the higher income classes. Consequently, people living in the low income settlements in Accra who have no household connection are completely dependent on water vendors (Van Rooijen*et al.*, 2008).

Furthermore, Peloso and Morinville(2014) observed in a study that when consumers were asked whether the price charged by vendors was good or fair, respondents generally said it was manageable but were also clear that they had to accept whatever price it was since there was nothing they could do about it; the price of water was up to the discretion of the vendor.

Access to domestic water and reliability is much worse in these areas and consumers generally spend between 4 and 18 times the normal tariff that is charged to consumers with direct access to piped water. The social and physical constraints to planning are affecting the poor more than the rich in terms of access and affordability (Van Rooijen*et al*, 2008).

Zuin*et al*., (2011) asserted that in Maputo (Mozambique), households with water connections in their premises have better service across virtually all indicators measured. These households express greater satisfaction with their service as compared with those using other water sources. However households purchasing water from their neighbors pay lower time and money costs per liter of water, on average, as compared with those using standpipes.

On the other hand, where the poor are enabled to access household connections, they benefit significantly from the convenience and cost savings of piped water. The benefits can also be significant in terms of economics and health (Franceys, 2005).

2.3 Groundwater Source Development

Groundwater is an important natural resource with high economic value and sociological significance. It is important that this resource be utilized in a sustainable manner in order to avoid a permanent depletion of the resource in both quantity and quality. In many cases, groundwater management practice is geared to facilitate usage and development. Meanwhile, as development progresses with more and more drilled wells scattered over the basin, issues such as overexploitation, equitable sharing of water and degradation of water quality become apparent in many basins. Hence, the groundwater management practice has to be changed in order to utilize the resource in an efficient, sustainable and equitable manner contributing to the economic and social well being of the broader community (Gupta &Onta, 1997).

There is an increasingly high dependency on groundwater in urban slums and many peri-urban communities. Groundwater development comes in the form of deep boreholes and shallow handdug wells. Shallow hand-dug wells are commonly used as a supplement for partial or intermittent piped water coverage in many urban informal settlements in sub-Saharan Africa. Such wells are often microbially contaminated. Kimani-Murageet *et al*., (2007) found that about 91% of people living in Langas slum used wells as the main source of domestic water out of which 100% of water samples from shallow wells tested positive for total coliforms.

Okotto*et al*., (2015) observed that though a few consumers of these wells drink it untreated, most consumers are aware of the health implications of their microbial contamination and hence use it for purposes other than drinking and cooking. There is also some evidence that some may mistake hand-dug wells for boreholes.

2.3.1 Cost of Groundwater Development

The full economic costs and benefits associated with groundwater use are determined from its use in various sectors (George *et al.* 2011). Groundwater use for domestic consumption or industrial production is difficult to ascertain because it is not directly priced. In this instance, the industrial and domestic value of groundwater is represented by the cost of obtaining alternative supplies, provided customers are willing to pay the additional amount to acquire the same volume of water (George *et al.* 2011).

However, in financial analysis, the direct cost of groundwater development is considered. The direct cost of the groundwater development includes: the costs of groundwater extraction in the form of annualized cost of capital investment, maintenance costs and cost of electricity supply (Kumar *et al*, 2012).

Pavelic *et al*, (2012) observed that the cost of developing a typical borehole and wells in Ghana includes the cost of geophysical exploration, drilling of the water well, pumping test, water quality test and installation of pump. The geophysical exploration is done to locate suitable aquifers and best points for boreholes and wells. It involves resistivity and electromagnetic (EM) profiling and vertical electronical sounding (VES).

The breakdown of each of the major cost components as showed by Pavelic*et al* (2012) are as follows: geophysical exploration costs 143 US dollars per poi for VES and 7 US dollars/meter for resistivity and EM profiling. Drilling costs 3,500 US dollars for typical borehole of 60m deep and 0.14m diameter; tube wells cost about 400 US dollars and a hand-dug well cost varies widely from 40-1,300 US dollars. Cost of pump testing is ranges from 1,285 to 3,200 US dollars while installation costs about 100 US dollars. The cost of water quality analysis was found to be 200 US dollars.

Borehole development costs depend mainly on the depth of the boreholes. Pavelic*et al.*, (2012) further observed that in Kenya, the average cost of sinking and casing a borehole is 70 US dollars per meter. The average cost of digging an open well is 1 US dollars per meter for unlined wells and between 10 and 100 US dollars per meter for masonry and concrete lined wells. Due to high cost of lined wells, many of the wells developed by individuals are not lined as they lack sufficient financial resources. The pumping costs depend on whether electric power or diesel engines are used to power the pumps. The pumping cost of a 2 kW pump powered by diesel engine is about 0.2 US dollars per hour, while the cost of a 2 kW electricity driven unit is 0.1 US dollars per hour.

CHAPTER 3: METHODOLOGY

3.1 Study Area

The area where this study was conducted is Dodowa. Dodowa is a peri-urban community located in the Shai-Osudoku district in the Greater Accra region of Ghana, West Africa. It is geographically located within latitude $5^0$53'N and longitude $O^0$7'E.

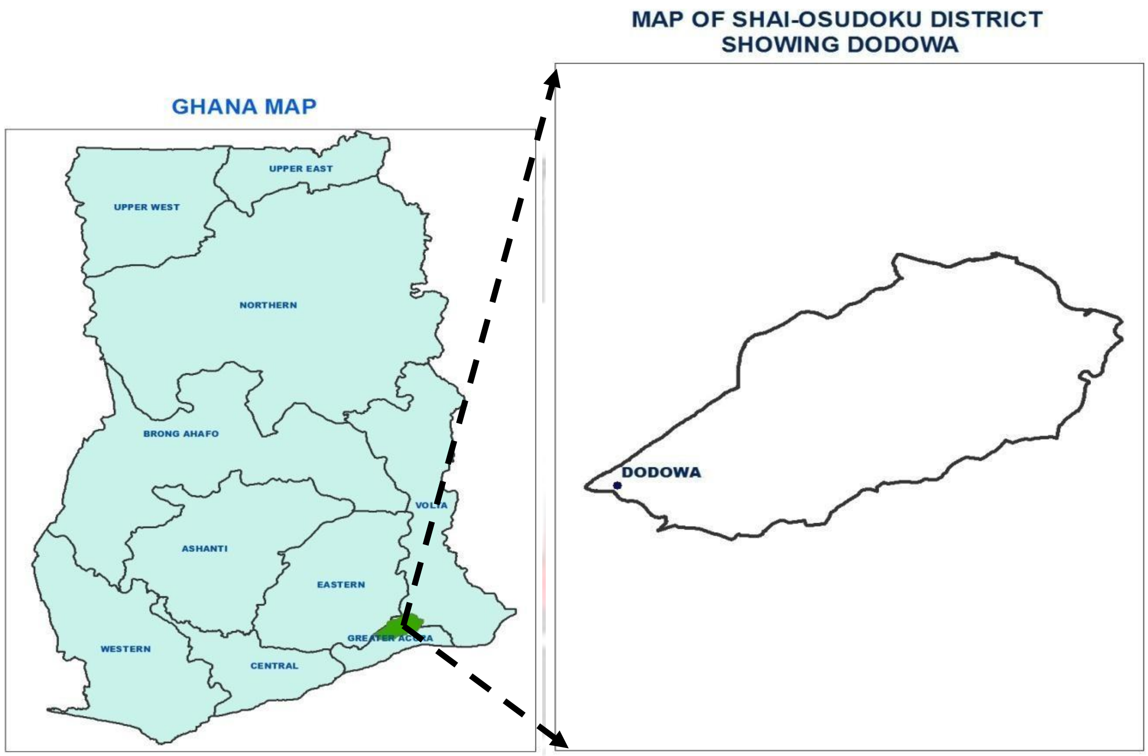

Figure 3.1: Map of Ghana showing Shai-Osudoku District and indicating the location of Dodowa

Below is a map of Shai-Osudoku District showing Dodowa in detail:

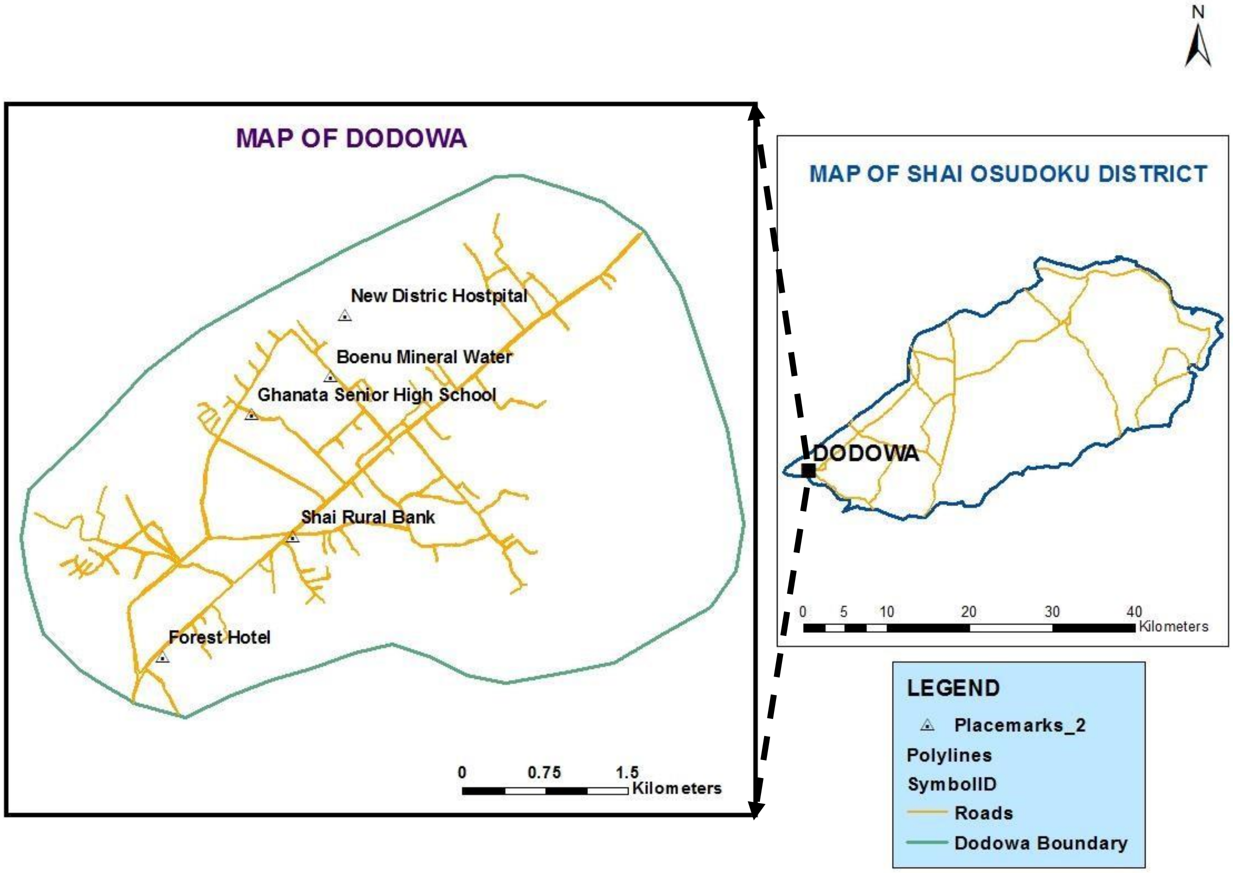

Figure 3.2: Map of Dodowa extracted from Shai-Osudoku District to show relevant landmarks

The satellite view (google image) of Dodowa has also been shown below:

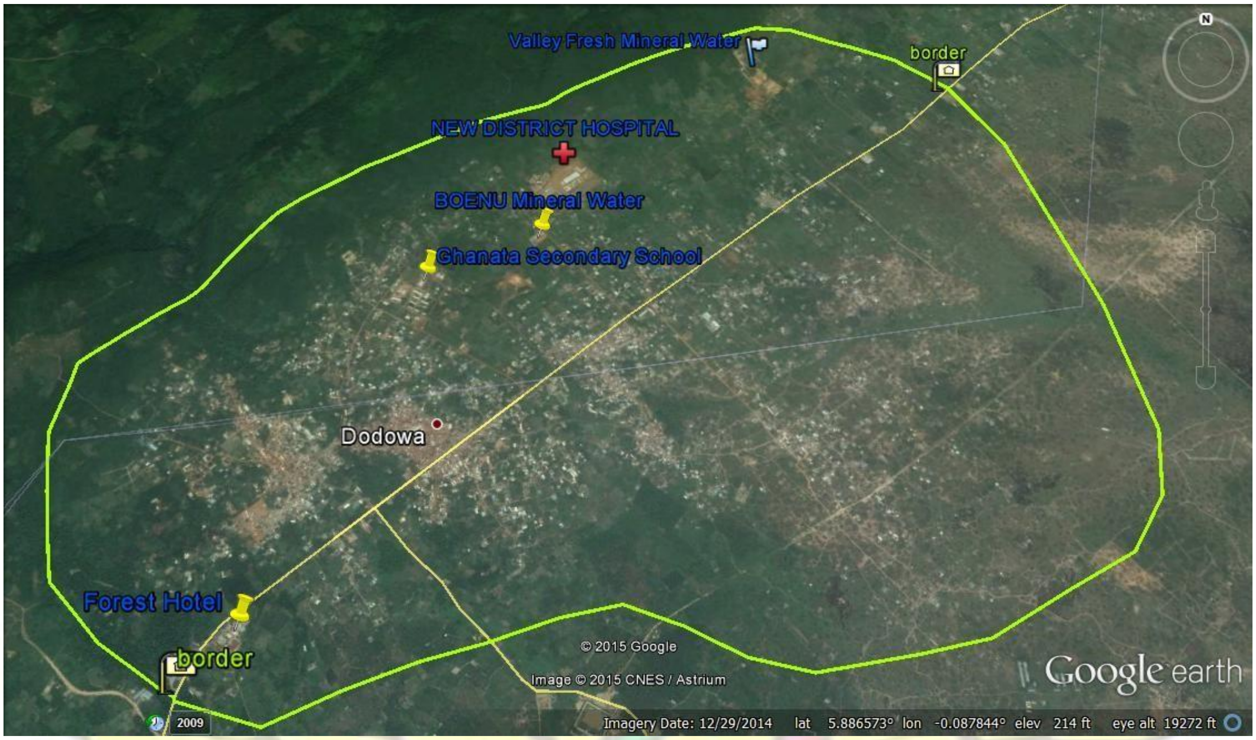

Figure 3.3: Satellite view of Dodowa Township (Google Image)

Dodowa has a total population of about 12,070 (Ghana Statistical Service, 2010) with an average household size of 5 and between 2200 to 2450 households. The type of settlement in Dodowa is in the dispersed form. The major occupation for the inhabitants of Dodowa can be categorized as skilled self employed which include people who offer services with a particular skill they have acquired to earn an income in return. Examples include sowing, carpentry, driving, hair dressing etc. However, there are also others who own and their private enterprises and a few government employees.

Generally the main water supply systems in Dodowa are groundwater systems which include boreholes and dug-wells and Surface water supply from Ghana Water Company Limited (GWCL).

The sanitation status in Dodowa includes shared community VIP toilets and communal dump sites for solid waste disposal.

Plate 3.1: Pictures showing environmental sanitation situation in Dodowa

3.2 Data Collection

In order to capture data on access to water supply, groundwater development and cost in the area, two activities were undertaken. These include household survey and an inventory of groundwater points. Open ended discussions were held in the community in few places to have a general idea about the area in terms of living conditions and water supply.

3.2.1 Household Survey

A questionnaire was designed as the household survey instrument use to capture information on demographic and socio-economic status of the people, access to water, cost and consumption.

A review of the questionnaire was done based on the information gotten from the open ended discussions to suit the community setting. The questionnaire was further piloted in a nearby town called Oyibi to assess to response and outcome of the survey, after which the final review and design of the questionnaire was done.

A sample size of 300 households was interviewed during this survey. The sampling technique employed for the household survey was a random type. However a systematic counting was used to randomly select households without bias. For a sample size of 300 households, every 7th household was selected for interview in order to cover approximately the entire study area.

3.2.2 Groundwater Inventory

An inventory was taken to map the groundwater systems in the area. As part of this inventory, groundwater supply points were mapped and the owners of the various water points were interviewed to capture information on the costs of development, operation and maintenance of the water points and the revenue received.

3.4 Data analysis

3.4.1 Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) and Excel spreadsheet were used for compilation and computation of the data obtained from the household survey. Summaries of access to water and their various proportions, descriptive statistics and correlations among access to water, cost, consumption and household income were obtained using SPSS and Microsoft Excel.

3.4.2 Financial Analysis

The data used for financial analysis of the various water source sales points (includes private owned boreholes and dug wells, and shared utility sales points) was obtained from interviews, water bills, electricity bills and other receipts obtained from the water point owners. Because of the difficulty of obtaining enough historical data on the finances of the water points, financial analysis was done on the water points established since 2012. Data needed for the financial analysis was obtained from only the recently constructed water points dating from 2012. Therefore financial analysis has been done for 3 years of operation of the water points from 2012 to 2015.

For each water point, the financial analysis involved estimating the capital cost, maintenance cost, labor cost, replacement cost and annual depreciation on the asset. This information was further processed to develop a cash flow stream for each water point from which payback analysis and rate of return analysis was done. An interest rate of 17.16% (average yearly inflation rate in Ghana from 1998 to 2016) was used in all computations and conversions.

3.4.2.1 Capital Cost

The capital cost is the sum total of investment made in the construction and the establishment of the water point. It includes drilling and abstracting cost for boreholes and dug wells, cost of pumping tests, cost of submersible pumps, the cost of treatment facilities (eg. Filters), cost of storage or any other facilities. It also includes other expenses that were made in the construction of the water points such as concrete works, plumbing works, and workmanship and connection fee (i.e. for the utility public tap / pipe supply).

3.4.2.2 Maintenance Cost

The maintenance cost used in this analysis is the total expenditure involved in operating the water points and maintaining the full performance of the various equipments such as pumps. It includes the cost of pump repairs and servicing, cost of cleaning the facility, cost of minor concrete repairs etc. It also includes electricity bills (the energy cost involved in pumping water), water bills (i.e. for the utility public tap/ pipe supply).

3.4.2.3 Labor Cost

The labor cost includes the cost involved in hiring water point's attendants, sales personnel and any other employee whose services are needed regularly in the operation of the water point.

3.4.2.4 Replacement Cost

This includes the cost involved in purchasing and installing retired equipments in the water point facility. Since this analysis was done for only the first 3 years of operatingthe water point, future replacement costs of equipments such as pumps were converted to annual costs using the formular below:

$A = F \times \frac{i}{(1+i)^{n}-1}$, where A is the annual uniform cost, F is the future cost, i is the interest rate and n is the number of years.

3.4.2.5 Depreciation

Depreciation is the loss of the value of an asset with time. In the financial analysis, the loss of the value of the water point facility was accounted for as an indirect cost. Straight line depreciation was used in estimating the annual cost incurred from the depreciation of the water point facility.

Depreciation is given by, $D = \frac{C-S}{N}$, where D is the annual depreciation charge/cost, C is the capital cost, S is the salvage value(the value of the asset at end of its useful life) and N is the useful life of the asset in years (in this research, a useful life of 15 years was used for the water points. This assumption was based on the design period of 15 years used in planning the water supply systems after which most of the facilities would be replaced and system expanded to meet an increase in demand).

3.4.2.6 Internal Rate of Return (IRR) Analysis

The internal rate of return was determined from the cash flow of the various water points. It is defined as the interest rate at which the present worth of benefits (PWB) equals the present worth of costs (PWC); in other words, the interest rate at which the net present worth (NPW) is zero (0).

To determine the present worth of future values, this formula was used to convert all values to the present worth:

$P = F / (1+i)^n$ where P is the present value, F is the future value, i is the interest rate and n is the number of years.

For a particular water point with a given cash flow, the present worth of benefits is given by;

$PWB = [B_1/(1+i)^1 + B_2/(1+i)^2 + B_3/(1+i)^3]$, where i is the interest rate, B_1, B_2 and B_3 are the benefits at the end of year 1, 2 and 3 respectively.

For a particular water point with a given cash flow, the present worth of costs is given by;

$PWC = C + [c_1/(1+i)^1 + c_2/(1+i)^2 + c_3/(1+i)^3]$, where i is the interest rate, C is the capital cost, c_1, c_2 and c_3 are annual total cost at the end of year 1, 2 and 3 respectively

Hence the net present worth is given by;

$NPW = PWB – PWC$

A graphical method was used hence arbitrary i values were fixed in the equation of which values of NPW was calculated. A plot of NPW against i gives a line which crosses the zero mark of NPW axis at a particular i. The i at which NPW is zero is the Internal Rate of Return for that particular water point.

3.4.2.4 Payback Period Analysis

This is a cumulative annual computation of Net Worth to determine the time at which the capital cost or initial investment in the water point is fully paid by the returns from the investment. A graphical method was used; a graph of annual net worth was plotted against time in years. The time at which the net worth is zero (that means initial cost is fully paid) is the payback period.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Access to Water Supply in Dodowa

Figure 4.1 below is a map of Dodowa showing the locations of households that were interviewed for data on access to water, consumption and cost:

MAP OF DODOWA SHOWING LOCATIONS OF HOUSEHOLD SURVEY

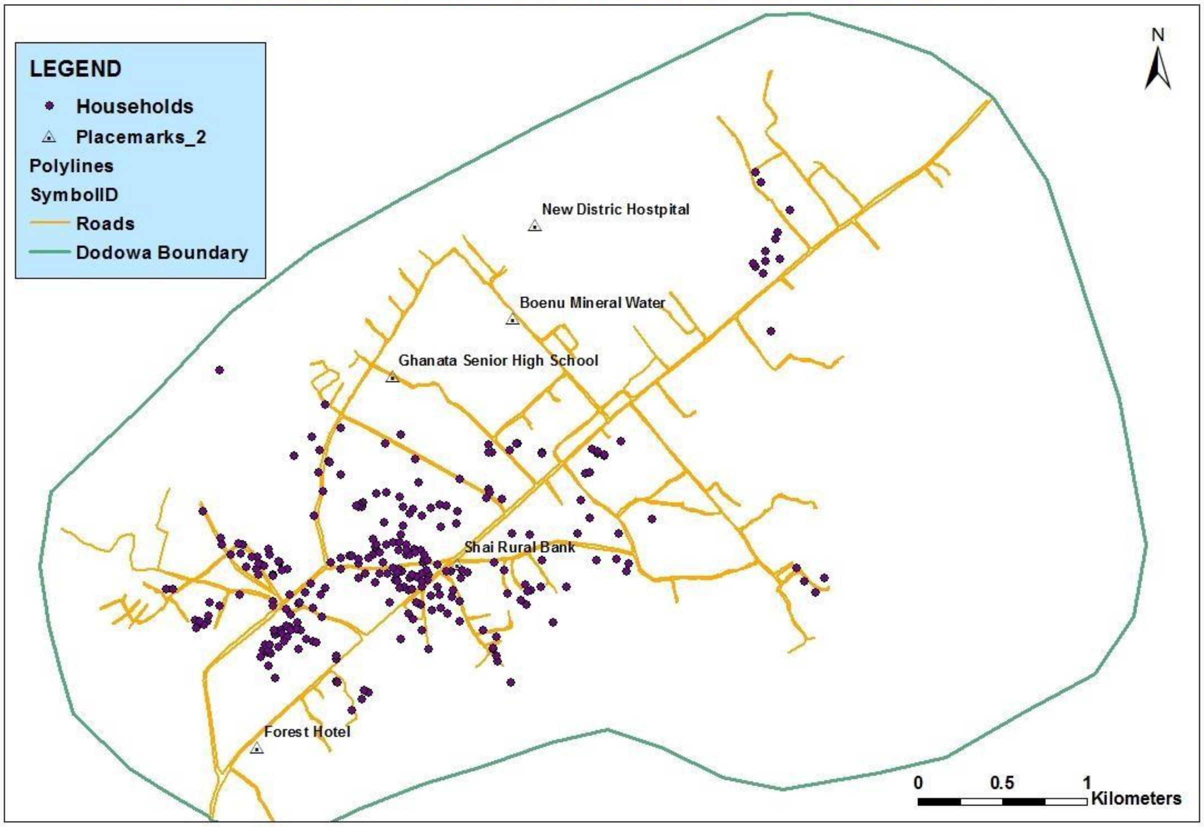

Figure 4.1: Map of Dodowa Showing Locations of Households Interviewed

The main sources and types of water supply and that were identified in Dodowa has been classified as follows:

- Piped into building (indoor/yard tap)
- Public Tap/Stand Pipe
- Borehole (Hand pump/Foot pump)
- Borehole (with Motorized Pump)
- Protected dug well
- Unprotected dug well
- Tanker/vendor water/cart/poly-tank
- Others (eg. Rain water harvesting)

However, the results showed that most of the people depend on more than one water source for consumption; a main source and a secondary option as a backup source mostly for washing. The consumers' perception about main source of water is very dicey. Some see the water that is fit for drinking and cooking as their main source and the water for other uses such as washing as a secondary source. However it was discovered from the results that the main source of water is the water that is used daily by the household for most of their activities such as for drinking, cooking, bathing and washing. Any other water source they use not too frequently is seen as a secondary or a backup water source.

4.1.1 Main source of water

The proportions of consumers' choice and access to main source of water are shown below in figure 4.2:

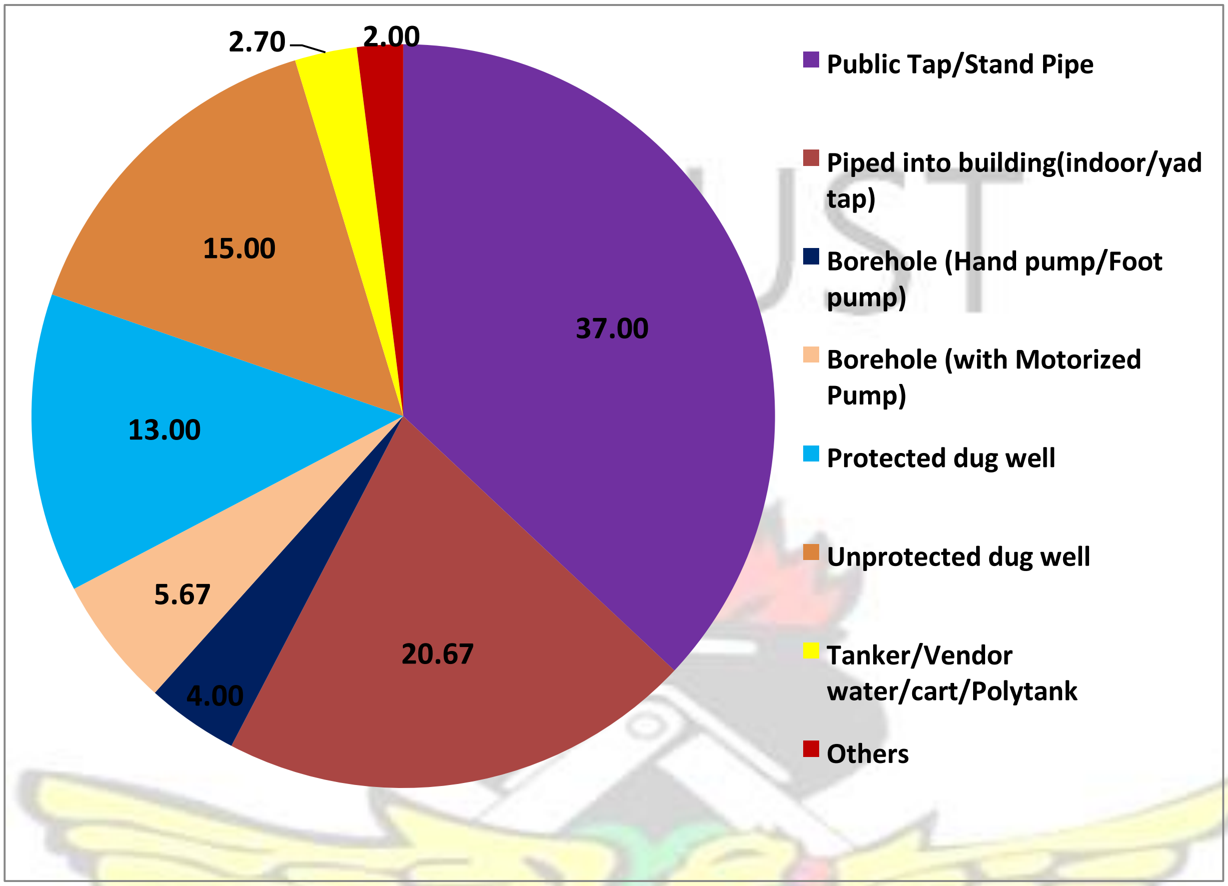

Figure 4.2: Pie Chart showing proportions of consumers' access to main source of water supply

It is evident from the pie chart (figure 4.2) above that out of the 300 households interviewed; public tap or standpipe has the highest dependency of 37% households using it as their main source of supply. The next water source with higher dependency for main supply is pipe water connected into buildings of the households. About 20.67% of the households have pipe water connected into their homes while 15% of the households use unprotected dug well as their main source of water supply. About 13% of households also use protected well as their main source followed by motorized borehole of 5.67% dependency and hand-pump borehole with 4% dependency. A few (2.7%) depend on tankers and venders for their main supply while the remaining 2% depend on other sources and types of supply such as rainwater harvesting as their main supply. Though almost all the households use rainwater, but it is recognize as their main supply because of its inconsistence and seasonal nature. It requires larger harvesting facilities to store water for major and consistence supply throughout the year. A few of these 2% have adequate harvesting facilities to store rainwater for consistent supply.

4.1.2 General Access to Various Water Sources

Apart from the main source of water supply, most of the households use other water sources as secondary supply or backup as stated before. The combined rate at which each water source is being accessed by the consumers either as a main source or a secondary or a backup source has been shown in the figure below:

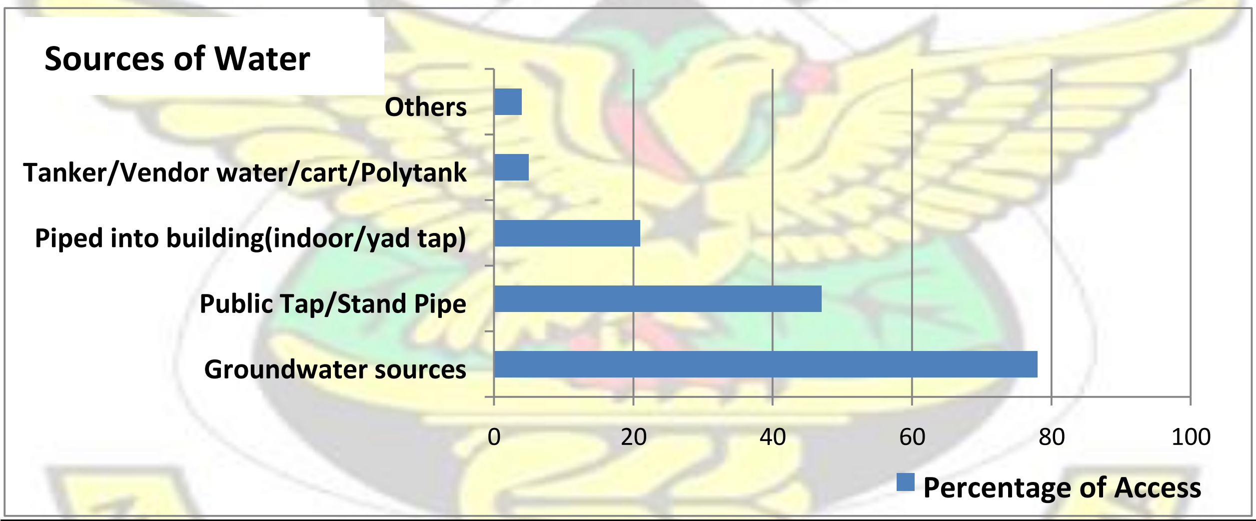

Figure 4.3: Combined rate at which consumers access and use each water source

The results displayed in figure 4.3 above shows that groundwater (including protected and unprotected dug wells, motorized boreholes and hand-pump boreholes) in general has the highest dependency of water supply with about 78% of households accessing it for consumption either as a main source or secondary/backup source. It was discovered through the survey that most of the households do not recognize groundwater as their main source even though they still use it. The reason is that most of them neither drink nor use for cooking but for bathing and washing. The second widely accessed water source is the public pipe tap (47%) followed by piped into building (21%) then tanker/ vendor water services (5%) and other sources (4%).

4.1.3Frequency of Water Supply

From the study, the frequency at which each water source is available and supplied to the consumers for consumption was also analyzed. The rate of availability has been classified into five (5) categories namely:

- Daily Availability (Constant supply throughout the days)
- Each Other Day (Water is made available day by day separately)
- Once a Week
- Twice a week
- Irregular

Below is a graph showing the frequency of supply among different sources of water supply:

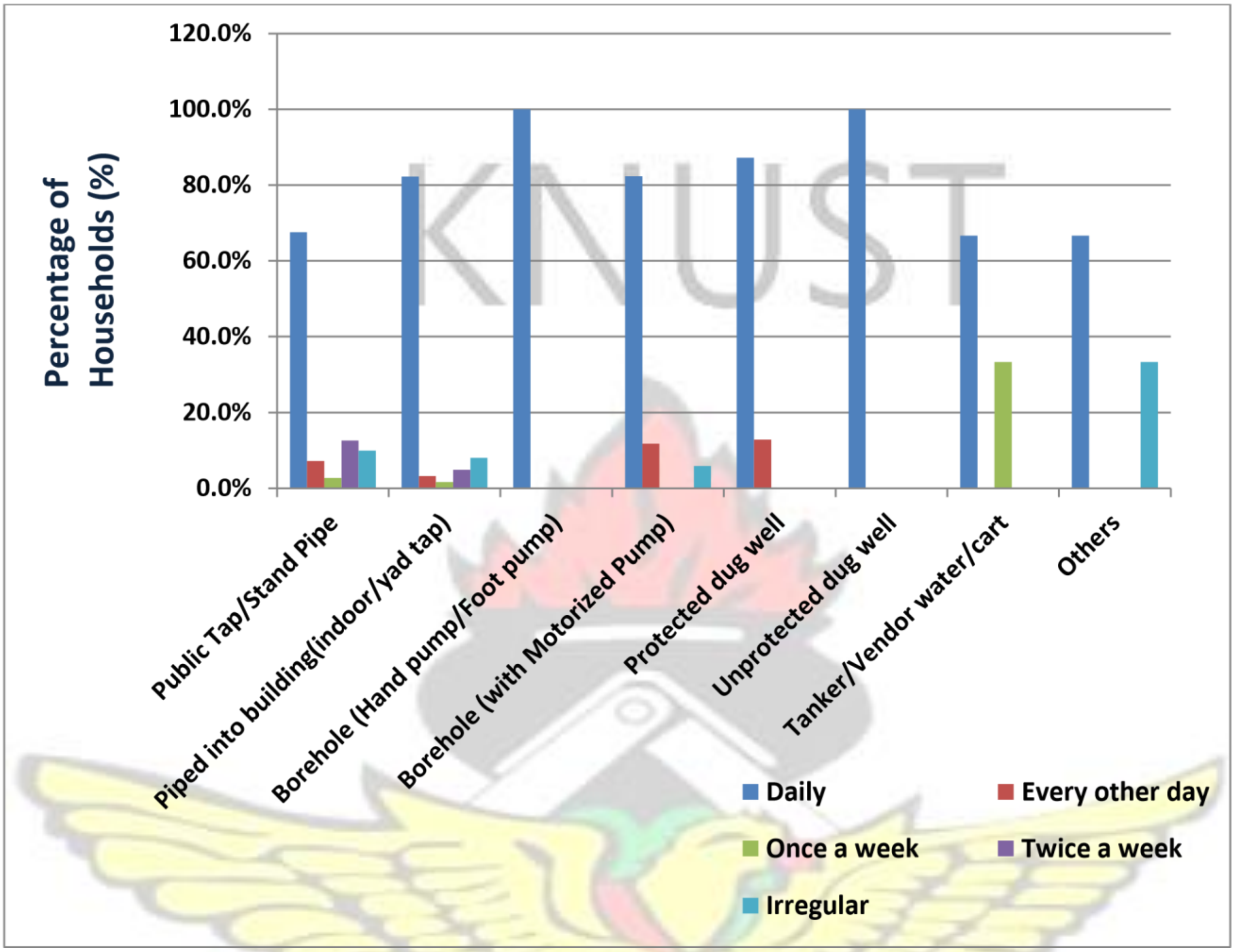

Figure 4.4: Frequencies of supply of Various Sources of Water

The results showed that for those households who depend on utility public tap, 67.6% have constant supply daily, 7.2% have water supply each other day but not 24 hours constant flow, 2.7% have water once a week, 12.6% have water twice a week and 9.9% have irregular water supply. For those with utility pipe connected to their buildings, 82.3% have constant daily supply, 3.2% have supply within some hours in each day, 1.6% have water once a week, 4.8% have water twice a week and 8.1% have irregular supply.

It is revealed from these results that in general, groundwater has higher frequency of supply and availability for consumption: for the households using hand/foot pump borehole and unprotected dug well, water is available daily; that is 100% constant daily supply. For the motorized borehole users, 82.4% have water daily, 11.8% have water within each particular day for some time and 5.9% have irregular supply of water. For those using protected dug well, 87.2% have water daily and 12.8% have water within some hours of each day.

Though groundwater has a higher frequency of supply and availability for consumption, water from motorized boreholes and protected dug wells are short in daily availability as compared to hand/foot pump borehole and unprotected dug wells. This is because all the motorized boreholes as well as some of the protected dug wells depend on electricity powered pumps for supply, so when the electricity is cut short, there is no supply of water for consumption.

For households who depend on water vendors and tankers, they buy the water in bulk which would last for a number of days depending on the availability of funds and household storage facilities. 66.7% of these consumers have water daily in their house while 33% have water once a week.

4.1.4 Sachet Water Use

It was also discovered through the survey that in general, about 96.3% of all the households use sachet water as a major source of drinking water. Though water sources such as public pipe tap and pipe into buildings are accepted by consumers as fit for drinking, most of them still prefer the use of sachet water in drinking due to the perception that it is cleaner and safer.

Below in figure 4.5is the distribution sachet water use rate within each main source of water:

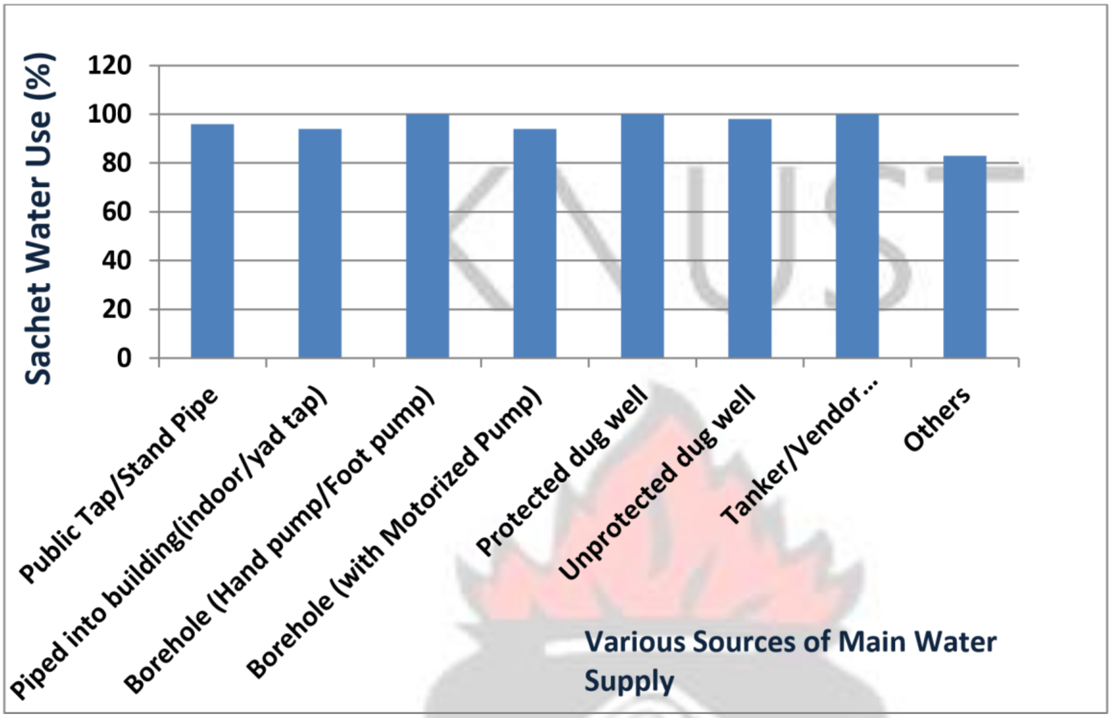

Figure 4.5: Sachet water use rate of consumers within each main water source

Among the households depending on as public pipe tap and pipe into buildings for main supply, 96% and 94% of them still buy sachet water for drinking respectively. About 98% of the households who use the unprotected dug wells as their main source of water supply see the wells as not fit for drinking because of its salty taste and uncleanliness. The same reason applies to the consumers of protected dug wells of which all of them use sachet water. Also because of the complaints about the salty taste of the boreholes, most of them buy sachet water as shown in the figure above. These consumers use the wells for bathing, washing and cooking whiles they buy sachet water for drinking.

All the households depending on tankers and vendors also use sachets water when it comes to drinking. The perception is that the quality of the water is compromised through the transport in tankers, polytanks and other containers.

4.2 Water Consumption, Cost and its Implication to Consumers

4.2.1 Per Capita Water Consumption of Various Water Sources

The water consumption per capita per day of various sources of water, as displayed in table 4.1 shows that those who have pipe water connected to their house consume more water than all other consumers. People with house connection have the opportunity of connecting direct to the kitchen, bath room, toilet etc and hence are more prone to using more water. Furthermore the amount they pay for water is lesser as indicated in figure 4.6 and hence more water is consumed with less cost. Sachet water on the other hand has the lowest per capita consumption per day (2.12 liters/day) because it is only used by households for drinking purposes. Some of the households consume less sachet water because they also drink from their primary source of water supply (eg. Those who use utility pipe water or borehole as their main source).The water source with the next higher per capita consumption is the utility public tap (39.12liters/day) followed by the boreholes and the dug wells. Households who have their water supply from vendors/water tanker operators are very critical in their water consumption because of its high cost (figure 4.6) **Table 4.1: Water Consumption per Capita/Day of Various Sources**

WATER SOURCE	PER CAPITA CONSUMPTION (LITRES/DAY)
Piped into building(indoor/yard tap)	40.78
Public Tap/Stand Pipe	39.12
Borehole (Hand pump/Foot pump)	37.15
Borehole (with Motorized Pump)	36.67
Protected dug well	35.6

Unprotected dug well	35.01
Tanker/Vendor	31.27
Sachet Water	2.12

4.2.2 Unit Cost of Various Water Sources

Based on the survey, the unit cost of the various water sources supplied in Dodowa have been computed and shown below:

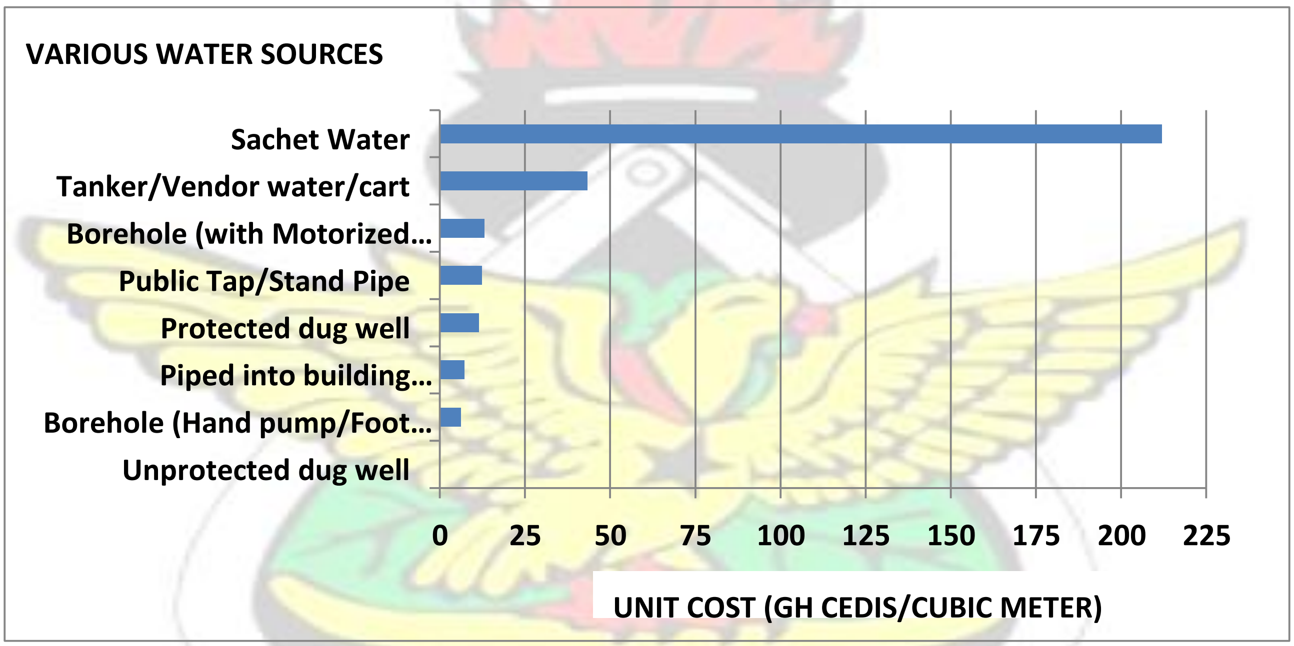

Figure 4.6: Unit Cost of various water source and supply types

It is evident in figure 4.6 above that sachet water which widely used by the households has relatively very high cost to consumers with a unit price of 212 Ghana Cedis per cubic meter. This implies that the households' expenses on water will be greatly increased by the purchase of sachet water. It was discovered that, averagely the purchase of sachet water amounts to 72% of a household's total water expenditure.

The next higher unit price is that of the tanker/ vendor water supply (43.42 Ghana Cedis per cubic meter). This is also a relatively high cost which is partly due to the cost in transporting the water to the consumers' house. The next higher unit price is that if motorized borehole which is found to be 13.06 Ghana Cedis per cubic meter. This is so because of the cost involved in construction, operation and maintenance. These motorized boreholes are owned by private business men and hence their profit is not would not be compromised in fixing the prices. Public pipe tap is the next higher priced water source of about 12.4 Ghana Cedis per cubic meter followed by protected dug well (11.52 Ghana Cedis per cubic meter).

Households whose have access to pipe in their buildings pay relatively less for water. They pay 7.17 Ghana Cedis per cubic meter for their water consumption. This is not beneficial for the poor because most of poor do not have that access to pipe water into their buildings; they are more dependent on public pipe taps, motorized boreholes and other shared sources of supply. The poor end up paying more for water.

However, there is also community owned hand-pump boreholes which cost relatively lesser (that is about 6.17 Ghana Cedis per cubic meter) and free to fetch unprotected wells.

4.2.3 Cost of Water and Household Income

In analyzing the implications of water cost on consumers, the fraction of their monthly income spent on water has been determined for each household. This was done to reveal how much of the household's monthly income is spent on water alone. Percentages of monthly income spent on water have been grouped as follows: those who spend less than 5% of their monthly income on water, those who spend from 5% to 10% of their monthly income on water, those who spend from above 10% to 20% of their monthly income on water, those who spend from above 20% to 30%

of their monthly income on water and those who spend more than 30% of their monthly income on water.

The results revealed that 42.86% of the households interviewed spend less than 5% of their monthly income on water. This implies that about 57.14% 0f these consumers spend 5% or more of their monthly income on water. Within this 57.14%, 30.71% spend from 5 to 10% of their monthly income on water, 20.71% spend between 10 and 20% on water, 4.29 spend between 20 and 30% on water while 1.43% of the households spend more than 30% of their monthly income on water.

Below in figure 4.7 is a graph household (in percentages) versus groups of water cost as a percentage of household income:

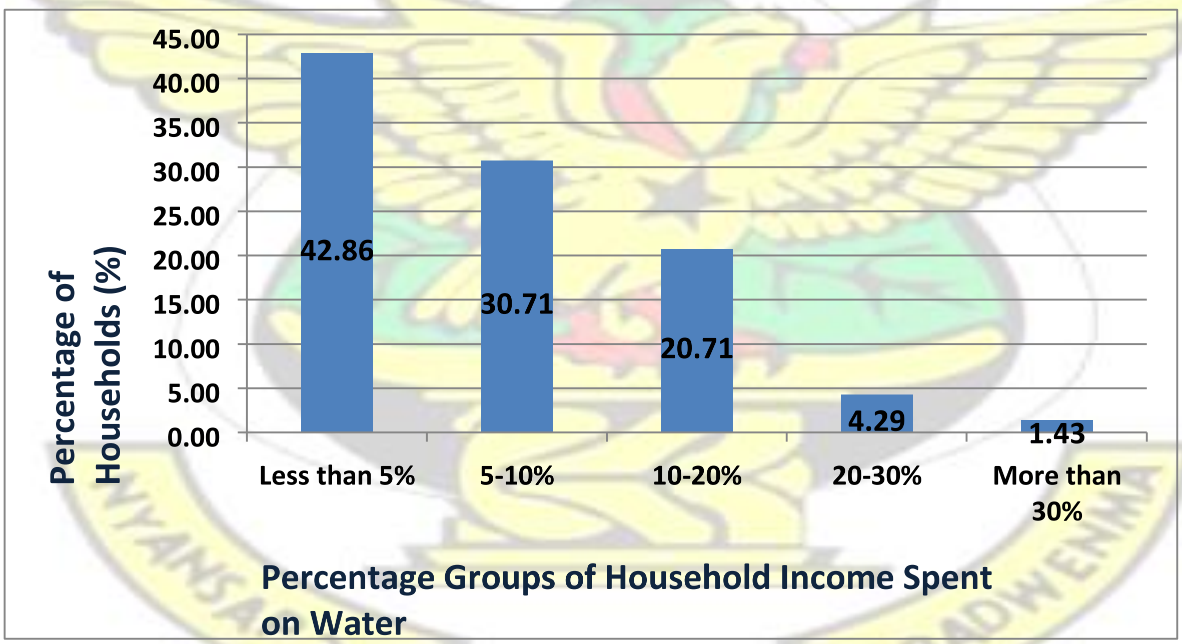

Figure 4.7: Percentage of Household Income Spent on Water

Furthermore, the average household monthly incomes have been grouped according to the various amount they earn as follows; those who earn less than 500 Ghana Cedis, those who earn from 500 to 1000 Ghana Cedis, those who earn between 1000 and 2000 Ghana Cedis and those earning more than 2000 Ghana Cedis a month.

The groups of percentages of household monthly income spent on water was plotted against these income groups in order to observe how these are distributed within each water cost/monthly income percentage groups The result is show below in figure 4.8:

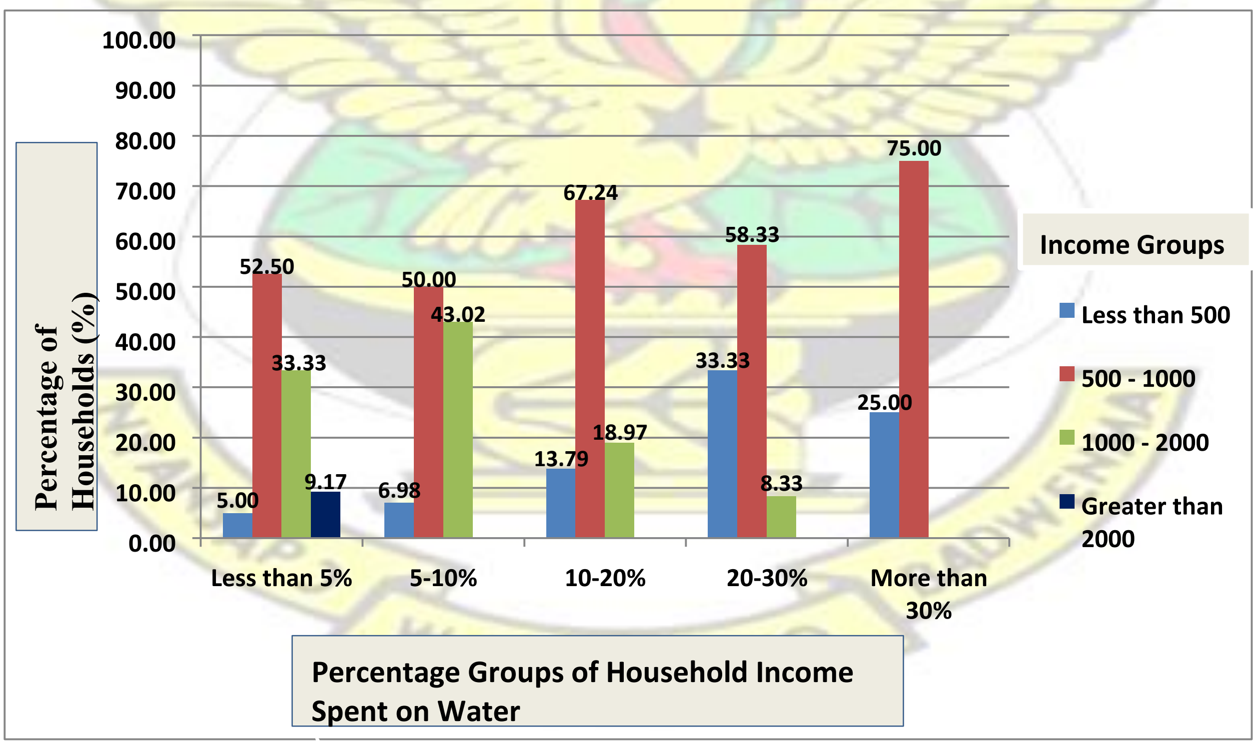

Figure 4.8: Percentages of Household Monthly Income Spent on Water and Income Groups

It was observed from the analysis that, out of households who spend less than 5% of their monthly income on water, the lowest income group (that is those who earn less than 500 Ghana Cedis monthly) form only 5%. It can also be observed that all the households who fall within the highest income group (that is those who earn more than 2000 Ghana Cedis monthly) spend less than 5% of their monthly income on water. It is also evident that households within the lowest income group are more as the water cost/monthly income percentage increases up to 30%. It is intriguing to observe that the households spending more than 30% of their income on water rather fall within the last two lower income groups (that; is less than 500 and from 500 to 1000 Ghana Cedis). It is therefore evident that the lower income groups spend higher percentage of their monthly income on water.

Furthermore, households who earn from 500 to 1000 Ghana cedis monthly are seen to be dominating in all the water cost/monthly income percentage groups. This shows that most of the households in Dodowa fall within this particular income group.

4.2.4 Water Cost Per Capita per Day and Household Income Groups

Results displayed in figure 4.9 shows the water cost per capita per day for different income groups. According to the results, a person from the least income group (that is those who earn less than 500 Ghana Cedis a month), pays more (0.84 Ghana Cedis) in a day for water than all other income groups. The lesser income groups do not have pipe connections in their homes and most of them can't afford owning a dug well and hence they are more dependent on public taps, water vendors and motorized boreholes which come at a higher cost. Furthermore, the trend is evident in the results such that the higher income groups pay less for water.

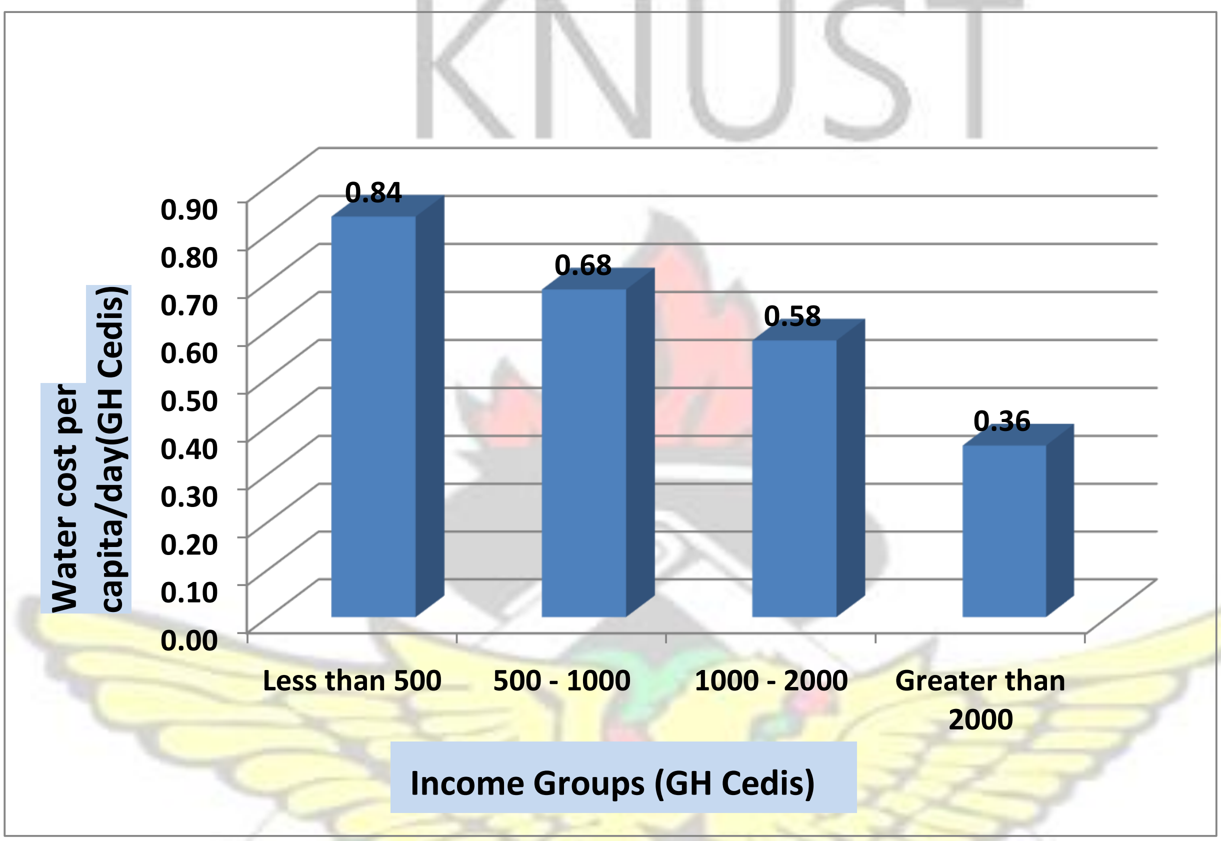

Figure 4.9: Water Cost per Capita per Day for Various Income Groups

4.3 Groundwater Development Technologies in Dodowa

The different technology options by which groundwater is accessed in Dodowa for domestic supply are hand-dug wells and boreholes. Based on the findings from the study, the hand-dug wells were classified into two namely; protected dug wells and unprotected dug wells. The protected dug wells were the wells which are well lined with concrete and fully covered. Unprotected dug wells are the wells without proper lining and not fully covered. Below are some of the pictures of dug wells found in Dodowa.

Plate 4.1: Protected Dug Wells

Plate 4.2: Unprotected Dug-Wells

The boreholes were also classified into two namely; motorized borehole and man powered borehole which is either hand-pump or foot-pump. The motorized boreholes are boreholes that are pumped by a motor into a reservoir for supply.

Below are pictures some man powered boreholes and a motorized borehole with an elevated storage tank:

Plate 4.3: Hand-Pump/Foot- Pump Boreholes

Plate 4.4: Motorized Borehole with Storage

4.3.1 Spatial Distribution of Groundwater Points in Dodowa

A total of 57 groundwater points were mapped across the entire community of Dodowa. Out of this number, 21 of them were Unprotected Dug Wells, 16 Protected Dug Wells, 10 Motorized Boreholes and 10 Hand/Foot-Pump Boreholes.

The coordinates of the groundwater points mapped in Dodowa have been displayed on a map as shown in figure 4.10 below:

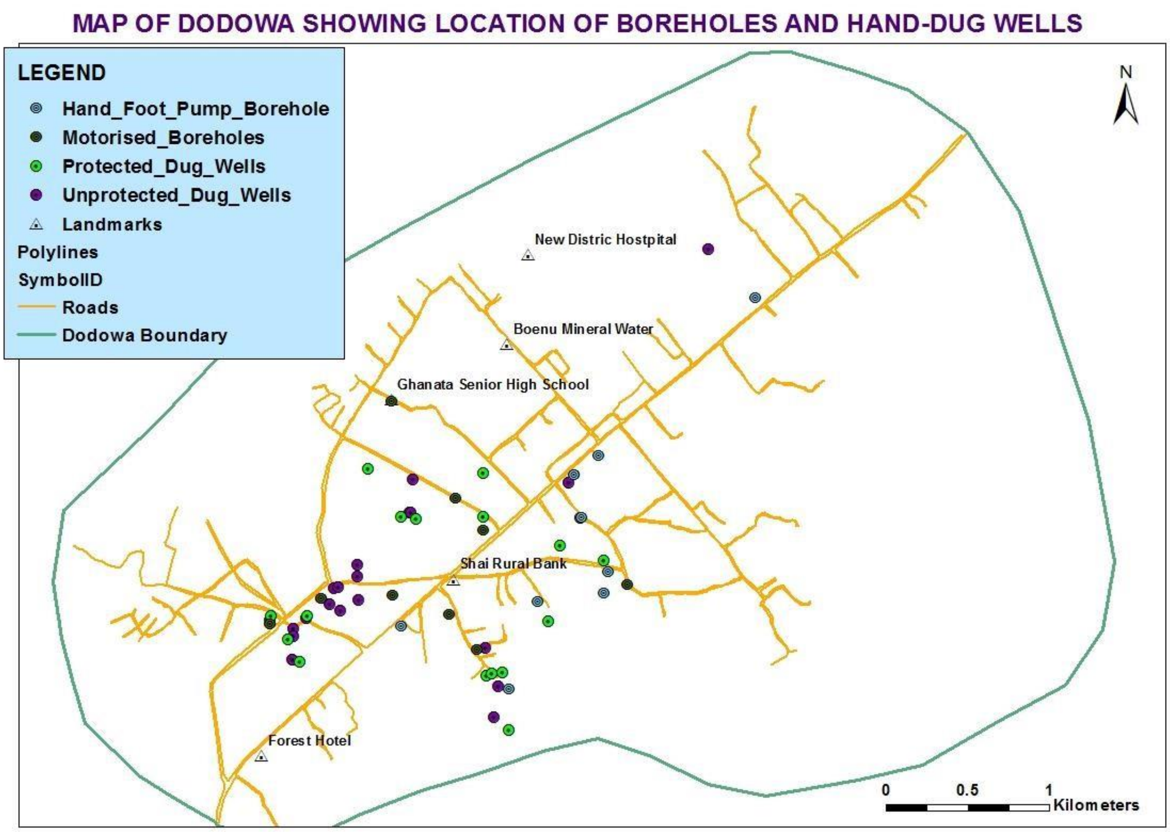

Figure 4.10: Map of Dodowa Showing Location of Boreholes and Hand-dug Wells

4.4 Financial Analysis of Water Points in Dodowa

During the inventory and the household survey, the following shared water sales point was discovered:

- Motorized borehole where an individual with a borehole treats (mainly by filtration) and pumps water into a storage system and sells to both neighbors and water vendor/tanker operators.
- Protected dug well where an individual with a protected well pumps into a storage system and sells to neighbors.
- Community owned hand/foot pump borehole where an individual appointed by the community sells the water to neighbors and renders accounts to financial committee set up by the community.
- Utility pipe (public tap) with storage where an individual with utility pipe connection buys from the utility provider (Ghana Water Company Limited) stores and sells to neighbors who are without utility pipe connection as well as water vendor/tanker operators.

A financial analysis has therefore been done to assess the profitability of managing these water points as a private business.

This analysis has been done solely based on financial data obtained from water point owners through interviews, receipts and bills as explained in the previous chapter. The results are therefore a direct representation of what is actually being practiced in the study area.

4.4.1 Motorized Borehole with Storage

This water point consist a motorized borehole where water is pumped into either an elevated concrete reservoir or a mounted poly tank of sizes ranging from 5000 liters to 10000 liters capacity. The main form of treatment that was observed to be done on this water point was mainly filtration and sometimes disinfection. This kind of groundwater points in Dodowa are managed by individuals as their own private business. The main customers are individuals from nearby households who access the water for their domestic consumption and water vendors/tanker operators who purchase in bulk and sell them to other consumers in Dodowa.

4.4.1.1 Cash Flow

Financial data obtained from this water point has been compiled and used to develop a cash flow as shown below in table 4.2 and figure 4.11:

Table 4.2: Cash Flow for Motorized Borehole Water Supply Point in Dodowa

YEAR	**2012**	**2013**	**2014**	**2015**
Capital Cost (GH Cedis)	13864			
Annual Maintenance Cost (GH CEDIS)		2744	3215	3767
Annual Labor Cost GH Cedis)		1200	1200	1500
Replacement Cost (GH CEDIS)		1559	1559	1559
Depreciation Cost (GH Cedis)		924.3	924.3	924.3
TOTAL ANNUAL COST (GH CEDIS)	**-13864**	**-6427.3**	**-6898.3**	**-7750.3**
ANNUAL REVENUE (GH CEDIS)		**11633**	**13630**	**15969**
NET ANNUAL PROFIT	**-13864**	**5205.7**	**6731.7**	**8218.7**
CASH FLOW	**-13864**	**-8658.3**	**-1926.6**	**6292.1**

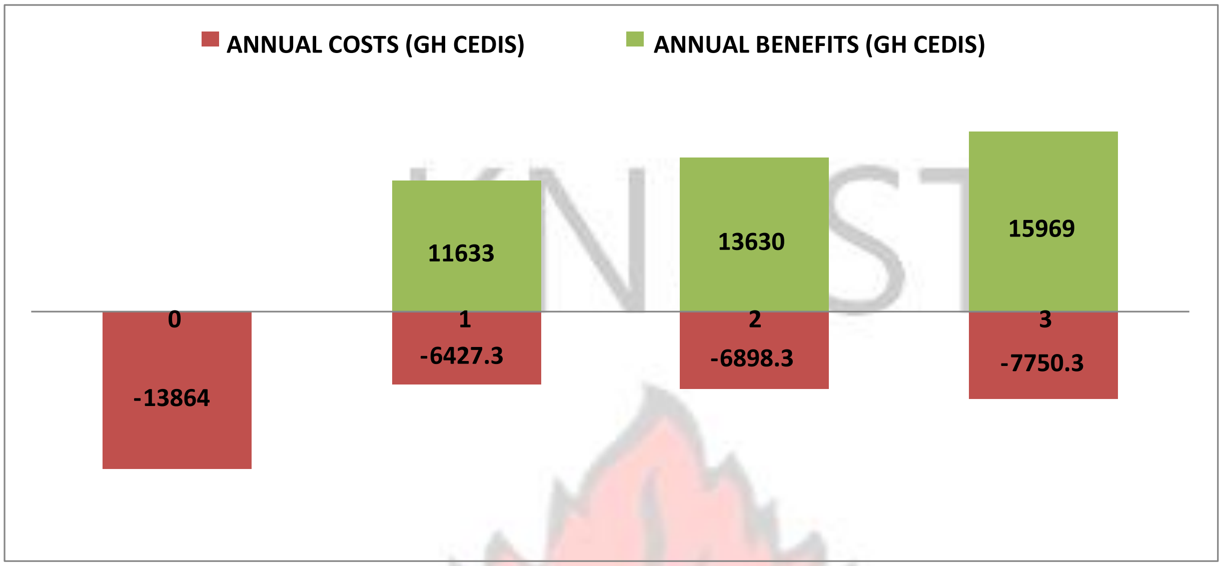

Figure 4.11: Cash Flow Diagram for Private Motorized Water Supply Point in Dodowa

4.4.1.2 Pay-back Period Analysis

For mortised borehole, a pay-back period of 2 years, 3months was obtained from the analysis. This show that within this short period the investment made on the water point assets would be fully recovered by the returns from the sale of the water. There almost no complains about the taste and quality of this water points as compare to other groundwater technologies such as the dug wells hence those who operate this groundwater point receive more customers than those operating the dug wells. The major difference in taste is mostly due to the depth of abstraction (ranging from 100 to 200 meters) as compared the dug wells.

Below in figure 4.12is the result of the payback analysis of the motorized borehole water point:

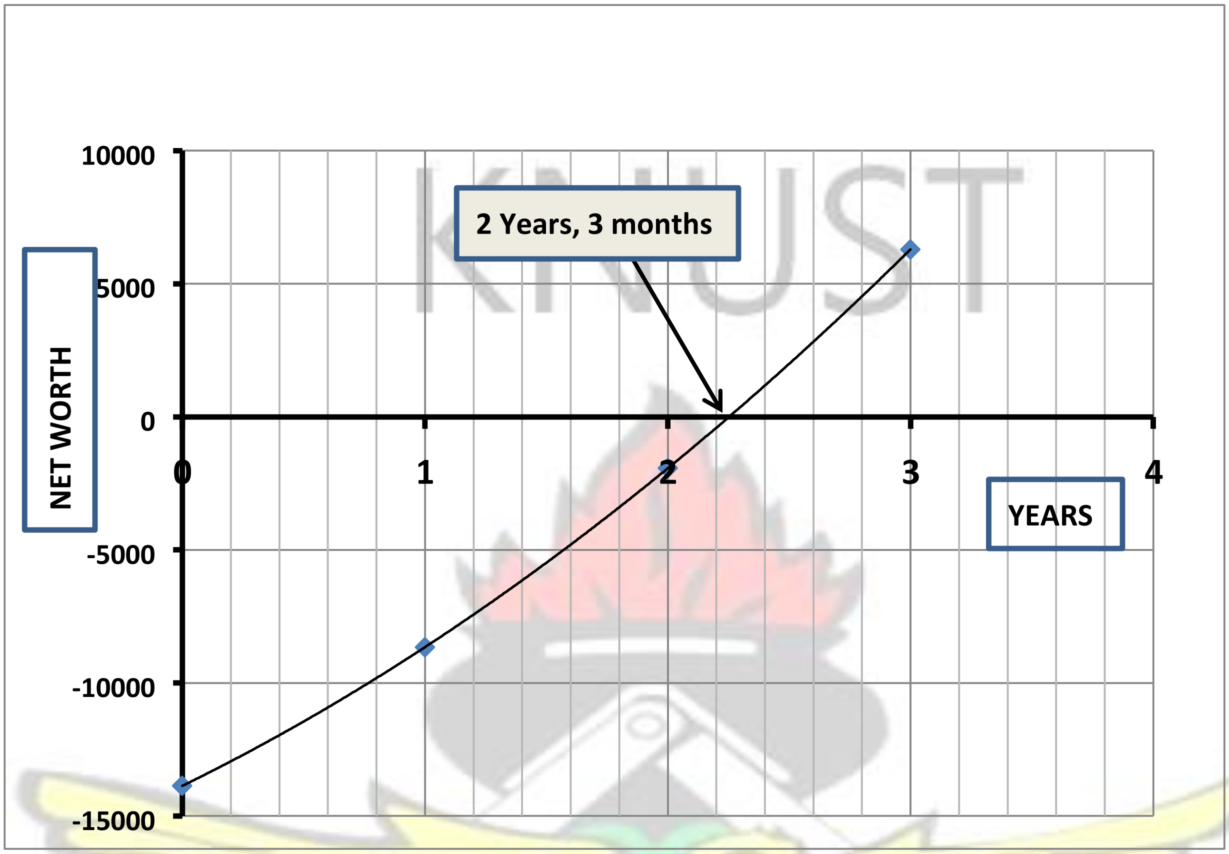

Figure 4.12: Pay-back Analysis of Motorized Borehole Water Supply Point

4.4.1.3 Internal Rate of Return Analysis

A rate of return of 19.5% was obtained from the analysis on the 3 years of operating this water point. Though according to the cash flow, high revenue is received by the end of each year but as a result of high cost of investment (capital cost) for the water, the rate of return could be much higher in a much longer years of operation.

Below in figure4.13 shows the results of the internal rate of return analysis of the motorized borehole water point:

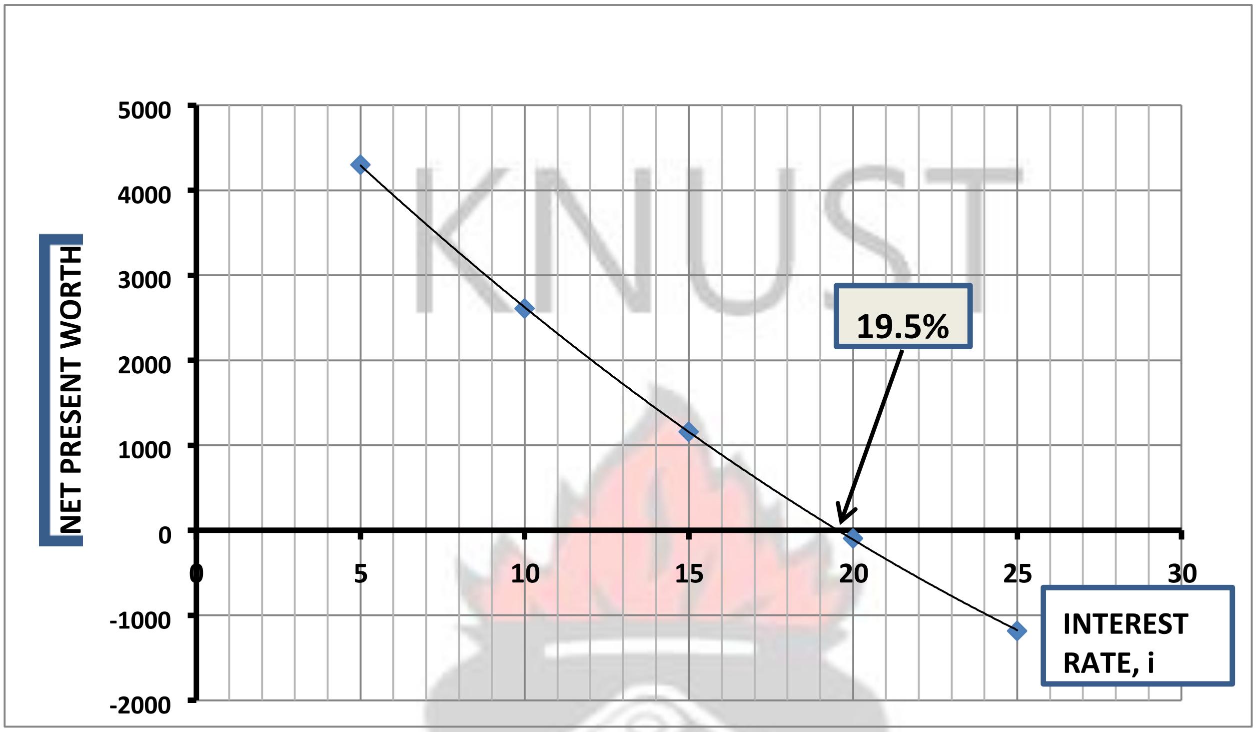

Figure 4.13: Internal Rate of Return Analysis of Private Owned Motorized Borehole Water Point

4.4.2 Protected Dug Well with Pump and Storage

This water point involves a hand dug well of depth ranging from 4 metersto 20 meters, properly lined with concrete and completely covered. A pump is connected to the well to pump water into a reservoir for supply. This water point is owned and operated by individuals as a private business.

4.4.2.1 Cash Flow

Financial data obtained from this water point has been compiled and used to develop a cash flow as shown below in table 4.2 and figure 4.14:

Table 4.3: Cash Flow for Protected Dug Well Water Supply Point in Dodowa

YEAR	2012	2013	2014	2015

Capital Cost (GH Cedis)	3000			
Annual Maintenance Cost (GH CEDIS)		874	1024	1200
Annual Labour Cost GH Cedis)		600	840	1200
Replacement Cost (GH CEDIS)		355	355	355
Depreciation Cost (GH Cedis)		200	200	200
TOTAL ANNUAL COST (GH CEDIS)	**-3000**	**-2029**	**-2419**	**-2955**
ANNUAL REVENUE (GH CEDIS)		**2415**	**2777**	**3350**
NET ANNUAL PROFIT	**-3000**	**386**	**358**	**395**
CASH FLOW	**-3000**	**-2614**	**-2256**	**-1861**

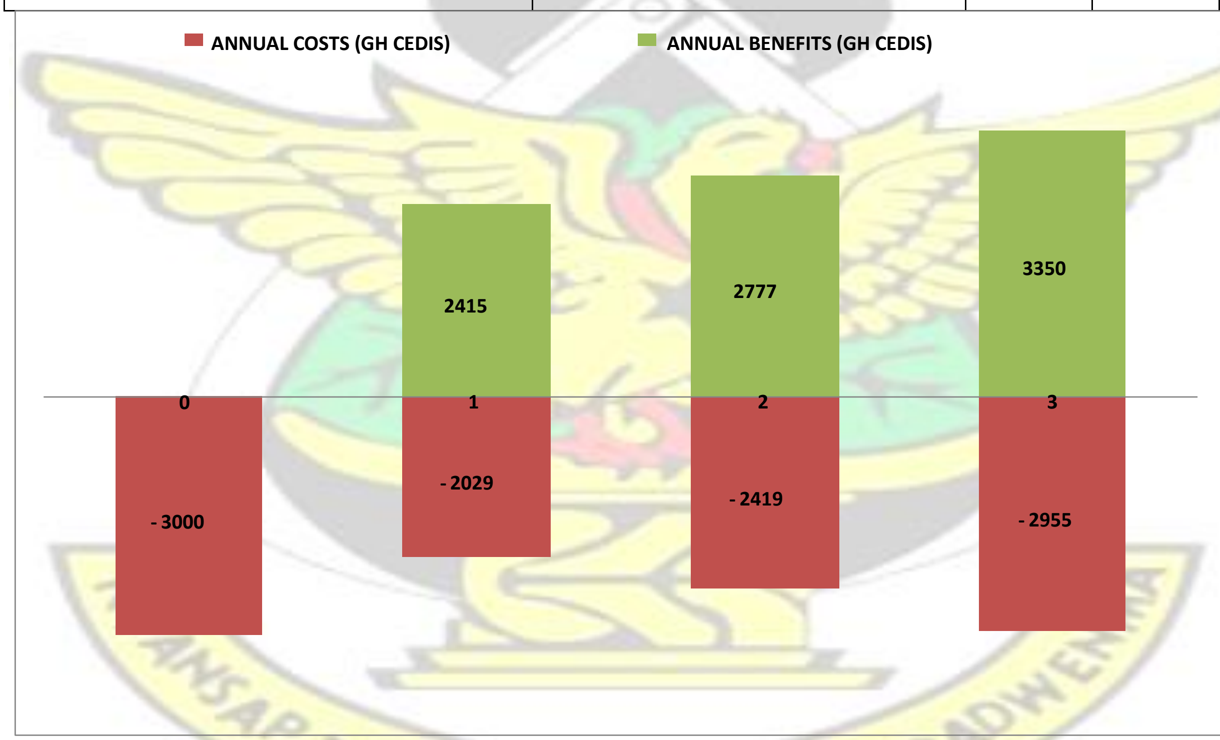

Figure 4.14: Cash Flow Diagram for Protected Dug Well Water Supply Point in Dodowa

4.4.2.2 Pay-back Period Analysis

For protected dug well, a pay-back period of 7 years, 9 months was obtained from the analysis.

This show that it will take a relatively longer period as compared to the motorized borehole until the investment made on the water point assets would be fully recovered by the returns from the sale of the water. The reason is that there are a many protected dug wells in Dodowa but a few of them are being managed as a business and sold to the people for profit making; the rest are free. Consequently, few consumers buy water from this water point since they could g*et al*most the same type of water for free in a nearby neighbor's house. Daily sales are therefore minimal; especially during the raining season where most people harvest rain water in their homes.

Furthermore, as a result of the shallow depth of the dug wells, there is more complains of bad taste and saltiness among the consumers than with the motorized boreholes which are deeper.

Below in figure 4.15 shows the pay-back analysis of the protected dug well:

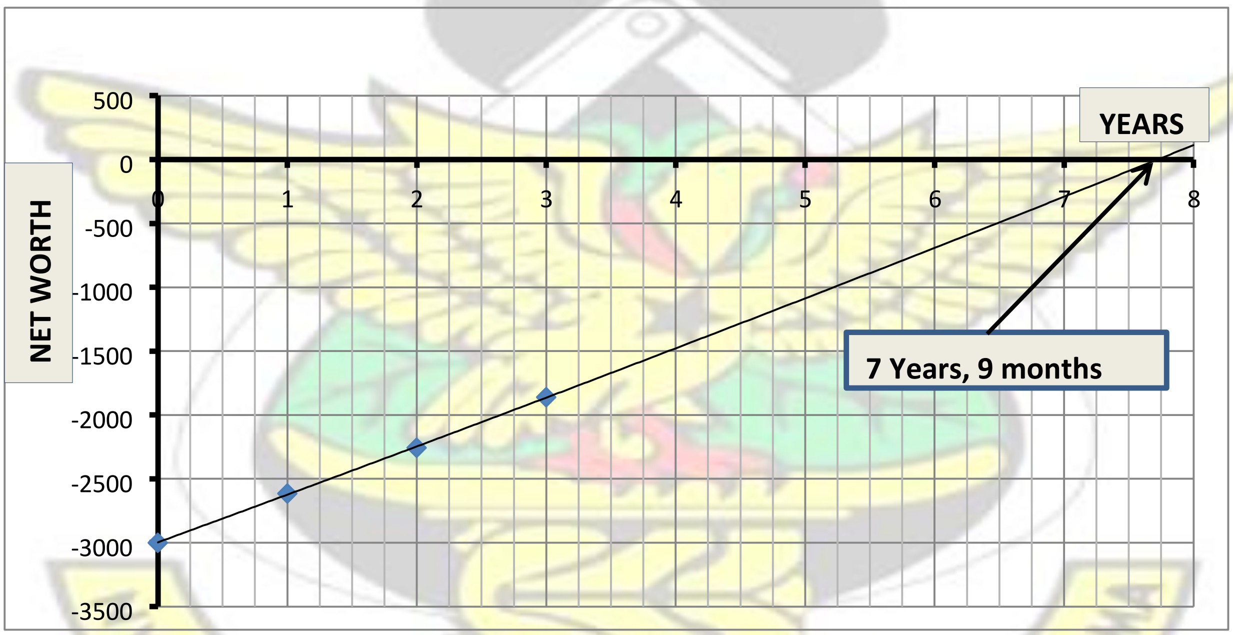

Figure 4.15: Pay-back Analysis of Private Managed Protected Dug Well Water Supply Point

As a result of more than seven years pay-back period, rate of returns on a 3 year analysis on this water point is negligible.

4.4.3 Utility Pipe (public tap) with Storage

For this water point, an individual who has pipe connection from Ghana Water Company Limited (GWCL) on a commercial status sells the water to households who do not have direct connections. The facility includes a public tap and a storage system (mostly poly tank). They are billed by GWCL monthly and they also recover cost by selling to consumers.

4.4.3.1 Cash Flow

Financial data obtained from this water point has been compiled and used to develop a cash flow as shown below in table 4.4 and figure 4.16:

Table 4.4: Cash Flow for Utility Pipe(Public Tap) Water Supply Point in Dodowa

YEAR	**2012**	**2013**	**2014**	**2015**
Capital Cost (GH Cedis)	2000			
Annual Maintenance Cost (GH CEDIS)		619	726	850
Annual Labour Cost GH Cedis)		1200	1200	1200
Replacement Cost (GH CEDIS)		360	360	360
Depreciation Cost (GH Cedis)		133.3	133.3	133.3
TOTAL ANNUAL COST (GH CEDIS)	**-2000**	**-2312.3**	**-2419.3**	**-2543.3**
ANNUAL REVENUE (GH CEDIS)		**3312**	**3809**	**4380**
NET ANNUAL PROFIT	**-2000**	**999.7**	**1389.7**	**1836.7**
CASH FLOW	**-2000**	**-1000.3**	**389.4**	**2226.1**

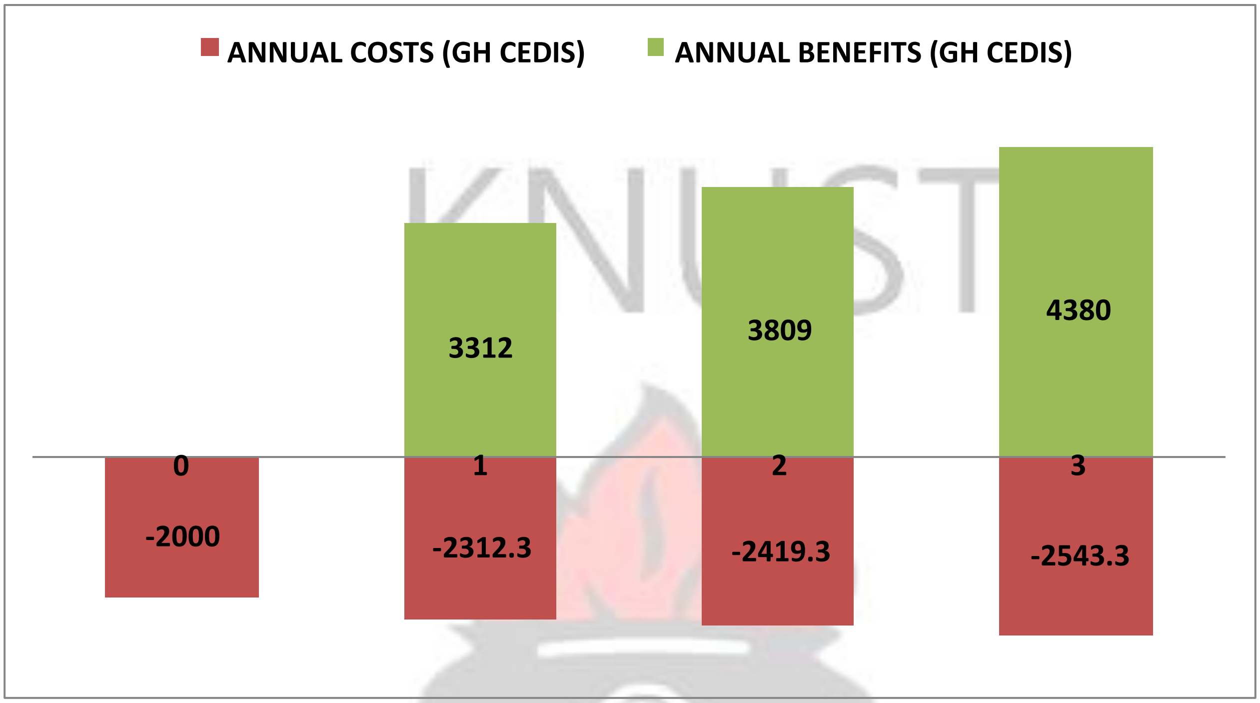

Figure 4.16: Cash Flow Diagram for Utility Pipe (Public Tap) Water Supply Point in Dodowa

4.4.3.2 Pay-back Period Analysis

According to the results from the pay-back period analysis shown in figure 4.17, it will take the water point owner one (1) year, nine (9) months to pay back in full the total investment made on the utility public tap water point. This shows that there is enough profit made from operating this water point in Dodowa. As compared to those managing the motorized borehole, this water point has a lower investment cost and hence a shorter time to recover the capital cost.

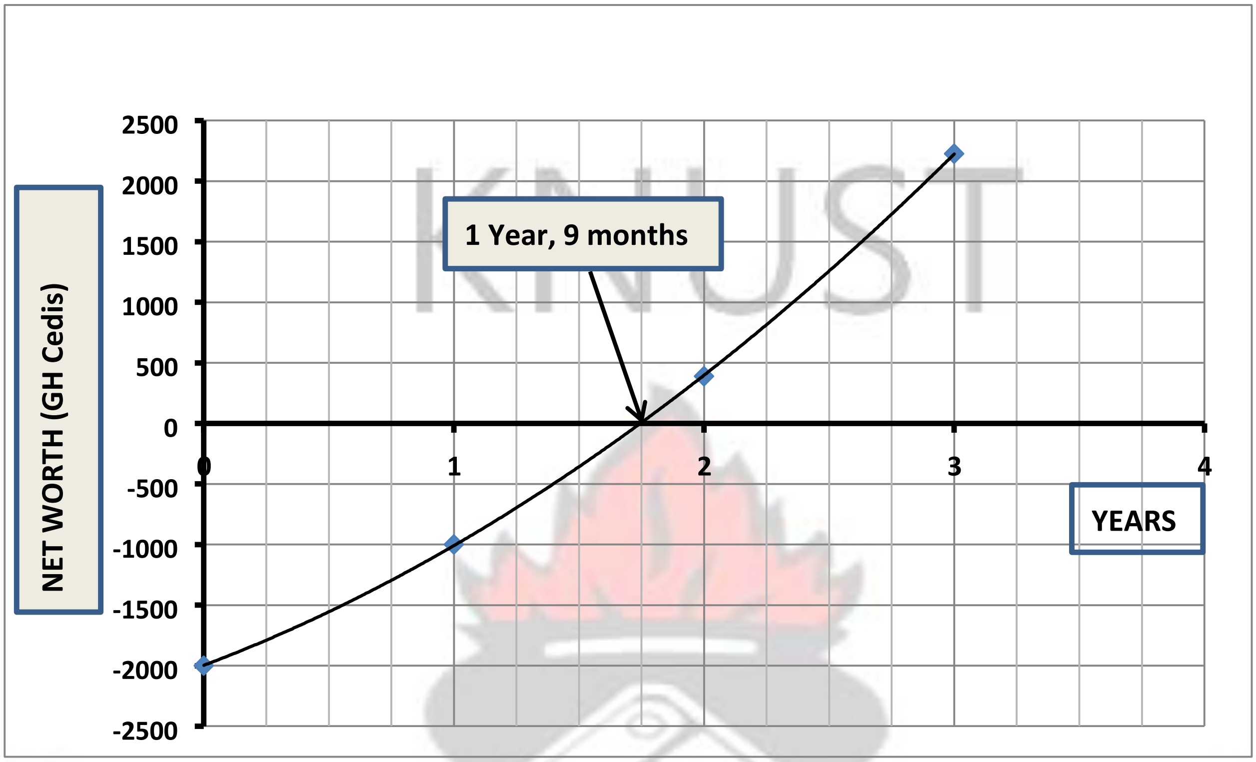

Figure 4.17: Pay-back Analysis of Utility Pipe (Public Tap) Water Supply Point

4.4.3.3 Internal Rate of Return Analysis

As shown in figure 4.18, a high rate of return of 43% was obtained for the analysis done on the management and operation utility pipe public tap. This water point as compared to motorized borehole requires a relatively lower investment cost. In addition, almost all the operators depend on the pressure in the water already from the utility provider to fill their storage tanks and supply and hence there is little or no energy cost in pumping water. Operation and maintenance cost therefore minimal. However, on a long term basis there could be significant changes as compared to the motorized borehole water point.

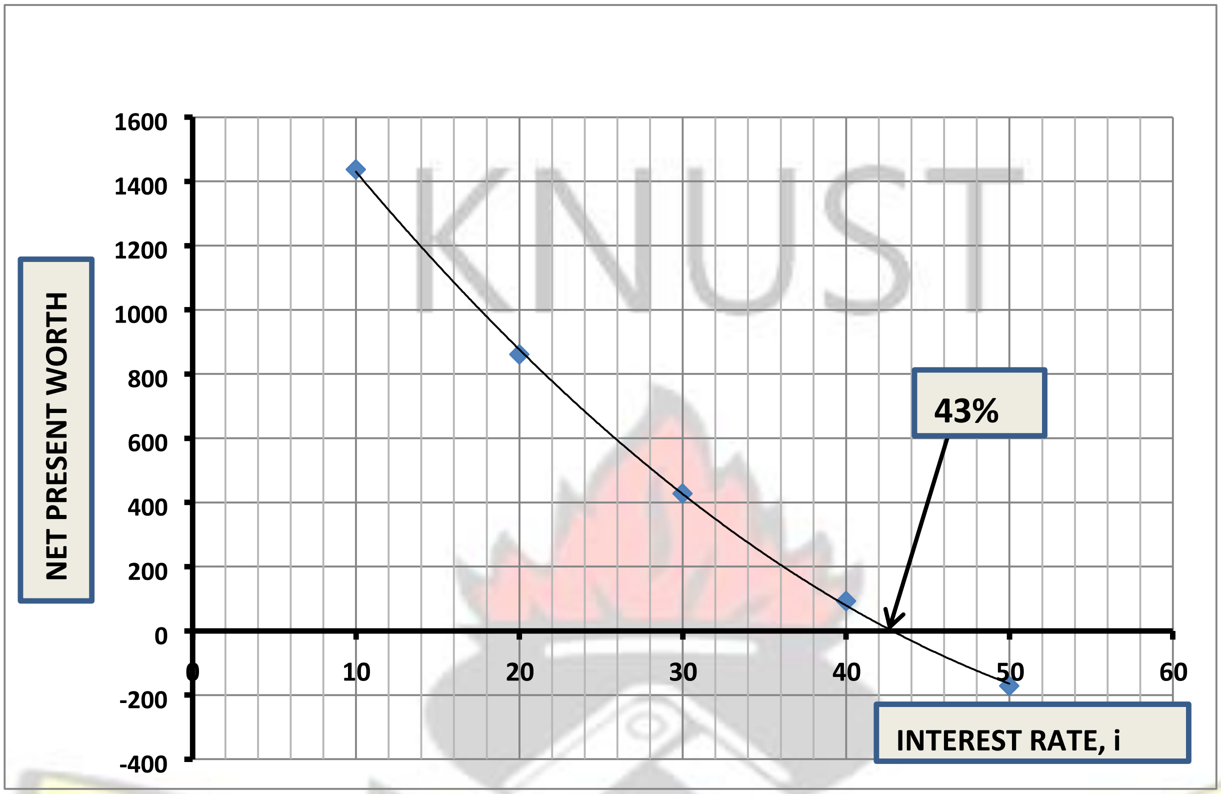

Figure 4.18: Internal Rate of Return Analysis on Utility Pipe (Public tap)

4.4.4 Community Owned Hand/Foot Pump Boreholes

This water point consists of borehole with either a hand pump or foot pedal by which water is accessed from underground. These boreholes are not private owned but constructed by the District Assembly (DA) for the community. They are managed by a group of elders in the community known as the Community Unit Assembly (CUA). This particular water point is not managed and operated for profit making. A token of 10 pesewas (0.1 Ghana Cedis) is paid by consumers irrespective of the size of the container used in fetching the water. This money is saved in a community accounts and used to pay the attendant of the water point and also for any kind of repairs and maintenance works that is needed. As at the time of the research, most of these boreholes were found to be faulty and yet not repaired. A major reason is the lack of funds and this is evident in the cash flow displayed in table 4.5 and figure 4.19

Table 4.5: Cash Flow for Community Borehole (Hand/Foot Pump)

YEAR	2012	2013	2014	2015
Capital Cost (GH Cedis)	10000			
Annual Maintenance Cost (GH CEDIS)		200	200	250
Annual Labour Cost GH Cedis)		150	150	150
Replacement Cost (GH CEDIS)		110	110	110
Depreciation Cost (GH Cedis)		666.7	666.7	666.7
TOTAL ANNUAL COST (GH CEDIS)	**-10000**	**-1126.7**	**-1126.7**	**-1176.7**
ANNUAL REVENUE (GH CEDIS)		**454**	**522**	**600**
NET ANNUAL PROFIT	**-10000**	**-672.7**	**-604.7**	**-576.7**
CASH FLOW	**-10000**	**-10673**	**-11277**	**-11854**

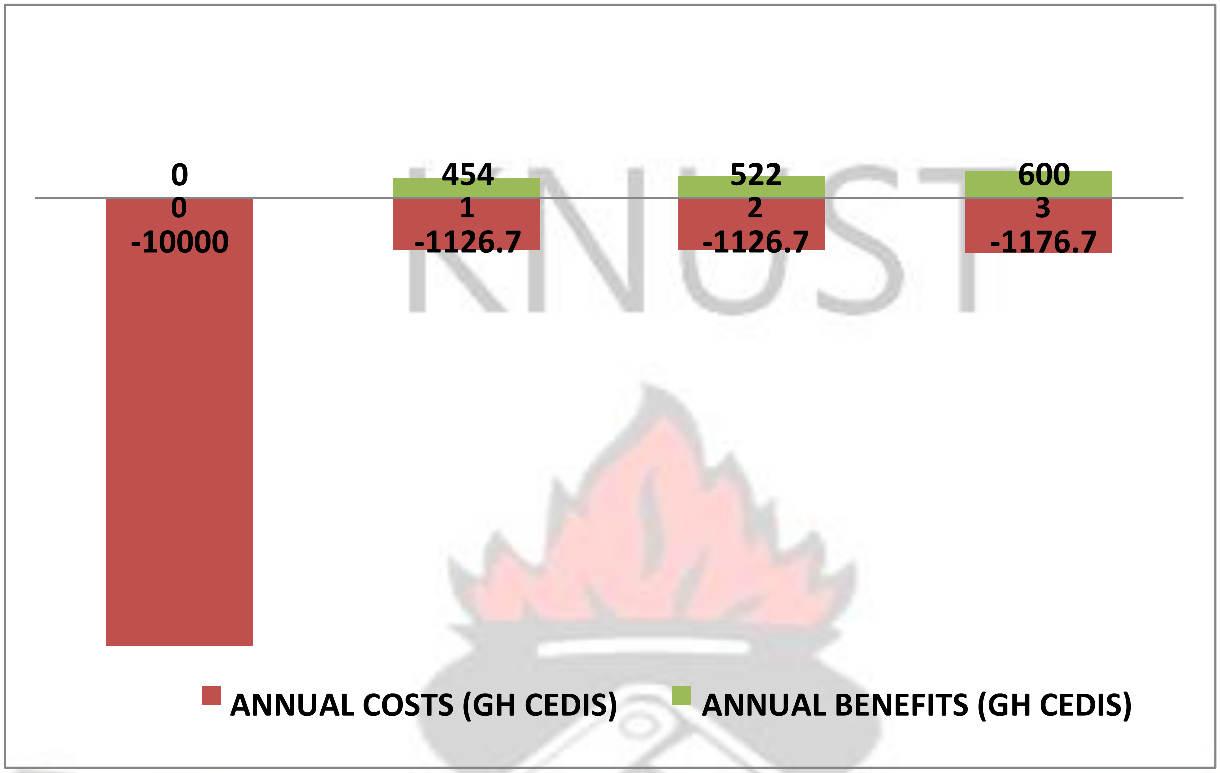

Figure 4.19: Cash Flow Diagram for Community Borehole (Hand/Foot Pump)

CHAPTER 5: CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

The following conclusions have been made from the study:

- Utility public tap is seen by consumers' perception as the main source of water supply; however, it can be concluded from this studies that groundwater is widely used than all other sources of main water supply in Dodowa. As much as 78% of all households use groundwater.
- Managing a utility public tap as well as motorized boreholes fetches good returns and hence can be concluded as a profitable business for private water point operators.
- It can be concluded that sachet water is inevitably in high demand and use in Dodowa as a major source of drinking water. As much as 96.3% of all households purchase sachet water irrespective of its high cost (212 GH Cedis per Cubic Meter) to consumers. The perception is that it's cleaner and safer for drinking.
- The water expenditure of households in Dodowa has been highly increased by the purchase of sachet water. Averagely, the cost of sachet water alone forms 72% of the total household water expenditure.
- It can also be concluded that more households in Dodowa spend too much on water. As much 57.14% of households spend 5% or more of their monthly income on water.
- Furthermore, the lower income groups in Dodowa community rather pay much higher for water than the higher income groups. The cost of water forms a higher percentage of the monthly income of the poor hence as they consume more water, they will lack enough funds to cater for other aspects of their lives.

5.2 Recommendation

After undertaking this study, the following recommendations have been made:

- Further research into the water quality of the groundwater to help to develop this water source very well to improve the water supply in Dodowa.
- This research may be furthered to include other economic factors such as time cost of water, health cost etc to have a complete economic study on the water supply in Dodowa.

REFERENCES:

Addo, L.Y., 2010. *Institutional Analysis of Urban Water Supply in Ghana: The Case of Accra Metropolitan Assembly* (Doctoral dissertation, MSc Thesis, University of Aalborg, Aalborg, Denmark. Available at: http://www. projekter. aau. dk/projekter/files/42618610/Thesis_Final_version_. pdf (accessed 12 September 2012)).

Banerjee, S., Skilling, H., Foster, V., Briceño-Garmendia, C., Morella, E. and Chfadi, T., 2008. Africa-Ebbing water, surging deficits: urban water supply in sub-Saharan Africa.

Fonseca, C., Franceys, R., Batchelor, C., McIntyre, P., Klutse, A., Komives, K., Moriarty, P., Naafs, A., Nyarko, K., Pezon, C. and Potter, A., 2011. Life cycle costs approach. *IRC International Water and Sanitation Centre*, p.38.

Foster, S., Tuinhof, A. and Garduño, H., 2006. Groundwater development in sub-Saharan Africa. *A strategic overview of Key issues and major needs. Sustainable groundwater management, lessons from practice, Case profile collection*, (15).

Franceys, R.W., 2005. Charging to enter the water shop? The costs of urban water connections for the poor. *Water Science and Technology: Water Supply*, *5*(6), pp.209-216.

George, B., Malano, H., Davidson, B., Hellegers, P., Bharati, L. and Massuel, S., 2011. An integrated hydro-economic modelling framework to evaluate water allocation strategies I: Model development. *Agricultural Water Management*, *98*(5), pp.733-746.

Gupta, A.D. and Onta, P.R., 1997. Sustainable groundwater resources development. *Hydrological Sciences Journal*, *42*(4), pp.565-582.

Hopewell, M.R. and Graham, J.P., 2014. Trends in access to water supply and sanitation in 31 major sub-Saharan African cities: an analysis of DHS data from 2000 to 2012. *BMC Public Health*, *14*(1), p.1.

Isoke, J. and Dijk, M.P., 2014. Factors influencing selection of drinking water technologies for urban informal settlements in Kampala. *Water and Environment Journal*, *28*(3), pp.423433.

Kimani-Murage, E.W. and Ngindu, A.M., 2007. Quality of water the slum dwellers use: the case of a Kenyan slum. *Journal of Urban Health*, *84*(6), pp.829-838.

Kosoe, E. A. and Osumanu, I. K. 2015. Water is Life: Situation Analysis of Access to Household Water Supply in the Wa Municipality, Ghana. *International Journal of Environmental Protection and Policy*. Vol. 3, No. 1, pp. 1-13.

Kumar, S., Lagudu, S., Pavelic, P. and Davidson, B., 2012. Integrating cost and benefit considerations with supply-and demand-based strategies for basin-scale groundwater management in South-West India. *Water International*, *37*(4), pp.460-477.

Liang, X., 2011. The Economics of Sustainable Urban Water Management: the Case of Beijing: UNESCO-IHE PhD Thesis. CRC Press.

McDonald, R.I., Douglas, I., Revenga, C., Hale, R., Grimm, N., Grönwall, J. and Fekete, B., 2011.Global urban growth and the geography of water availability, quality, and delivery. *Ambio*, *40*(5), pp.437-446.

Nkrumah, E, Nyarko, K. B, Dwumfour-Asare B, Oduro-Kwarteng, S, and Moriarty, P. 2011.Drivers of capital expenditures of rural piped water systems in Ghana: the case of

Volta, Ashanti and Northern regions, 6th Rural Water Supply Network Forum 2011 Uganda Rural Water Supply in the 21st Century: Myths of the Past, Visions for the Future .

Okotto, L., Okotto-Okotto, J., Price, H., Pedley, S. and Wright, J., 2015. Socio-economic aspects of domestic groundwater consumption, vending and use in Kisumu, Kenya. *Applied Geography*, 58, pp.189-197.

Pavelic, P., Giordano, M., Keraita, B., Ramesh, V. and Rao, T., 2012.Groundwater availability and use in Sub-Saharan Africa: a review of 15 countries (No. H046186). International Water Management Institute.

Peloso, M. And Morinville, C. 2014. "Chasing for water": Everyday practices of water access in peri-urban Ashaiman, Ghana. Water Alternatives7(1): 121-139

Van-Rooijen, D.J., Spalthoff, D. and Raschid-Sally, L., 2008. Domestic water supply in Accra: how physical and social constraints to planning have greater consequences for the poor. In *33rd WEDC International Conference: Access to Sanitation and Safe Water: Global Partnerships and Local Actions*(Vol. 5).

Zuin, V., Ortolano, L., Alvarinho, M., Russel, K., Thebo, A., Muximpua, O. and Davis, J., 2011. Water supply services for Africa's urban poor: the role of resale. *Journal of Water and Health*, *9*(4), pp.773-784.

APPENDICES

Appendix A: Household Survey and Water Point Mapping Instrument

HOUSEHOLD SURVEY INSTRUMENT DODOWA – (QUESTIONNAIRE)

Interviewer's initials ....Date ..../...../2015 Serial no. ....

1.1 Name of suburb/location .... 1.2 House ID ....

1.3 Coordinates Lat. _ _ _ _ _ _ _ _ Long. _ _ _ _ _ _

1.4 Name of respondent ………………………………………………………………… Gender M [ ] F [ ]

READ OUT: This household survey is being conducted by the UK funded T-Group Research Team to understand the groundwater usage in Dodowa. Your responses will be archived and kept strictly confidential and we promise that your identity will be protected.

A. DEMOGRAPHIC AND SOCIO-ECONOMIC DATA

Be careful to distinguish between info regarding the respondent him/herself, and such relating to household head or the entire household. 'You' normally refers to the whole household (HH).

A1a. Gender of the *household head*?[1] M [ ] [2] F [ ] A1b. Age of HH head ……

A2. What is the age of the *respondent* (if not = the HH head)? …….

A3. What is the education of the *household head?*

[1] Never been to school [ ] [2] Primary school [ ]

[3] JHS/Middle school [ ] [4] Secondary [ ]

[5] Post secondary/training colleges [ ] [6] Higher/tertiary [ ]

A4. What is the *primary* occupation of the *household head* [1] Trading [ ]

[2] Unemployed [ ] [3] Formal employee [ ]

[4] Retired [ ] [5] Skilled self-employed [ ]

[6] Agriculture/Farming [ ] [7] Other [ ] Specify…...…………………….…

A5. What is the *secondary* occupation of the *household head*, if any

[1] Trading [ ] [2] Formal Employee [ ]

[3] Skilled Self-Employed [ ] [4] Agriculture/Farming [ ]

[7] Other [ ] Specify……………..………………… [DK] [ ] NA [ ]

A6. What is *your* education (*respondent's*)

[1] Never been to school [ ] [2] Primary school [ ] [3] JHS/Middle school [ ]

[4] Secondary [ ] [5] Post secondary [ ] [6] Higher/tertiary [ ] A7.

How long has your family lived here in Dodowa?

[1] ……….....…yrs [2] Born here [ ]

A8a. Number of household members (regular/permanent)?..................……………

A8b. Is there *more* than 1 HH in this house? [1] Yes [ ] [2] No [ ] (just 1 family) A9.

Do you own this house and land?

[1] Yes [ ] [2] No, renting [ ] [3] Current tenancy period (years) ....

A10. If you pay rent, how much per month? …………………

A11. How many rooms do you have? …………………………

A12. What is the total/combined average income of the HH?

GHc......................... ....per week or ....per month

A14. How much do you spend on food per week?………………………………………………

A15a. Do you have electricity? [1] Yes [ ] [2] No [ ] A15b. If yes, how much do you pay for electricity monthly?......... …………….

A15c. If no, why not?

[1] Cannot afford [ ] [2] We need service extension [ ] [3] Other …………..………

A16. How much do you pay for school fees per year?...... ………………….

A17. How much do you pay for health insurance per year?

[1] GHc.......…………………………………... [2] No insurance [ ]

A.18 How much do you pay for other expenses (phone top up, transport etc) ....

....

B. LIST OF WATER POINTS/WATER SOURCES

First of all, ask about all the 'water sources' they use from the below options and tick them here:

[1] Piped water /public tap/standpipe [2] Piped into building (indoor taps or yard tap)

[3] Borehole/tubewell with hand-pump [4] Borehole/tubewell with motorized pump

[5] 'Protected' dug well (with lid) [6] Open or semi-open, 'unprotected' dug well

[7] Tanker /vendor water/ cart with small tank/drum

[8] Poly tank or similar

[9] Others, eg piped water storage, etc

(specify)……………………………………………………………………………….

NOTES: Supply additional notes e.g. Water source in house or in own yard or elsewhere, Dug well is lined with concrete or with cement interior, bricks or pre-cast concrete rings, raised, with lid poor lid…; Neighbor's well, Neighbor can come and fetch … Fill DK (don't know) if respondent is unsure!

B1. Water point or source 1

[1] Specify 'Source'……………

[2] NOTES on this source…………………………………………………………………………………………

……

[3] Functional as of today Yes [ ] No [ ]

[4] Is this your main water source, or one of the main ones? Yes [ ] No, it's a backup [ ]

[5] Distance from home ca. …………………………………… meters

[6a] Fit for drinking purposes Yes [ ] No [ ] [6b] Fit for cooking Yes [ ] No [ ]

[7] Is the water pre-treated at source? Yes [ ] No [ ]

[8] Is the water point/source shared? Yes [ ] No [ ]

[9] Who owns the water point/source?

……………………………………………………………………

[10] Who operates & manages the water point/source? ……………………………………..

……

………… DK [ ]

[11] Who funded/paid for the construction? …………………………………………………

…………………………………………………………. How much …………………. DK [ ]

[12] When was it constructed? ………………………….. DK [ ]

[13] Is this water source seasonal? Yes [ ] No [ ]

[14] Do you have to pay for water from this source? Yes [ ] How much ……………

……

……….. No [ ]

[15] How often is water available from this point/source? [1] Daily [ ] [2] Every other day [ ] [3] Once a week [ ]

[4] Twice a week [ ] [5] Irregular [ ] [DK] [ ]

[16] How long is the water available on a daily basis from this point/source? [1] All the time (24 hrs) [ ] [2] During daylight hours [3] 6-8 hours [ ] [4] 3-5 hours [ ] [4] 1-2 hours [ ] [DK] [ ] [17] How often was water available during the dry season?

[1] Every day [ ] [2] Once in a week [ ] [3] Irregular [ ] [DK] [ ]

[18] What is your level of satisfaction with the availability of water from this source,

from to 5 where 1 = Very dissatisfied & 5 = Very satisfied? ………………..…….

[19] If you are dissatisfied or very dissatisfied, why (Check all that applies)? [1] Expensive [ ]

[2] Too far away [ ] [3] Irregular supply [ ]

[4] Bad taste [ ] [5] Dirty [ ] [6] Other (specify) [ ] ……………

……

…………………..……

[20] Do you feel safe using this water point/source after dark? Yes [ ] No [ ]

B2. Water point or source 2

[1] Specify 'Source'……………

[2] NOTES on this source……………………………………………………………………………………

[3] Functional as of today Yes [ ] No [ ]

[4] Is this your main water source, or one of the main ones? Yes [ ] No, it's a backup [ ]

[5] Distance from home ca. …………………………………… meters

[6a] Fit for drinking purposes Yes [ ] No [ ] [6b] Fit for cooking Yes [ ] No [ ]

[7] Is the water pre-treated at source? Yes [ ] No [ ]

[8] Is the water point/source shared? Yes [ ] No [ ]

[9] Who owns the water point/source?

……………………………………………………………………

[10] Who operates & manages the water point/source? ……………………………………..

………

………… DK [ ]

[11] Who funded/paid for the construction? …………………………………………………

…………………………………………………………. How much …………………. DK [ ]

[12] When was it constructed? ………………………….. DK [ ]

[13] Is this water source seasonal? Yes [ ] No [ ]

[14] Do you have to pay for water from this source? Yes [ ] How much ……………

………

……….. No [ ]

[15] How often is water available from this point/source? [1] Daily [ ] [2] Every other day [ ] [3] Once a week [ ]

[4] Twice a week [ ] [5] Irregular [ ] [DK] [ ]

[16] How long is the water available on a daily basis from this point/source? [1] All the time (24 hrs) [ ] [2] During daylight hours [3] 6-8 hours [ ] [4] 3-5 hours [ ] [4] 1-2 hours [ ] [DK] [ ]

[17] How often was water available during the dry season? [1] Every day [ ] [2] Once in a week [ ] [3] Irregular [ ] [DK] [ ]

[18] What is your level of satisfaction with the availability of water from this source, from to 5 where 1 = Very dissatisfied & 5 = Very satisfied? ………………..…….

[19] If you are dissatisfied or very dissatisfied, why (Check all that applies)? [1] Expensive [ ]
[2] Too far away [ ] [3] Irregular supply [ ]

[4] Bad taste [ ] [5] Dirty [ ] [6] Other (specify) [ ] ……………

[20] Do you feel safe using this water point/source after dark? Yes [ ] No [ ]

B3. Water point or source 3

[1] Specify 'Source'……………

[2] NOTES on this source………………………………………………………………………

[3] Functional as of today Yes [ ] No [ ]

[4] Is this your main water source, or one of the main ones? Yes [ ] No, it's a backup [ ]

[5] Distance from home ca. …………………………………… meters

[6a] Fit for *drinking* purposes Yes [ ] No [ ] [6b] Fit for *cooking* Yes [ ] No [ ]

[7] Is the water pre-treated at source? Yes [ ] No [ ]

[8] Is the water point/source shared? Yes [ ] No [ ]

[9] Who owns the water point/source? ………………………………………………………………

[10] Who operates & manages the water point/source? ……………………………………..

……………………………………………………………………………………………………

………… DK [ ]

[11] Who funded/paid for the construction? ……………………………………………………

…………………………………………………………… How much …………………. DK [ ]

[12] When was it constructed? ………………………….. DK [ ]

[13] Is this water source seasonal? Yes [ ] No [ ]

[14] Do you have to pay for water from this source? Yes [ ] How much ……………

…………………………………………………………………………………………………

……….. No [ ]

[15] How often is water available from this point/source? [1] Daily [ ] [2] Every other day [ ] [3] Once a week [ ]

[4] Twice a week [ ] [5] Irregular [ ] [DK] [ ]

[16] How long is the water available on a daily basis from this point/source? [1] All the time (24 hrs) [ ] [2] During daylight hours [3] 6-8 hours [ ] [4] 3-5 hours [ ] [4] 1-2 hours [ ] [DK] [ ]

[17] How often was water available during the dry season? [1] Every day [ ] [2] Once in a week [ ] [3] Irregular [ ] [DK] [ ]

[18] What is your level of satisfaction with the availability of water from this source,

from to 5 where 1 = Very dissatisfied & 5 = Very satisfied? ………………..…….

[19] If you are dissatisfied or very dissatisfied, why (*Check all that applies*)? [1] Expensive [ ]

[2] Too far away [ ] [3] Irregular supply [ ]

[4] Bad taste [ ] [5] Dirty [ ] [6] Other (specify) [ ] ……………

…………………………………………………………………………………………………

…………………..……

[20] Do you feel safe using this water point/source after dark? Yes [ ] No [ ]

B4-6 Others

B4a. Do you buy sachet water? [1] Yes [ ] [2] No [ ]

B4b. If yes, why? [1] Taste [ ] [2] Cleaner/safer [ ] [3] Other ……………................................

B5a. Do you buy bottled water? [1] Yes [ ] [2] No [ ]

B5b. If yes, why? [1] Taste [ ] [2] Cleaner/safer [ ] [3] Other …………................................

B6a. Do you harvest/collect rainwater [1] Yes [ ] [2] No [ ] [DK] [ ]

B6b. If yes, how do you collect it? (Check all that apply)

[1] Bucket/s/, drums or similar [ ] [2] Polytank [ ]

[3] Rain gutter [ ] [4] Underground sump [4] Others means [ ] B6c.

If not, why?

[1] No need [ ] [2] No space [ ] [3] Too expensive to install [ ] [4] Landlord will not allow [5]

Other reason [ ] ……………………………………………..

C. WATER CONSUMPTION AND COSTS

Fill the table individually for each source to which the questions apply

	Source 1	**Source 2**	**Source 3**		**Sachet**	
Name of source (MAIN Sources)						
C1. How many buckets/jerry cans/containers/sachets are used in a day in the HH?						

C2. What is the size of the bucket/containers used to fetch water? ca. liters						
C3. What is the water price per buckets/jerry can/ container/ sachet?						
C4. If you pay for water, how much do you pay in total per day for the HH for what you fetch?						
Calculation: Household water consumption ca. liters per day						
C5. How long does it take you to get to the water point and back (fetching time in minutes per collection trip)? [N/A] Water is on premises [DK]						
C6. Do you normally have to stand in queue when you fetch water? how long?…………………... [1] Yes, always [2] Sometimes [0] Never [DK]						
C7a. Do you store water at home [1] Yes [2] No C7b. How [1] Buckets [2] Drum [3] Bottles [4] Containers [5] Other way [0] Nothing is stored [DK] [ ]						

D. TREATMENT & MAINTENANCE

Multiple options can sometimes be chosen

D1. Do you treat/purify the water before drinking? Yes [ ] No [ ] [DK] [ ]

D2. If not treating the water, what is the main reason/reasons why (Check all that apply)

[1] Cannot afford to [ ] [2] No time [ ] [3] No need to [ ] [4] Sachet water [ ][5] Other reason [ ] ....…………………………………………….. [DK] [ ]

D3. If yes, how do you treat your drinking water? (Fill all that apply in table below)

[1] Let it stand and settle

[2] Bleach/chlorine

[3] Alum

[4] Boiling

[5] Filtering with piece of cloth

[6] Use a household water filter (ceramic, sand, composite, etc.)

[7] Solar disinfection (UV light)

[8] Other (specify) …………………………………

	Source 1	Source 2	Source 3	Source 4
Name of source				
Treatment				

D4. Has anyone told you that it is important to treat your drinking water?

[1] Y [ ] ……………………………………………………………………..……… [2] N [ ]

D5. What problems (if any) exist with your main source/s/ of water supply? *(Read all options first; Check all that apply)*

[1] Unreliable water supply [ ]

[2] Not enough water [ ]

[3] Insufficient water pressure [ ]

[4] It tastes bad [ ]

[5] Too salty

[6] Broken pipes [ ]

[7] Other (specify) [ ]

…………………………………………………………………………………………..

MAPPING OF WATER POINTS FOR GROUNDWATER ECONOMY STUDY

Data on the following was collected during the mapping of water points

1. Name of ward/suburb
2. Water points coordinates
3. Type of technology for public use by the urban poor or slum dwellers
    a. Spring source
    b. Hand dug well
    c. Borehole with hand pump

d. Borehole with mechanised pump and storage

e. Utility piped standpipe ground water source

f. Utility piped standpipe surface water source

g. Others specify......................

4. Owner of water point

5. Management of water point

6. Users and water uses of water point

7. Other users of water point

8. Alternative sources of main users and water uses of alternative sources

9. Payment for water – prices per unit volume of main water point

10. Estimation of water production or consumption per month of main water point

11. Estimation of revenue per month of main water point

12. Cost of construction (Investment cost),

13. Operation and maintenance cost

14. Replacement cost

15. Technology Preference –level of service,

16. Water quality – visual and taste, Fluoride?

Appendix B: Tables on Access to Water

Table B.1: Households' Main Source of Water

Main Water Source	Frequency	Percentage
Public Tap/Stand Pipe	111	37.00
Piped into building(indoor/yad tap)	62	20.67
Borehole (Hand pump/Foot pump)	12	4.00
Borehole (with Motorized Pump)	17	5.67
Protected dug well	39	13.00
Unprotected dug well	45	15.00
Tanker/Vendor water/cart/Polytank	8	2.70
Others	6	2.00

Total	300	100.00

Table B.2: Sachet Water Use with Main Sources of Water

Main Water Source	**Sachet water use rate (%)**
Public Tap/Stand Pipe	96
Piped into building(indoor/yad tap)	94
Borehole (Hand pump/Foot pump)	100
Borehole (with Motorized Pump)	94
Protected dug well	100
Unprotected dug well	98
Tanker/Vendor water/cart/Polytank	100
Others	83

Table B.3: Overall Use and Dependency on Various Sources of Water in Dodowa

Water Sources	**Number of users/300**	**Percentage of Access**
Groundwater sources	234	78
Public Tap/Stand Pipe	141	47
Piped into building(indoor/yad tap)	63	21
Tanker/Vendor water/cart/Polytank	15	5
Others	12	4

Table B.4:Frequency of Supply of Various Sources of Water

WATER SOURCE	**Daily**	**Every other day**	**Once a week**	**Twice a week**	**Irregular**
Public Tap/Stand Pipe	67.6%	7.2%	2.7%	12.6%	9.9%
Piped into building(indoor/yad tap)	82.3%	3.2%	1.6%	4.8%	8.1%

Borehole (Hand pump/Foot pump)	100.0%	0.0%	0.0%	0.0%	0.0%
Borehole (with Motorized Pump)	82.4%	11.8%	0.0%	0.0%	5.9%
Protected dug well	87.2%	12.8%	0.0%	0.0%	0.0%
Unprotected dug well	100.0%	0.0%	0.0%	0.0%	0.0%
Tanker/Vendor water/cart	66.7%	0.0%	33.3%	0.0%	0.0%
Others	66.7%	0.0%	0.0%	0.0%	33.3%

Table B.5: Unit Prices of Various Sources of Water

WATER SOURCE	UNIT COST (GH CEDIS/CUBIC METER)
Unprotected dug well	0
Borehole (Hand pump/Foot pump)	6.17
Piped into building (indoor/yad tap)	7.17
Protected dug well	11.52
Public Tap/Stand Pipe	12.4
Borehole (with Motorized Pump)	13.06
Tanker/Vendor water/cart	43.42
Sachet Water	212

Appendix C: Tables on Financial Analysis on Management of Water Points

Table C.6: Payback Period Analysis - Motorized Borehole

PAY BACK PERIOD				
Year	0	1	2	3
Net Worth	**-13864**	**-8658.3**	**-1926.6**	**6292.1**

Table C.7: Internal Rate of Return Analysis - Motorized Borehole

INTERNAL RATE OF RETURN ANALYSIS					
INTEREST RATE, (i)	5	10	15	20	25

NET PRESENT WORTH (NPW)	4299.282	2606.674	1156.757	-94.9329	-1183.18

Table C.8: Payback Period Analysis - Protected Dug Well

PAY BACK PERIOD				
Year	0	1	2	3
Net Worth	**-3000**	**-2614**	**-2256**	**-1861**

Table C.9: Payback Period Analysis - Utility Pipe (Public Tap)

PAY BACK PERIOD				
Year	0	1	2	3
Net Worth	**-2000**	**-1000.3**	**389.4**	**2226.1**

Table C.10: Internal Rate of Return Analysis - Utility Pipe (Public Tap)

INTERNAL RATE OF RETURN ANALYSIS					
INTEREST RATE, (i)	10	20	30	40	50
NET PRESENT WORTH (NPW)	1437.27	861.05787	427.3113336	92.45335	-171.681