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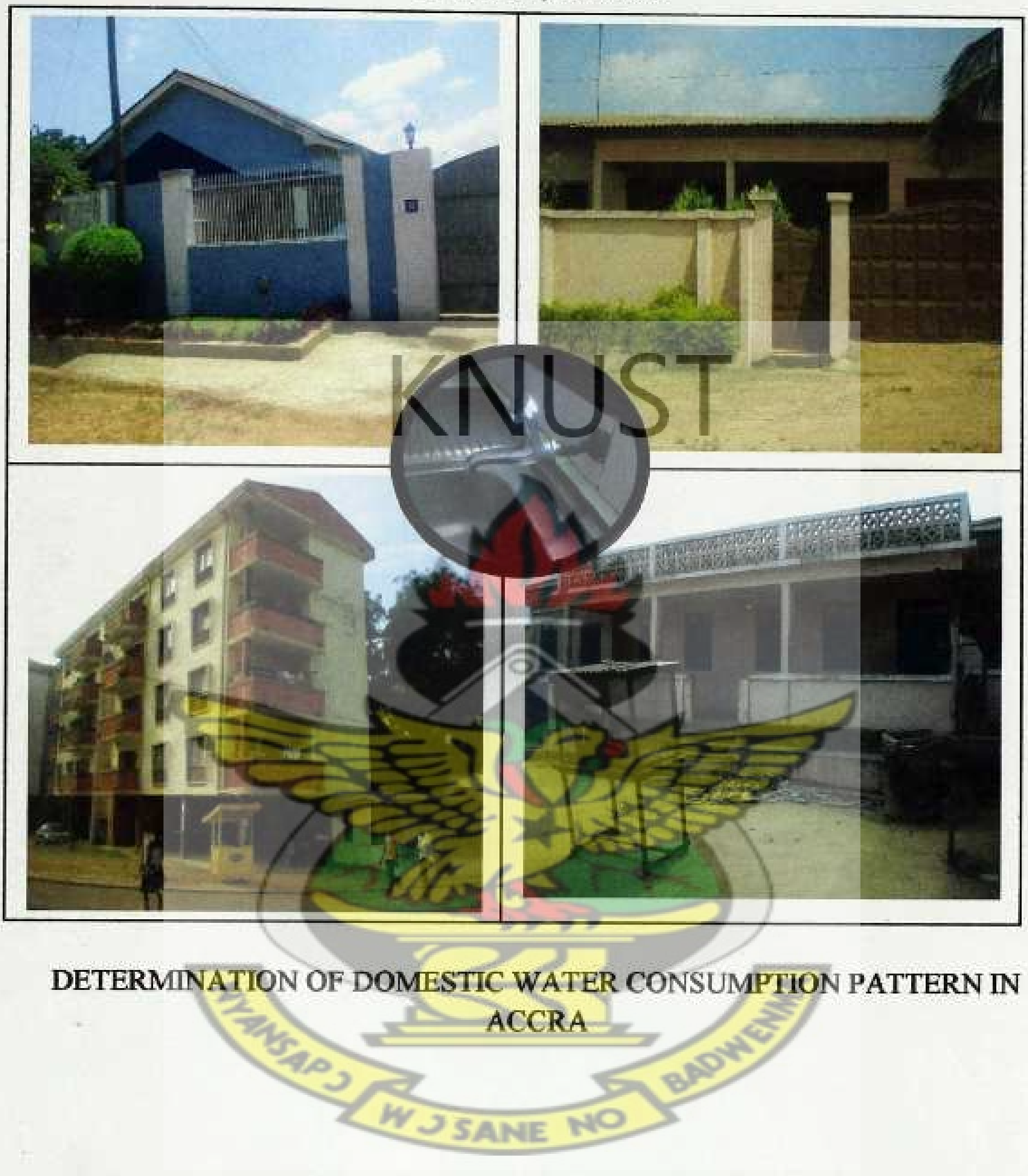

DETERMINATION OF DOMESTIC WATER CONSUMPTION PATTERN IN ACCRA

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DETERMINATION OF DOMESTIC WATER CONSUMPTION PATTERN IN ACCRA

By

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Master of Science

In

Water Supply and Environmental Sanitation

CERTIFICATION

I hereby declare that this submission is my own work towards the MSc. 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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DEDICATION

This thesis is dedicated to God Almighty and the following people; my late grand mother, Mary Teiko Ankrah, my mother, Gifty Mary Plange, my wife Mrs. Esther Lamptey, my two children Mary-Ann Lamptey and David Brainard Lamptey, my sister Mrs. Faustina Amoasi and all family members especially Richied Kotey and Florence Quarcoopome whose contribution and encouragement have brought me this far.

ABSTRACT

The research on domestic water consumption pattern in Accras was based on the hypothesis that domestic water consumption is influenced by income class and the type of dwelling. The research explored the water consumption pattern of households living in three different income groups namely; high income, middle income and low income as defined by the Planning Authorities in Accra Metropolis. The consumption pattern of four dwelling types, namely, detached, semi detached, apartment and compound house under different supply conditions were also assessed. An overall finding of the research is that per capita consumption of some of the people living in detached (stand alone) houses are marginally higher than those of semi detached, followed by apartment and the lowest is that of compound (high density) houses. Income class and dwelling type were found to influence domestic water consumption. The conclusion drawn from the research is that per capita consumption for high and low income is higher than the demand used for design in distribution systems. The rationing programme in the study area is not effective. This research made the following recommendations: Further research should be conducted by the utility company to elicit insight into the attitudes of households to water consumption and conservation. This research should be replicated in Tema and Accra West region.

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LIST OF ABBREVIATION

AMA	-	Accra Metropolitan Assembly
AVRL	-	Aquah Vitens Rand Limited
BPD	-	Building Partnership for Development
GWCL	-	Ghana Water Company Limited
PURC	-	Public Utility Regulatory Commission
WHO	-	World Health Organization
GPRS	-	Ghana Poverty Reduction Strategy
ATMA	-	Accra Metropolitan Area
PMU	-	Project Management Unit
GSS	-	Ghana Statistical Services

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To all and sundry I say I am grateful you and God bless you.

CHAPTER ONE

1 INTRODUCTION

1.1 Background

The water supply situation in Accra, the capital of Ghana has worsened in recent times with people traveling long distances with containers in search of water. This situation is not peculiar to Accra since research has shown that the global consumption of water is doubling every twenty years, more than twice the rate of human population growth (Sampath et al., 2002 as cited by Gyeabour., 2008). In the last decade, there has not been any major expansion of the water systems in Accra which has resulted in perennial shortage of water in the capital; however there has been rapid development of residential properties both by government and private developers in Accra. These projects are not planned in an integrated manner, since expansion of water supply systems are not considered in the project planning and execution stages, as a result of which demand of water for domestic use has become a big challenge for the urban water providers - GWCL/AVRL.

Moreover, the main production center which supply water to most part of the study area (Kpong Headwork) have not seen any major expansion since its construction, although a report by Tahal International on an ATMA Water Supply Master Plan in 1982 suggested that the capacity will not be able to meet demand of the city after 1986. In view, of the above challenges, supply of water is rationed to most areas in the study area, and in order to equitably distribute the inadequate water in the region, consumption pattern of different socio-economic groups will be relevant to the success of any supply management programme being implemented in the study area.

Since estate developers are developing large tracts of land in the regions with different housing types for different income groups, there is the need to know the consumption pattern of these income classes and dwelling types in order to use it as an input into any supply management programme, so as to improve the effectiveness and efficiency of the programme. Industrial activities have increased in the study area over the past decade, especially industries that use water as raw materials such as beverage companies and water bottling companies and this has affected supply to domestic areas. Due to the scarcity of water in most parts of the study area, private tanker operators have taken advantage to supply water to areas with poor flow conditions, and this has led to the installation of many water filling points in the distribution areas of the region. The activities of these private filling point operators and their tanker operators have further aggravated the supply situation in the Accra East Region. The most affected socio-economic groups are the low income communities since most of them live closer to the coast and the central business districts where distribution mains are very old resulting in reduced flows. The study focused on the actual water consumption pattern by income groups which will afford policy makers the opportunity to plan for their water needs to improve sanitation in such areas and the well being of the people, since water supply and demand are backbone of development in most urban centers.

There are two distinct management arrangements for the provision of water in Ghana, with a separation into urban and rural/small town water supply. The Ghana Water Company Ltd. is responsible for urban water supply and at the moment has about 86 systems serving a total population of some six million (PURC, 2005). As of 2004, urban water coverage was estimated at 59% and is expected to reach 85% by 2015 in line with the Millennium Development Goals (GPRS II, 2006),

Many urban communities face short falls in water supply. The situation is even more critical in the major cities, where the urban poor have to pay more than ten times the tariff for water through secondary and tertiary providers (PURC, 2005).

1.2 Problem statement/Justification

Increase in both population and residential developments in Accra without expansion of the water system have worsened the already poor water supply situation in the study area.

It is therefore necessary for a study to be conducted into water consumption pattern in urban areas since the knowledge resulting from the study may be used for planning and design for water supply systems. The knowledge can also be used for decision making as well as supply management programmes.

1.3 Objective of study

To determine domestic water consumption pattern in Accra.

1.3.1 Specific objectives

- Determine consumption pattern of consumers by income groups, dwelling type and supply condition between the year 2004 and 2008
- Determine effectiveness of demand management (rationing) programme in the study area.

1.3.2 Research question

- Does consumption between income groups differ significantly in the study area?
- Does dwelling type influence consumption pattern in the study area?
- Does consumption between flow conditions differ significantly in the study area?

1.4 Scope of the study

This study is carried out in Accra East Region, which is one of the administrative regions of GWCL/AVRL in the Greater Accra Region of Ghana. The data used for the study was metered domestic customers in the study area. The data for the analysis of consumption pattern did not include other sources of supply. Factors such as price of water, climate, frequency of billing, service pressures and water quality were not considered in the study.

1.5 Organization of report

Chapter 1 of the report set out the background of the study, problem/justification and the objective of the study. Chapter 2 reviews the findings of other comparable studies to set the context for the analysis. Chapter 3 gives an overview of the study area and outlines the methodology and data used. Chapter 4 presents the results of the study and analysis of the data. Chapter 5 presents conclusion and recommendation on the study.

CHAPTER TWO

2 LITERATURE REVIEW

Currently, water is rationed to most communities in Accra, especially the study area (Accra East Region of GWCL), due to increase in daily demand as a result of increase in population of both permanent residents and those who come to Accra to transact business. Currently 61% of urban population in Ghana has access to potable water (UNDP, 2006).

The production centre (Kpong Treatment Plant) which supplies the bulk of water in the study area was constructed in 1965 but has seen no expansion till date, except for some rehabilitation works in 1980s. The area also receives supply from Weija Treatment Plant but due to increase in demand of water in the Western part of Accra the supply from Weija is not enough to solve the perennial water shortage in the study area.

An assumption that a project to connect the Western part of Accra to the East dubbed "East-West interconnection" project expected to improve the supply situation failed, since domestic and industrial demands in the Western part of Accra were not properly factored into the design. The completion of the project therefore did not improve the supply situation.

In view of the above reasons, it has become relevant for a study into domestic water consumption pattern in the study area to be conducted, since the knowledge resulting from the research will be used for planning of water supply systems, decision making as well as pricing policy by the utility company.

Gyeabour (2008) in his study on "water consumption pattern in Kumasi" showed that the per capita consumption for the high income middle income and low income class were 135 l/c/d, 107 l/c/d and 63 l/c/d respectively which were higher than the "design demand' used by GWCL/AVRL. The research concluded that, there were significant differences between domestic water consumption by High income, Middle income and Low income households and also per capita consumption increases with income levels.

Moreover, a study by Troy *et al.* (2005) into domestic water consumption in Sydney concluded that per capita water consumption in different types of dwelling were comparatively similar. While people living in detached houses consumed the highest amount of water on average, which was only marginally higher than the amount consumed by those in high rise flats and with people in low rise flats and semi-detached houses having lower per capita consumption, and there was also a clear indication that socio-economic status has an impact on domestic water consumption in Sydney.

However a study of domestic water consumption in Perth between 1998 and 2001 by Loh and Coghlan, (2003) found that in-house consumption *per capita* per day was essentially the same for both single residential dwellings and multi-residential dwellings (155 l/c/d compared with 166 l/c/d). The study also found that the components of in-house consumption were essentially the same for single and multi-residential development. But total average annual water consumption for single residential dwellings was substantially above that of multi-unit dwellings (460m^3 compared with 280m^3).

Some studies on water consumption have focused on price of water and have sought to identify the price at which water consumption can be reduced (Davies and Dandy 1995; Espey *et al.,* 1997). Loh and Coghlan (2003), sought to establish socio – demographic explanation of water consumption. Other researchers have sought to determine variables that influence domestic water demand which constitutes an essential ingredient for designing pricing policies in the domestic water supply sector (Martinez-Espineira, 2002, Arbues *et al,* 2003). During the last few years a lot of work has been devoted to the specification and estimation of residential water demand functions (Nieswiadomy and Molina, 1989; Renwick and Archibald, 1998; Hansen, 1996; Nauges and Thomas, 2000; Martinez-Espincira, 2002) and Arbues et al., (2003) in their research showed that water use increases with increasing resident population, number of water consuming fixtures, lot size and garden size.

Presently, no research has been conducted into the water consumption pattern in Accra in relation to dwelling type and socio-economic status and hence this research.

The immediate implication of the study will be the increase in knowledge on consumption patterns in Accra and facilitation of planning and design of water systems in urban areas.

2.1 Urbanization and water demand

Residential water consumption tends to increase with changes in levels in urbanization.
When urban communities are well developed with less shanty towns their residential consumption under the same climatic conditions will be high than urban communities that are less developed. in Table 2.1 Spain for instance have a per capita consumption of 289l/c/d which is higher than that of United Kingdom, however Spain cannot be said to have more developed urban community than United Kingdom therefore this may be due to other factors which may include climatic conditions. In the same respect Italy and Denmark having per capita consumption higher than that of Germany, does not mean that these countries have more developed urban communities than Germany but there may be historical and natural reasons why these trends are not uniform. It is obvious from the table that residential water consumption varies extremely across countries.

Table 2-1: Domestic water consumption in different European Countries

Country	l/c/d	Country	l/c/d
Austria	150	Italy	237
Denmark	220	Luxemburg	150
Finland	145	Holland	126
France	150	Spain	289
Germany	130	Sweden	180
Belgium	120	Ireland	135
Greece	200	United Kingdom	150

Source: Mohareji *et al.* (2003).

Households in urban areas with high income are normally able and willing to pay more for a given quantity of water than households with lower incomes. In relative terms (as a percent of income) however, people with higher incomes are prepared to pay smaller percentages of their income for water than people with lower incomes (Gyeabour, 2008)

2.1.1 Water demand

The "effective demand" for water is the quantity of water demanded at a given quality and a specified price. The analysis of demand for water, including realistically forecasting future levels of demand, is an important and critical step in the economic analysis of water supply projects. It is useful to note the difference between "effective demand" for water and "actual consumption" of water. Water consumption is the actual quantity of water consumed whereas effective demand relates that quantity to the price of water. For example, a low level of water consumption may not represent effective demand but may instead indicate a constraint in the existing supply of water. The demand for water is rising rapidly, resulting in water becoming increasingly scarce. At the same time, the unit cost of water is increasing, as water utilities shift to water sources farther away from the demand centers. Water from more distant sources may also be of lower quality. The costs of transporting water from the source to the consumer and that of water treatment necessary to meet potable water standards are becoming significant components of the unit cost of water. The factors which determine domestic demand may differ between the urban and the rural sector.

2.1.2 Water consumption

Consumption has emerged as one of the key concerns in social sciences and more especially in urban studies more specifically. It has been recognized that consumer perceptions, actions and experiences have a role to play in urban social life, and consumption has been considered as a fundamental focus for social expression. In addition, there is a growing acknowledgement about the need to establish links in the consumption-related aspects of globalization in order to understand both the effects of changing cultural styles and practices related to material consumption, and the environmental consequences of this consumption.

It is difficult to estimate the amount of water needed to maintain acceptable or minimum living standards. Moreover, different sources use different figures for total water consumption and for water use by sector of the economy. A range of 20 to 40 liters of freshwater per person per day is generally considered to be a necessary minimum to meet needs for drinking and sanitation alone, according to Gleick, (1998). These figures may not deviate much from what pertains in Accra since water for drinking and cooking may be estimated at 10 l/c/d and if water for household cleaning and sanitation are included then an extra amount of 40 l/c/d will be needed for that purpose. About 45 l/c/d will be needed for bathing and laundering. These estimated figures may be for consumers using stand pipes, however, with domestic consumers having connections and using showers and bath tubs the consumptions may be higher.

If water for bathing and cooking is included as well, this figure varies between 27 and 200 liters per capita per day. Several different amounts have been proposed as minimum standards. Gleick (1998) proposes that international organizations and water providers adopt "an overall basic water requirement of 50 liters per person per day" as a minimum standard to meet four basic needs—for drinking, sanitation, bathing, and cooking. Gleick (1998) estimated that 55 countries with a population of nearly 1 billion people did not meet this standard as a national average. Falkenmark (1998) uses the figure of 100 liters of freshwater per capita per day for personal use as a rough estimate of the amount needed for a minimally acceptable standard of living in developing countries, not including uses for agriculture and industry (UNDP, 1998)

2.2 Variables that determine consumption

2.2.1 Housing characteristics

There are houses that are used seasonally, and it is important to distinguish these residence from those used throughout the year (Nauges and Thomas 2000). Other housing features such as the number of bathrooms, water closets, showers, bathtubs may be relevant in the study of domestic water consumption. Troy *et al.*, (2005) explained in their research that there is correlation between water consumption and type of dwelling.

2.3 Service levels

Service levels are standards of supply a water utility affords its customers. The three principal levels of services which relate to the performance of distribution are the following: *Hydraulic performance* which defines the minimum pressure and flow domestic consumers should experience. In England and Wales, a flow rate of 9 l/min at a pressure of 10m head at the property boundary of the customer is the reference level of service required. In practice the pressure is difficult to measure at this point and therefore a 'surrogate' pressure of 15m in the main supplying the property may be used.

Continuity of supply is measured by the number, duration and circumstance relating to interruptions or deficiencies of supply. In England and Wales, utility companies are required to report the number of properties affected by interruption to supply of more than 6, 12, and 24 hours by the following categories:

- Unplanned interruption due to burst, etc.
- Planned and warned interruptions due to planned maintenance, and new connections.
- Unplanned interruptions caused by third party, for example another utility damaging a water pipe while excavating for their own service.
- Unplanned interruption due to overrun of a planned and warned interruption.

It should be noted that the requirement above apply to privatized water companies in England and Wales, however the same standard could be required from public utility companies. For many utility companies in countries which are not able to afford a 24 hours supply, a frequent aim is to achieve 4-hours supply morning and evening, with standpipes for low income householders. (Twort A. C *et al* 1998)

2.4 Intermittent supply condition

In many countries, water companies are only able to provide intermittent supplies due to lack of source capacity and limited financial resources. Water rationing is then practiced by operating distribution valve daily to apportion water to different areas. The operation of valves must be controlled in order not to subject part of the network to vacuum pressures which could cause groundwater infiltration and contamination of the supply. Most consumers use times of supply to fill storage receptacles which often overflow and the water go waste. Many water utility companies in developing countries have distribution systems which need rehabilitation and repair, which accounts for non revenue water of about 50% - 55% of the supply. The lack of rehabilitation by the companies has led to increase in intermittent supply because of scarcity of supply, which leads to losses of water (and revenue) through leaks, wastage, and unpaid supplies. When the supply is intermittent leakages are difficult to detect since in most cases due to scarcity of supply the pressures are low. In the event of a leakage it will take a very long time for it to be detected and hence wastage. The loss of revenue due to intermittence of supply is due to the inefficient way of managing rationing and due to customer dissatisfaction some customers refuse to pay their water bills. Traditional methods of leak detection suitable for 24-hour supplies, such as waste metering, step-testing and sounding, become impracticable because many consumers leave taps open, ready to discharge water into storage receptacle to cover periods of non-supply (Twort A. C *et al* 1998)

2.5 Domestic water consumption

In many developing countries, domestic water consumption is strongly related to the class of property served. Water consumption for an average middle class having property such as kitchen, bathroom or washroom, and some form of water borne sanitation range from 120 – 155 l/c/d irrespective of climate or country. Other factors, such as occupancy and household income, influences consumption, however these factors are unstable and very difficult to ascertain. The class of dwelling occupied in terms of type (flat or house), and value (size, age etc), is the most practicable basis for estimation of domestic consumption, since it permits visual identification of the predominant class in an area (Twort A. C *et al.*, 2000). Table 2.2

below gives reasonable water supply allowances to make for average in-house consumption according to the type of property served. The figures are not to be taken as exact or always applicable, but they represent the average supply that should be sufficient to meet usual in-house domestic requirements, given reasonably efficient control of consumer wastage and leakage, and reasonably efficient metering, billing, and income collection practices. The figures exclude water used for cooling, bathing pools and the irrigation of lawns and garden.

Table 2-2: In-house domestic water demand - suggested design allowances

Class occupancy and type of property	UK and Europe l/c/d	Elsewhere in warm climate(l/c/d)
A1: Highest income groups: villas, large detached houses, large luxury flats	190	230 - 250
A2: Upper middle income groups: detached houses, large flats	165	200 - 230
B1: Average middle income groups: two or three-bed roomed houses of flats, with one or two WCs one kitchen, one bath and/or shower	155	
B2: Lower middle income groups: generally small houses or flats with one WC one kitchen, one bathroom.	140	130
C1: Low income groups: small cottages, flatlets, bedsits with kitchen and bathroom	90 - 110	
C1: Tenement blocks, high density occupation with one shower, one Asian toilet, one or two taps		90
C2: Lowest income groups: above poverty line: low grade tenement blocks with one or two-roomed dwellings and high density occupation	110	
C3: lowest income groups: one tap dwelling with shared toilet or none, dwelling with intermittent supply		50 - 55

Note. Figures exclude lawn and garden irrigation, bathing pool use and use of evaporative coolers; but include allowance unavoidable consumer wastage (data collected in 1998)

Source: (Twort A. C *et al.*, 2000)

CHAPTER THREE

3 STUDY AREA/METHODOLOGY

3.1 Study area

Figure 3-1: Map of study area

Ghana Water Company has four administrative areas in Ghana namely Area I, Area II, Area III and Area IV. Area I consisting of Accra–Tema Metropolitan areas comprises of Accra West Region, Accra East Region and Tema Region. This study is in the Accra East Region which forms part of Accra, the capital city of Ghana and covers an area of about 170 km². Accra has an estimated population of about 1.66 million (GSS, 2002). The population growth rate is estimated at 3.4 % per annum in the city itself but up to 10% in its peri-urban districts. Accra has a very youthful population with 56% of the population being under the age of 24 years (GSS, 2002).

Accra lies within the coastal-savanna zone with low annual rainfall averaging 810 mm distributed over less than 80 days in a year. The Odaw River is the main river that flows through Accra. Accra's main water supply is from the Weija Dam on Densu river with some water being pumped from the Akosombo dam in the Volta River.

The pattern of residential development in Accra suburbs is a mixture of varied income groups. Nevertheless, the dominance by certain income groups in some suburbs is obvious. Some of the low income residents reside mostly in unplanned communities and slums around the central business areas of Accra or at the newly developing peri-urban areas. For most areas in the metropolis, water supply is intermittent throughout the week. The supply situation in the Accra East Region is the worst of the ATMA regions owing to the geographical location of the region (relative to the water production centers). The Region is far from the two main production centers which also supply Accra West Region in the western corridor and Tema in the Eastern corridor. The Region receives the "surplus" water after the two other regions have been supplied.

Areas within this region have been divided into three pressure zones depending on their elevation above sea level as follows:-

- (0 - 30m) - Low pressure zone
- (30m - 60m) - Medium Pressure zone (MPZ) and
- >60m - High Pressure Zone (HPZ)

The figures above do not reflect the service pressures but rather the elevations to be overcome during distribution of water.

Due to old age of both transmission and distribution pipelines as well as pumping station, booster station equipment (pumps, electrical panel, switches, etc) there are frequent system failures which lead to interruptions. Encrustation of the pipelines due to their old age leads to reduced flows in pipelines. Physical bursts/leakages are so frequent and result in isolations in the distribution network to allow repairs to be carried out. Shut downs at booster stations/pumping stations in the system resulting from frequent breakdown due to old age of equipment also occur quite frequently.

3.2 Methodology

3.2.1 Desk study

Desk study was carried out and information was obtained from the internet, journals on related works, other relevant documents from institutions such as GWCL/AVRL where customers consumption information from 2004 – 2008 were obtained with information on supply conditions in the Metropolis.

An income class map produced by Accra Metropolitan Area (AMA) was obtained from the Town and Country Planning office of AMA.

3.2.2 Questionnaire design

Questionnaire was administered to obtain socio-economic and demographic data such as resident population, number of households, level of service, nature of billing and alternative sources of supply. (see Appendix1).

To test for the validity of the questionnaire, a pilot survey was carried out to check whether the right questions have been asked in achieving the objective of the study.

3.2.3 Data collection

Data for the study area water consumption was obtained from the Data Processing Unit of Accra East Region of GWCL/AVRL.

Out of 11000 domestic customers in the Accra East District Billing data, 800 service accounts with consumption data from 2004 to 2008 randomly selected.

Dependent variable: monthly average water consumption per service account for the period 2004 – 2008.

Explanatory variable: resident population, dwelling type, service levels, socio- economic and demographic data.

3.3 Study approach

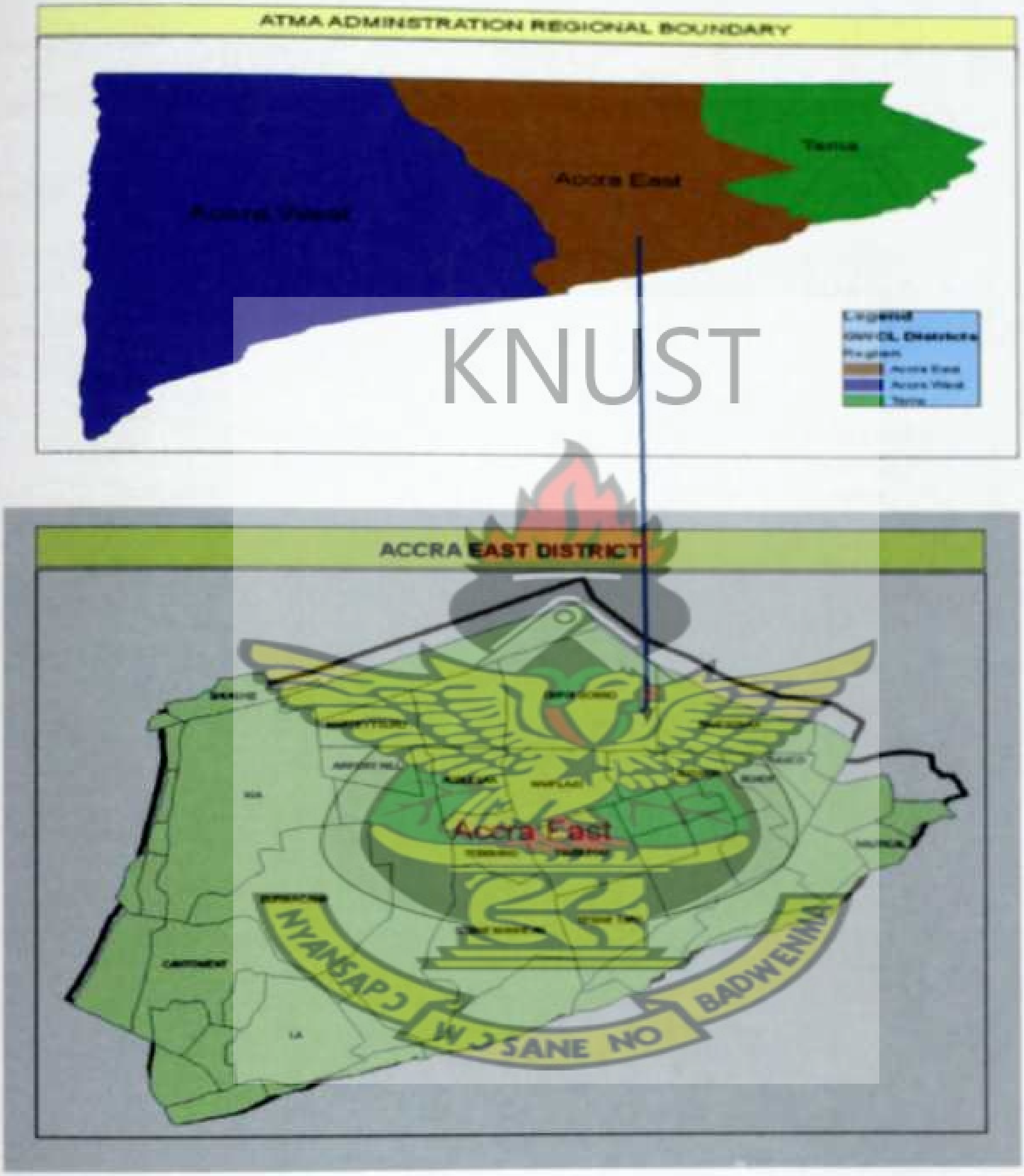

Figure 3-2: Location of respondents

The respondents for the study were customers from Accra East District of East Accra Region. GPS coordinates of 800 randomly selected domestic customers from the billing data was plotted on an Income class map obtained from AMA.

With the help of water supply condition map of the study area, the respondents were categorized under flow conditions.

Indicators such as house type, access road, solid waste management and type of sanitation (see Table 3.1) were used in the creation of income class map by AMA.

Table 3-1: Indicator for income class classification

INCOME GROUP	HOUSE TYPE	ACCESS ROADS	SOLID WASTE MANAGEMENT	TYPE OF SANITATION
HIGH INCOME	Deluxe, exclusive, gated community with swimming pool, lawn and garden	All houses have access, with good drainage system in the area	Waste in the community is managed by waste management company which uses rear loading hydraulic compactor trucks	Water closet with septic tanks and underground sewerage systems
MIDDLE INCOME	Detached houses and semi detached house with garden and flower beds	All houses have access, with poor drainage system in the area	Private individual cart waste by means of human pedal cart, human hand cart, tractor and trailer and dump into a secondary collection point in the community for a fee.	Water closet and KVIP
LOW INCOME	Compound houses, yards shanty houses and barracks	There are no access to most buildings in the area and there are no drains most of the time	Household members carry solid waste to secondary collection points or burn the rubbish or practice crude dumping of waste	KVIP, Pan latrine and the use of public toilets.

Source: AMA, (2009)

Self-administered questionnaires were used to collect socio-economic and demographic data on customers. Monthly water consumption data, measured in m³/month, were obtained from billing records of customers in GWCL data base covering the period January to December of

2004 to 2008. For each customer account the average of the five years consumption figures was chosen to represent a typical level of consumption per month for any service connection.

Four dwelling types: Apartment, Detached house, semi-detached house and compound house within the income group classification were also assessed for their influence on domestic water consumption.

The survey information were linked to the customer data and analysed with MS Excel tool where patterns of water consumption by various income groups living in the different dwelling types under different flow conditions were assessed.

The per capita consumption for the various dwelling types and income groups were computed by categorising the respondents into the different income class and dwelling type, after which the average monthly consumption for the respondents in the five year period was computed in addition to the average resident population per category. The average per capita consumption for the respondents was then computed by dividing the average monthly consumption per category by the number of days in the particular month and subsequently dividing the results by the average resident population of the specific income group or dwelling type.

CHAPTER FOUR

4 RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents result of the survey, analysis and discussion of the outcome of the survey in respect of how water consumption patterns are influenced by socio-economic factors and flow conditions. Socio-economic factors like income class and dwelling types were considered in this study. After excluding respondents who are domestic users but are located in either commercial or industrial areas (mixed used development) and customer without account information in all the five years, the total number of respondents used for the analysis was 680. Out of the 680 respondents, 408 are metered and the 272 are on estimated billing. The consumption pattern was generated from metered customers only.

4.2 Consumption by dwelling types

The section answers the research question regarding the effect of dwelling type on domestic water consumption. The analysis of the survey data by means of MS Excel filter tool and subsequent computation of per capita consumption by dwelling types are showed in the tables and figures below.

Table 4-1 show summary of survey result in relation to dwelling type and supply condition for metered customers. For respondents under intermittent supply, an average of five hundred and seventy hours per month of water supply is considered as good intermittent supply and an average of three hundred and twenty hours of supply per month is considered as poor supply. From the results, no conclusion can be drawn on detached houses, apartment houses, and compound houses under continuous supply regime, since the number of respondents are too small for any generalization. The Table also shows that 50% of the respondents are in poor flow supply conditions.

Table 4-1: Number of respondents per dwelling type under flow conditions

DWELLING TYPE	NUMBER OF RESPONDENTS			
	Continuous flow	Intermittent good flow	Intermittent poor flow	Total
Detached house	15	40	30	**85**
Semi detached house	30	42	60	132
Apartment building	7	20	80	107
Compound house	13	37	34	84
Total	65	139	204	**408**

Figure 4-1 shows the dispersion of the different dwelling types within the study area. Majority of houses in the high income areas are detached types, semi detached and compound houses are predominant in middle and low income respectively. There are no compound houses in high income areas.

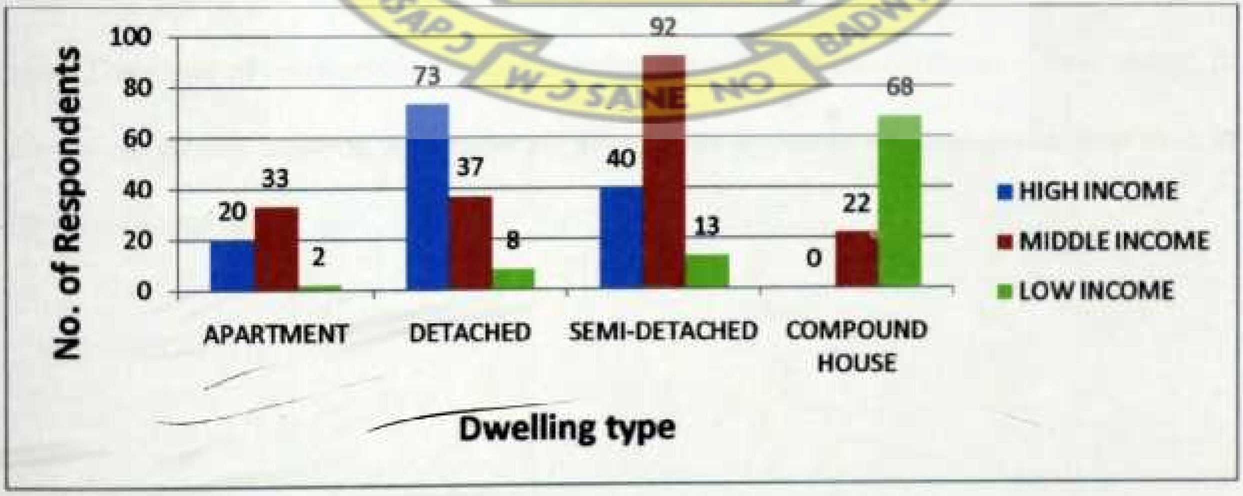

Figure 4-1: Number of respondents per dwelling type in income groups

Figure 4-2 shows consumption per dwelling type between 2004 and 2008 under continuous flow condition. The per capita consumption pattern is almost constant throughout the year for Detached (stand alone), Semi detached and Apartment buildings. There is no significant difference though between consumption for the three dwelling types. However,the differences between the three dwelling types and the compound houses is very significant (see appendix 8)

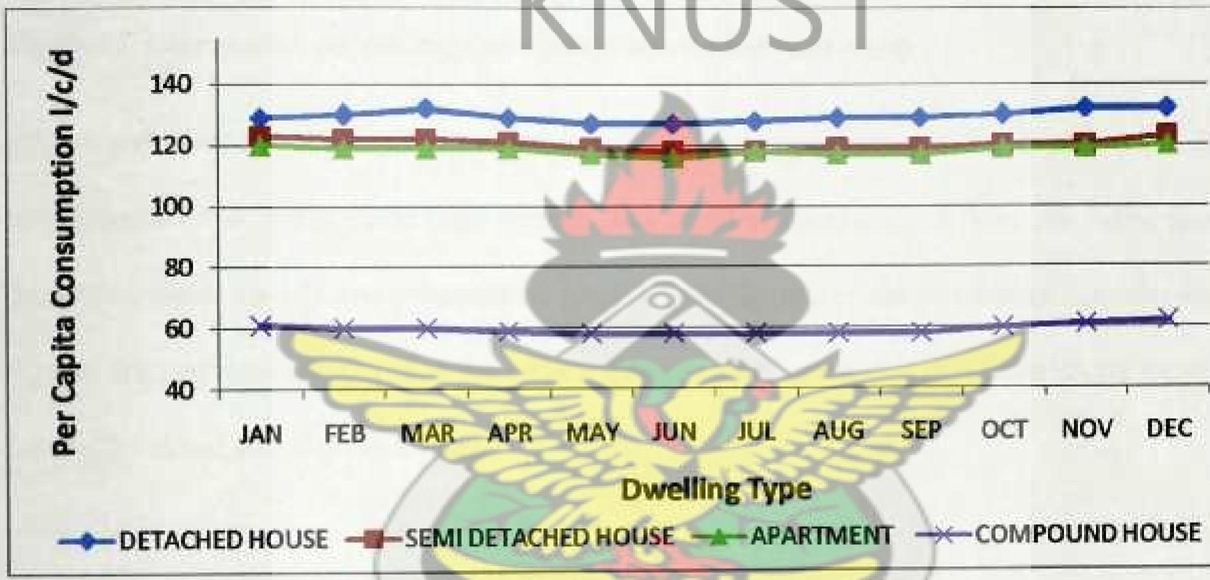

Figure 4-2: Consumption per dwelling type (2004-2008) - continuous supply

Figure 4-3 shows consumption per dwelling between 2004 and 2008 under intermittent good flow. The trend of consumption does not differ from that of the continuous flow except in the per capita consumption figures which are slightly higher in the continuous flow than in the intermittent flow.

Figure 4-3: Consumption per dwelling (2004-2008) - intermittent good supply

Figure 4-4 shows consumption pattern per dwelling type between 2004 and 2008 for respondents under intermittent poor supply. The trend of consumption does not differ from both continuous supply and intermittent good supply, however the per capita consumption figures are very low compared to the others. Respondents under this flow conditions receive supply for about two days in a week.

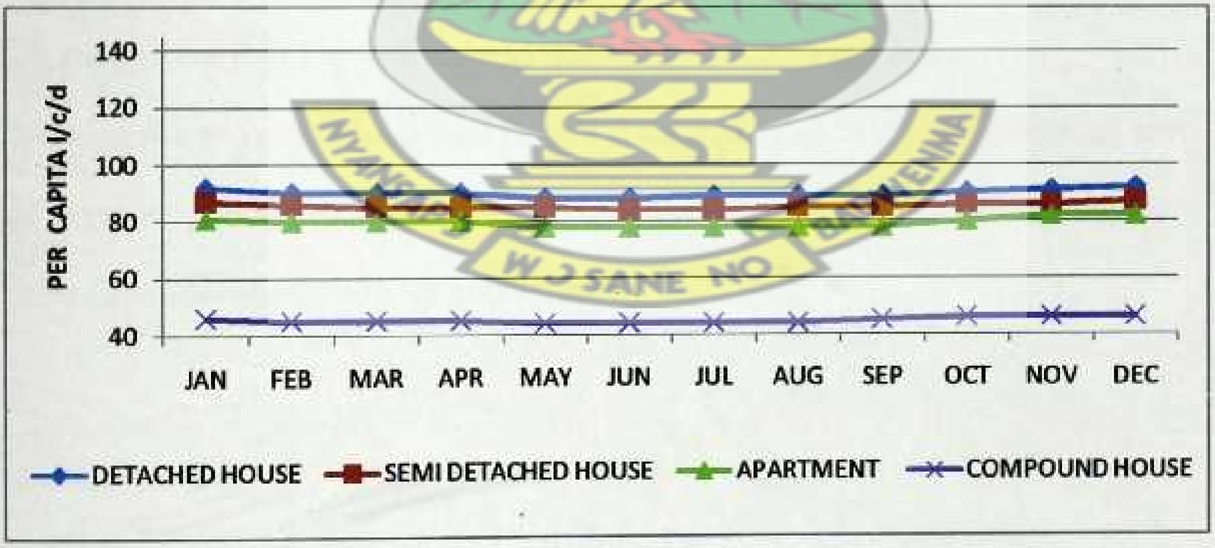

Figure 4-4: Consumption per dwelling (2004-2008) intermittent poor supply

4.2.1 Discussion of results of dwelling type

This portion of the report explains consumption in relation to the type of dwelling of the consumer and also tries to answer the research question regarding the effect of dwelling type on domestic water consumption.

Table 4-2 shows consumption figures by different dwelling types in the study area. The maximum per capita consumption by respondents in detached dwelling type between the year 2004 and 2008 is 132 l/c/d. The maximum consumption is most often recorded between November and December in the period under discussion. An average of 130 l/c/d and a minimum of 127 l/c/d are recorded during April and November respectively. In the case of semi detached houses, the maximum per capita consumption of 123 l/c/d is recorded between November and December during the period under discussion. The average and minimum per capita consumptions are recorded in November and July respectively. Respondents in apartment buildings have their maximum per capita consumption of 120 l/c/d recorded between December and January in years under discussion. An average of 118 l/c/d and minimum of 116 l/c/d are recorded in July and June respectively.

Moreover, respondents in compound houses in the study area have their maximum, average and minimum per capita consumptions of 62 l/c/d, 59 l/c/d and 58 l/c/d being recorded during December April and May respectively.

Table 4-2: Consumption figures by different dwelling type under different supply conditions

DWELLING TYPE	PER CAPITA CONSUMPTION l/c/d		
	CONTINUOUS SUPPLY	INTERMITTENT SUPPLY	
		GOOD	POOR
DETACHED	130	122	90
SEMI DETACHED	120	119	85
APARTMENT	118	111	80
COMPOUND HOUSE	59	56	45

Intermittent good supply

Table 4-2 also shows consumption figures by dwelling type under intermittent good flow. The figures are indicative of the fact that per capita consumption is related to condition of flow in the study area. A respondent under intermittent good flow who lives in a detached house consumes about 93% of what his counterpart in continuous flow consumes per capita. This analysis reinforces the assertion that some respondents are managing with the supply available and may change their lifestyle when supply to the area increases.

Intermittent poor supply

Table 4-2 above also gives information on per capita consumption of respondents under intermittent poor supply. From the table, it is obvious that respondents under intermittent poor supply consumes far less than their counterparts in continuous supply. For example, a respondent under intermittent poor flow who lives in detached house consumes about 69% of what his counterpart receiving continuous flow consumes per capita. This analysis shows that the poorer the supply condition, the lower the per capita consumption.

From Figure 4-1, it could be deduced that majority of high income and middle income earners lives in detached, semi detached, and apartment houses in the study area. In view of that, the per capita consumption of respondent in those dwelling types is marginally different, but significantly different from their counterparts in compound houses. Moreover, some modern dwelling houses are fitted with high water consuming facilities such as washing machines, showers, dish washers and bathtubs which may offer some explanation to consumption patterns of respondents. Detached houses having marginally higher per capita consumption than the semi detached and apartment dwelling may be due to larger lawn sizes and gardens in the detached houses compared to the other dwelling types.

The analysis of the patterns showed in Figures 4-2 to 4-4 above reveals that per capita consumption patterns in different types of dwelling were comparatively similar. People living in detached houses consumed the highest amount of water on average, which is higher than the amount consumed by semi detached and apartment dwelling. However, per capita consumption by people living in compound houses was relatively lower. Moreover, modern detached houses in the study area are associated with high income earners and who tend to have more than one bathroom and water closet. Many of the apartment and semi-detached buildings in the study area are older than the detached houses which are mostly found in plush areas with delux or executive size mansions. These older buildings have little in the way of gardens and recreational facilities and are mostly inhabited by middle income earners. Many old apartments may not have common or shared laundry nor are the individual apartment necessarily equiped with washing machines.

Given that those who live in older apartments need to wash their clothes, those who have no washing machine may use public facilities. This means personal consumption of water for self maintenance is not confined to water consumed in their own dwellings. This may result in reduction in per capita consumption which may explain the difference between Detached houses, semi detached, and apartment buildings.

Analysis of survey data showed that majority of respondent living in compound houses are low income earners and have high average resident population. Respondents do not have high water consuming faclities such as showers, washing machine and dish washing machine and few respondents use water closet with none of the respondents having lawns , gardens, or swimming pools.

4.3 Water consumption pattern by income groups

This section focuses on water consumption pattern by various income groups in the study area. The survey data was filtered using tools in MS Excel into different income groups, and the average monthly consumption for each income group was computed in addition to computed average resident population. The per capita consumption for the different income group was thereafter computed under different flow conditions.

Table 4-3 shows the dispersion of respondents within the various income groups under the different flow conditions. From the data below, it is obvious that majority of respondents are in middle income group which is the predominant group in the study area, however, 50% of the respondents are under intermittent poor flow conditions, about 23% of respondents in high income group under continuous flow condition and about 11% and 16% of respondents in middle and low income group respectively under continuous flow condition.

Table 4-3: Respondents per income group under flow conditions

FLOW CONDITIONS	NUMBER OF RESPONDENTS PER INCOME GROUP			
	High Income	Middle Income	Low Income	Total
continuous	30	20	15	65
Intermittent good	40	60	39	139
Intermittent poor	63	104	37	204
Total	133	184	91	**408**

Figure 4-5 shows consumption pattern for income groups under continuous flow regime, respondents under this flow condition receive water continuously for twenty four hours per week. There is significant difference between consumption by the various income groups with the high income groups having the highest per capita consumption followed by middle income and low income respectively. The trend of consumption is almost constant for the various income groups throughout the year.

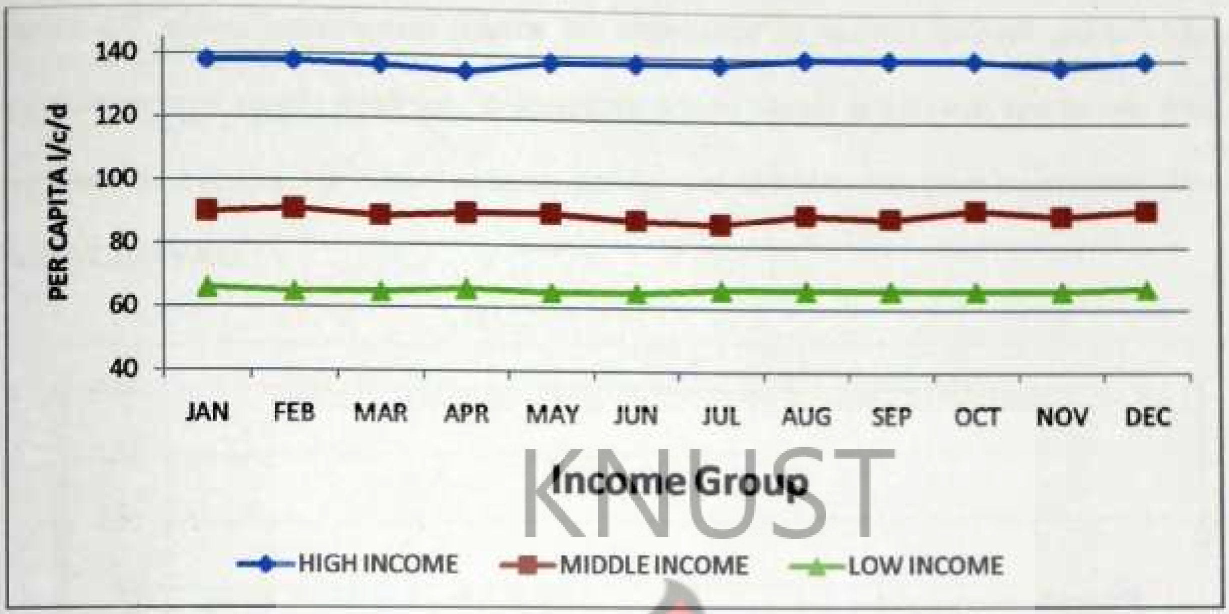

Figure 4-5: Consumption per income group (2004-2008) - continuous supply

Figure 4-6 shows consumption pattern for respondent in various income group under intermittent good supply condition. These are consumers whose supply is less than twenty four hours per day. Respondents whose supply is between five to six days per week for between twenty to twenty four hours per day are considered as good intermittent flow by GWCL/AVRL.

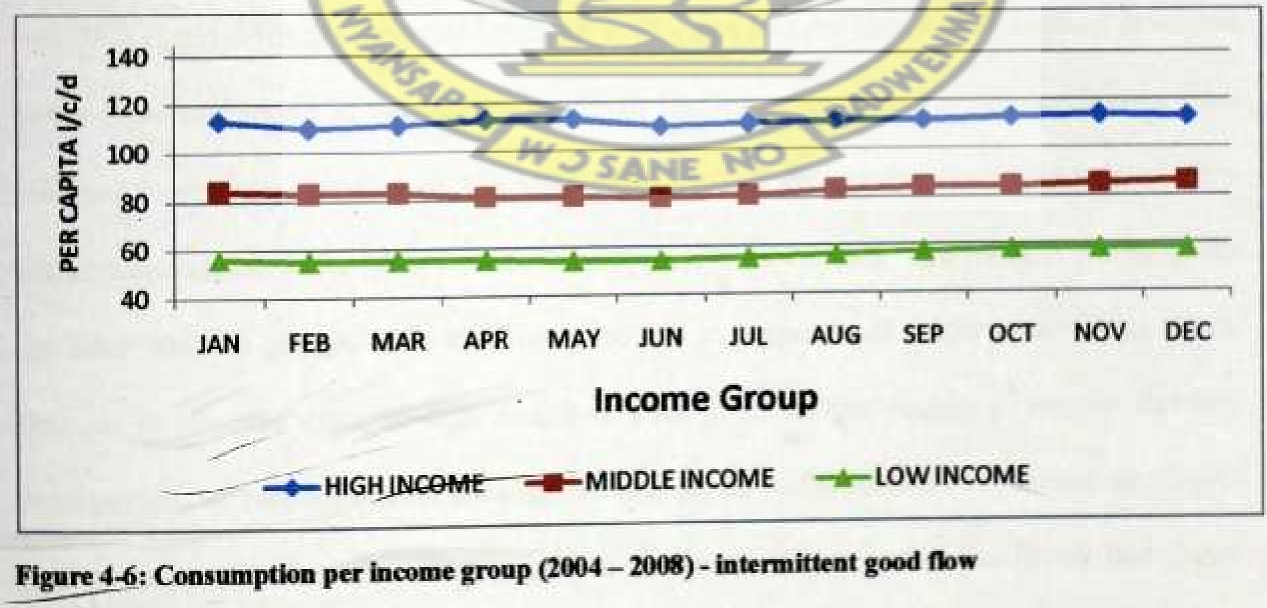

Figure 4-6: Consumption per income group (2004 – 2008) - intermittent good flow

Figure 4-7 shows consumption pattern for respondent in various income group under intermittent poor supply condition. Respondents whose supply is between one to two days per week for between six to twelve hours per day are considered as poor intermittent flow by GWCL/AVRL.

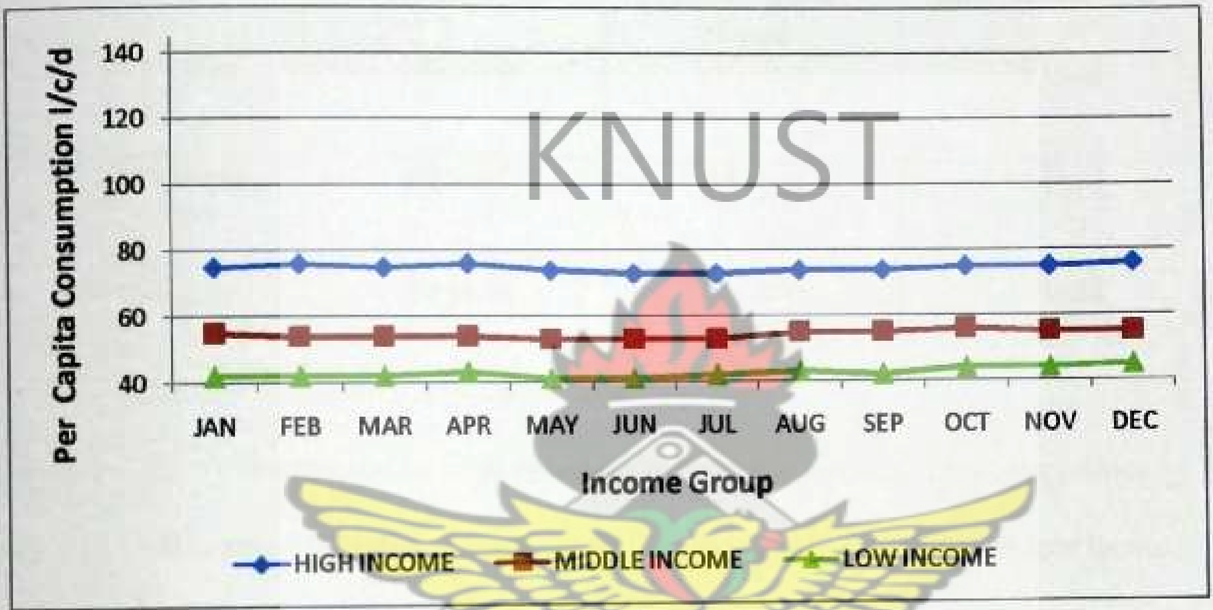

Figure 4-7: Consumption per income class (2004 – 2008) - intermittent poor flow

Table 4-4 shows average per capita consumption for various income groups between 2004 and 2008 under different flow conditions. It is obvious that per capita consumption is related to the flow conditions in the study area. High income respondents under continuous flow with per capita consumption of 138 l/c/d reduce to110 l/c/d under intermittent good flow whilst respondents under poor flow consumes as low as 75 l/c/d. The trend is the same for the other income groups. This trend may be due to respondents under intermittent flows, changes in attitudes towards water usage as a result of the inadequacy of supply. Seventy three percent of respondents in the high income group under intermittent flow may change their attitude and life style when supply is increased. There is the likelihood that future expansion of production centers may not yield the desired effect. It is therefore important for the utility operators to consider demand management programmes to forestall any future water crisis.

Table 4-4: Per capita consumption in income groups under different flow conditions

INCOME GROUP	FLOW CONDITION		
	Continuous	Intermittent Good	Intermittent Poor
High Income	138 l/c/d	110 l/c/d	75 l/c/d
Middle Income	90 l/c/d	83 l/c/d	54 l/c/d
Low Income	66 l/c/d	56 l/c/d	43 l/c/d

Table 4-7 shows information used in design of distribution network for communities by GWCL/AVRL. From the table, the per capita demand for high, middle and low income groups are 120 l/c/d, 90 l/c/d and 60 l/c/d respectively.

Table 4-5: GWCL design parameters

Income Group	Per Capita consumption (l/c/d)	Average Resident population	Household size	Average monthly consumption/m^3
High Income	120	8	1	28.8
Middle Income	90	12	2	32.4
Low Income	60	15	>3	27

Source: GWCL, 2006

4.3.1 Consumption pattern of high income group

Table 4-6 is analysis of survey results which showed the average per capita consumption of 138 l/c/d, 90 l/c/d and 66 l/c/d for high, middle and low income respectively. From the data, it is obvious that per capita consumption in high income group is higher than the designed demand, an indication that consumption may be trending upwards among the high income group.

Table 4-6: Income group under continuous flow

Income group	Per capita Consumption (l/c/d)	Resident population	Household size	Monthly consumption(m^3)
High Income	138	8	1	33.0
Middle Income	90 l/c/d	10	2 – 3	27.0
Low Income	66 l/c/d	18	>3	35.0

This trend may be due to high standard of living among the high income group. The standard of living of high income group affords them the use of high water consuming appliance such as showers, bathtubs, washing machines and water closets etc. The standard of living and lifestyle is also a factor that influences consumption in the high income group. Respondents in this income group's affinity for lawns, gardens and swimming pools may also explain the high per capita consumption.

4.3.2 Consumption pattern of middle income group

The data also showed that the per capita consumption by middle income group does not differ from the designed per capita demand. The average per capita demand for the middle income group is 90 l/c/d which is recorded between May and June. From the analysis of the survey data and from the results above, 50% of respondent in middle income groups dwell in semi detached houses. The middle income group may not have large lawns as compared with the high income and may not be able to afford the lifestyle of the high income group which my explain the significant difference in the per capita consumption. Just as in the case of high income, consumption is related to flow conditions in the study area. In the event of increase in production, the respondents in intermittent flow may change their attitude to water usage which may increase their per capita demand. In cases where the income of the respondents in the middle income changes, their attitude towards water usage may change. In view of the above discussion, it will be prudent for the utility company (GWCL/AVRL) to initiate demand management programmes in the near future to forestall any water crisis in the study area.

4.3.3 Consumption by low income group

The increase in per capita consumption by low income group above the designed per capita consumption may be due to the increase in the use of water borne sanitation in the low income communities and the use of showers by some respondent in the communities.

From the analysis of survey data, it was realised that most respondent in low income, do not use high water consuming appliances like water closets, showers, bathtubs, washing machines etc. There may be less external use for watering lawns, gardens, fountains and swimming pools. Low consumption may also be due to use of water for very essential purposes like drinking, laundry and for hygiene purposes only. Other reasons may be due to low income dwellers inability to pay for water used.

From the discussions above it may be concluded that standard of living influences consumption of water in any social settings

4.3.4 The effect of supply condition on consumption

Table 4-7 shows consumption figures in different income groups under different supply conditions. From the table, the following deductions can be made:

- Per capita consumption is related to supply conditions
- Respondents under intermittent supply consumes between fifty to eighty per cent of what their counterparts in continuous supply consumes.
- The average per capita consumption for consumer in high and low income groups is higher than the figures used by GWCL/AVRL for design

The above deduction may be due to the inadequate water in the study area, and there may be the tendency for consumers increase their consumption with improvement in supply. Analysis of the survey result showed that most of the respondents in the study area are under intermittent poor supply, and this may be due to increase in urban population in the Accra west and Tema Regions were water treatments plant in Accra are situated and since Accra East region depends on these regions for their supply, there can only be improvement in supply when enough water is supplied from the two regions.

In view of the above, any future expansion of treatment plant should factor the actual demand of the consumers under intermittent supply.

Table 4-7: Consumption figures by different income group under different flow condition

INCOME GROUP	PER CAPITA CONSUMPTION l/c/d		
	CONTINUOUS SUPPLY	INTERMITTENT SUPPLY	
		GOOD	POOR
HIGH INCOME	138	110	75
MIDDLE INCOME	90	83	57
LOW INCOME	66	56	54

In Accra East Region where most of the consumers are under intermittent supply water is rationed by operating distribution valves daily to apportion water in rotation to different areas. The effect of rationing may induce negative pressures which can cause ground water infiltration and contamination of the supply. There is also the possibility that flow of water will be impeded during the rationing period. These situations may explain why some consumers under these flow conditions either get low pressures during the rationing period or do not get supply at all. The scarcity of supply, may lead to losses of water (and revenue) through leaks, wastage, and unpaid supplies. Most consumers use time of supply to fill their storage receptacles, and in most case, these receptacles often overflow and water goes waste.

Most of the unaccounted for water, in the utility companies may be by consumers in this flow regimes.

4.4 Assessment of the effectiveness of supply management programme

This part of the research report investigates the effectiveness and efficiency of the supply management programme in the distribution area. The map used for rationing (see appendix 24) was compared with the actual duration of supply during rationing in the distribution area as gathered from the survey data. From the analysis of the survey data and the rationing map, it could be deduced that there are discripances between supply management map used for the rationing programme and the actual supply situation in the study area. Table 4-8 shows rationing programme for High Income communities in the study area. It can be observed that areas that are scheduled to get 24 hours per day for seven days per week actualy received less than was planned for. Since service pressures are dependent on elevations, during rationing periods, areas at low elevation receive supply immediately, but those on high elevation receive it after the distribution line is fully charged.This delays the supply time and hence duration of supply in areas with high elevation.In the study area, the distribution system is made up of loop and branch system with some dead ends, so it becomes difficult to isolate some areas during the rationing, which is the reason why some respondents get more than schedule for whilst others get less than planned for. However, in the case of middle income areas, analysis shows that majority of the communities receive less duration of supply than planned for, except for Borabora estate. In the same respect, Teshie Manhean and Teshie town are the only communities in low income areas that get more than planned for. The rationing programme as is currently practised is dependent on the distribution officer who trottles valves to direct water to communities during the rationing, however, there are circumstances where the officer forgets to re-direct the supply to other areas which gives advantage to one area over the other. Discussions with

GWCL/AVRL management also reveal that the rationing programme is disrupted by private water filling points in the distribution areas. The activities of this private filling points disturb the service pressure during the rationing period.

Table 4-8: High income rationing programme

Community	Planned supply	Actual supply	
	Hours/month	Hours/month	Percentage
Cantoment	576	134	23
North Labone/Labone Estate	672	123	18
Switch Back Road	672	100	15
Trade Fair	576	94	16
Martey Tsuru	480	130	27
Regimanuel/ Manet Estates	480	136	28
Nyaniba Estates	96	301	313

Table 4-8 above shows the relation between rationing and per capita consumption in high income areas. It can be observed from the analysis of the results that the supply management plan in the study area is not efficient, and that has affected per capita consumption in the high income areas. Consumption in the intermittent supply area is between 56% to 75% of consumers under continuous flow. The analysis above has the potential to affect revenue generation of the utility company since consumers may spend more on alternative source and hence feel reluctant to pay their bills. For the utility company, the high income areas are those who readily pay their bills and so if supply is not consistent, it will affect their revenue generation. There may be the tendency for consumers to leave their taps on in anticipation of supply, which may lead to over flow of storage tank and hence wastage. The disparities in the rationing programme and the actual supply situation may also be attributed to the phenomenon of water hammer which is the occurrence of pressure changes in closed pipes caused by changes in the velocity of the fluid flows which consequently results in both over pressure and under pressure (vacuum pressures) and in some cases due to the intermittences of the supply air is trapped in the lines which impedes flow of water during rationing. Other reasons may be due to the indiscriminate installation of water filling points in the distribution areas which have the tendencies of reducing pressures in the line.

Table 4-9: Low income rationing programme

community	Planned supply	Actual supply	
	Hours/month	Hours/month	Percentage
Teshie Manhean	192	220	43
La	192	173	34
South La Estate	192	176	35
Teshie Town	192	192	40
Coco beach/ Cold store	192	171	34
Nungua old Town	480	380	53
Teshie Zongo	192	168	32

Table 4-10: Middle income rationing programme

community	Planned supply	Actual supply	
	Hours/month	Hours/month	Percentage
Agblesaa	384	115	30
Teshie Nungua estate	480	133	28
New Nungua	480	183	38
Adogon	192	133	69
Baatsonaa	384	137	36
Ravico	480	267	56
Reg Gray Estate	384	226	59

Table 4-9 and Table 4-10 above showed actual supply condition with corresponding per capita consumption by low and middle income groups respectively. Gleick (1990) estimates 50 liters per capita per day as a minimum standard to meet four basic needs: for drinking, sanitation, bathing and cooking. By this standard, none of the low income group under intermittent flow meets the minimum standard for the four basic needs and in the middle income group, Aglessa and Adogon communities consume below the minimum standard for the four basic needs.

Moreover, Falkenmark, (1998) proposed a figure of 100 liters of fresh water per capita per day for acceptable standard of living in developing countries, and by Falkenmark's standards, none of the income groups under intermittent supply condition meets requirement for acceptable standard of living.

From the discussion above, it may be concluded that the rationing programme in the distribution area is poor and does not meet the minimum requirement for acceptable standard of living in developing countries. These tendencies have the potential of affecting revenue by the urban water providers.

CHAPTER FIVE

5 CONCLUSIONS AND RECOMMENDATION

5.1 Conclusion

From the results and discussions above the following conclusions can be drawn:

- Consumption in various income groups is influenced by flow conditions with consumers in continuous supply having higher per capita consumption than their counterparts in the intermittent supply conditions.
- The average per capita consumption for high and low income dwellers are 138 l/c/d and 66 l/c/d respectively which are higher than the figures used for design by GWCL. This information can be used to estimate demand in these income groups which can subsequently be used in hydraulic model that can be used to effectively manage rationing programmes in the area.
- The consumption patterns of different dwelling types in Accra is necessary for effective and efficient planning and design of distribution network in a newly developed areas in the Metropolis since the data could be used to estimate flows and hence accurately size distribution mains.
- The results of the study can be used as an input into any pro poor programme aimed at reducing poverty by implementing tariff structure which may subsidized bills for the poor.
- The rationing programme being implemented in Accra East is not efficient, which has resulted in communities having consumptions lower than the minimum consumption required for acceptable standard of living.

- There is a correlation between dwelling type and income class with the effect that consumption increases with increase in standard of living.

5.2 Recommendation

- GWCL/AVRL should develop a Hydraulic model for Accra which should be used to effectively manage the rationing programme in order in order to improve customer satisfaction.
- A water study audit should be conducted by GWCL/AVRL in Accra know the volume of water used for domestic sanitation, laundry cooking, bathing and other external uses which could serve as an input into demand management programmes.
- GWCL/AVRL should meter all households in compound houses, which will allow low income dwellers to benefit from any subsidy design by the utility company.
- A research should be conducted by the utility company to elicit insight into the attitudes of households to water consumption and conservation.
- This research should be replicated in Tema and Accra West region of Greater Accra Region so that consumption patterns can also be established for them since they have production centers.
- The number of water filling point on the distribution network should be regulated in order to improve the rationing programme

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APPENDICES

Appendix 1 : Questionnaire for household survey

Area…………………. Date…………………………

I am conducting a survey concerning residential water use issues in your neighborhood, to help solve the water shortage problem and for my Master Thesis. The information gathered will be used to identify water use patterns and problems in order to suggest ways that municipal water supply and service could be improved in future. All the specific information you provide will be treated confidentially. I hope that you will be willing to help me with this study.

1. Are you connected to Ghana Water Company distribution network?

   Yes ☐ No ☐

2. Do you have other source of water apart from Ghana Water Company?

   Yes ☐ No ☐

3. If question 2 above is yes, what is the source?

   a. Well/Borehole b.Rain water

   c. Private providers' d.Tanker service

4. How many days in a week do you get water? ……………………………

5. How many hours in a day do you get water? ……………………………

6. Do you have water storage facility in this house? Yes☐ N☐

7. What is the capacity of your tank? If you know………………

8. How long does your stored water take you when water is not flowing?

   a.1-3 three days
   b. 1 week
   c. Others, please specify…………………………….

9. What type of toilet system do you use?

   a. Water closet b. KVIP

b. Others please specify.................................

10. If you use WC, how many do you have in the house? ....

11. Does anybody own a car in this house? Yes☐ No☐

12. If yes, how many are they?

a. Private cars..............................

b. Commercial........................

13. How many households use the GWCL connection?

14. How many people are there in each household?

15. Do you have water meter? Yes/No

16. If question 15 above is yes, do you receive your bills regularly?

17. Do you have a. Lawn b. garden?

18. If yes, which of them do you water?

a. Lawns b. Gardens c. None

19. Do you take measures to reduce water use in this? Yes ☐ No ☐

20. How many Rooms are in this House? ....

Appendix 2: Alternative source of supply by middle income class

ALTERNATIVE SOURCE	PERCENTAGE(%)
TANKER	45
RAIN HARVEST	12
WATER VENDOR	30
NEIGHBOUR	9
WELL/BOREHOLE	3
OTHERS	1

Appendix 3: Income groups under intermittent good flow

Income group	Per capita con.	Resident pop.	Household size	Monthly consumption(m^3)
HIGH INCOME	112 l/c/d	8	1	26.9
MIDDLE INCOME	84 l/c/d	10	2 – 3	25.2
LOW INCOME	56 l/c/d	18	>3	30.2

Appendix 4: Income groups under intermittent poor flow

Income Group	Per Capita Consumption	Resident Population	Household Number	Monthly consumption (m^3)
High Income	75 l/c/d	8	1	18.0
Middle Income	53 l/c/d	10	2 – 3	15.9
Low Income	41 l/c/d	18	>3	22.1

Appendix 5: Average per capita consumption (2004 - 2008) -continuous supply

DWELLING TYPE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DETACHED HOUSE	129	130	132	129	127	127	128	129	129	130	132	132
SEMI DETACHED HOUSE	123	122	122	121	119	118	118	119	119	120	120	123
APARTMENT	120	119	119	119	117	116	118	117	117	119	119	120
COMPOUND HOUSE	61	60	60	59	58	58	58	58	58	60	61	62

Appendix 6: Average per capita consumption (2004 - 2008) by dwelling types- intermittent good supply

DWELLING TYPE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DETACHED HOUSE	124	123	123	122	120	120	121	122	122	123	122	124
SEMI DETACHED HOUSE	121	121	120	120	117	116	116	117	118	120	120	122
APARTMENT	113	112	112	111	110	109	109	110	110	112	112	114
COMPOUND HOUSE	58	56	56	55	54	54	55	55	55	57	57	58

Appendix 7: Average per capita consumption (2004 - 2008) by dwelling type - intermittent poor supply

DWELLING TYPE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DETACHED HOUSE	92	90	90	90	88	88	89	89	89	90	91	92
SEMI DETACHED HOUSE	87	86	85	85	85	84	84	85	85	86	86	87
APARTMENT	81	80	80	80	78	78	78	78	78	80	82	82
COMPOUND HOUSE	46	45	45	45	44	44	44	44	45	46	46	46

Appendix 8: Average per capita consumption (2004 -2008) pattern by income class - continuous supply

INCOME GROUP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
HIGH INCOME	138	138	137	135	138	138	138	140	140	140	138	140
MIDDLE INCOME	90	91	89	90	90	88	87	90	89	92	90	92
LOW INCOME	66	65	65	66	65	65	66	66	66	66	66	67

Appendix 9: Average per capita consumption (2004 -2008) pattern by income class - intermittent good supply

INCOME GROUP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
HIGH INCOME	113	110	111	113	113	110	111	112	112	113	114	113
MIDDLE INCOME	84	83	83	81	81	80	81	83	84	84	85	86
LOW INCOME	56	55	55	55	54	54	55	56	57	58	58	58

Appendix 10: Average per capita consumption (2004-2008) pattern by income class - intermittent poor supply

INCOME GROUP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
HIGH INCOME	75	76	75	76	74	73	73	74	74	75	75	76
MIDDLE INCOME	55	54	54	54	53	53	53	55	55	56	55	55
LOW INCOME	42	42	42	43	41	41	42	43	42	44	44	45

Appendix 11: Anova single factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
DETACHED	12	1554	129.5	3.181818182
SEMI DETACHED	12	1444	120.3333	3.333333333
APARTMENT	12	1420	118.3333	1.696969697

Appendix 12: Anova results

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	850.8889	2	425.4444	155.4206642	1.61E-17	3.284918
Within Groups	90.33333	33	2.737374			
Total	941.2222	35				

Appendix 13: Anova Results for intermittent supply (good) per dwelling type

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
DETACHED	12	1466	122.1667	1.787879		
SEMI DETACHED	12	1428	119	4.363636		
APARTMENT	12	1334	111.1667	2.515152		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	769.5556	2	384.7778	133.1923	1.58E-16	3.284918
Within Groups	95.33333	33	2.888889			
Total	864.8889	35				

Appendix 14: Anova results for intermittent supply (poor) per dwelling type

Anova: Single Factor

summary

Groups	Count	Sum	Average	Variance		
DETACHED	12	1078	89.83333	1.787879		
SEMI DETACHED	12	1025	85.41667	0.992424		
APARTMENT	12	955	79.58333	2.44697		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	634.3889	2	317.1944	182.042	1.49E-18	3.284918
Within Groups	57.5	33	1.742424			
Total	691.8889	35				

Appendix 15: Anova results for intermittent supply (poor) per income group

Anova: Single Factor

summary

Groups	Count	Sum	Average	Variance		
HIGH INCOME	12	896	74.66667	1.151515		
MIDDLE INCOME	12	652	54.33333	0.969697		
LOW INCOME	12	511	42.58333	1.537879		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6323.389	2	3161.694	2592.197	5.22E-37	3.284918
Within Groups	40.25	33	1.219697			
Total	6363.639	35				

Appendix 16: Anova results for intermittent supply (good) per income group

Anova: Single Factor

Summary good supply

Groups	*Count*	*Sum*	*Average*	*Variance*		
HIGH INCOME	12	1345	112.0833	1.719697		
MIDDLE INCOME	12	995	82.91667	3.356061		
LOW INCOME	12	671	55.91667	2.265152		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	18937.56	2	9468.778	3869.593	7.27E-40	3.284918
Within Groups	80.75	33	2.44697			
Total	19018.31	35				

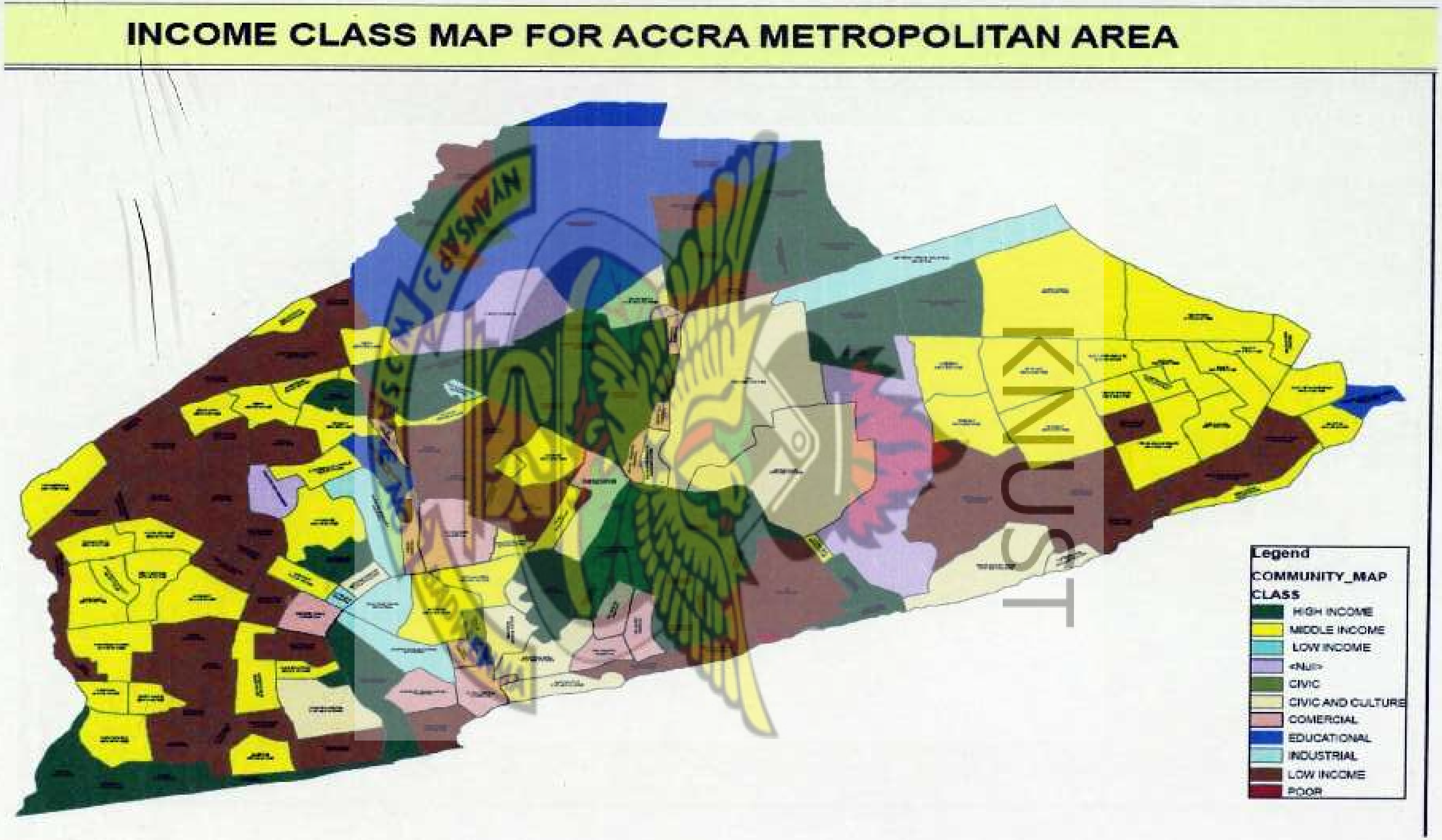
Appendix 17: Anova results for continuous supply per income group

Anova: Single Factor

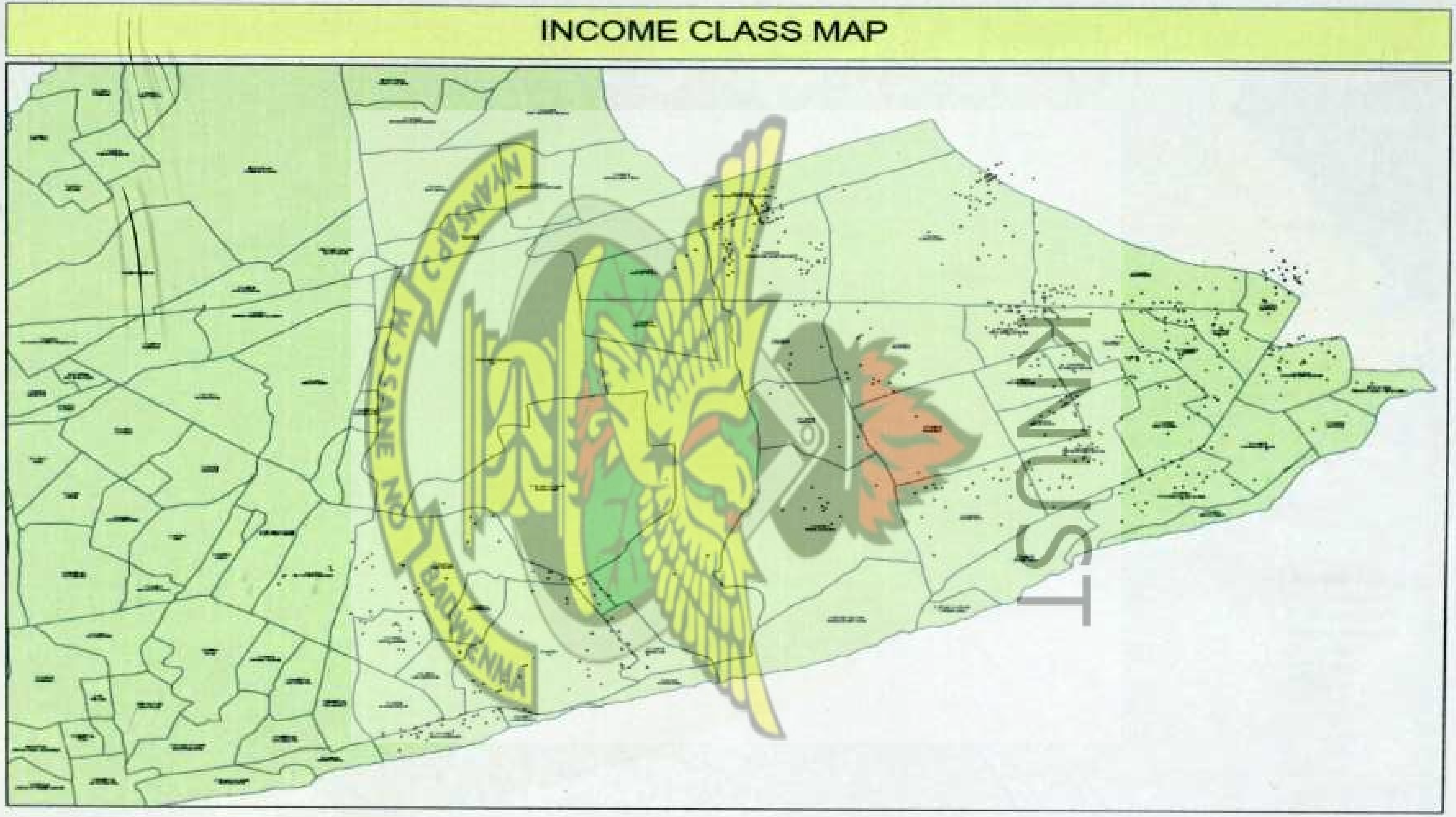
Summary continuous

Groups	*Count*	*Sum*	*Average*	*Variance*		
HIGH INCOME	12	1660	138.3333	2.242424		
MIDDLE INCOME	12	1078	89.83333	2.151515		
LOW INCOME	12	789	65.75	0.386364		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	32802.39	2	16401.19	10292.98	7.41E-47	3.284918
Within Groups	52.58333	33	1.593434			
Total	32854.97	35				

Appendix 18: Income class map



Appendix 19: Income class map showing customer location



Appendix 20: Accra East rationing map