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MSc Thesis

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Water Demand Management of Domestic Water in the Accra, Tema Metropolitan Area (ATMA), Ghana.

Kassim Yakubu Al-Hassan

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Master of Science Thesis
by
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This research is done for the partial fulfillment of requirements for the Master of Science degree at the UNESCO-IHE, Institute for Water Education, Delft, the Netherlands

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DEDICATION

I dedicate this to my entire family of father, mother, bothers and sisters and all siblings. It also goes to my lovely honey and all the people of the developing world who at this moment lack access to potable water.

ABSTRACT

One of the major problems in the world today especially in Africa due to urbanization is the scarcity of water resources specifically drinking water supply. The main water-related urban challenge in developing countries remains ensuring adequate water and sanitation and sustainable waste water management.

The general solutions to water demand problems had been more engineering –oriented where the idea is always to increase supply by developing other sources of water. However for sustainability to be ensured so that we do not exhaust our water resources, much emphasis is needed on alternative approaches to demand problems. One of such approaches is Water Demand Management (WDM) a paradigm shift in managing water demand and this aims at ensuring the efficient use of water to make it available to other people who need it.

Accra Tema Metropolitan Area (ATMA) is currently faced with severe drinking water scarcity, thus majority of the suburbs do not have regular supply of drinking water and currently depend on the limited availability of water that reaches them through the rationing programme employed by the water utility.

The aim of this research is to analyze the scarce water situation in terms of WDM in ATMA to come out with recommendations to help improve it. The thesis is centered on analyzing the current status of WDM in ATMA (i.e. how successful is the current WDM and its impact on the scarcity of water in ATMA by comparing the current situation with that of the recommended key indicators), analyzing the influence of some factors (i.e. population, rainfall, GDP growth rate and water rationing) and the outcome of scenarios of WDM on the water use of ATMA and finally analyzing the prospects of implementing WDM at household level in ATMA.

The approach adopted in this research was based on literature review and direct contact with relevant stakeholders for data and information. Questionnaires were administered to households in areas of affluent and non-affluent. The basic tools used in the analysis were Multi Linear Regression model and key performance indicators.

The current status of WDM indicated that few strides has been made in terms of WDM in ATMA as the level of Unaccounted for Water (UFW) is very high ranging from a minimum of 57% in Accra East to a maximum of 66% in the Tema regions of the GWCL and this is due mainly to leakages through pipe burst. Also educational campaigns on WDM are limited to only the electronic and print media and not continuous.

A multi linear regression analysis was developed to analyze key factors affecting water use. Population growth, rainfall, gross domestic product and water rationing are the main factors considered influencing water use or supply. The result indicated that a yawning gap exists between the crude per capita consumption and the actual calculated per capita

consumption over years to present. Assuming that the same factors will continue to be influential, future water use was projected and the per capita consumption was also projected for intensive, regular and business as usual water demand management. With the business as usual WDM, the per capita consumption decreases sharply to 43 l/c/d by the year 2025. With regular WDM, per capita consumption increases steadily to about 61 l/c/d with UFW reducing to about 38% and with intensive WDM, per capita consumption increases abruptly and then maintains a stabilized much narrow gap between the crude per capita and the actual calculated per capita consumption whilst reducing UFW to 20.5% by the year 2025.

Household interviews through questionnaires indicated that educational campaigns on water use efficiency is limited to the electronic and prints media, there are less household metered connections in the non-affluent high density areas; attitudinal respond to leakages in ATMA is not encouraging. The analysis of household consumption also indicated that the affluent consume more water on the average than the non-affluent.

Thus it is concluded that the current status of WDM in ATMA has had insignificant positive effect on the water demand. With intensive WDM in ATMA there will be an improvement in the water situation without developing any new supply system in the short to medium term. Finally the physical infrastructural set up in ATMA hinders the implementation of an effective WDM.

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LIST OF ACRONYMS

ATMA	Accra Tama Metropolitan Area
AVRL	Aqua Vitens Rand Limited
DM	Demand Management
ECOWAS	Economic Community of West African States
ERS	Economic Research Service
GDP	Gross Domestic Product
GWCL	Ghana Water Company Limited
GWSC	Ghana Water and Sewerage Corporation
HPZ	High Pressure Zone
IHE	Institute of Hydraulic Engineering
IUCN	International Union for the Conservation of Nature and Natural Resources
IWA	International Water Association
IWRM	Integrated Water Resources Management
LPZ	Low Pressure Zone
MDG	Millennium Development Goals
MIS	Management Information Systems
MLR	Multi Linear Regression
MPZ	Medium Pressure Zone
NRW	Non- Revenue Water
PURC	Public Utilities Regulatory Commission
RUAF	Resource Centers on Urban Agriculture and Food Security
SADC	Southern African Development Community
UFW	Unaccounted for Water
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Education
UNICEF	United Nations Children's Fund
WAWRC	Western Australian Water Resources Council
WCD	Water Commission on Dams
WD	Water Demand
WDM	Water Demand Management
WHO	World Health Organization
WRC	Water Resource Commission

CHAPTER 1 INTRODUCTION

1.1 Background

1.1.1 General Overview

The increasing urbanization in the world is one of the major threats to development today especially in the low and middle income nations. The high population in urban areas with limited resources calls for an approach to ensure sustainability of resource use. One of the major problems in the world today especially in Africa due to urbanization is the scarcity of water resources specifically drinking water supply. The main water-related urban challenge in developing countries remains ensuring adequate water and sanitation and sustainable waste water management.

According to the WHO/UNICEF Joint Monitoring Programme, if the Millennium Development Goal (MDG) of halving the proportion of people without sustainable access to safe drinking water supply and basic sanitation is to be met by 2015, 961 million urban dwellers must gain access to improved water supply (WHO and UNICEF, 2004)

Water planners, managers as well as different users have to deal with many challenges as we passed the threshold of the 21st century. Today's rapid population growth, depletion of groundwater, scarcity of untapped water sources, competitive use of water and the increase in the number of droughts calls for the need to develop alternative schemes to manage water resources.

The general solutions to water demand problems had been more engineering –oriented where the idea is always to increase supply by developing other sources of water. However for sustainability to be ensured so that we do not exhaust our water resources, much emphasis is needed on alternative approaches to demand problems.

A solution to providing water to increasing number of urban consumers is through Water Demand Management (WDM) which aims at ensuring the efficient use of water to make it available to other people who need it. Since the proportion of urban population for some African countries is expected to reach 50% by 2025, WDM in urban centers will become more important as delivery of adequate quantities of water will escalate thus bringing unprecedented challenges in infrastructure provision and management of return flows (Gumbo, 2004). Although the concept WDM has been in existence, most countries have failed in their bid to undertake a successful water demand management mechanisms and for some it is entirely a new thing yet to be implemented.

Thus there is the need for a thorough research in to the study of WDM that can be adopted especially in the urban areas and asses how efficient these methods of demand management can help impart on urban water conservation.

In this research, I analyzed the current situation of WDM by comparing it with the recommended key indicators, the influence of population, rainfall, GDP growth rate and water rationing on water use in ATMA, analyze the domestic water consumption patterns of some areas within ATMA and the prospects of implementing WDM in these areas and ATMA as a whole.

1.1.2 Problem Statement

In order to be able to make water available to increasing number of people in urban areas especially the developing world, the time has come for water managers to aim at methods that will lead to conservation of the quantity of water through its usage and supply. This could be a good approach towards sustainable management of the limited water resources.

WDM and other related sustainable methods of water use are being relegated and the focus is rather on the supply oriented methods. In most cases the concept of Demand Management (DM) is not well understood by professionals and stakeholders in the water sector in general.

Studies by Brooks et el. (1997) and Gumbo (2004) show that even though the concepts of WDM feature prominently in the Southern African Development Community (SADC) region, they are seldom implemented in practice. This is also confirmed by Ramsey and Mobbs (2001) who observed that just less than 50% of water utilities in Africa have a WDM programme or policy. The result of the above research and other peculiar factors could account for the current water situation in ATMA where the non-revenue water is 40% to 50% and the water quantity delivery system is fast deteriorating. Also the concept WDM and its implementation may not be on the priorities of utilities in solving water problems even though it is sustainable. Another issue of major concern is the level of educational campaigns that enhances the consumer's change of attitude towards the use of water. A sizable number of consumers due to their ignorance of the importance of water seem to mismanage the water available to them thus depriving others of it.

WDM may be implemented, however if it is not efficient, then the aim of the WDM may not be achieved. Thus it is very important to have well structured programme of WDM which is strictly adhered to.

Different countries apply different methods of demand management depending on the enabling environmental factors at their disposal. For instance a countries socio-economic status, institutional arrangement, political apparatus etc could have an influence on the methods of WDM.

Accra, the capital of Ghana and Tema the industrial city of the country have had their share of the rapid urbanization with most people drifting from other parts of the country particularly the rural areas in search of non existing jobs. This has consequently led to severe pressure on the limited resources especially drinking water supply which is fast becoming a menace. Although lots of efforts has been made by the government to improve the water situation in ATMA in terms of financing, lots more can be done especially in the area of Water Demand Management to improve the current water dilemma.

The situation has been compounded by the country's socio-economic status such that the government alone cannot afford to develop new water sources which are becoming increasingly costly. Thus one of the solutions to the water scarcity in ATMA lies in shifting from the traditional resource development to that of WDM which is becoming the global trend.

The research aims at establishing the influence of some factors on the use of treated drinking water in ATMA. It also analyses what accounts for the current water situation in terms of DM, then it zooms in on analyzing the use of domestic water in some affluent and non-affluent areas within ATMA and finally analyzes the prospects of implementing WDM in these areas and ATMA as a whole that will contribute in solving the current water situation.

1.2 Research Description

1.2.1 Scope of Research

The scope of this research is to access the current status of WDM in ATMA, to find out the influence of some factors on water use and the prospects of implementing WDM at distribution and household level.

1.2.2 Research Objectives

The objective of this research is to identify the major problems in ATMA that causes the current scarcity of drinking water. Another objective of this research is to be able to come out with solutions for the management of the identified problems. Similarly the research aims at finding out the relationship between affluent and non-affluent neighborhood in ATMA in terms of water consumption since the implementation of WDM also depends on knowing the levels and patterns of water consumption (Dube and Van der Zaag, 2003). It is also of the view that this research gives the general picture of WDM in

ATMA and the prospects of implementing WDM where necessary. The areas of particular interest in this research will be the methods applied by the water utilities in respond to demand vis-à-vis the principles of WDM.

Consequently the specific objectives are to:

- To analyze the treated water use patterns of ATMA as this will give an indication of whether management of the demand over the years had been supply oriented or otherwise.
- To quantify factors that affects the treated water supply in ATMA to be able to know the extent to which changes in the factors affect demand.
- To forecast the future supply and consumption of ATMA based on the quantified factors to able to come out with a corresponding solution.
- To analyze the monthly water consumption patterns of some affluent and non-affluent neighborhoods in ATMA with the view of identifying suitable WDM measures applicable in these areas.
- To analyze the prospects of implementing WDM at household levels in the affluent and non-affluent areas.
- To identify possible WDM measures with regard to all of the above objectives applicable in ATMA to achieve a stable balance between demand and supply of water.

1.2.3 Research Question

Based on the research objectives, the overall research question is:

- To what extent can WDM in ATMA influence current and future Water Demand (WD)?

The specific research questions are:

1. What is the current status of WDM in ATMA (i.e. how successful is the current WDM by comparing it with the recommended key indicators for WDM?)
2. What are the influences of population, GDP growth rate, water rationing, rainfall and the corresponding WDM measures of regular and intensive on the water use in ATMA?
3. What factors influence domestic water use patterns in affluent and non-affluent areas in ATMA?
4. What are the prospects of implementing WDM at household levels in ATMA?

1.2.4 Hypotheses

The following hypotheses are proposed for this research:

- WDM does not feature prominently in ATMA and its effect on the current WD is insignificant
- For an intensive WDM in ATMA, desirable level of water demand can be achieved.
- There is less incentive for a sizable number of consumers to practice WDM at household level.
- Prospects of implementing WDM at household level in ATMA are constrained by absence of physical WDM infrastructure.

1.2.5 Research Justification

The scarcity of urban drinking water supply in especially the developing countries has been aggravated by the lack of financial and human resources for the rehabilitation, operation and maintenance of water conveyance systems resulting in leaks which contribute to unaccounted-for water, a situation that calls for the potential benefits of WDM. To be able to address these major problems, it calls for consented efforts by all stakeholders in the water fraternity towards the implementation of a more sustainable and viable management of the scarce water resources. This will help reduce poverty and hunger in general as well as aid in the realization of the Millennium Development Goals (MDG's). In the light of this, there have been various researches conducted by renowned academicians on how to help manage sustainable and improve upon the scarce water supply situation, notably among this is the International Union for the Conservation of Nature and Natural Resources (IUCN WDM) Phase I and II programmes organized for the Southern African Countries.

However, due to the difference in the environmental settings (different macro environment, policy, legal and regulatory frameworks) in addition to the varying political, economic and social status existing across the developing countries, some countries have made fewer strides if not at all in finding alternative lasting solutions to their water crisis.

Accra the capital of Ghana and its environs is currently caught in a dilemma of scarce drinking water as a result of the non-existence of long term sustainable management plans and methods of the drinking water utility, a situation that has necessitated in the private management of the Ghana Water Company Limited (GWCL) by the Aqua Vitens Rand Limited (AVRL), a company acting for and on behalf of the GWCL.

This research is focused on bringing to bare some of the challenging vital issues of the urban water supply sector in the Accra Tema Metropolitan areas where it intends to contribute to a better understanding of the issues that confront the management of water supply in ATMA. It will also help to sensitize professionals of the water sector of the need to use sustainable methods such as WDM interalia in the management of the nation's water resources. The outcome of this research is expected to be of benefit to all stakeholders in the water sector and help in the improvement of the accessibility to water supply services in ATMA. The findings of this research are expected to be also relevant to other cities worldwide having peculiar water supply problems as ATMA.

Finally this research aims in the achievement of the capacity building programmes initiated by the UNESCO-IHE with the view to helping train professionals to acquire skills and knowledge to be able to identify and solve essential water problems in their countries and beyond.

1.2.6 Structure of Thesis

The whole thesis is structured in to six major chapters namely sequentially as Introduction, Literature Review, Methodology, The Study Area, Discussion & Analysis and Conclusion & Recommendations.

Chapter one provides an introduction to the research and it mainly focuses on the objectives of the study, scope of the research, research questions needed to be answered at the end of the research, the hypotheses and the research justification. The second chapter reviews all the major literature and documentations of WDM in line with the objectives of the research. The methodology and research strategy used for the study is presented in chapter three. Chapter four gives a description of the project study area and describes the water supply systems in ATMA.

Chapter five analyses all the information and data collected within the scope of the research including the water use patterns of some affluent and non-affluent areas and the water use trend in ATMA over the years. The basic tools used in the analysis were statistical tool i.e. the multi linear regression, performance indicators and models among others. In chapter six, the conclusions of the research are presented together with the recommendations, which give concrete measures to be taken to improve upon the water supply delivery system of ATMA.

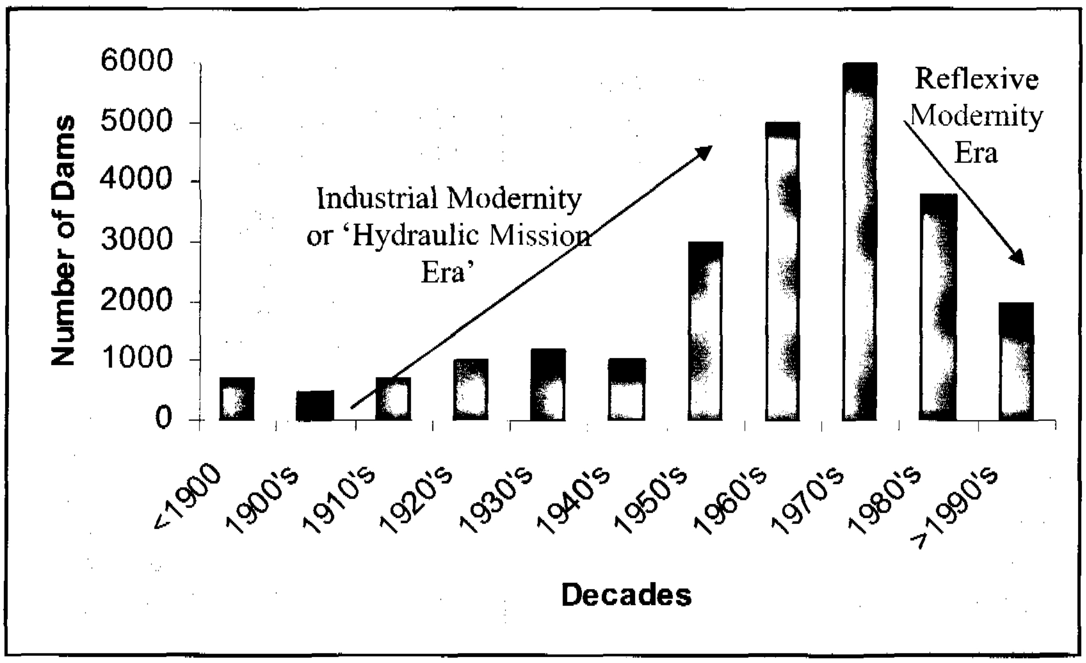
CHAPTER 2 LITERATURE REVIEW

2.1 The Genesis of Water Supply-Sided Management to Water-Demand Management

For the last century water management has been more supply-management oriented than demand management. This has been manifested in the water sector as the twentieth century was an era of building large dams.

It can be said with some confidence that the last century was the era of dam-building, to the extent that today around 3,800 km^3 of freshwater is withdrawn annually from the worlds lakes, rivers and aquifers, which is twice the volume abstracted just 50-years ago (WCD, 2000). In fact, the World Commission on Dams has shown that globally, the largest numbers of dams were constructed in the decade of the '70s, as shown in the Figure 2.2 and this period has been termed the golden age of Supply-Sided Management, or what some call the "hydraulic mission" period of water resource development (Allan, 2000; Reisner 1993; Swyngedouw, 1999a; 1999b).

Figure 2.1: The Global Construction of Dams by decade (1900-2000) (WCD, 2000:9) Showing the Industrial modernity and Reflexive Modernity Eras.



Development through the supply of new systems increased drastically until a time that the rate of the development started to fall. This was the time that the development was seen as having limitations as it was a potential cause of environmental degradation and a threat to existence of life on Earth. This time is referred to as the 'The Reflexivity Era' and can be linked with WDM in the water sector.

Reflexivity is said to exist when a given social grouping becomes concerned with the undesirable and unintended consequences of their actions (Giddens, 1990), such that as environmental degradation caused by industrialization, and actively seek to limit those consequences by developing coherent strategies and policies to effect this desire (Turton, 2000). Giddens (1984; 1990) has noted that there are various periods of human development. The early period called pre-modernity which was followed by an era of industrial modernity after the industrial revolution occurred and then once technology has advanced to such an extent that humans became aware of the unintended consequences of their actions, then the period of reflexive modernity was born.

This historical trend of developments is an indication of a general shift from a paradigm that is based on Supply –Sided Management approaches to water resource management, towards a more Demand-Side Approach.

2.2 Water Demand Management and Millennium Development Goals

WDM and the MDGs are closely related and the successful implementation of the former can contribute immensely to achieving the latter.

The Millennium development goals (MDGs) emanate from the Millennium Declaration signed in September 2000 by 189 countries, including 147 heads of state and it set targets for reductions in poverty, improvements in health and education, and protection of the environment (Gumbo et al., 2005) . They commit the international community to an expanded vision of development that vigorously promotes human development as the key to sustaining social and economic progress in all countries, and they recognize the importance of creating global partnerships for development and the elimination of poverty (Cosgrove and Rijsberman, 2000). The goals have been commonly accepted as a framework for measuring development progress (MDG, 2000; UNDP, 2003).

The goals and targets of the MDGs are interrelated and more often viewed in a holistic manner, however those that are key and related to WDM are Goals 1 and 7. Goal 1 is about eradication of extreme poverty and hunger and Goal 7 refers to ensuring environmental sustainability. In particular, Target 10 of Goal 7 which reads: Halve, by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation (MDG, 2000; UNDP, 2003).

In the majority of the African cities and Accra in particular where potable water is becoming scarce day by day, it is the poor who are vulnerable and much affected financially. This is because the poor will have to travel far in search of portable water which they buy at much higher prices. This worsens their poverty whilst the rich will continue to afford for water irrespective of the scarcity and even bring it to their door step quite easily. Not only do the poor end up spending more on water but also being subjected to an unbearable life situations where they have to spend also most of their precious time on water. This is even more compounded when the girl child is deprived of precious time supposedly meant for schooling. The MDG aims at making water available for people without access and in turn help eradicate poverty. WDM is one concept that ensures the conservation of water and optimum use of water and making water available to the usually poor people without water, hence helping in the reduction and eradication of poverty leading to the achievement of the MDG.

2.3 Water Demand

Demand is a general concept used by economists to denote the willingness of consumers or users to purchase goods, services, or inputs to production processes. The willingness varies with the price of the commodity being purchased. Engineers and water managers interpret water demand in a more technical sense as the quantity of water required by a user. Since there are divided opinions on water as a basic requirement and water as an economic good, it will not be prudent to define water demand in pure economic or technical terms. Water Demand is the demand expressed by a water user to satisfy its basic needs or its inputs required for industrial or agricultural production or to improve the standard of living.

Water demand comprises of consumptive use such as drinking water and non-consumptive use such as water for transportation and recreation. It is worth mentioning that the term water demand has been found to be very complex and thus its usage often creates confusion as a result of the often loosely usage of the term, hence it is strongly recommended for specifications when it comes to the usage of the term WD (IUCN, 2002)

Water demand includes categories, such as the following (IUCN, 2002):

- Domestic consumers for sanitation, cooking, gardening etc. Domestic consumers ranging from indigent people to high income groups.
- Non-domestic demand, mostly for productive sectors such as agriculture, mining, industries and the service sector.

Water Demand may be understood as the following (IUCN 2002):

- Actual consumption during a certain period
- Planned demand given a certain water price (the traditional economic demand curve)
- Water needs i.e. both met and unmet

2.3.1 Water Demand Management

WDM is said not to have a single universal definition that could be used by everyone but rather it is work-in-progress approach and its definition solely depends on the scale and depth to which one applies it. Thus the concept of WDM has been defined in several ways of which the following are some:

- ✓ WDM is the program which is adopted to achieve effective management of the use of water resources in order to meet the general objectives of economic efficiency, environmental conservation, and community and consumer satisfaction (WAWRC, 1987).

- ✓ Another definition of WDM is that of Dr. Judith Rees which is defined as policies and practices which can influence the level of water use and the measures which allow existing water supplies to be used in a more effective, efficient , environmentally sensitive, equitable or politically acceptable manner (WAWRC, 1987).

- ✓ WDM is described as consisting of actions which promote more desirable levels and patterns of water use. "More desirable level" should be understood to permit either decreases or increases in water use, as needed (UNDTCD, 1991). This definition is also in conformity to that of Emmanuel Dube and Pieter van der Zaag (2003) that WDM aims at achieving desirable demands and desirable uses and it influences demand in order to use scarce resources efficiently and sustainable .

  Thus with regard to this definition WDM should not only be restricted to the objective of ensuring measures that will reduce water consumption if the available water is more than the necessary threshold of desirability but rather also to aim at measures that will also promote increase in consumption when it is below the desirable threshold.

- ✓ Savenije and Van der Zaag (2002) defined WDM as the development and implementation of strategies aimed at influencing demand so as to achieve sustainable use.

- ✓ However of all the above definitions the most widely used one is that of the International Union for the Conservation of Nature and Natural Resources (IUCN) (2002). The IUCN defined WDM as a management approach that aims to conserve water by controlling demand through the application of measures such as regulatory, technological, economical and social at all spatial and institutional levels.

From the above varying definitions, WDM could therefore been seen as not a very rigorous but rather specific and flexible approach.

For the purpose of this research, no single definition of the above will be strictly adhered to but rather a combination of all the above definitions that aims at achieving desirable water level for ATMA through specific measures.

Measures in this sense will encompass technical and non-technical aspects of WDM measures that influence demand and supply in one way or the other to achieve desirable level.

From the above definitions, WDM can be regarded as a set of actions taken by water managers to ensure sustainable water consumption. The reasons why water managers and decision makers at all levels should try to control demands for water are (Savenije, 2000):

- The use of water is increasing, whereas resources are limited;
- Water resources are deteriorating rapidly, either through over-utilization or pollution:
- The cost of developing new resources are increasing;
- Financial constrains limit investments;
- The environmental carrying capacity of water resources systems is limited.

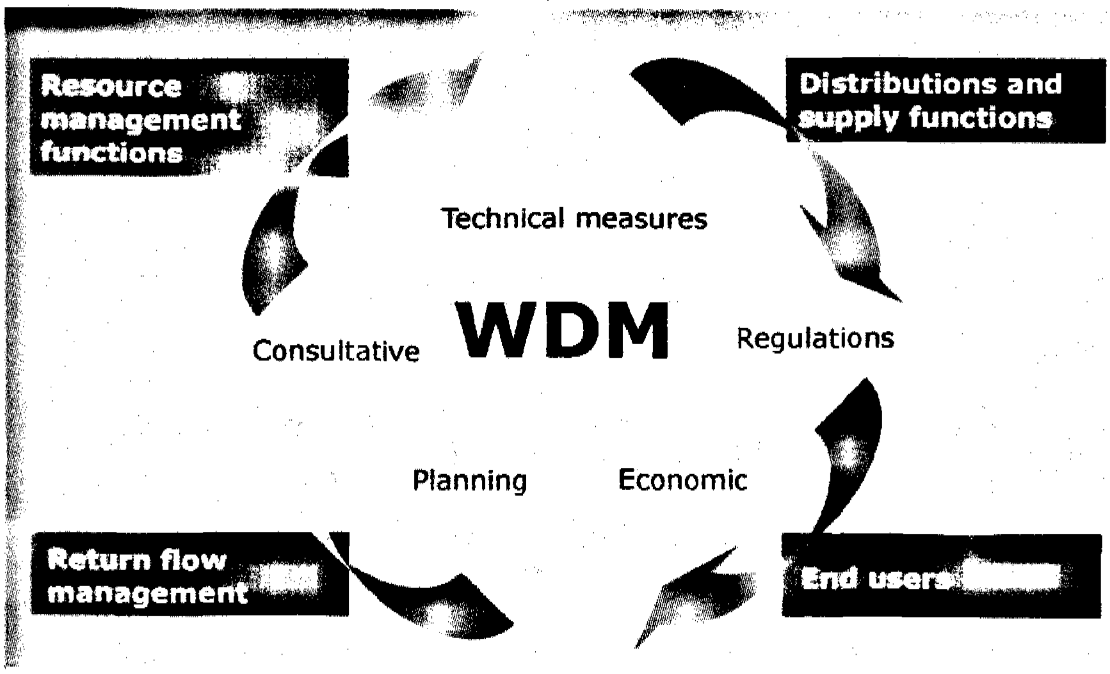
Many have also interpreted WDM to mean water conservation but this interpretation is contrary to the views of others. It is in the wake of this interpretation that Marunga et al (2006) argued that WDM should not be understood as water conservation, which (i.e. conservation) is defined by Beukman (2002) as efforts to save water during situations of water shortage, and is normally a strategy reserved for short-term situations where water may be in short in supply, usually as a result of drought conditions.

WDM targets four different stages of the water management cycle and can affect different groups of stakeholders associated with each phase of the cycle (IUCN, 2002). These stages are as follows:

- Water resource management (e.g. types of supply, allocation)
- Water distribution methods (e.g. cutting distribution losses)
- Consumer demand management (e.g. decrease wastage)
- Return flow management (e.g. consider the merits of direct use of return flows)

This is also illustrated diagrammatically below:

Figure 2.2: Water Demand Management targets groups and measures (Source: IUCN, 2002)



In this research, the focus will mainly be on Distributions and supply functions and End users.

From the above stages of WDM, the IUCN (2002) further came out with a wide range of different measures that can be implemented at each specific stage of the water cycle. This is illustrated in the Table 2.1: below:

Table 2.1: Examples of range of WDM measures (Source: IUCN, 2002)

WATER CYCLE STAGES	TECHNICAL WDM MEASURES	WDM IN PLANNING	WDM IN REGULATIONS	WDM IN ECONOMICS	WDM IN CONSULTATIVE PROCESSESS
Resource Management	Removal of invading alien species Wetland rehabilitation Dam storage optimization(e.g. less evaporation) Optimization of dam operating rules Artificial recharge and below surface water storage	Water catchments management Protection from over-utilization Managing land use Water quality management Drought contingencies Allocative efficiency Efficient green water management	Best Available Technology (BAT) water prices as compulsory alternative in Environmental Impact Analysis(EIA) / Social Economic Analysis (SEA) procedure in water stressed areas		Awareness and education, social marketing
Distribution and supply functions	Infrastructure optimization Parallel infrastructure for different water classes Loss minimization Metering Pressure management Prepaid meters Common-property management of standpipe	Town planning services Re-use and reclamation WDM in building standards	Regulations, norms and guidelines	Incentives Higher energy prices make pumping expensive Volume-based effluent charges	Education, Awareness, training Covenants for monopolies and WSPs

WATER CYCLE STAGES	TECHNICAL WDM MEASURES	WDM IN PLANNING	WDM IN REGULATIONS	WDM IN ECONOMICS	WDM IN CONSULTATIVE PROCESSESS
End users	Metering Different service levels Loss Minimization Retrofitting existing systems	Irrigation scheduling Crop choice Agricultural extension Auditing Minimizing institutional use	Domestic use guidelines and restrictions Guidelines for private and public sector Drought restrictions Proper level and structure of tariffs Amendment of water irrigation fees	Effective billing and pricing Product standards Differential tax rates (e.g. VAT) Higher energy tariffs make pumping expensive Volume based effluent charges Tradable water rights	Education, awareness, training
Return flow management	Minimizing infrastructure Minimizing pollution Minimizing losses Minimizing infiltration Reclamation	Infrastructure optimization Minimizing pollution	Effluent standards	Effluent charges	Education, awareness, training Covenants for irrigation sector and public sector

2.3.2 Water Conservation

Water conservation has been identified as an important component of DM strategies. Similarly like DM, conservation has not got a specific definition, however it has been defined as any beneficial reduction in water use or in water losses strategy. Water – management practice constitutes conservation when it meets the following two criteria:

- It conserves a given supply of water through reduction in water use (or water losses)
- It results in a net increase in social welfare.

The first criterion ensures that the practice results in a reduction in water use, whereas the second establishes that overall benefits exceed cost (that the practice is consistent with the conservation of all scarce resources).

A reduction in water use occurs when water –management practice is implemented, resulting in reduction in water use at some time or compared to the level of water use expected in the absence of the practice. The decreased water us at some time may be accompanied by increased water use at another time. Such a practice could still be qualified as water conservation provided the second criterion (beneficial reduction) is met.

A reduction in water use is beneficial if the aggregate of all beneficial effects resulting from implementation of the water management practice exceeds the aggregate of all adverse effect occasioned by such implementation. The practice should result in a net increase in social welfare, thus assuring that all scarce resources are being conserved.

From the definitions given by WDM and Conservation it is quite clear that the latter forms a component of the former and it is a strategy to achieve WDM. Similarly WDM is a long term management programme whereas Conservation could be a short term measure for instance in times of drought.

2.3.3 The Concept of Unaccounted for Water & Non-Revenue Water

- **Unaccounted for Water**

Unaccounted-for water (UFW) represents the difference between "net production" (the volume of water delivered into a network) and "consumption" (the volume of water that can be accounted for by legitimate consumption, whether metered or not).

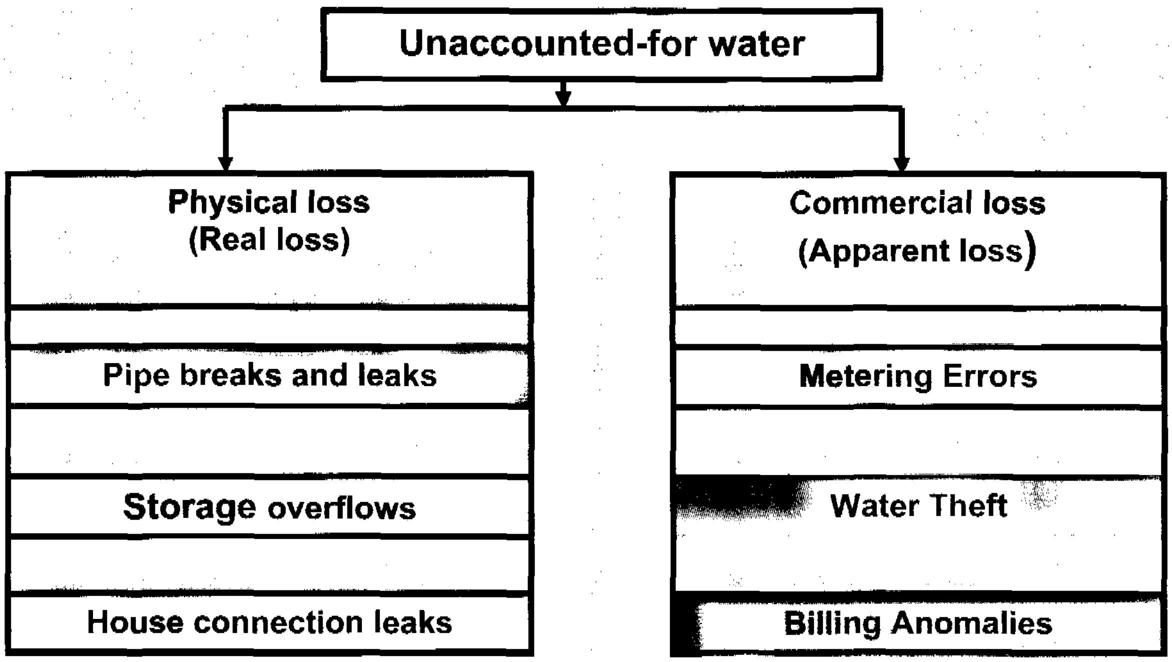
UFW = “net production” minus “legitimate consumption”
The components of UFW are:

- **Physical loss (Real loss)**
  Water lost through pipe breaks and leakage, overflows of distribution tanks and house connection leaks

- **Commercial loss (Apparent loss)**
  Water consumed but not paid for (meter under-registration, illegal connection or otherwise accounted for by government or other public use)

The component of UFW is represented in the figure below.

Figure 2.3: Components of UFW (Source: Saroj Sharma, 2006)



- **Non-revenue water (NRW)**

Non-revenue water (NRW) represents the difference between the volumes of water delivered into a network and billed authorized consumption.

NRW = "Net production" – "Revenue water"
= UFW + water which is accounted for, but no revenue is collected (unbilled authorized consumption).

The standard terminologies are summarized in the Table 2.2 below based on the IWA recommended practices. However the IWA has dropped the term 'unaccounted for water" (UFW) in favor of "non-revenue water (NRW), because there is no accepted definition of UFW, and all components of water balance can be accounted using the process in Table 2.2 (Thornton, 2002)

Table 2.2: The International Standard Water Audit (Source: IWA, 2000 in Water Loss Manual by Thornton, 2002)

System Input	Authorized Consumption	Authorized Billed Consumption	Billed Metered Consumption	Revenue Water
			Billed Unmetered consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water
			Unbilled Unmetered consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Metering Inaccuracies	
		Real Losses	Leakage on Mains	
			Leakage and overflows at storages	
			Leakage on Service Connections up to Point of Customer Metering	

The reduction of UFW in the distribution network through leakage repairs, detection of illegal connection among others is part of WDM process.

2.3.4 Constraints and Incentives of Water Demand management

WDM like any beneficial project to the society and the world at large has its own constraints and incentives to its implementation. However the constraints and incentives of WDM have been found to vary according to the water management situation.

Krugman and Mwasambli (2003) during their work in Southern Africa identified some key constraints to the implementation of WDM. Among theses are:

- Lack of financial resources, skills and institutional capacity among most water service providers to implement WDM and operate and maintain their infrastructure effectively.
- Lack of proper understanding of the benefits to be achieved from WDM
- Water supply bias among water engineers, decision-makers, politicians.
- Inappropriate training of professionals in the water sector.
- Lack of understanding of the need for WDM among water sector institutions
- Weak policy and legal instruments for WDM

- Negative attitudes toward WDM arising from existing myths and misconceptions about it.

2.3.5 Motivating Factors for Water Demand Management

The IUCN (2004) has also come out with factors that motivate water managers in water stressed regions to implement WDM. The factors are summarized in the Table 2.3.

Table 2.3: Push factors for WDM (Source: IUCN 2004)

Environmental Push factors	• Current or future water scarcity • Drought • Avoidance or postponement of the negative environmental impacts • Social environmental impacts of dams and well fields
Economic Push factors	• Lower cost of WDM compared with new cost schemes • Possible savings on operation and maintenance cost • Increase competitiveness of enterprise that adopt WDM • Used of saved water to promote economic growth
Equity Push factors	• Used of saved water to provide water to more people • Increased water security and risk aversion • Lower cost leading to improved affordability
Empowerment and growth push factors	• Building upon indigenous knowledge and resource management systems • Incentive for technology development and innovation • A means to meet water and sanitation policy goals • Opportunities for re-use and recycling

2.3.6 Components of Water Demand Management

The IUCN (2004) has argued that there are several components of WDM that need to be in place for its proper implementation which include the following

- **An enabling policy environment**

This is mostly determined at the national and water catchments area level, but can also be determined at local level, by making by-laws, adopting standards and norms. However, many factors may inhibit WDM implementation such as a backlog in water provision (e.g. for historical reasons), non payment for services by consumers leading to large debts, and political considerations such as free water for basic needs

- **Right institutional set-up**

Apart from the enabling environment needed for a sound WDM, the institutional arrangement is also important. There must be a shared responsibility so that a specific sector or ministry should be responsible for WDM. The responsibilities must clearly be divided between central and local government as well as parastatals and the private sector. Most countries have developed their own distinct water management structures over time, based on local features. It is important that the WDM structure takes this into account, and finds the most suitable niches in the existing water institutions. Two important new elements should be noted:

a) A specific institution should be responsible for WDM
b) A decentralized water basin approach should be adopted as a good platform for IWRM and WDM

- **Right Measures and Implementation**

This is selecting the appropriate measures and a proper implementation plan. This is usually done by national and local agencies. In view of the limited WDM capacity, there is the need to start with WDM measures that can easily be implemented and have a large impact on water consumption.

2.4 Types of Water Demand Management

WDM measures can be distinguished into two separate fields namely the structural and non-structural The structural measures are the engineering side of WDM which involves carrying out leak detection and pressure management and the use of less consuming water devices.

The non structural measures are the side of WDM that looks at the regulatory, economical, social and institutional aspects of enhancing water availability

2.4.1 Structural Measures

- **2.4.1.1 Pressure Management**

Most losses in distribution systems are as a result of leakages in the distribution pipes. Theses leakages contribute to the very high unaccounted for water in the distribution system. Pressures in the distribution systems have been found to have a direct relationship with the leakage. High pressures in the systems lead to a high leakage of water and consequently high losses. Thus pressure management has been identified as one of the WDM tools used to control level of leakages in the system. Pressure control strategy can be used to minimize excess pressures as far as possible whilst ensuring that the consumers demand are met at all times. This is because some consumers demand can be met at pressures far below a particular high pressure especially when the demand is volumetric and not time dependent (i.e. in terms of fill time).

Pressure Management is a tool that is worth implementation because many systems are designed with minimum pressure requirements in mind but not maximum pressure limitations, so many systems have areas which are grossly over-pressured. Pressure Management has been found to be one of the most basic and cost effective forms of optimizing a system and can in many instances provide fast paybacks on large investments (Thornton, 2002). This is so especially when no room is made for high pressures at the time of installations.

Undertaking pressure management does not only enhance leakage reduction but also leads to water conservation. It also used as a source of ensuring that consumers who do not pay their bills but receive continue supplies do so. This is can be done by reducing pressures of the supply to such areas whilst maintaining the minimum flow. This can also be done to the consumptions that fall under the authorized unbilled so that by reducing the pressures the excess consumption will be reduced while maintaining a minimum level of supply in order to optimize losses and conserve resources. Pressure reduction will reduce the demand from open tap uses such as garden watering and showering, and will also reduce the demand and consequent loss of water associated with leakages (Burn et al., 1999).

It also worth noting that pressure management is not only the practice of reducing high pressures in the distribution system but also when and where necessary increasing pressures to attain desirable levels of demand.

- **2.4.1.2 Leakage Detection**

Routine leak detection and repair is also a method for WDM to prevent water losses in urban distribution systems. Major unaccounted for water (UFW) has been attributed to leakages in the pipelines. Some of the leaks are however invisible especially those that are buried underground for which special instruments are needed for their detection. Some of these technological leak detection methods are acoustic survey, hydrant survey, geophone survey among others. A good pressure management technique can be able to also expose the invisible leaks in the system.

- **2.4.1.3 Detection and Reduction of Illegal Connection**

The major problem in the urban sector is unaccounted for water through illegal connections. The detection of illegal connections is dependent on the goodwill of the community in terms of reporting, and on inspections by officials of the water services institutions. The UFW where leaks have not been indicated could be attributed to illegal connections. Sometimes illegal connections can also be detected through loss of pressure in the distribution system. Thus the detection of illegal connections is an important WDM tool.

- **2.4.1.4 Metering**

Appropriate metering is a basic and essential tool for successful water demand management. This is the basis for the link between consumption and price. It is an effective means of ensuring that consumers conserve water. Water metering can be implemented in stages starting from the large water consumers like industry, commercial users, high-income domestic users and others. Well-maintained and working meters, read accurately and regularly, followed up by efficient billing procedures ensure that consumers do not abuse municipal water supplies.
When the whole distribution system is well metered, it affords the opportunity to trace existing leakages in the system by knowing the volume of treated water entering and leaving a particular node.

Proper metering is a pre-requisite for the proper management of any water supply system. Without reliable metering, the water supply managers will have little control over the losses in the system since they will be unable to identify and quantify them. Meters are required throughout the distribution system to establish the volume of water harvested, treated, imported, stored and consumed.

2.4.2 Non Structural Measures

- **2.4.2.1 Public Awareness**

This method of WDM management is focused on the education of the masses on the need to practice WDM. This is done through the dissemination of information about WDM through televisions and radio stations where panels discuss the necessity to implement WDM and the benefits to accrue from it. It also involves the delivery of education and training needs which are essential in increasing awareness and equipping various stakeholders with the necessary skills and tools to implement WDM
One of the identified major constraints to the adoption of WDM measures is the absence of well structured educational and training programmes or courses suitably targeted to all stakeholders in the water management chain (Mwendera et. al., 2003; Gumbo and Van der Zaag, 2002).

Public awareness campaigns are very important in spreading the message of water conservation to the consumers. Most of water suppliers wishing to promote water conservation organize various activities designed to create awareness in water conservation issues such as:

- National Water weeks in which government officials and well meaningful and high personalities as well as celebrities undertake activities which are heavily publicized to create awareness for conservation issues.
- Articles or advertisements in newspapers and popular magazines highlighting some aspects of water conservation.
- Water-Wise poster displayed at all garden centers for effective garden watering and how to minimize irrigation requirements.
- Water bills sent to consumers should be accompanied with pamphlets and leaflets on how to save water.
- Public places of social gathering and visits should be decorated or displayed with stickers which sends out the message of saving water to the general public

- **2.4.2.2 Tariffs**

Water pricing is recognized as one of the most important non-structural incentive measures for demand management to achieve the objective of efficiency and sustainability of scarce water resources. It aims at achieving financial sustainability rather an instrument for water allocation (Liu et al.; 2003). . An ineffective tariff structure especially one that makes the price of water low to consumers also creates an avenue for consumers to use large quantities of water easily with large quantity of waste produced as well, which worsens water scarcity. Thus the tariff can be used to control consumers' behavior of using water and make consumers discard the notion that water is a social good. However this is not say that water should always be regarded as an economic good, a concept in line with the fourth Dublin Principle which emphasis that water should be regarded as an economic good. Thus there has to be a balance and this is through an effective tariff system that ensures that water is efficiently used and at the same time affordable to the less privilege. In the light of these two extremes of treating water as a social good or a basic human right and an economic good, there has been a very high advocacy for the use of the Increasing Block Tariff Systems that ensures the conservation incentives are impose on some target groups of large users.

- **2.4.2.3 Legal and Regulatory Framework**

This is the formulation of rules and legislation that forms the basis of WDM policies. Policies and regulations are critical to the successful implementation of WDM, and need to be developed at both national and local levels.

Regulatory instruments may include (IUCN 2004):

- By-laws that deal with regulating water use in swimming pools, watering of gardens
- Regulations against wastage
- Formal certification and registration of plumbing contractors

2.5 Water Demand Managements as a Component of Integrated Water Resource Management

The practice of WDM can be said to be an approach which is line with the targets of the concept of Integrated Water Resources Management (IWRM). WDM involves a holistic approach towards the solving of the increasing scarcity of water problems without compromising for other environmental factors. This is manifested in the shifting from the era of dam building and development of new supply sources to the era of managing the available limited water resources to meet the ever yeaning demand gap which forms the basis for which WDM stand for. Several projects components have been developed with the objective of promoting and adoption of WDM as a means of supporting sustainable IWRM in countries and institutions of Southern Africa (Gumbo et al., 2005)

2.6 Forecasting in water Demand Management

Various factors are responsible for the pattern of consumption of water or water use by consumers in general. In a bid to try to forecast or project the demand for water, it will then be appropriate to consider and incorporate these factors in demand forecasting. Most of the key factors that influence water demand include population, income level, and household size, living conditions, size of garden and yard and employment.

The four main groups of forecasting methods are (IUCN, 2004):

- **Judgmental-subjective**

This method is based on the opinion of experts and stakeholders about the demand trend. It is subjective and its results depend heavily on the competency of experts. The quantitative results of this method are usually difficult to justify.

- **Trend analysis**

This is a commonly used method which is based on extrapolation of historical trends or on population growth figures multiplied by capita consumption figures.

- **Component analysis**

This method dissects the main demand sectors, and develops separate forecasts for each of them based on the key determinants of water demand for each sector. The method is mostly accurate but costly and demanding.

- **Regression analysis**

This analysis develops a regression equation that is used to project future demand. The equation contains expected demand determinants such as income, population and price, and the equation is tested with historical data.

2.7 Summary of Literature Review

The genesis of Water supply –sided management to WDM is linked historically to the Industrial Modernity or "hydraulic Mission Era" to the Reflexive Modernity Era. WDM and the MDGs are closely related and the successful implementation of the former immensely lead to achieving the latter especially Goal 1 and target 10 of Goal 7. WDM does not have a single universal definition but rather it is a work-in-progress approach and its definition depends on the scale and depth to which one applies it. Four target groups and measures have been identified for WDM which are "Distribution and Supply Functions, Resource Management, Return Flow Management and End User". However for the purpose of this research the focus is on the Distribution and Supply and the End User. Water Conservation is not WDM but rather it is an important component of DM strategies. WDM has got its constraints, incentives as well as its motivating factors. Several components of WDM exist for its proper implementation of which some are: An enabling policy environment, right institutional set-up and right measures and implementation. There are generally two types of WDM measures which are structural measures and non-structural measures. Examples of structural measures are pressure management, leakage detection, detection and reduction o illegal connection and metering whilst non-structural measures involves public awareness, tariffs, legal and regulatory WDM framework. Finally WDM involves forecasting and projections of which four main groups of identified forecasting are: Judgmental subjective, Trend analysis, Component analysis and Regression analysis.

CHAPTER 3 METHODLOGY

3.1 Introduction

ATMA is considered as the study area in this research because currently the water situation is such that desirable levels of demand are not achieved. Also urban water service delivery is considered on the basis of Accra and Tema together which makes up ATMA.

Various approaches have been used, after identification of key stakeholders, to collect data related to the research objectives. Thus information was collected from the specific institutions responsible for them using various approaches. Depending on the accessibility and availability of the information needed, these approaches include literature reviews, key informants interviews, direct observation and discussion.

The major data collected were on key variable factors that likely affect water supply and water use in ATMA. These are rainfall, population, water rationing and gross domestic product (GDP) growth rate. Other information collected are annual treated water produced for ATMA, WDM indicators such as level of UFW, percentage of metered connections, percentage level of coverage etc and the monthly water consumptions of households. The rest of the data were collected through the administering of questionnaire in different residential areas of high density and low density.

In ATMA, although there are not precise areas classified as affluent and non affluent, there are specific areas that are naturally predominantly affluent. This is manifested by the types of buildings, the cars and the ostentatious life style of the place. These areas are low densely populated and include places like Airport Residential, Roman Ridge, Dzorwulu etc. Similarly areas of non-affluent are quite easily identified based on the life of the people over there especially the educational level, the clustered houses and level of unemployment. These areas include Nima, Mamobi, and Accra Newtown and are all densely populated. Thus it was quite obvious to identify affluent and non-affluent areas in ATMA. This is to ensure a good assessment of the prospects of implementing WDM under the two circumstances.

3.2 Sources of Information and Data

The major stakeholders and agencies that were contacted for data and information are:

- The Ministry of Water Resources
- The Water Resources Commission
- The Ministry of Finance and Economic Planning

- The Ghana Statistical Services
- The Ghana Census Secretariat (a subset of the Ghana Statistical Service)
- The Ghana Meteorological Services Agency
- The Ghana Water Company Ltd
- Aqua Vitens Rand Ltd (acting for and on behalf of GWCL)
- Domestic Consumers (households)

The major information gathered from the specific stakeholders includes annual rainfall data for the past years provided by the Ghana Meteorological Agency and this covers the annual rainfall of ATMA. Similarly the Ministry of Finance and Economic Planning and the Ghana Statistical Services were able to provide information on the annual growth rate of the economy of the country as well as the population figures of ATMA based on the 1984 and the 2000 population census. The GWCL productions units also provided part of the data on the treated water production of ATMA as the rest was gathered from literature studies of past work done in the area by OTUI, a French engineering consultancy firm. The Public Utilities Regulatory Commission also provided estimates of some of the treated water produced for ATMA over the years. AVRL provided information on all performance indicators for WDM and last but not the least household consumers gave information through the questionnaire.

3.3 Approach adopted for data collection

Based on the research questions to be answered, the following methodologies were used to collect data for the specific research questions:

- About research question RQ 1 i.e. ***What is the current status of WDM in ATMA? (i.e. how successful is the current WDM by comparing it with the recommended key indicators for WDM),*** the following methodologies were used to collect the data:

    - Literature Review: Use of literature including documented data on the initial review of the whole of ATMA

    - Key Informant Interview: This involves direct and open discussions with the personnel's and officers of the various stakeholders and agencies.

    The methodology used to achieve this research question is by collecting all the key available data on performance indicators in ATMA and then compare it with the recommended key indicators for assessing the status of WDM. Based on the comparisons of the two scenarios, the current status of WDM in ATMA can be assessed. The recommended key indicators used in the comparison is shown in Table 3.1

Table 3.1: Recommended 12 key indicators for WDM monitoring and evaluation

	Indicator	Concept	Unit	Recommended Value
1	WDM strategy	Existence of a continually reviewed WDM strategy represents the blue print (business plan) for planned action	-	Always
2	Coverage	Percentage of population or customers having minimum standard of service	%	>90%
3	Gross UAW	Expressed as percentage of the difference between water billed and total water supplied	%	<20%
4	Metering practice	Percentage of connections that are metered , recalibrated and replaced	%	>70%
5	Pipe network	Expressed as number of leaks and burst recorded per kilometer per month of entire pipe network	No/km /month	<0.1
6	Quality of service	For continuous reticulated supply systems this can be expressed as number of complaints divided by number of connections	No/No	<0.15
7	Average tariff	Expressed as US$/m3. The tariffs should be set to reflect scarcity of water, long run marginal cost and possible subsidies for the poor	US$/m^3	US$0.25 to 0.5
8	Financial performance	Could be expressed as a ratio of annual operating cost to annual operating revenue	Ratio	<1.0 to >0.5
9	WDM recurrent expenditure	Expressed as percentage of WDM cost to annual operating revenue (N.B. cost does not include capital expenditure and major network rehabilitation programmes)	%	1% or more
10	Overall Staffing	Expressed as number of staff per 100 water connections	ratio	4 to 10
11	WDM Staffing	Expressed as number of WDM staff per 100 water connections	Ratio	0.5 to 2
12	WDM education and awareness programme	Education and awareness Programme targeted to all stakeholders (sectors, customers and internal staff)	-	continuous

(Source: Gumbo, 2004)

- About research question RQ 2 i.e. ***What are the influences of population, GDP growth rate, water rationing, rainfall and the corresponding WDM measures of regular and intensive on the water use in ATMA?***, the following methodologies were used to collect the data:

    - Literature Review: Use of literature including documented data on the population, the growth rate, the annual rainfall of the study area and the annual treated water for the whole of ATMA. The World Wide Web was also used to acquire some information.

    - Key Informant Interview: This involves direct discussions with the personnel's and officers of the various stakeholders and agencies

    - Field Observation: I made direct observation during my visits to the headworks where data on productions are collated

    The procedures used to answer this research questions are as follows:

    a) Using Multi Linear Regression analysis with the independent variable as the treated water produce and the other factors i.e. population, rainfall, GDP and water rationing as the dependent variables to quantify these factors.
    b) Model the treated water use and project the future water use
    c) Calculate the per capita consumptions and the projected per capita consumptions and comparing it with the crude per capita consumption.
    d) Analyze the effect of undertaking slack, regular and intensive WDM measures on the water situation in ATMA

- About research question RQ 3 i.e. ***What factors influence domestic water use patterns in affluent and non-affluent areas in ATMA?***, the following methodologies were used to collect the data:

    - Use of literature including documented data on the monthly billed consumption of the selected areas.

    - Key Informant Interview: This involves direct discussions with officers and meter readers of GWCL to demarcate areas of affluent and non-affluent.

    - Open discussions with domestic water consumers of different financial and residential status.

    - Field Observation: I made direct observation to some of the selected areas during the interviews.

The procedure to be used to answer this research question is to analyze the monthly consumption patterns of these areas over a period of one year.

- About research question RQ 4 i.e. ***What are the prospects of implementing WDM at household levels in ATMA?,*** the following methodologies were used to collect the data:
-
  - Data on monthly billed consumption from GWCL
  - Interviews through questionnaires.
  - Field Observation: I made direct observation to some of the selected areas during the interviews

3.4 Household Interviews

3.4.1 Sample Size

I chose a total sample size of 75 in 5 different areas of socio-economic status and population densities. The number chosen was relatively small because of the limited time. Each of the areas had a total sample of 15 and the households where chosen at random

The partitioning of the household into different areas is shown in Table 3.2. I pick three areas that have high population densities and which are low income areas and two low densely populated areas that are high income or affluent in status.

Table 3.2 Household interview's sample size in the various socio economic areas.

Residential Status	**Area (Resident)**	**Sample Size**	**Percentage**
Affluent / Low density	Airport Residential	15	20%
	Dzorwulu	15	20%
Non-affluent / High density	Accra Newtown	15	20%
	Mamobi	15	20%
	Nima	15	20%

3.4.2 Choice of areas for interviews and analysis

Areas have been classified in terms of affluent and non-affluent based on their life style and assets. These areas have been chosen with the help of meter readers from the offices of GWCL. Thus the classification of the residential areas is based on living standards (type of house) which do not necessarily reflect the income level in each case. Households for interview have also been chosen at random for interviews in these areas.

Once the areas for interviews have been selected, I went with a meter reader to the households to do the interviews.

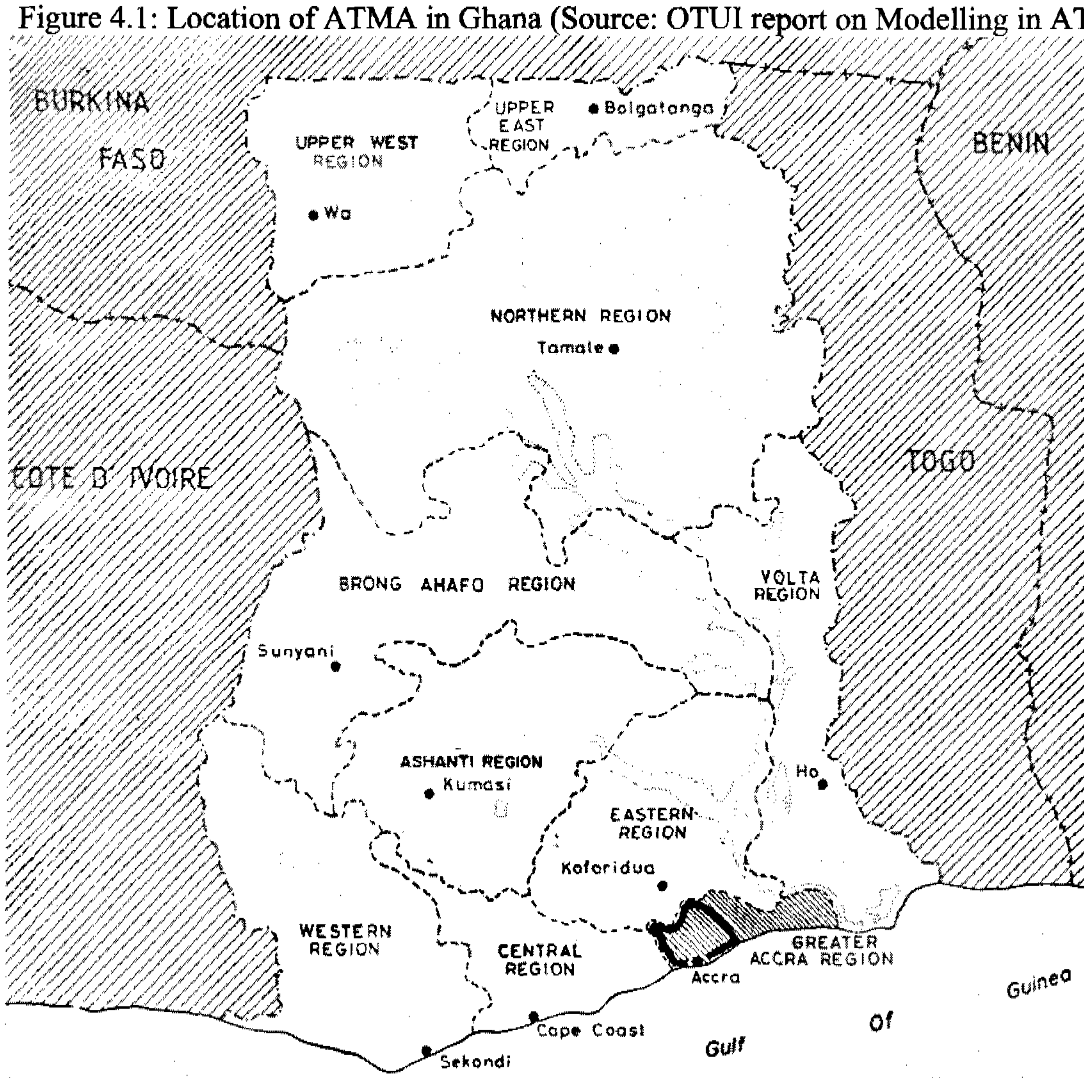
CHAPTER 4 THE STUDY AREA

4.1 Local Context Overview

4.1.1 Geography and Population

Accra and Tema are located in the Greater Accra Region which is the smallest out of the ten regions in Ghana. The two cities together form the Accra Tema Metropolitan Area known as ATMA for short.

Figure 4.1: Location of ATMA in Ghana (Source: OTUI report on Modelling in ATMA)



The Greater Accra Region occupies a total land surface of 3,245 square kilometers or 1.4 per cent of the total land area of Ghana. In terms of population, however, it is the second most populated region, after the Ashanti Region, with a population of 2,905,726 in the year 2000 accounting for 15.4 per cent of Ghana's total population.

Accra and Tema lies within the coastal –savanna zone with low annual rainfall averaging 810 mm. The rainfall pattern of ATMA is bimodal with the major season falling between the months of March and June, and a minor rainy season around October. The mean annual rainfall is about 730mm. The average daily temperature of ATMA is 30°C (86F). Mean annual temperatures vary from 24 °C to 28 °C. The coolest time of the year is between June and September when the main rainfall occurs (RUAF).

4.1.2 Socio Economic Aspects

Accra is the most urbanized city in Ghana. The urbanization has been mainly due to the rapid increase in population as a result of among others the urban-biased development strategies adopted by policy makers since the colonial era. Thus, the concentration of industry, manufacturing, commerce, business, culture, education, political and administrative functions in ATMA since independence till date which continues to attract migrants, not from all over the country but also from neighboring countries as well (RAUF).

The political administration of the region is through the local government system. Under this administration system, the region is divided into five districts namely, Accra Metropolitan area, Tema Municipal Area, Ga East District, Ga West District, Dangme West and Dangme East District. Each District, Municipal or Metropolitan Area is administered by a Chief Executive, representing central government but deriving authority from an Assembly headed by a presiding member elected from among the members themselves (Ghanadistricts, 2006).

The major ethnic groups are the Akan (39.8%), Ga-Dangme (29.7%) and Ewe (18%). The Gas form the largest single sub-ethnic grouping, accounting for 18.9% percent. Christians constitute the largest religious group (83.0%), followed by Moslems (10.2%), people who profess no religion (4.6%) and adherents of traditional religion (1.4%) (Ghanadistricts, 2006).

Accra and Tema can actually also be regarded as the urban areas of the Greater Accra Region. The Accra Metropolitan Area is Ghana's biggest, most diverse and most cosmopolitan city, in the national capital. Apart from being the country's biggest city, it is also the second largest industrial centre in Ghana. The size of the city relative to others is matched by its comparative affluence. About half of all the motor vehicles in Ghana are located in the city. Importantly, Accra is well connected to the outside world by an international airport, as well as a modern harbour, located about 30 kilometers to the east in the neighboring city of Tema.

Tema, which serves as the administrative capital of the Tema municipality is a coastal city situated 25 kilometers east of Accra, the national capital. The Greenwich Meridian (00 Longitude) passes through the city of Tema. The municipality shares common boundaries with the Accra Metropolis on the west, the Ga District Assembly on the North West and the Dangme West District on the northern and eastern borders. It is bordered to the south by the Gulf of Guinea. Until 1952, when the Government of Ghana decided to develop a deep seaport there, Tema was a small fishing village. Tema became an Autonomous Council in 1974 and was elevated to the status of a Municipal Assembly in December, 1990 (Ghanadistricts, 2006).

4.2 Description of the Key Water Institutional Stakeholders in ATMA

Some of the key institutions relevant for the management of domestic water in ATMA and Ghana as a whole are:

4.2.1 The Ministry of Water Resources

The Ministry of Water Resources has its main functions as the formulation and co-ordination of policies and programmes for the systematic development of the country's infrastructure requirement in terms of Water Supply and Sanitation and Hydrology. The Ministry co-ordinates and supervises, by way of monitoring and evaluation of the performance of both public and private agencies responding to and participating in the realization of the policy objectives established for the sector. The Ministry controls the water sector which is very vital to the livelihood of the economy. It is the policy of the Ministry that every community in Ghana will have access to portable water.

4.2.2 The Water Resources Commission (WRC)

The Water Resource Commission (WRC) is responsible for the regulation and management of the utilization of water resource in Ghana and the co-ordination of policy in relation to them. It began its activities in 1998, two years after it had been established by an act of parliament, (the Water Resource Commission Act 552 of 1996).The responsibilities of the Commission are wide ranging, but the primary tasks are related to the allocation of the water resources among various competing users. The functions of the commission are to:

- Propose comprehensive plans for the utilization, conservation, development and improvement of water resources.
- Initiate, control and co-ordinate activities connected with the development and utilizations of water resources.
- Grant water rights.

- Collect, collate, store and disseminate data or information on water resources in Ghana.
- Require water user agencies to undertake scientific investigations, experiments or research into water resources in Ghana.
- Monitor and evaluate programmers for the operation and maintenance of water resources.
- Advise the government on any matter to have adverse effect on the water resources of Ghana.
- Advise pollution control agencies in Ghana on matters concerning the management and control of pollution of water resources.
- Perform other functions that are incidental to the above

4.2.3 The Public Utilities Regulatory Commission (PURC)

The Public Utilities Regulatory Commission is an independent body established under the Public Utilities Regulatory Commission Act 1997 (Act 538), to regulate and oversee the provision of utility services in the country. It is committed to ensuring the development and delivery of the highest quality of services to consumers and aims to achieve efficiency, reliability and equity in the provision of services. Until the PURC was established, the then Ghana Water and Sewerage Corporation (GWSC) was largely influenced by governmental officials for the approval of tariff. Thus the issue of tariff had been previously highly politicized to the extent that during electioneering period, increases in water bills are sometimes put to halt by way of wooing votes from the ordinary Ghanaian electorates. The coming into existence of the PURC has to a wider extent reduced political influence on tariffs. However there is still some element of political interference as far as tariff or water bills implementation is concerned, in the sense that government has to protect the majority poor who are much more vulnerable to high increases in tariff whilst on the other hand the GWCL need to put in place appropriate tariff to be able to render sustainable services of water delivery. Thus the onus lies heavily on the PURC to ensure cost recovery operations as well as affordable water by all.

The main functions of the PURC as far as drinking water is concerned are:

- To provide guidelines for the rates to be charged for the provision of utility services
- To examine and approve water rates
- To protect the interest of consumers and providers of utility services
- To monitor and enforce standards of performance for the provision of utility services
- Promoting fair competition among public utilities
- Receiving and investigating complaints and settling dispute between consumers and public utilities

- Advice any person or authority in respect of any public utility

4.2.4 The Ghana Water Company Limited (GWCL)

GWCL is the public utility responsible for urban water supply in the whole of the country. It is a highly centralized organization with its head office based in Accra and the regional offices in all the ten regional capitals.

The internal structure of GWCL has two main branches, the finance/administration and operations. A deputy Managing Director (operations and maintenance) supports the regional operations and maintenance activities from the Head Office. The GWCL regional offices are headed by the Chief Managers, who are responsible for carrying out all operations and maintenance in the region.

The regional Directors for each of the administrative regions report directly to the Deputy Managing Director responsible for operations. The head office personnel department is responsible for recruitment and transfers of staff between regions. Regional budgets are set by GWCL head office on the basis of "bids" submitted by the regions. Budgets allocated have been below what regional managers have perceived as necessary to maintain and operate the system effectively. District management offices are responsible for supervision of technical and commercial operations at the system level.

The GWCL has decentralized offices under the three regional offices of the GWCL. These offices ran the day to day activities of the GWCL within much smaller area coverage in ATMA. It reports directly to the head offices

4.2.5 Aqua Vitens Rand Limited (AVRL)

This is a joint company of Vitens International B.V. of the Netherlands and Rand Water Services of South Africa, that has contract to manage the Ghanaian utility under a five – year Management Contract, under the Urban Water Project and as part of the reforms in the urban Water Sector. In the performance of its obligations the AVRL shall have access to GWCL's assets for providing potable water. The private operator's task is to:

- Conclude contracts with customers for the supply of potable water
- Issue bills on delivery of potable to customers
- Receive payments from customers
- Disconnect customers for non-payment of bills

The performance indicators under the contract are to:

- Maintain water quality and pressures that meet or exceed standards determined by the Ghana Standards Board and/or the Consumer Charter requirements, and the Drinking water Safety Plan

- Achieve yearly reduction in Non-revenue Water by 5% per annum i.e. to achieve 0.95% of the previous year level
- Increase volume of water produced from existing installations (e.g. by reducing waste)
- Optimizing power consumption
- Optimizing chemical usage while maintaining high water quality
- Reduce to 48 hours, the time taken to respond to consumer complaints and request for services
- Obtain increased cash flow through improvements in bill payments

4.3 Description of Water Supply System in ATMA

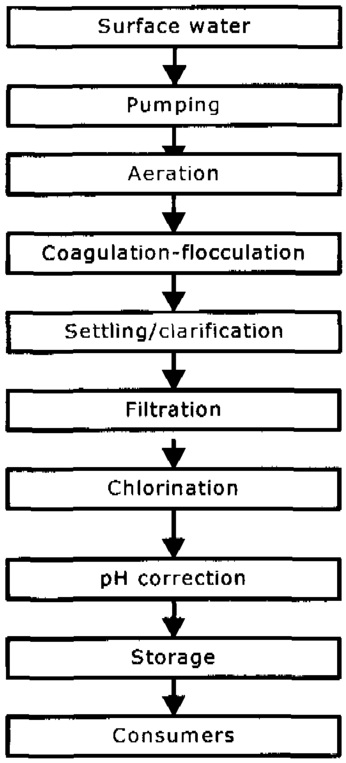
The Ghana Water Company Limited is the sole provider of drinking water services in ATMA as well as other urban areas of the country.

As far as water delivery is concern, ATMA has been divided into three regions namely the Accra East, Accra West and Tema. The regions have further been divided in to GWSC districts and water bills are accounted for per the GWSC district. The GWCL organization by districts allows an initial break down of the consumption billed which can further be broken because each District is divided into Cycles and Walks.

The drinking water supply system in ATMA is supplied with raw water from two principal sources reservoir created by first a dam on the Densu River which feeds the Weija installations and then we have the Kpong installations, located northeast of Accra-Tema, fed with raw water from the Volta River 7kms upstream from a hydroelectric dam.

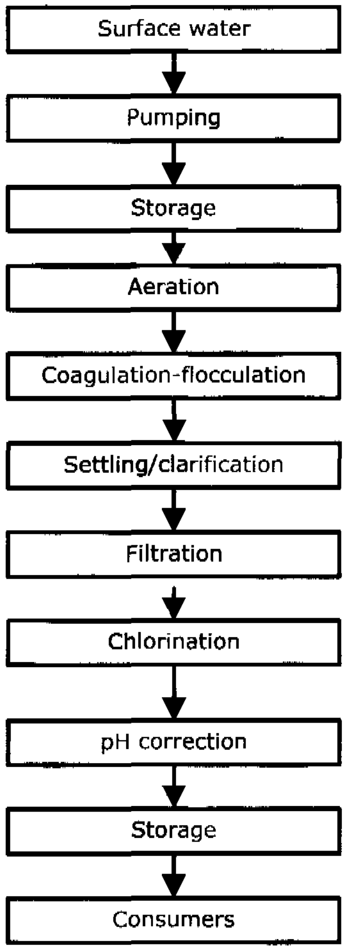
The Weija headwork has three different systems namely Adam-Clark, Candy and Bamag. The treatment site consists of an impounding reservoir with 115,000m^3 of storage capacity. The treated water produced from the Weija is mainly distributed to the Accra East and Accra West service areas. The Weija Adam Clark system has an installed capacity of 134,000m^3/day and a current allowable yield of 122,999m^3/day. The current average water produced per day from the Adam-Clark is 128,350m^3/day out of which an average of 112,610m^3/day is distributed. Thus it has an efficiency of 96% production and 88% distribution. The process steps of the Weija Adam-Clark systems are presented in Figure 4.2.

Figure 4.2: Process flow diagram of Weija-Adam Clark System



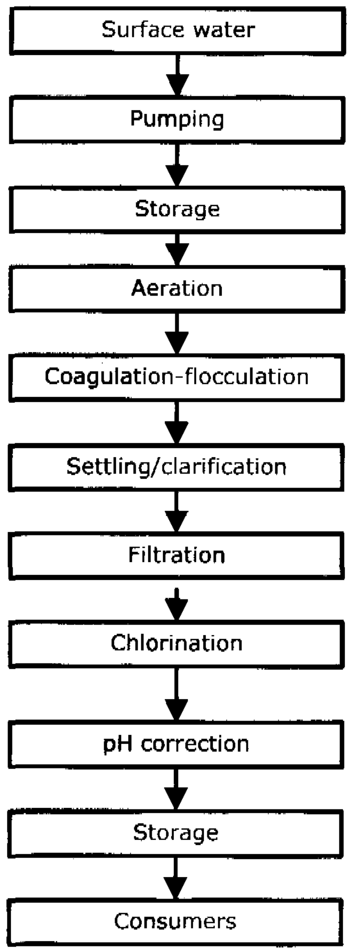
The Weija Candy system has an installed capacity of 39,740m^3/day with an average water production per day of 32,418m^3/day and distribution of 32,418m^3/day. This makes it 82% efficient of treated water produced and 100% efficient of treated water distributed. The process steps of the Weija Candy systems are presented in figure 4.3.

Figure 4.3: Process flow diagram of Weija Candy System



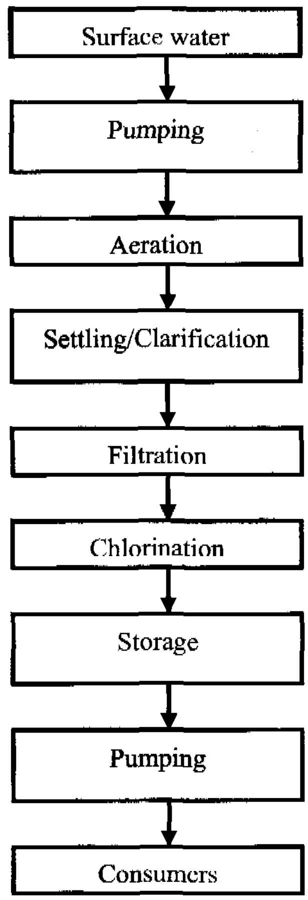
The last of the three Weija systems is the Weija Bamag which has an installed capacity of 30,240m^3/day with an average daily water production of 25,593m^3/day out which 25,593m^3/day is distributed. Hence it has an efficiency of production and distribution of 85% and 100% respectively. The process steps of the Weija Bamag systems are presented in Figure 4.4.

Figure 4.4: Process flow diagram of Weija Bamag System



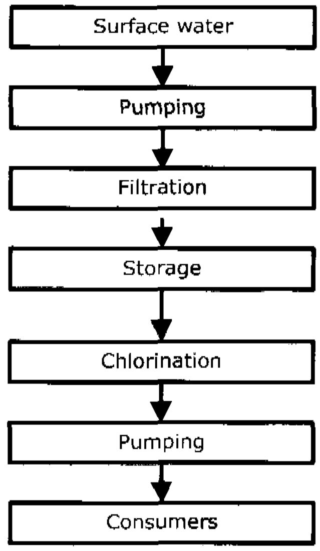
The Kpong installations consist of two production units i.e. the old and new treatment plants. The Kpong New System has an installed capacity of 181,818m^3/day and the average treated water produced daily is 167,205m^3/day whilst the volume of water distributed is 163,037m^3/day. The Kpong Old system on the other hand has an installed capacity of 38.636m^3/day with an average production and distribution of 30,634m^3/day and 30,247m^3/day respectively. . The process steps of the Kpong systems are presented in Figure 4.5.

Figure 4.5: Process flow diagram of the Kpong Old and New System



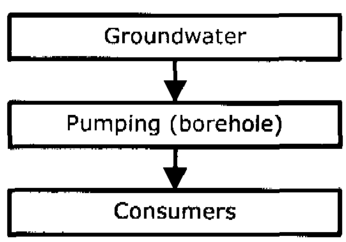
In addition to these two major sources of treated water supply to ATMA is the quite recent Keseve Adafoah system which receives it raw water from the Volta River. This system comprises of an intake and conventional treatment plant at Keseve. From the treatment plant the supply is transferred by high lift pumps to Adafoah in the south and Todze in the north. The allowable yield of the system is 1423m^3/day with an installed capacity of 1,363m^3/day making it 104% efficient. The current average water production and distribution is 1,423m^3/day ensuring 100% efficiency of production. The process steps of the Keseve /Adafoah systems are presented in Figure 4.6.

Figure 4.6: Process flow diagram of Kesevoh/Adafoah System



The last and the most recent infrastructural water supply system to ATMA is the Dodowa Well field system. In order to increase the production level of drinking water in ATMA boreholes had been drilled at Dodowa for the abstraction of groundwater which is pumped directly into the distribution or transmissions mains to consumers. The allowable yield and installed capacity of the system is 1,680m^3/day and this is the same as the volume of water produced and distributed per day, hence 100% efficiency. The process steps of the Dodowa Well Field systems are presented in Figure 4.7.

Figure 4.7: Process flow diagram of Dodowa Well Field System



4.4 Mode of Water Supplied from Sources to various Regions

The Kpong New System supplies two Sub-Regions. The Kpong New System, the three Weija Systems, and the Dodowa Well Field System supply the Accra East Region. The Kpong New System, the Kpong Old System and the Keseve/Adafoah System supply the Tema Region, which is situated east of the ATMA Region.

The scheme of water supplied in 2005 is presented in the Mass Balance Figures 4.8 to 4.11 below:

Figure 4.8: Mass Balance showing the scheme of water supplied to Accra East region

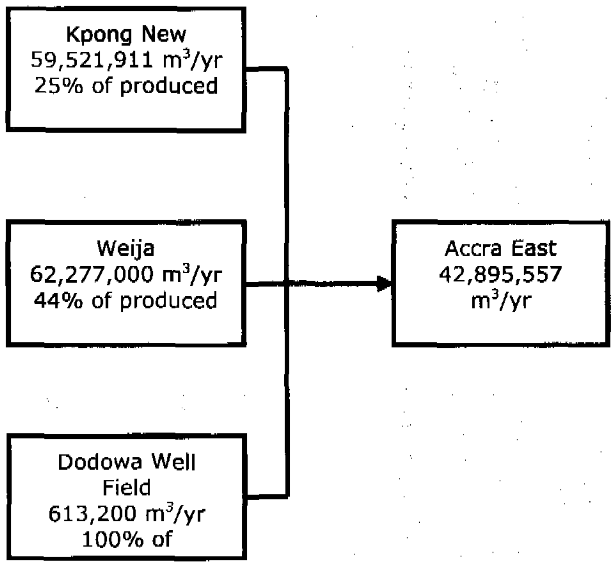


Figure 4.9: Mass Balance showing the scheme of water supplied to Accra West region

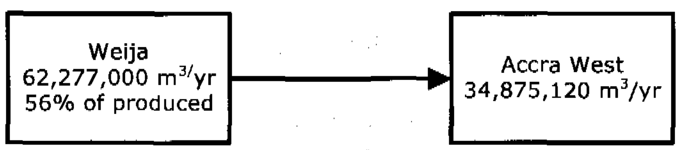


Figure 4.10: Mass Balance showing the scheme of water supplied to Tema

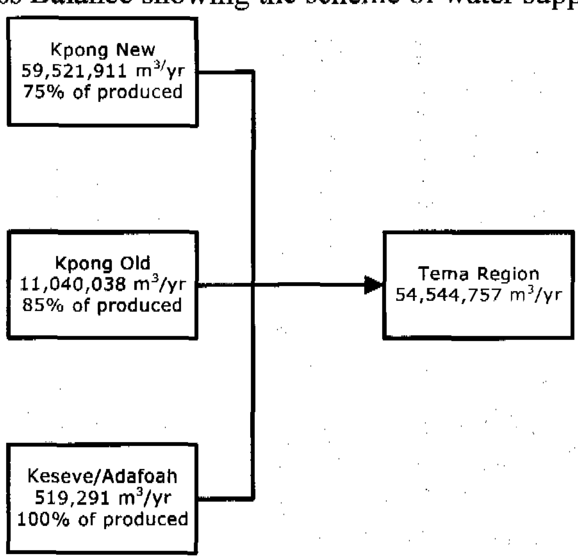
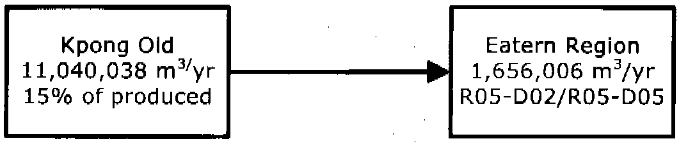


Figure 4.11: Mass Balance showing the scheme of water supplied to Eastern Region of Ghana



CHAPTER 5 DISCUSSION AND ANALYSIS OF THE STUDY AREA

5.1 General Status of WDM in ATMA

The assessment of the status of the current WDM in ATMA is based on available data and literature review as presented in Table 5.1. This provides the basis of benchmarking the progress and success in WDM programmes by using selected key performance indicators in Table 3.1.

Table 5.1: Summary of performance indicators for ATMA (Source: AVRL Initial review)

INDICATOR	Tema	Accra West	Accra East
Managing Institution	Private	Private	Private
Coverage (%)	50	77	26
Average rainfall (mm/a)	700	700	700
% stand post and others	0.8	0.06	0.12
Number of connections	19,558	62,171	63,843
% metered connections	66.5	N/A	34
WDM strategy	None	None	None
WDM policy	None	None	None
WDM legislation	None	None	None
WDM education and awareness	low	low	low
Major customer complaints	Inadequate supply, Billing	Inadequate supply, Billing	Inadequate supply, Billing
Dedicated WDM section	None	None	None
Total number of employees in water section	1064		
Number of employees/1000 connections	7		
Recycling, reclamation and reuse	No	No	No
% level of unaccounted for water	66	65	57
Average cost of water (US$/$m^3$)	N/A	N/A	N/A
Tariff for unmetered connection	Flat rate	Flat rate	Flat rate
Tariff for metered connection	Increasing 2 blocks	Increasing 2 blocks	Increasing 2 blocks
Is essential volume free or at reduced price	Reduced Price	Reduced price	Reduced Price
Financing of WDM as a % water account	N/A	N/A	N/A

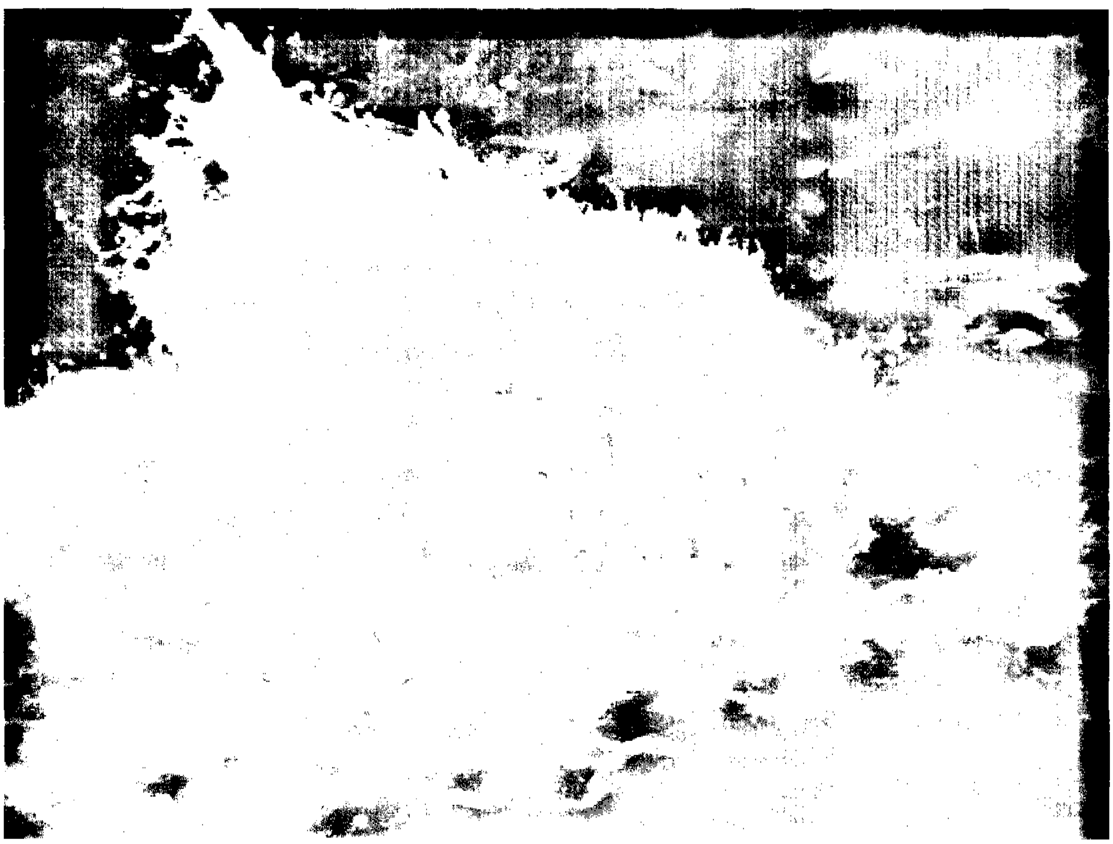
5.2 Deductions:

5.2.1 Unaccounted for Water

Comparing Tables 5.1 and 3.1, it is clear that within all the three regions in ATMA that very few strides in terms of WDM have been made. This can be attested to the fact that the level of UFW in all the operational regions is quite high. This is quite astonishing as for a long time GWCL has not been able to account for almost half of the treated water produced. This seemingly high level of UFW could be attributed to high levels of non-revenue water zooming in specifically to illegal connections. A significant contribution to this level of UFW is the physical losses in the system through leakages. The rate of respond to leakage repairs is quite not encouraging and most reported leakages are left for hours before they are attended to. An example of such leakages can be shown in the figure 5.1 below which occurred as a result of pipe burst close to Alajo junction along the Nsawam road. This pipe burst was left for hours with the gushing treated water used for washing cars.

Figure 5.1: A pipe burst gushing out fresh treated water

(Courtesy: Kassim Yakubu Al-Hassan on the 7th of February, 2007)



This was actually the second of pipe bursts in this particular area within five weeks with the first one occurring around the Caprice Bridge approximately five hundred meters from the second burst. This is an indication of very high uncontrolled pressures in this area that forcefully causes these pipe burst along the main pipe lines.

The host of uncontrolled pressures in other areas with similar elevation like Alajo cause conspicuous pipe burst. This together with the inconspicuous bursts that occurs on deep buried pipes may be the major cause of the UFW in ATMA.

Another example of an unattended leakage is depicted in the figure below which was culled from the Ghanaian Daily Graphic newspaper. This pipe burst according to the residents has been left for almost two months.

Figure 5.2: A short piece on pipe burst left unattended in Gbawe, a suburb of Accra. (Source: Daily Graphic, February 6, 2007)

Daily Graphic, Tuesday, February 6, 2007.

Gbawe residents take GWCL to task

Story: Hilda Owusu

SOME residents of Gbawe in Accra have criticised the Ghana Water Company Limited (GWCL) for not repairing a burst pipeline in the area.

A resident, Mr Alexander Fiifi Yankson, who spoke to the *Daily Graphic* said water had been gushing out of the pipe since November 21, 2006, thereby flooding the area.

He said persistent appeals to the GWCL had fallen on deaf ears, adding that the attitude of officials of the company was a display of negligence which amounted to causing loss to the state since the government had invested so much into providing potable water for consumers.

He added that the waste had deprived some residents of water, which was an essential commodity for domestic and commercial activities.

Mr Yankson said apart from the area being flooded, the supply of water had been affected due to low pressure caused by the water leakage.

He said GWCL had initially refused to attend to the problem, blaming it on the weedy nature of the area and the need for an excavator before work could commence on the burst pipe.

When contacted on phone, the Accra West Regional Engineer of the GWCL, Mr Jacob Yandoh, told the *Daily Graphic* that an excavator had been arranged to work on the rehabilitation of the pipeline on Monday.

He added that officials of the company were unable to locate the area where the problem occurred hence the delay.

5.2.2 WDM Strategy, Policy and Legislation

There is no WDM strategy, policies and legislation. There is no doubt that the starting point for a comprehensive WDM programme is setting out a clear strategy which is acceptable to the main stakeholders, namely, the water utility, customers and the politicians and this strategy has to be backed by a comprehensive national WDM policy and framework (Gumbo, 2004). Currently in ATMA, the management of water is through rationing. This in the view of the GWCL will ensure a fair share of the potable water to consumers as a result of the inadequate existence of the drinking water. However it can be said that these measures towards the management of demand is not in conformity with the concept of WDM. This is because this measure of water rationing may not lead to achieving desirable level of water supply to the majority of consumers in ATMA. The method of rationing may not be based on a well planned research that suggest when and how long a particular area should receive water and approximately how much water should be pumped to these areas considering factors such as pressures, population density and number of connection in the area. This may cause few places to enjoy desirable levels whilst others do not.

5.2.3 Educational Campaign

WDM through educational campaigns exist in ATMA but it is rather on the low profile. This is mainly through the electronic and print media to reach out to the consumers on the need to use water efficiently. However, absolutely insufficient is the level of these educational campaigns which is limited to only the media. For an in-depth WDM educational campaign, it should transcend the boundary of the electronic media to the grassroots through area or community meetings at the local levels. This is because a sizable number of consumers especially the less privilege in terms of education and wealth may not be able to grasp these forms of educational campaigns through the electronic and print media only.

The current scarcity of potable water in ATMA is normally compounded during the months of the dry seasons when consumers have no access to rain water for their household chores and thus fall on the treated water produced for such activities. In order to ensure the efficient use of water during this time of the year, the new management AVRL has initiated a series of educational campaigns through both the electronic and print media to make consumers conscious of the need to use water wisely. One of these new efforts by the AVRL is illustrated by the advertisement shown below which was culled from the Thursday, February 8, 2007 edition of the Ghanaian national daily newspaper (i.e. the Daily Graphic) with serial number 149968:

Figure 5.3: An example of educational campaign in a Ghanaian newspaper
(Source: Daily Graphic, February 8, 2007, No. 149968

12 Daily Graphic, Thursday, February 8, 2007

Aqua Vitens Rand Ltd.

acting for and on Behalf of Ghana Water Company Ltd. as the Operator

DRY SEASON WATER CONSERVATION MEASURES

The Management of Aqua Vitens Rand Limited, acting for and on behalf of Ghana Water Company Limited as the Operator, wishes to inform the general Public to Strictly observe the following conservation measures during the dry season:-

- (a) **Cease indiscriminate watering of lawns.**
- (b) **Moderate the use of water for vehicle washing**
- (c) **Shut all taps when not in use.**
- (d) **Repair all minor leakages**
- (e) **Report all major leakages immediately to the nearest GWCL offices.**
- (f) **Report persons who use treated water illegally for gardening**
- (g) **Practice water storage.**
- (h) **Avoid encroachment of catchment areas.**

Management of AVRL- the operator wishes to appeal to the general public to co-operate.

5.2.4 Metering

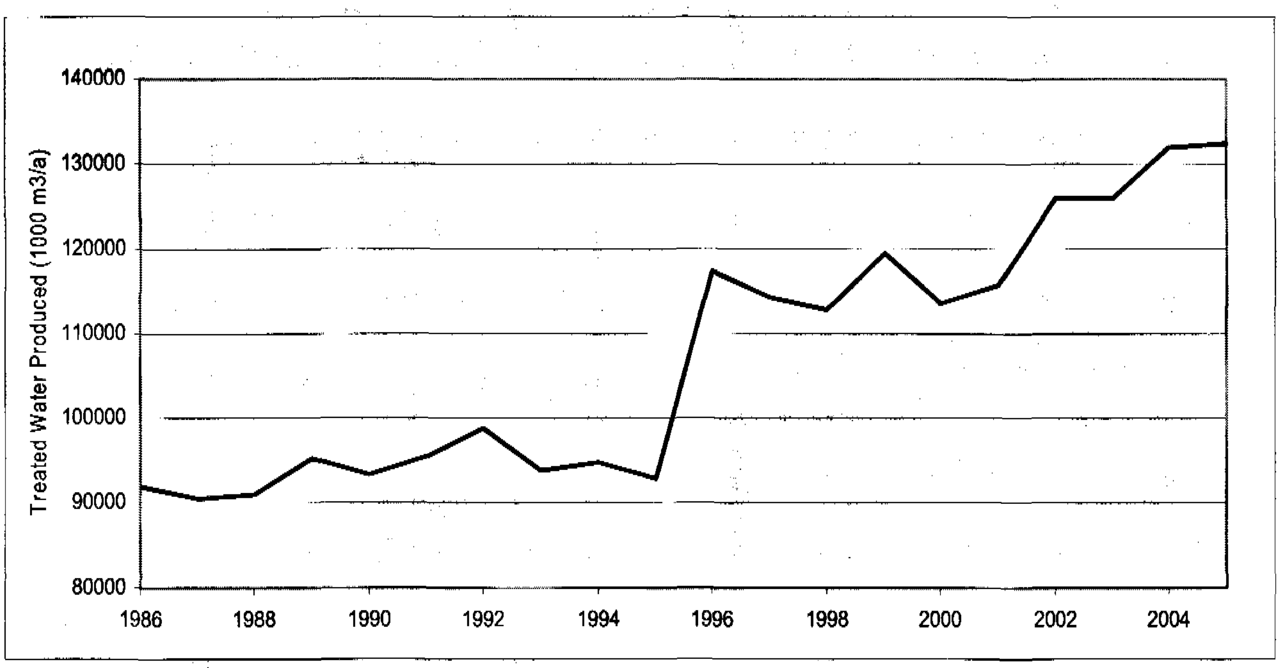
It is also clear from the table that the percentage of consumers that are metered in ATMA is lower than the recommended 70% WDM standard. The low number of metered connections makes it difficult for WDM as precise levels of consumptions cannot be determined.

5.3 Analysis of the influence of key variable factors on treated water use in ATMA

5.3.1 Trends in Water Use in ATMA

From the Figure 5.4, generally water use in ATMA has increased as water production has been seen to generally go up over the years. The drastic fall in water production and a sudden increment in 1995-1996 are actually due to the general face lift of the two and only major sources of water supply by then (personal communication with Mr. Ebo and Mr. Abroakwa, both are station managers at the Kpong and Weija head works respectively). These are the Weija and Kpong headworks. Between these years the Weija-Candy and Weija-Bamag treatment plants as well as the Kpong Old and Kpong New treatment plants underwent renovation works to increase their respective capacities. As a result of these works, production was running on shift basis of the plants, thus reducing the total daily production in order to pave way for the renovation works. It is after the expansion of the capacities, that production assumed a sudden increase at the tail end of 1996 hence accounting for the below trend of water produced. After 1996 water use has generally increased with consistent slightly drops in 1998, 2000 and 2003. These may be due to other factors such as rainfall, water rationing etc.

Figure 5.4: Production of treated water or supply, ATMA, 1986-2005.



5.3.2 Factors Influencing Treated Water Use

Various factors affect treated water use ranging from social, economic, to political among others. However with the objective of this thesis and the availability of data, a few of the factors will be considered namely the annual population of ATMA, the annual rainfall, the GDP growth of the Ghanaian economy which is a representation of the income or the money in the pocket of a consumer and then last but not the least rationing of water. The main objective is to quantify these factors and observe how they influence water use or supply in ATMA. The summary of data set needed to quantify the influence of these factors was considered on a year span of twenty starting from 1986 to 2005 as in table 5.2. Rationing was considered on the basis of YES or NO with YES meaning rationing took place and NO meaning rationing did not take place, hence actual rationing of water started in the year 1995 in ATMA (Source: Verbal communication with Mr. Musah, the distribution engineer of the Accra East Regional Head office).

Table 5.2: Data set of ATMA, 1986-2005 used for the MLR analysis

Year	Population 1000	Rainfall mm/a	GDP growth %	Rationing Yes/No	Observed Treated water produced 1000 m3/a
1986	1254	545.2	5.2	0.0	91880
1987	1304	640.3	4.8	0.0	90456
1988	1356	988.9	6.2	0.0	90907
1989	1410	656.7	4.5	0.0	95328
1990	1466	568.6	3.3	0.0	93239
1991	1524	1008.0	5.3	0.0	95419
1992	1585	557.0	3.9	0.0	98916
1993	1648	509.3	4.0	0.0	93772
1994	1714	547.9	3.3	0.0	94742
1995	1782	1029.8	4.0	1.0	92745
1996	1853	716.6	4.6	1.0	117286
1997	1926	1223.5	4.2	1.0	114216
1998	2003	513.6	4.7	1.0	112742
1999	2083	641.8	4.4	1.0	119473
2000	2165	512.2	3.7	1.0	113571
2001	2251	837.6	4.2	1.0	115598
2002	2341	1010.0	4.5	1.0	125883
2003	2434	887.0	5.2	1.0	126000
2004	2531	574.2	5.6	1.0	131796
2005	2632	777.9	5.9	1.0	132315

5.3.3 Quantification of Factors Influencing Water Use (Supply)

For a better understanding of the factors affecting water use in the study area, a Multi Linear Regression (MLR) analysis was carried out with respect to these factors.

For the MLR, the following model equation was used: (compare with Dube and Van der Zaag, 2003)

$$Q = a + b*N + c*P + d*G + e*R \qquad (1)$$

Where Q is the annual treated water use in ATMA (1000 m^3/a)
N is the population of ATMA (1000)
P is the annual precipitation in mm/a
G is annual GDP growth in %
R is the factor for rationing
a,b,c,d and e are constants.

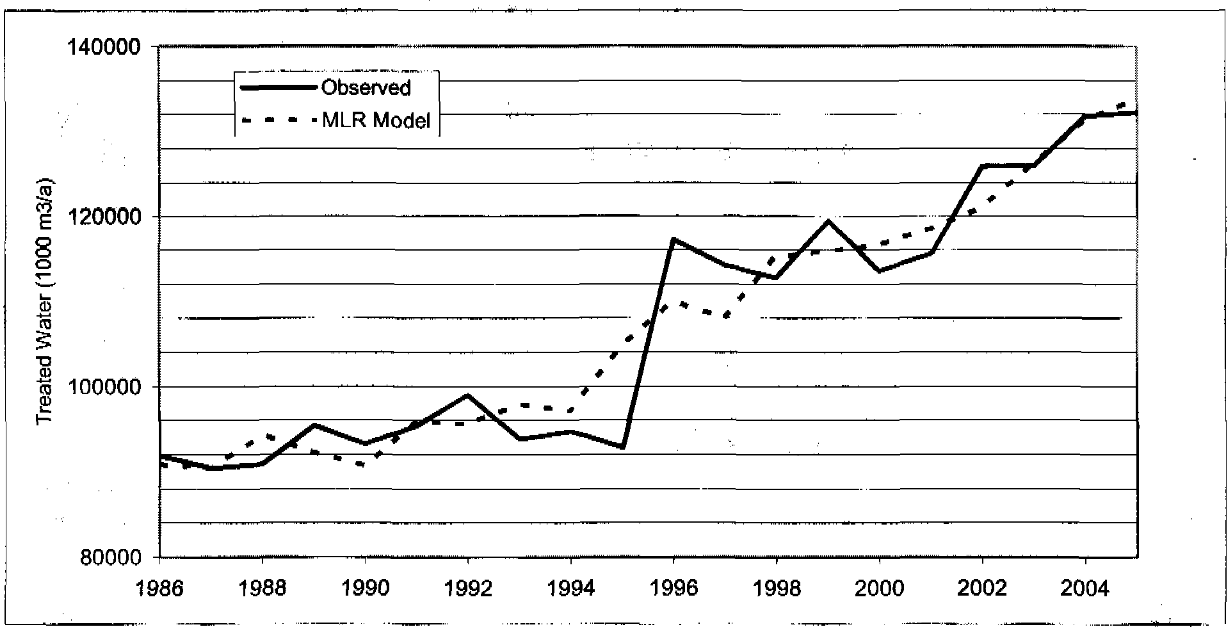
The multi linear regression model for the period 1986-2005 yield the following values for the constants.

$$Q = 45360 + 26.1 * N - 5.2 * P + 2990 * G + 6190 * R \qquad (2)$$

$r^2 = 91.5$

The model analysis resulted in the fit shown in figure 5.5 below.

Figure 5.5: Observed and modelled water use or supply, ATMA, 1986-2005



From equation 2, it implies that:

- Constant a ($45{,}360*10\ m^3/a$) represents water use that are more or less fixed and independent of population, rainfall, GDP and rationing. These uses include water losses of ATMA some of which are unavoidable and some due to institutional water uses.

- Population alone explains 89% of total water supply.

- Constant c ($5.2*10^3\ m^3/mm$) means that if rainfall is 100mm above the average of 700 mm/a, water use decreases with 520,000 m^3/a; if rainfall is 100 mm below the average, water use increases with the same amount. Including the rainfall factor improves the correlation with 0.002%.

- Constant d ($2{,}990*10^3\ m^3/a$) implies that GDP growth has a significant effect on water supply: a 1% increase in GDP leads to an increase in water supply of

2,990,000 m^3/a. Including this factor increases the correlation with 1.7% to a total of 90.4%.

- Constant e (6,190*10^3/a) indicates that rationing has a significant impact on water use or supply with an influence of 6,190,000 m^3/a. Including this factor improved the correlation by 1.1%, yielding a total of 91.5%.

5.3.4 Projection of water supply in ATMA

The future water supply for ATMA was then projected based on the assumption that the factors that influenced past water use as considered in the MLR analysis will still have the same influence on water use in the near future. Also the projected annual GDP of the country was sourced from that of the projections made quite recently (last update on 12/19/06) for Ghana by the World Bank World Development Indicators developed by the Economic Research Service (ERS) (see appendix 2b for detail). The ERS estimated projection was up to the year 2017 and the GDP projections from thereon was estimated as the average of the immediate last ten years. In addition to this, the following assumptions were made:

- The rainfall will be average (i.e. 700 mm/a)
- The population growth rate will be the current estimate of 3.9% per annum
- There will be no rationing of water (one of the future ambitions of ATMA)

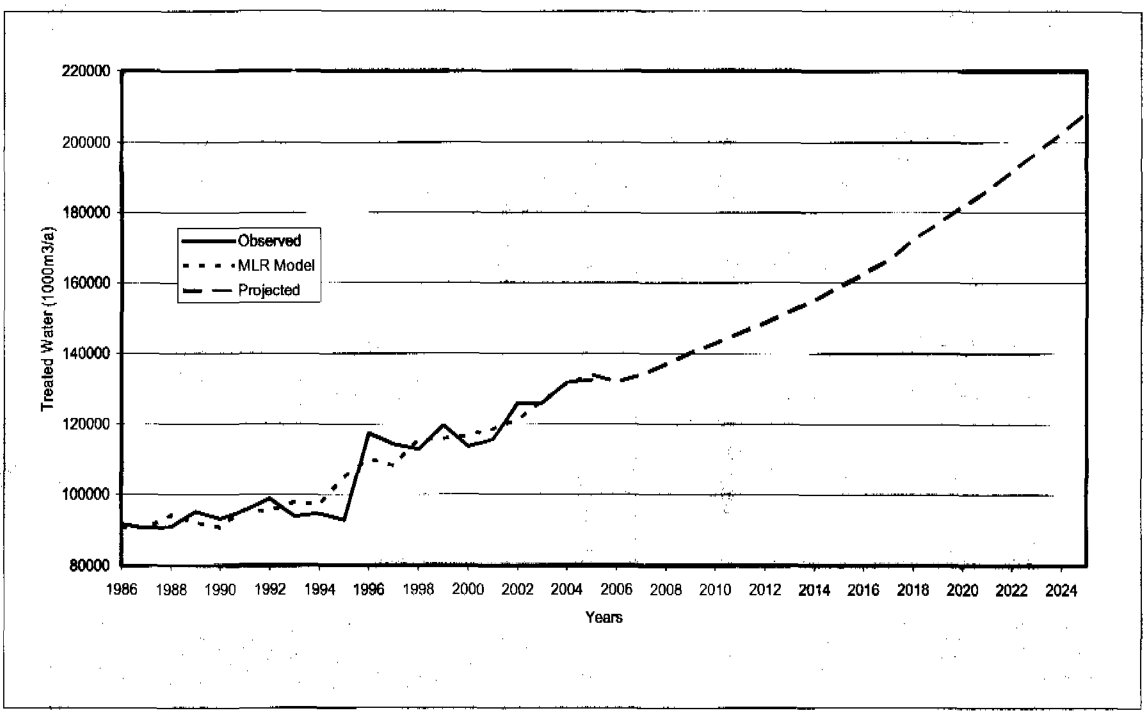
The above assumptions and the yielded projected supply from the MLR analysis are represented in table 5.3. From the table it shows that if nothing is done about the supply and demand water use is going to increase to about 208Mm^3/a by the year 2025 which is approximately 57,600 m^3/day.

The projected supply from the MLR analysis is also shown in figure 5.6 showing the level of unrestricted supply.

Table 5.3: Projection of unrestricted supply, ATMA

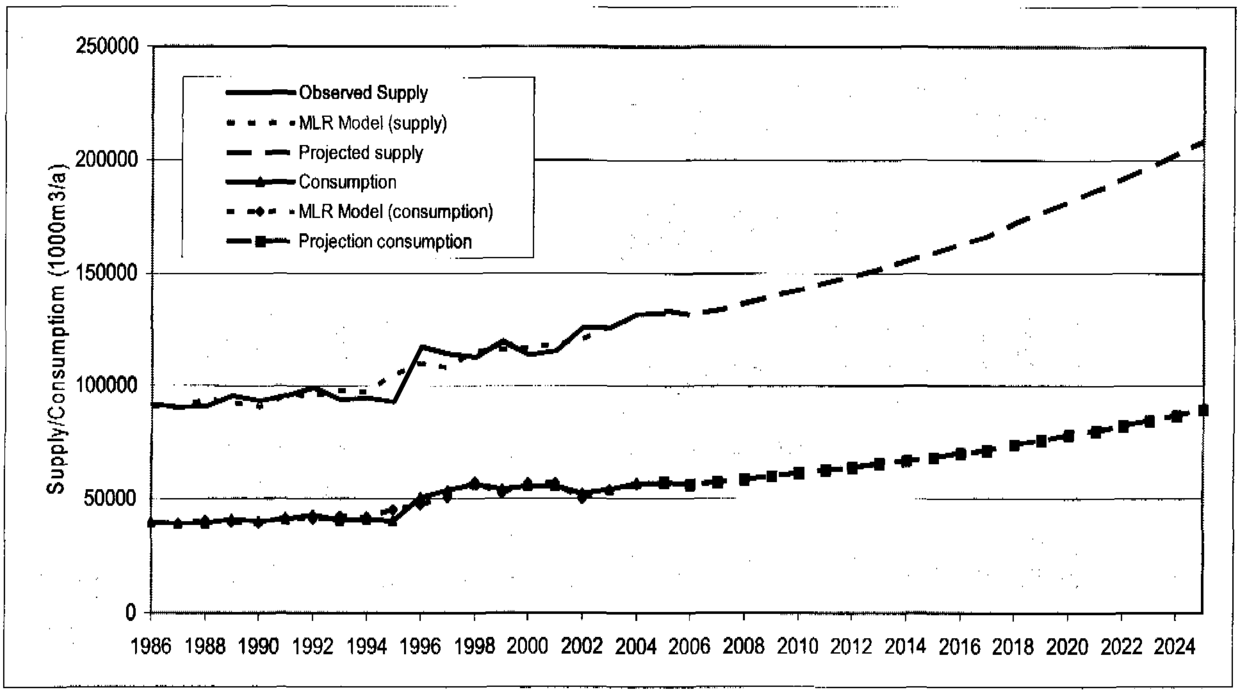
Year	Output	Imput		
	Water use (Mm3/a)	Population (in 1000)	Rainfall (mm/a)	GDP growth (%)
2005	134	2632	777.9	5.87
2006	132	2736	700	6.20
2007	134	2845	700	5.90
2008	137	2958	700	5.96
2009	140	3076	700	6.02
2010	143	3198	700	5.90
2011	146	3325	700	5.72
2012	149	3458	700	5.55
2013	152	3595	700	5.44
2014	155	3738	700	5.33
2015	159	3887	700	5.22
2016	163	4042	700	5.12
2017	167	4202	700	5.02
2018	172	4369	700	5.53
2019	177	4543	700	5.53
2020	182	4724	700	5.53
2021	187	4912	700	5.53
2022	192	5107	700	5.53
2023	197	5310	700	5.53
2024	203	5522	700	5.53
2025	208	5741	700	5.53

Figure 5.6: Projection of supply to 2025 without WDM, ATMA



With the values of the UFW over the years, the actual water consumption of ATMA was then estimated and projected into the future. It is assumed in the projection of the consumption that the UFW will remain at 57.1% which is the average over the last three years. This result of the projection is then compared with the projected supply in figure 5.7 below. It is realized that the actual water consumption in ATMA is far below the water supply. This is an indication of undesirable level of demand which may be due to the non-implementation of WDM.

Figure 5.7: Projection of supply and demand to 2025 without WDM, ATMA



Based on the information from the treated water supply and the population estimated, the crude per capita water consumption was then calculated for the past years and this was found to be quite high with a value of 201 l/c/day in 1986 to 138 l/c/day in 2005. This absolute high estimate of per capita consumption in ATMA presumes that over the years to present, there is enough water in the distribution system that may be capable of satisfying all consumers; however this is rather contrary to the existing situation. This is actually a true manifestation of the very high leakages in the system as the expected per capita consumption is not experienced. Figure 5.8 gives an illustration of the yawning gap between the crude per capita consumption and the real calculated per capita consumption, This huge difference in addition to the free falling real per capita consumption reiterates the existence of a below desirable level of demand in ATMA. It is therefore very relevant to narrow this huge gap by increasing the demand and lowering the projected supply in order to achieve desirable level of water consumption in ATMA through WDM measures.

Figure 5.8: Calculated per capita consumption, ATMA, 1986-2005

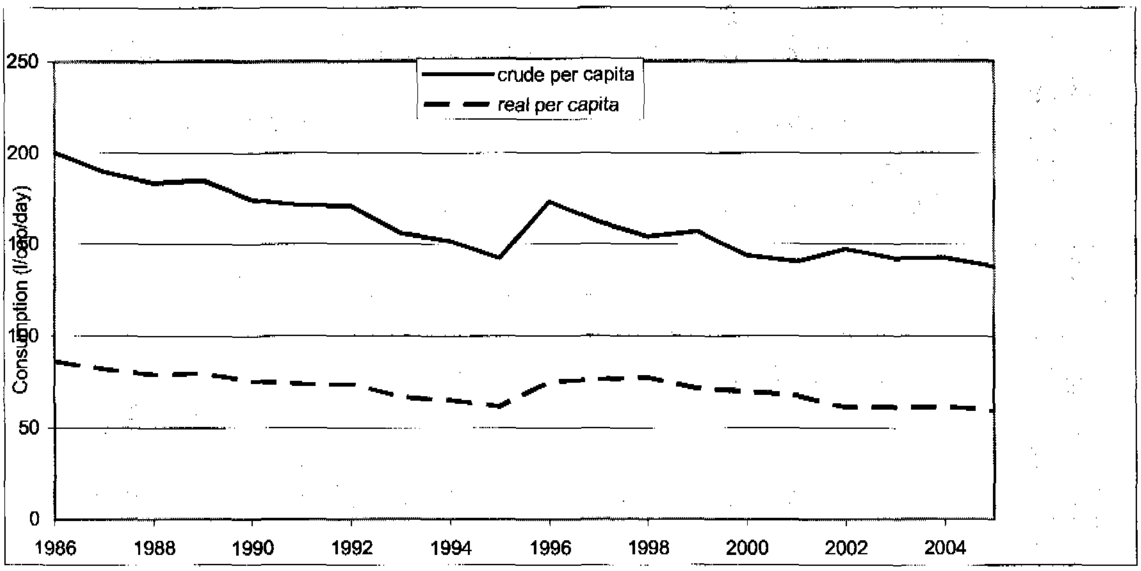


Table 5.4: Calculated per capita consumption, ATMA, 1986-2005.

Year	Treated produced observed 1000m3/yr	Non-billed (UFW) (%)	Treated Billed Calculated 1000m3/yr	Population 1000	Crude per capita l/c/d	Real per capita (calculated) l/c/d
1986	91880	57.0	39508	90844	201	86
1987	90456	57.0	38896	90445	190	82
1988	90907	57.0	39090	94246	184	79
1989	95328	57.0	40991	92247	185	80
1990	93239	57.0	40093	90666	174	75
1991	95419	57.0	41030	95797	172	74
1992	98916	57.0	42534	95539	171	74
1993	93772	57.0	40322	97813	156	67
1994	94742	57.0	40739	97063	151	65
1995	92745	57.0	39880	104784	143	61
1996	117286	57.1	50351	109975	173	74
1997	114216	53.2	53419	108077	162	76
1998	112742	50.2	56202	115249	154	77
1999	119473	54.8	53978	115871	157	71
2000	113571	51.4	55252	116640	144	70
2001	115598	52.2	55244	118533	141	67
2002	125883	58.5	52191	121071	147	61
2003	126000	57.1	54117	126235	142	61
2004	131796	57.1	56606	131376	143	61
2005	132315	57.1	56829	133816	138	59

NB: Crude per capita consumption is obtained by dividing the treated produced observed by the population whilst the estimated real per capita is obtained by dividing the treated bill calculated by the population.

5.3.5 Water Demand Management Measures

- **5.3.5.1 Scenario 1: Business as Usual Water Demand Management**

Using the UFW over the years and the treated water supply, the real per capita consumption was then calculated as in indicated in Table 5.4 above.

Similarly the results from the MLR analysis were used to calculate the modeled real per capita consumption and then this was projected into the future. This was done on the assumption that the UFW remains 57.1% (the average over the last three years). The values used in the projection of the per capita consumptions are given in Table 5.5 and the corresponding model results illustrated graphically in Figure 5.9. From the graph it is clear that per capita consumption is going down drastically and without WDM, the per capita consumption will be 43 l/c/day by the year 2025 and will further drop in the subsequent years. This situation calls for an effective WDM measures to be able to increase the per capita consumption in terms of UFW reduction.

Figure 5.9: Projected per capita consumption without WDM compared to the crude per capita up to 2025

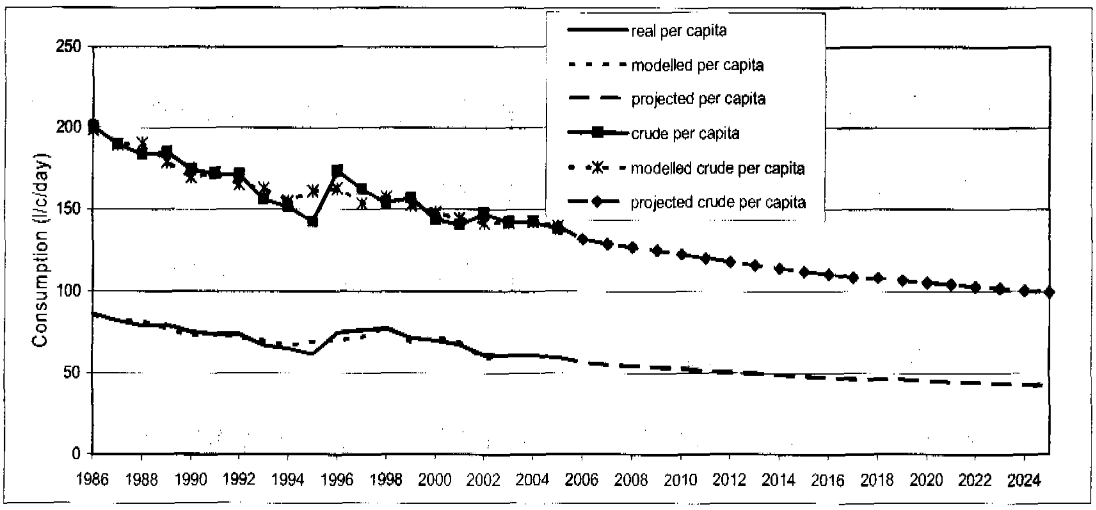


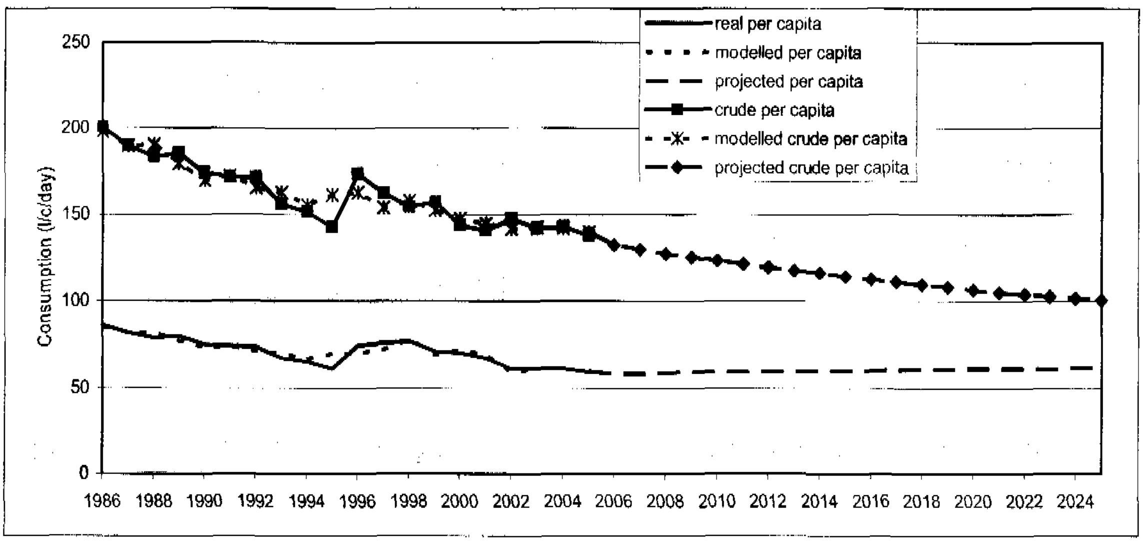
Table 5.5: Projected per capita consumption, ATMA, 2005-2025

	Year	Treated produced (modelled) 1000m3/yr	Non-billed (UFW) (UFW) (%)	Treated billed modelled 1000m3/yr	Population 1000	Real per capita (modelled) l/c/d
	1986	90844	57.0	39063	1254	85
	1987	90445	57.0	38891	1304	82
	1988	94246	57.0	40526	1356	82
	1989	92247	57.0	39666	1410	77
	1990	90666	57.0	38986	1466	73
	1991	95797	57.0	41193	1524	74
	1992	95539	57.0	41082	1585	71
	1993	97813	57.0	42059	1648	70
	1994	97063	57.0	41737	1714	67
	1995	104784	57.0	45057	1782	69
	1996	109975	57.1	47212	1853	70
	1997	108077	53.2	50548	1926	72
	1998	115249	50.2	57451	2003	79
	1999	115871	54.8	52351	2083	69
	2000	116640	51.4	56745	2165	72
	2001	118533	52.2	56647	2251	69
	2002	121071	58.5	50196	2341	59
	2003	126235	57.1	54218	2434	61
	2004	131376	57.1	56426	2531	61
	2005	133816	57.1	57474	2632	60
PROJECTED	2006	131758	57.1	56590	2736	57
	2007	133705	57.1	57426	2845	55
	2008	136841	57.1	58773	2958	54
	2009	140095	57.1	60171	3076	54
	2010	142933	57.1	61390	3198	53
	2011	145719	57.1	62586	3325	52
	2012	148667	57.1	63853	3458	51
	2013	151932	57.1	65255	3595	50
	2014	155340	57.1	66719	3738	49
	2015	158897	57.1	68246	3887	48
	2016	162638	57.1	69853	4042	47
	2017	166539	57.1	71529	4202	47
	2018	172425	57.1	74057	4369	46
	2019	176966	57.1	76007	4543	46
	2020	181688	57.1	78035	4724	45
	2021	186598	57.1	80144	4912	45
	2022	191703	57.1	82336	5107	44
	2023	197011	57.1	84616	5310	44
	2024	202530	57.1	86987	5522	43
	2025	208269	57.1	89451	5741	43

- **5.3.5.2 Scenario 2: Regular Water Demand Management**

This is a demand management strategy whereby there is a consistent and regular reduction in unaccounted for water by 2% per annum i.e. achieving 0.98% of the previous year level. With this measures put in place the projected per capita consumption is expected to increase gradually with an average of about 60 l/cap/day. The per capita consumption will be increased to 62 l/cap/day by the year 2025 when the UFW will have been reduced to 38.1%. This is illustrated graphically in Figure 5.10 below. With the per capita consumption of an average of 60 l/cap/day is an improvement in achieving desirable level of demand; however the UFW still remains high which needed to be reduced.

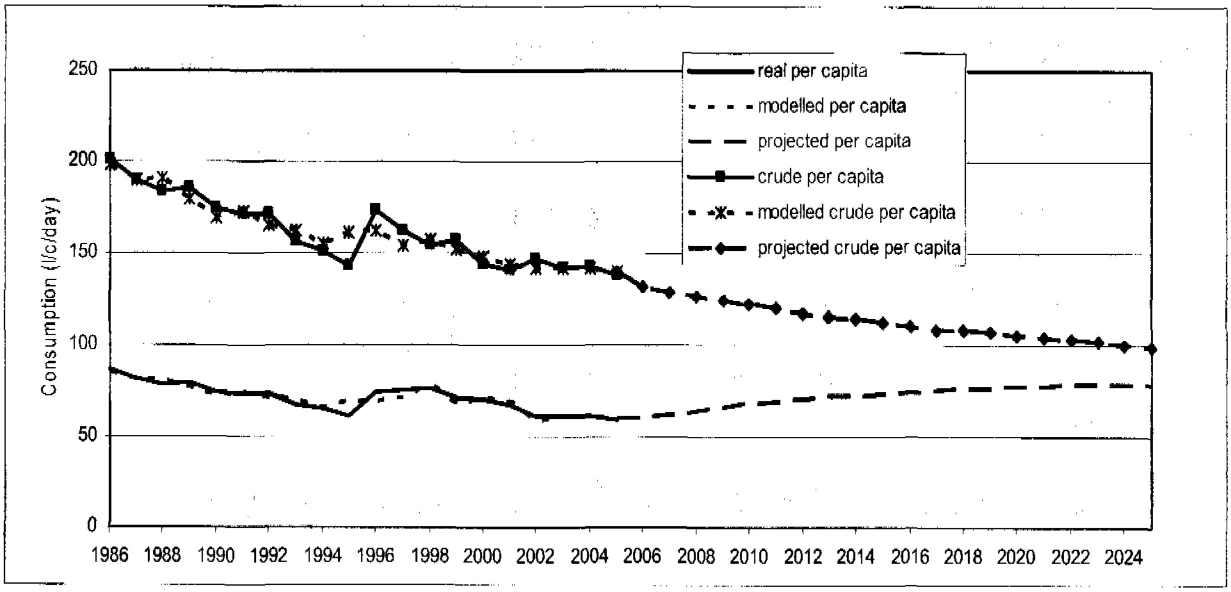
Figure 5.10: Projected per capita consumption by reducing UFW by 2% per annum compared to the crude per capita up to 2025



- **5.3.5.2 Scenario 3: Intensive Water demand Management**

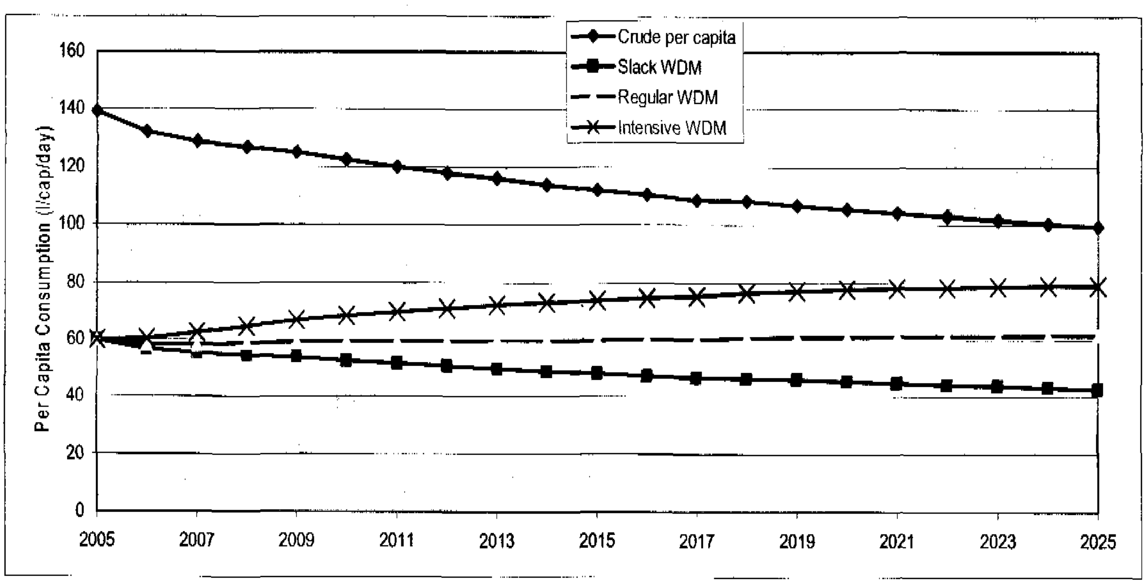
This demand management strategy is in line with the performance indicator set up for AVRL i.e. achieve yearly reduction in UFW by 5% per annum (achieving 0.95% of the previous year level). The corresponding result of the projected per capita consumption is shown below. In this scenario it assume that after the end of the management contract of AVRL in about 5 years time, the GWCL will still continue with the intensive WDM strategy. With this measure, the capita consumption increases sharply with an average of 73 l/cap/day within the projected span of 20 years. The UFW will also be reduced to 20.5% by the year 2025 which is almost the recommended WDM standard of less than or equal to 20%. This strategy stabilizes the per capita consumption with a maximum of 79 l/cap/day in 2025.

Figure 5.11: Projected per capita consumption by reducing UFW by 5% per annum, to 20.5% in 2025



For a very clearer picture of the three scenarios, the outcome of their various projected results only is together compared to the projected crude per capita consumption as shown in Figure 5.12 below.

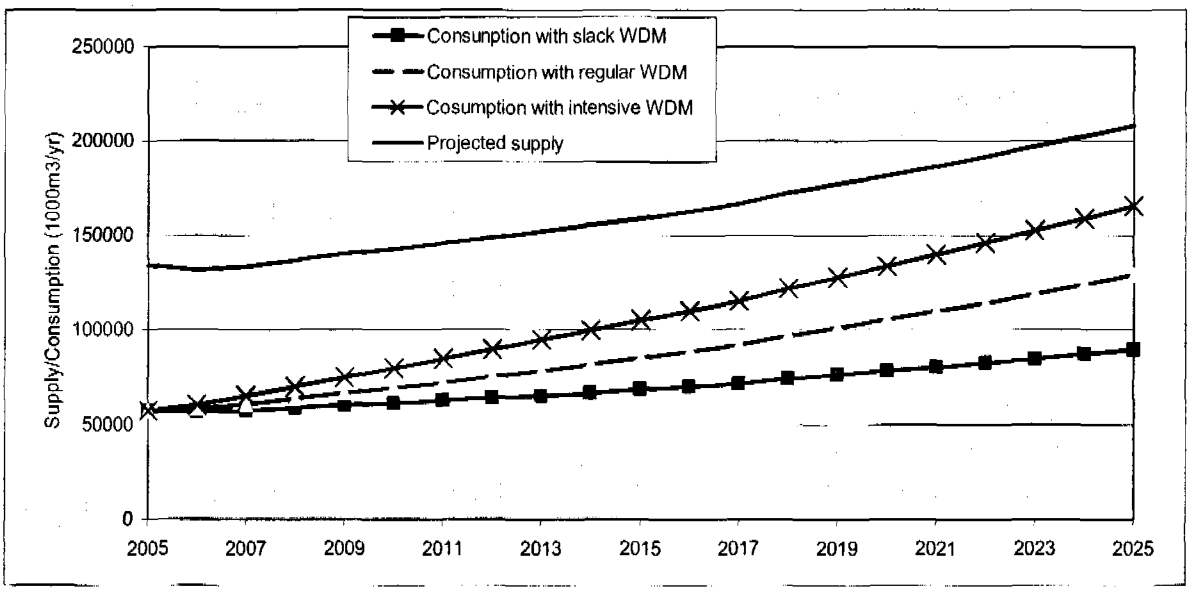
Figure 5.12: Slack, Regular and Intensive WDM scenarios



From the graph it is quite obvious that the intensive WDM strategy is the most appropriate short to medium term measure for ATMA out of the three scenarios. This is because after a point in time the wide gap which is the UFW is narrowed to a modest level and then it stabilizes completely to the year 2025 as well achieving a quite desirable level of water for consumption. However the reduction of UFW has a cost implication taking into consideration the unit cost of UFW reduction. Thus the cost will have to be considered in choosing the appropriate scenario.

The above three scenarios transformed into demand (consumption) and compared with supply is represented in the figure 5.13 below derived from Table 5.6.,

Figure 5.13 Projected consumptions with WDM compared to the supply



From the projected consumptions graph, it is obvious that with the intensive WDM measure scenario, the low level demand will attain an appreciable level as per capita consumption will relatively be high.

Table 5.6: Projected Consumptions with WDM and Projected Supply

Year	Slack WDM Consumption 1000m3/yr	Regular WDM Consumption 1000m3/yr	Intensive WDM Consumption 1000m3/yr	Projected Supply 1000m3/yr
2005	57474	57474	57474	133816
2006	56590	58093	60348	131758
2007	57426	60447	64863	133705
2008	58773	63364	69908	136841
2009	60171	66375	74996	140095
2010	61390	69224	79836	142933
2011	62586	72077	84609	145719
2012	63853	75038	89438	148667
2013	65255	78190	94429	151932
2014	66719	81452	99486	155340
2015	68246	84829	104621	158897
2016	69853	88342	109862	162638
2017	71529	91983	115199	166539
2018	74057	96778	121928	172425
2019	76007	100879	127731	176966
2020	78035	105133	133667	181688
2021	80144	109547	139745	186598
2022	82336	114127	145975	191703
2023	84616	118881	152366	197011
2024	86987	123818	158929	202530
2025	89451	128945	165675	208269

5.4 Analysis of factors affecting Water Consumption in affluent and non-affluent households

Implementing WDM depends on knowing the levels and patterns of water consumption (Dube and van der Zaag, 2003). To be able to know this, Residential areas of part of Airport, Abelemkpe, Dzorwulu and Roman Ridge were considered as affluent with an average household sample size of 2353 whilst the residential areas of Nima, Mamobi, Kotobabi and Accra Newtown considered as non-affluent with an average household sample size of 2148. The monthly water consumption data for both the affluent and non-affluent areas were derived from the monthly billing data of the GWCL ranging from the month of November 2005 to October 2006 as indicated in Tables 5.7 and 5.8. The combined estimated monthly consumption patterns of the different residential areas in meter cubic per month per connection considered in the study area over the period of twelve months is shown in Figure 5.14.

Figure 5.14: Graphs of pattern of consumption for affluent and non-affluent areas

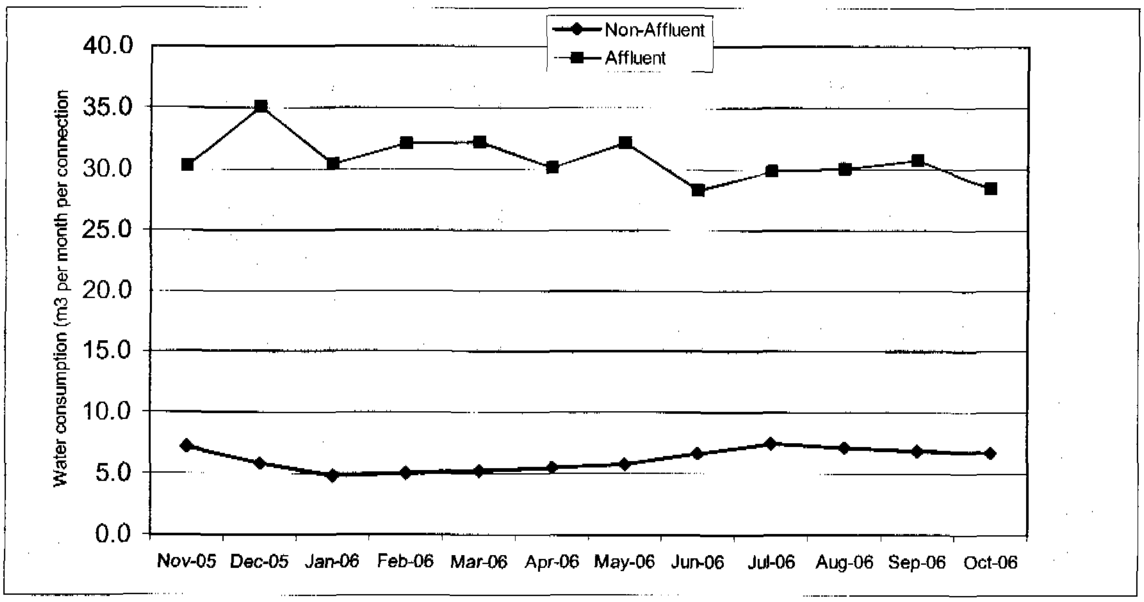
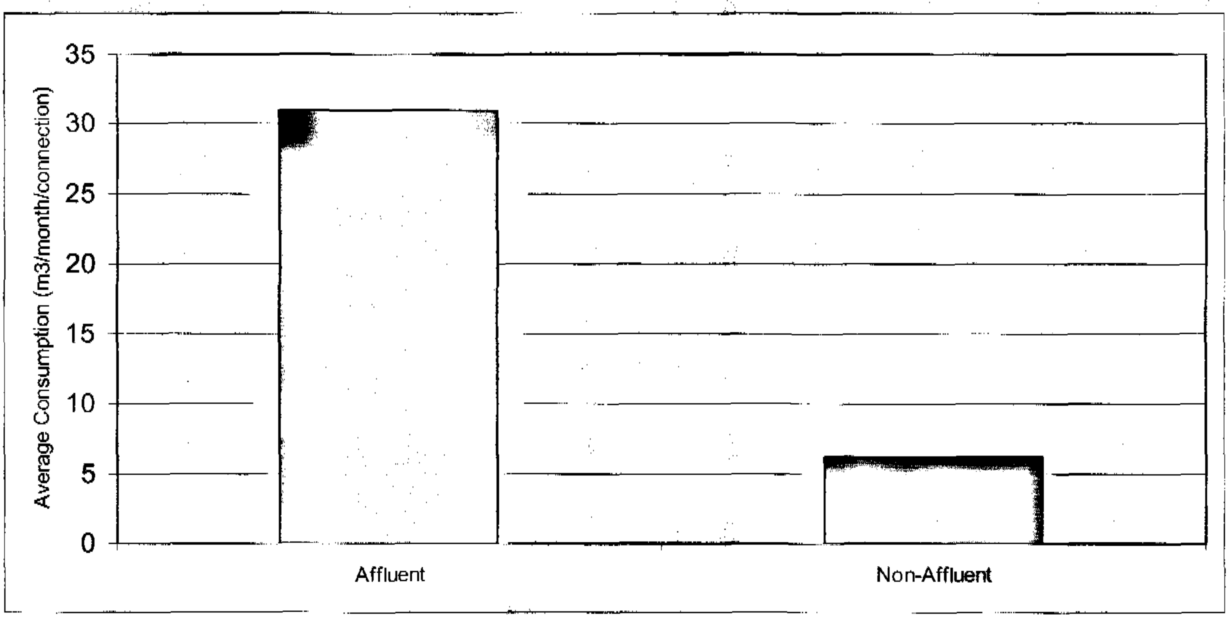


Figure 5.14 above indicates that the monthly consumption patterns of the affluent and non-affluent areas do not follow any similar pattern, whilst the non-affluent consume more in the months of June, July and August which is ironically the peak of the rainy season, the affluent consume rather more in the month of December which is around the dry season when the harmattan begins. In October and November, the non-affluent average consumption is relatively high which is quite understandable because these are also the months within the period of the dry season, however quite surprising is the relatively low consumption of the non-affluent in the months of January, February and March as these are within the dry season.

It is also quite obvious that there is actually a yawning gap between the water consumption of the affluent (consuming 31 m^3/month on average) and non-affluent households (6.2 m^3/month). The reason for this gap could probably be attributed to the fact that the non-affluent households generally do not use so much water because of their inability to pay (further research needed to proof this) as a result of their low incomes and also do not have assets that require the excess usage of water such as cars that will be washed, lawns to be watered whilst the affluent generally could afford to pay for water irrespective of the price and usage. Most of the rich houses have also more than one car that are washed, large plots of land used as garden to beautify homes which all require the usage of substantial quantity of water. However the consumptions per household looks quite lower than will be expected in other areas for the period considered in the analysis. This could be due to the severe rationing exercise going on in ATMA of which some areas like Accra Newtown, Kotobabi, and Roman Ridge are among the most seriously affected areas. Even water flow to these areas is not regular as a result of the high geographical elevation of these localities. As part of the rationing exercise going on, some of these areas receive potable water twice in every three weeks and to the extreme once or in worst cases report to the authorities before they are considered.

Figure 5.15: Graph showing the total average consumption of the affluent and non-affluent



Considering the average consumption of the different residential areas separately as indicated in Figure 5.16, it is obvious that Airport Residential, Roman Ridge and Dzorwulu have relatively high consumptions. These areas are amongst the very rich places in Accra where most of the dignitaries are staying. Accra Newtown seems to have a very low consumption with a negative deviation from the average of the non-affluent areas. Again this could be that it is the most hit by the current rationing exercise ongoing in ATMA in the non-affluent areas. This reason is also justified by the geographical location of Newtown as it has a quite high elevation relative to the other areas, thus pressures will be expected to be very low making it quite impossible for water to flow to some households within these areas. What this situation of rationing implies is that the significant number of households in the non-affluent areas especially Accra Newtown which do not have meters are being charged at rate far above their consumption. This was actually confirmed by interacting with some few consumers in the Nima area who were now yelling to be provided with meters as the circumstance is not favoring them at all in terms of the payment.

Abelemkpe's negative deviation to the affluent average (i.e. lower consumption relative to the average consumption) could not only be due to rationing but also some possible unmetered households whose real consumption might far outstrip the fixed rate set up by the PURC which is 28,794 Cedis (approximately 3 euros) per month equivalent to 7m3.

Figure 5.16: Graph showing the average water consumptions per residential area

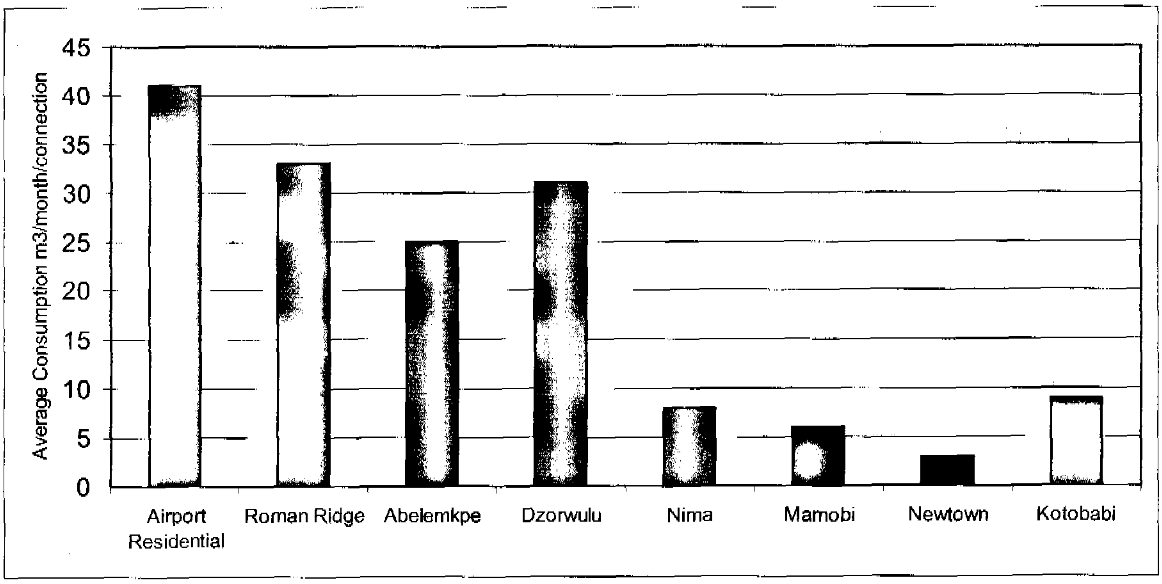
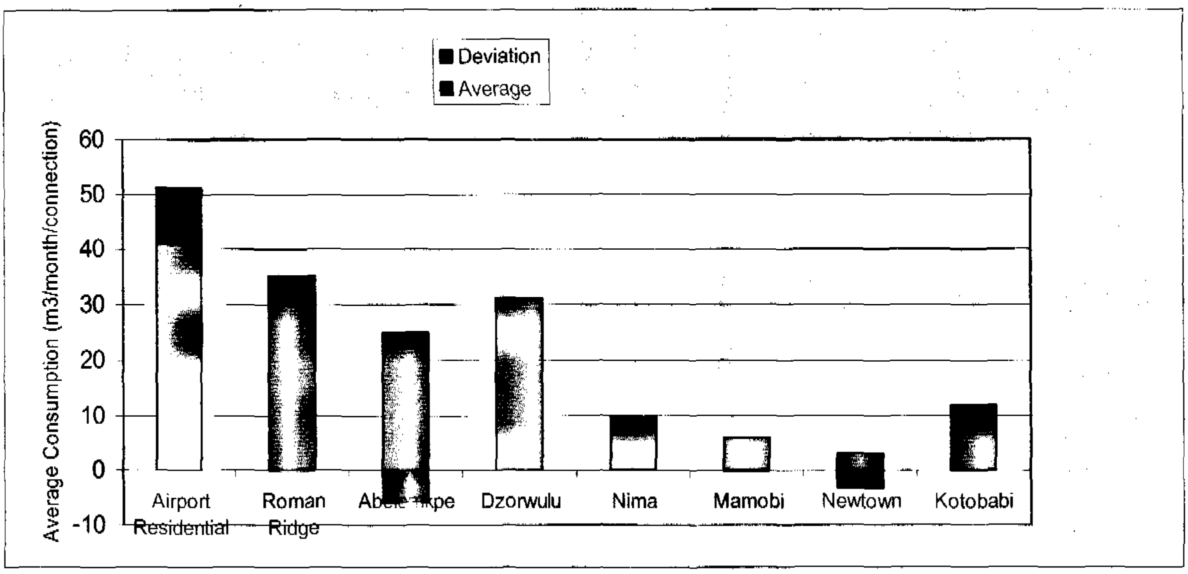


Figure 5.17: Graph showing the deviations (difference) in consumption with respect to the average consumptions.



Considering the various residential areas on the basis of population, connections and consumptions as shown in Figure 5.18, there is also an obvious indication that, the affluent areas have relatively quite low population compared to the non-affluent. This again reiterate the fact that the rich even though are less in number than the poor, they consume excess water because of their water consuming assets and ability to pay for. There is also an indication that the number of households connections is relatively very high in the affluent areas than in the non-affluent areas. This means that the rate of connections in the rich areas is shooting up so drastic whilst in the non-affluent the connection to the population is averagely lower. The relatively higher connections in the Accra Newtown area can also account for the lower pressures in the area which mean that during rationing the minimum quantity of water that is pumped to this area had to be competed for by the larger connections. This has probably led to the substantial number of households which have mounted in-line suction pumps in their houses to compound the situation by preventing water being supplied to other consumers in these areas, since this type of connection exerted pressure on the low lying areas.

Figure 5.18: Graph showing the area average consumption, population and connections

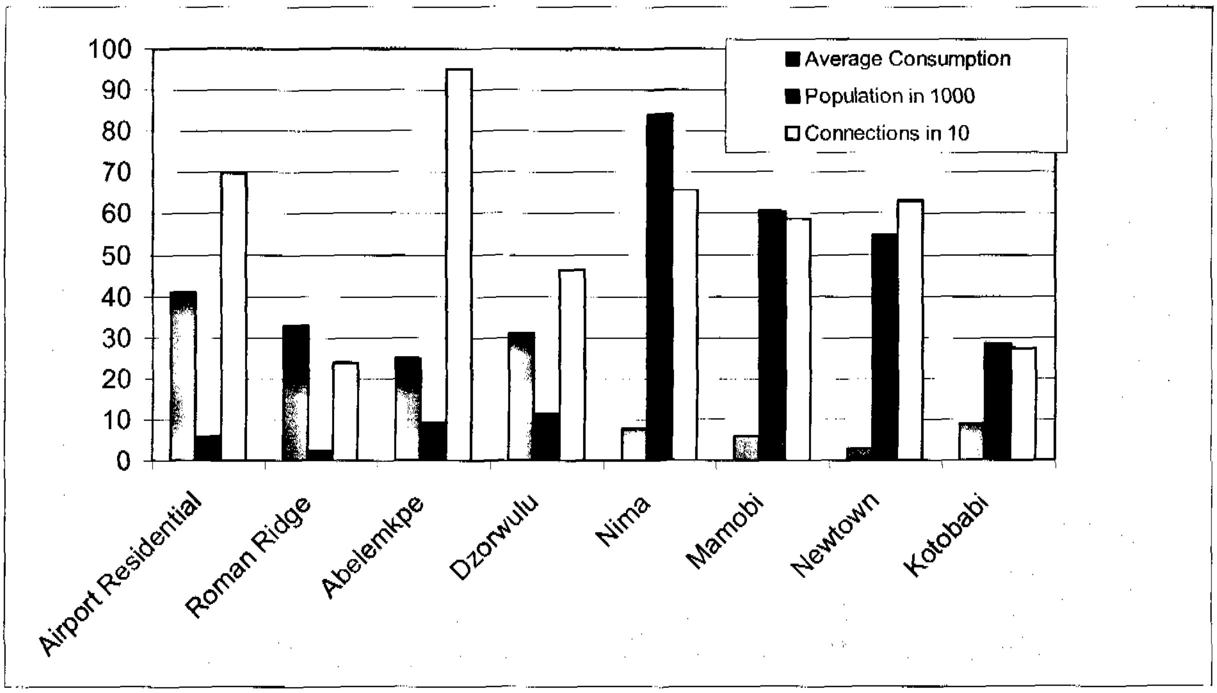


Table 5.7: Monthly consumptions and connections of affluent areas

	Airport Residential		**Roman Ridge**		**Abelemkpe**		**Dzorwulu**		Total	Total	Consumption
Month	Comsumption (	Connections	Comsumption	Connections	Comsumption	Connections	Comsumption	Connections	Consumption	Connections	m3/mon/con
Nov-05	27377	703	5423	237	24617	954	13984	467	71401	2361	30.2
Dec-05	36662	702	5569	238	25032	954	15484	467	82747	2361	35.0
Jan-06	27543	704	5226	238	24212	956	14948	468	71929	2366	30.4
Feb-06	27369	701	5444	238	25914	956	17151	468	75878	2363	32.1
Mar-06	29713	705	5351	238	25164	957	15890	465	76118	2365	32.2
Apr-06	28767	694	5584	238	22543	953	13937	465	70831	2350	30.1
May-06	30992	694	5781	238	22827	955	16109	466	75709	2353	32.2
Jun-06	24285	701	6257	238	22174	947	13616	458	66332	2344	28.3
Jul-06	25624	698	6231	238	22870	947	15180	458	69905	2341	29.9
Aug-06	29320	695	5242	239	24227	948	11601	459	70390	2341	30.1
Sep-06	29557	694	5504	239	23315	950	13535	459	71911	2342	30.7
Oct-06	26585	695	5656	239	23068	950	11364	460	66673	2344	28.4
							Average Consumption in m3/month/connection				30.8

Table 5.8: Monthly consumptions and connections of non-affluent areas

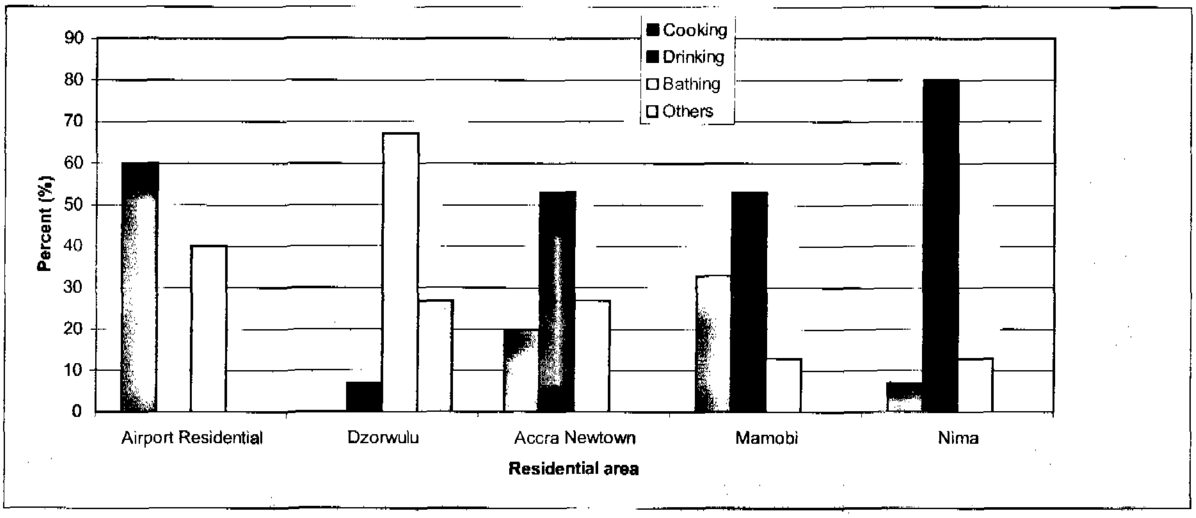
	Nima		**Mamobi**		**Newtown**		**Kotobabi**		Total	Ttotal	Consumption
Month	Comsumption	Connections	Comsumption	Connections	Comsumption	Connections	Comsumption	Connections	Consumption	Connections	m3/mon/con
Nov-05	5643	659	3702	582	3418	634	2728	276	15491	2151	7.2
Dec-05	4871	659	3050	583	2202	636	2479	276	12602	2154	5.9
Jan-06	3880	660	2562	583	1527	636	2420	276	10389	2155	4.8
Feb-06	3661	657	2750	584	1678	636	2693	276	10782	2153	5.0
Mar-06	4065	659	2979	584	1687	636	2443	276	11174	2155	5.2
Apr-06	4634	658	3064	585	1708	627	2371	276	11777	2146	5.5
May-06	4601	657	3457	590	1822	627	2465	276	12345	2150	5.7
Jun-06	5997	652	3839	591	2166	626	2262	277	14264	2146	6.6
Jul-06	6701	653	4120	591	2414	626	2725	279	15960	2149	7.4
Aug-06	6249	657	4117	589	2409	625	2484	279	15259	2150	7.1
Sep-06	6032	657	3422	589	2480	625	2804	279	14738	2150	6.9
Oct-06	5917	657	3007	589	2325	626	2959	242	14208	2114	6.7
							Average Consumption in m3/month/connection				6.2

5.5 Analysis of Prospects of implementing WDM at household levels

5.5.1 Water use and availability

From the analysis of the questionnaires administered, it came out that water uses in the different areas varied. However there is quite an obvious trend in some of the uses in the different areas. In Airport Residential and Dzorwulu which are low density and relatively affluent areas, cooking and bathing is their first priority of water use respectively and drinking being the last priority use. However in all the high densely populated areas (i.e. Accra Newtown, Mamobi and Nima), drinking is their first priority of water use. This trend of priority use is an indication that the affluent may rely more on bottled water bought from market for drinking.

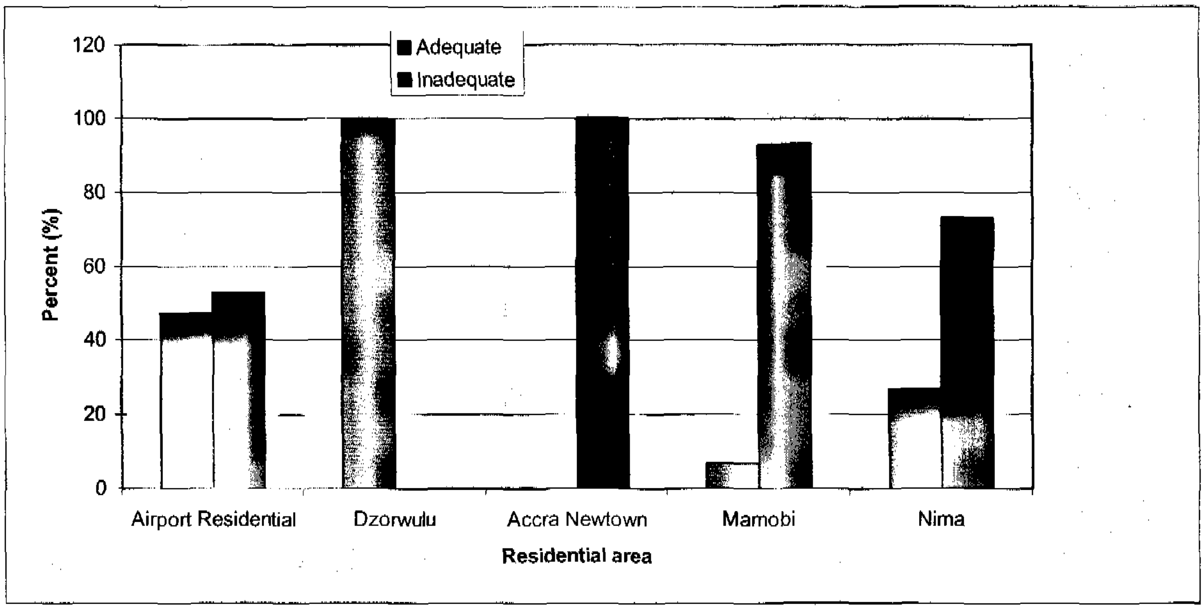
Figure 5.19: Priority of water use



Respondents also have varying perceptions regarding the adequacy of water supply as shown in Figure 5.20. It is only in Dzorwulu that all the respondents perceive that the water they were receiving was enough although water situation in ATMA is below the per capita consumption. .However majority of the people especially respondents in all the low density areas and Airport Residential area felt that they were not receiving enough water at all.

The result of the perception on adequacy of water reiterates the finding that certain areas benefit much more than others by the rationing and more importantly that the water in the system does not reach the intended consumer.

Figure 5.20: Perceived adequacy of water

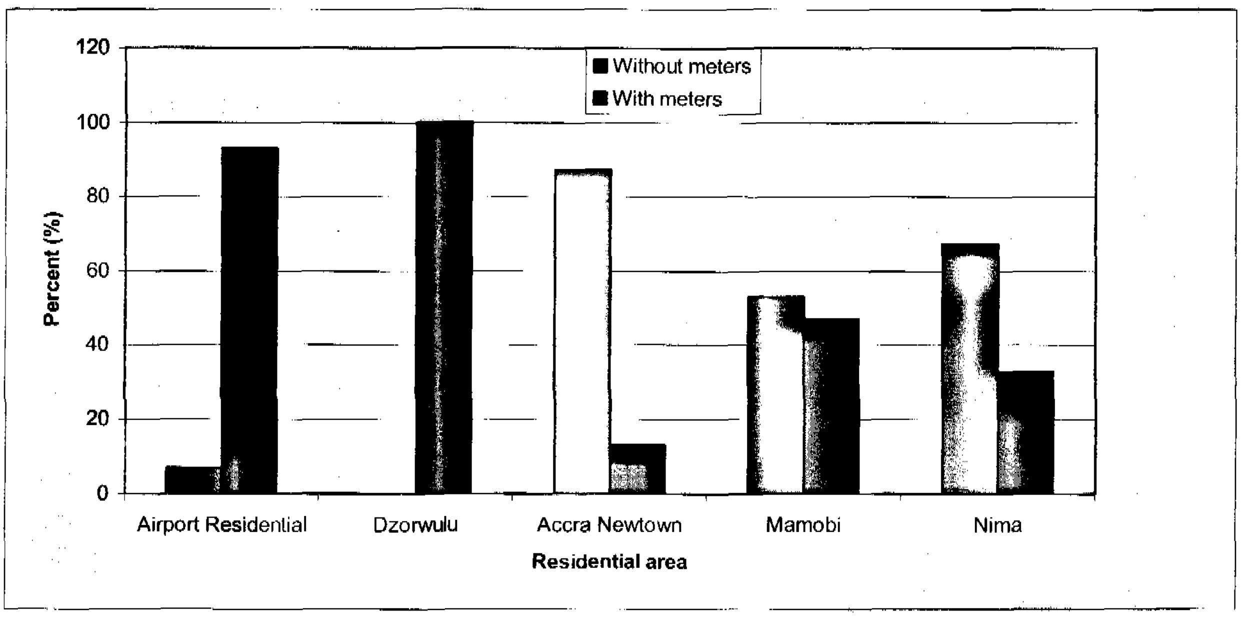


5.5.2 Physical Infrastructure (Metering)

Metering as has been mentioned in the literature review is one of the structural measures for implementing WDM. In all 57% of the total respondents have meters which are functioning. Out of the 57%, 67% make up respondents who have meters in the low density populated areas whilst in the high density areas only 33% of the respondents are connected with meters. Also in all the residential areas of the high density non-affluent, the number of unmetered connections exceeds the number of metered connections. In certain instances, some of the connected meters cannot be accounted for as this was made obvious during the field interviews. Some of the observations made during the interview indicated that some residents especially in the high density areas have their meters damaged or not functioning and some do not take proper care of the meters. In such cases the GWCL resort to fixed rate per cubic meter of consumption. An example is shown in the Figure 5.21 below depicting a resident whose meter is sealed underground and as a result the meter is not functioning, whilst selling the water to the public. Under such circumstances the customer consumes far more than what is being charged for due to the sale of the water. The excess consumption then becomes part of the water that cannot be accounted for in the distribution system although such consumptions are billed. Consumers meters are required if customers are being charged for the water used which is one of the key elements of any WDM strategy. If consumers are not charged in accordance with their use, there is little incentive to save water and this makes consumers to use two to three times the volume of water that they would normally use under normal conditions.

Figure 5.21 (a) A consumer with a meter buried (b) Ground surface of buried meter (Courtesy: Kassim Yakubu Al-Hassan, 30th January, 2007)

Figure 5.22: Residential households with and without meters

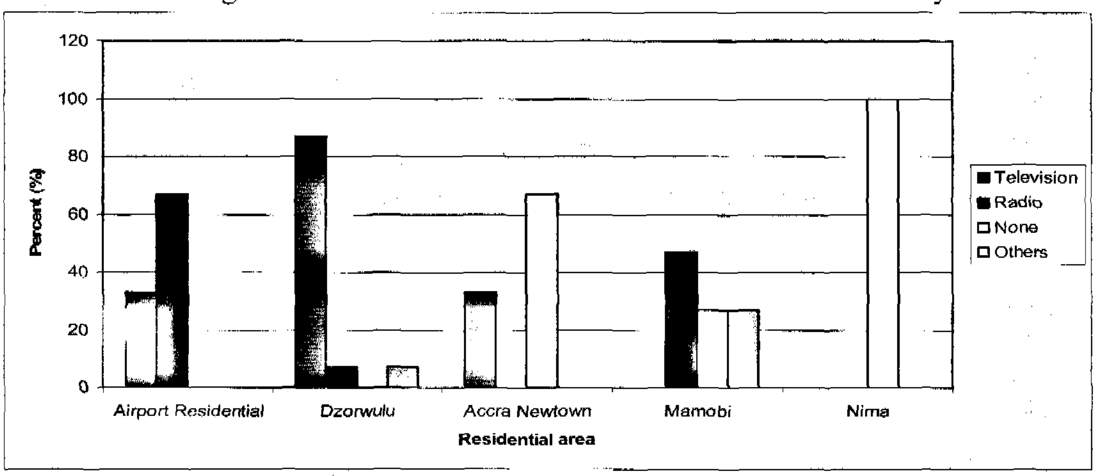


From the result on the meters, it is seen that majority of the households in the high density and non- affluent areas are not connected with meters. This could be an indication why residents of such areas are crying foul of payment under the current rationing programme. This is because they are being charged at fixed rate and consuming far less as in certain instances some gets water once or not at all in a month. This not withstanding, a few who use the water for commercial purposes by selling will rather benefit. The very low level of consumer meters makes WDM a bit difficult because the true pattern of water consumption cannot be determined. The solution to this problem is to ensure that if consumers use more than a certain amount of water, they must pay for it. This requires the use of domestic meters and so it is obvious that without domestic meters, there can be little control on the domestic water use.

5.5.3 Education or Knowledge on WDM

Respondents were asked questions to assess the level of the educational campaign of WDM in ATMA. This was done by asking them if they are aware of method of ensuring efficient use of water and the source from which they gathered such information. In all 31% of the respondents said they acquired such information from adverts on television, 24% answered that from the radio stations, 5% said from personal meeting, 7% indicated that they have such information from other sources and 33% answered that they have no knowledge on water use efficiency. Of all the respondents who had knowledge from the electronic media of television and radio, 71% are from the low density and affluent areas and just 29% are from the high density populated and non-affluent areas. However all the respondents who do not have knowledge of any WDM are from the non-affluent areas. The detailed percentage in the respective areas on the answers from respondents on the sources of information is shown below:

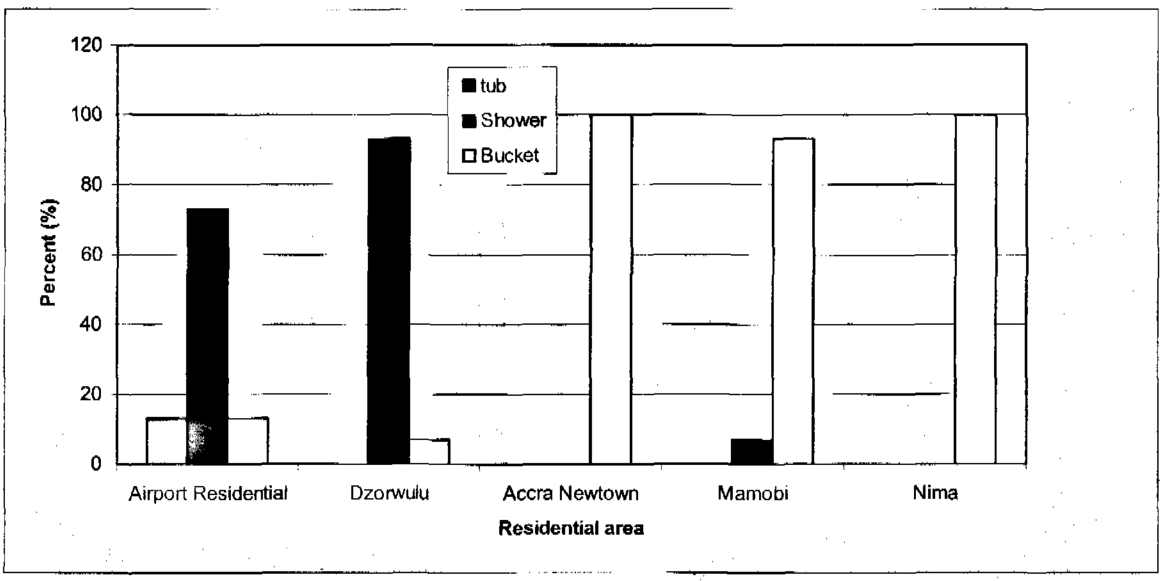
Figure 5.23: Source of information on water use efficiency



The results of the knowledge or educational campaign and the sources of such knowledge is an indication that most of the non-affluent densely populated in ATMA know little on water use efficiency. Also the medium of dissemination of such information is mostly through the television and the radio (from the result) and this benefit the affluent low density areas more than the non-affluent high density. Thus for an effective WDM in ATMA the methods of the educational campaigns has to target all consumers. This can be in a form of incorporating it in the basic school curriculum.

Respondents had different water use practices for activities such as brushing of teeth and bathing. Figure 5.24 shows the methods of bathing in the different residential areas. In the high density areas, showers are mostly used by consumers for bathing whilst in the low density areas buckets is mainly what is used in bathing. Buckets used in bathing mostly save much water compared to showers, however showers are also designed to save water by using less water saving devices. This is normally done by using low flow showerhead in both domestic and commercial installations whilst ensuring that the individual using the shower is still satisfied with the showerhead. Thus for an effective WDM at household level, residents should be encourage to use low flow showerheads in the affluent areas.

Figure 5.24 Bathing Methods in different residential areas.



CHAPTER 6 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

From the literature review, WDM can be seen as a sustainable and a modern option towards the management of the scarce water resources in ATMA.

The main finding and deductions from the research are:

- About the research question RQ 1 (*What is the current status of WDM in ATMA*?)
  - UFW is extremely high in ATMA ranging from 57% in the Accra East region to 66% in the Tema region
  - Pipe burst and leakages in ATMA account for the substantial quantity of UFW.
  - Pressures management is not taken into consideration in the water supply distribution system of ATMA. This cause pipe burst in areas of high pressures leading to loss of treated water.
  - The percentage of connections that are metered is quite low and this does not ensure a comprehensive WDM.
  - WDM educational campaigns in ATMA are not continuous. The campaigns are also restricted to the electronic and print media only.
  - Non-existence of a comprehensive national WDM policy and legal framework.
  - The attitude towards respond to leakages is not encouraging.

In summary it can be concluded base on the findings of RQ 1 that the status of WDM in ATMA has no very sound and strong foundation as it is hindered by lack of WDM policy and legal framework leading to high UFW, high pressures, and vast leakages among others.

About the research question RQ 2: *What are the influences of population, GDP growth rate, water rationing, rainfall and the corresponding WDM measures of regular and intensive on the water use in ATMA?*

- Population increment in ATMA is the major factor that put stress on the water use or supply as from the MLR analysis the population alone explain 89% of total water supply.
- GDP growth has a significant effect on water supply in ATMA as a change in GDP leads to substantial increase in supply because an increase in GDP of 1% equally leads to a corresponding increment of 2,990,000m^3/a in supply.
- Rationing of water of water has a significant impact on the water use.

- Rainfall has a relatively lower influence on the supply as a 100mm change in rainfall leads to 520,000m^3/a change is supply.
- There is so much water lost in the distribution system which does not reach the end user as the crude per capita consumption is quite over 100 l/c/d more than the calculated real per capita consumption. In other words, over 100 l/c/d of water intended to get to each consumer does not. This may actually be the crux of the woes of the water situation in ATMA because instead of each person having access to about 139 liters of water a day, it is rather about 59 liters of which the rest cannot be accounted for.
- For business as usual WDM, the overall real per capita consumption will drop to 43 l/c/d by the year 2025, due to excessive constrained supply.
- For a regular WDM i.e. reducing UFW by 2% per annum, the yawning gap between the crude per capita and the real per capita will be narrowed steadily and the real per capita consumption may increase to 61 l/c/d by the year 2025.
- For an intensive WDM strategy, i.e. reducing UFW by 5% per annum until it is reduced to 20.5% in the year 2025, the per capita consumption stabilizes around 79 l/c/d.
- Business as usual scenario, new source is required now.

In summary it can also be concluded base on the deductions and findings from RQ 2 that as a result of the lack of intensive WDM measures in ATMA, population increases, rationing of water and annual GDP growth have all contributed to the skyrocketing trend of water supply whilst desirable level of demand is not met as a result of huge losses of treated water in the distribution system.

- About the research question RQ 3 (*What factors influence domestic water use patterns in affluent and non-affluent areas?*)

  - Income is a major factor affecting water consumption as seen in the analysis that the affluent with even less population consume much more water than the non-affluent. Thus income overshadows population in terms of the influence in this case.
  - Rationing influences patterns of consumption in both affluent and non-affluent areas. Areas that are subjected to severe and prolong rationing consume less than areas with relatively regular supply of water.
  - Coverage of water supply is higher in the affluent areas than the non-affluent areas. This influences water consumption in the non-affluent areas since the low coverage cannot match with the high population hence an equally low pattern of consumption in the non-affluent areas.
  - Metering influences consumption patterns in both the affluent and non-affluent areas. This is because metered houses will discipline their consumption whilst those on fixed charges are likely to consume much more, hence both cases influencing the pattern of consumption.

- Pressures influence patterns of consumption as very low pressures minimizes the water flow to the end user. This is a typical case of Accra Newtown as seen in the analysis.

From the findings and deductions made from RQ3, it can also be concluded that significant influence of water consumption patterns in affluent and non-affluent areas are income or wealth, water rationing, metering and the extent of coverage of water supply.

- About the research question RQ4 (*What are prospects of implementing WDM at household levels in ATMA?*)
-
    - The affluent uses more of showers for bathing which may use so much water. This is an indication that for the implementation of WDM in ATMA, affluent areas must be targeted for the use of showerheads with low flow designs.
    - The low level of metered connections at household levels is a limitation on the possibilities of implementing sustainable WDM. This is because without meters a good water budget cannot be kept and the true estimates of water levels cannot be determined, all of which are required for the implementation of WDM
    - Most people of the non-affluent high density areas have no knowledge on water use efficiency and thus making it a very difficult task implementing WDM in these areas. This is because one of the basic tools necessary for the implementation of WDM at household level is to make sure the consumer has got the basic knowledge on how to use water efficiently.
    - Educational campaigns on water use efficiency through the electronic media have less impact on the non-affluent high density area which is also a limitation to implementing WDM in the non-affluent high density areas.

The findings and deductions from RQ 4 implies that prospects of implementing WDM at household level is hindered by physical infrastructure such as meters and lack of educational knowledge of water use efficiency

From all the above specific findings and deductions as well as the conclusions drawn for each of the research questions above, I can conclude generally that there had been few strides in terms of WDM and the current practices of WDM has yielded less positive significance effect on the WD of ATMA, hence the scarcity of drinking water in ATMA. Similarly the prospects of implementing WDM at household levels currently look quite difficult as this is hindered by the physical infrastructure among others mentioned in the above findings. However an intensive WDM measures incorporated with good practices of all the lapses identified above can help solve or ameliorate the water dilemma of ATM in the short term to medium term.

About the following research hypotheses:

- *WDM does not feature prominently in ATMA and its effect on the current WD is insignificant.*
- *For an intensive WDM in ATMA, desirable level of water demand can be achieved.*
- *There is less incentive for a sizable number of consumers to practice WDM at household level.*
- *Prospects of implementing WDM at household level in ATMA are constrained by absence of physical WDM infrastructure.*

From the above deductions and the conclusions, the following can be said with regard to the hypotheses set up:

- There has not been a continuous policy, strategy for WDM in ATMA.
- Substantial number of households knew little about WDM especially in the high density areas.
- Substantial number of households especially in the high density areas does not have meters.
- Water scarcity in ATMA is worsening as measures currently adopted to manage the demand have no significant influence.
- With a well practiced WDM, the water situation in ATMA may improve enormously especially through intensive WDM since desirable level may be achieved in addition to minimizing greatly the water losses in the distribution system.

Hypotheses

Thus for the first hypothesis it can be summarized that WDM does not feature prominently in ATMA and the demand management processes has not had a significant improvement on the current water demand of ATMA, hence this hypothesis is **not rejected.**

For the second hypothesis, it has been proven from the analysis that implementing intensive WDM increases greatly the per capita consumption, hence achieving desirable level of supply. This hypothesis is also **not rejected**

The absence of meters in some households as established in the research creates room for consumers to use water much more than they will if they had meters, thus this situation does not auger well for an effective WDM and as such the third hypothesis test is **not rejected.**

Finally the lack of physical infrastructure like meters and the low level knowledge or education on water use efficiency especially in the high density non affluent areas is actually a limitation to the implementation of WDM at household level in ATMA. The fourth hypothesis test as well is **not rejected**.

6.2 RECOMMENDATIONS

From the findings and deduction made from the research, my recommendations are as follows:

- An intensive WDM which incorporates all the measures of WDM should be implemented. That is ensuring continuous educational campaigns, manage pressures, respond actively to leakages as well as managing the supply etc.
- Educational campaigns on WDM should transcend the boundary of the electronic and print media only to meetings with grassroots consumers and teachings in schools.
- Supply options to WDM should not always be the priority and the focus should be on intensive WDM since this will help to make water much more available in the system for the immediate short and medium terms.
- The basic infrastructure necessary for the implementation of WDM should be put in place. This involves the increase in coverage of metered connections.
- Information is a prerequisite for WDM and thus information on all water budgets and WDM should be recorded and kept very well for future analysis.
- Management Information Systems (MIS) should be used in ATMA to be able to get adequate information on WDM. This involves the use of network modeling or hydraulic modeling e.g. EPANET as this help in decision making regarding WDM.
- The international community and NGOs should help emulate what the IUCN is doing for the SADC region in other Sub Sahara regions like the Economic Community of West African States (ECOWAS).

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APPENDECES

Appendix 1
Estimate of Population figures for ATMA

Year	n	Population
1984	0	1160112
1985	1	1206255
1986	2	1254233
1987	3	1304119
1988	4	1355989
1989	5	1409923
1990	6	1466002
1991	7	1524311
1992	8	1584940
1993	9	1647980
1994	10	1713527
1995	11	1781681
1996	12	1852546
1997	13	1926230
1998	14	2002845
1999	15	2082507
2000	16	2165337
2001	17	2251462
2002	18	2341012
2003	19	2434125
2004	20	2530940
2005	21	2631607
2006	22	2736277
2007	23	2845111
2008	24	2958273
2009	25	3075937
2010	26	3198280
2011	27	3325490
2012	28	3457759
2013	29	3595289
2014	30	3738289
2015	31	3886977
2016	32	4041579
2017	33	4202330
2018	34	4369475
2019	35	4543268
2020	36	4723974
2021	37	4911867
2022	38	5107233
2023	39	5310370
2024	40	5521586
2025	41	5741204

NB: The above estimate was done base on the census population figures of the years1984 and 2000 using the formula: $P = P_0 e^{rt}$ and a calculated growth rate of 0.039.

Where P is the population to be estimated in the year t, P_o is the initial population and r is the growth rate.

Appendix 2a

GDP Growth

GROSS DOMESTIC PRODUCT

	Constant Prices mill. cedis	**Current Prices mill. cedis**	Growth rate %age
1985	5,420.100	343,048.400	5.1
1986	5,701.900	511,372.700	5.2
1987	5,975.300	745,999.800	4.8
1988	6,346.900	1,051,196.300	6.2
1989	6,632.600	1,417,214.400	4.5
1990	6,853.400	2,031,686.300	3.3
1991	7,216.600	2,574,774.100	5.3
1992	7,498.000	3,008,779.200	3.9
	At Constant 1993 Prices (billion cedis)	**At Current Prices (billion Cedis)**	
1993	3,872.500	3,872.500	4.0
1994	3,999.100	5,205.200	3.3
1995	4,160.000	7,752.600	4.0
1996	4,351.200	11,339.200	4.6
1997	4,533.874	14,113.400	4.2
1998	4,746.683	17,295.709	4.7
1999	4,956.890	20,579.791	4.4
2000	5,142.086	27,152.701	3.7
2001	5,357.141	38,070.743	4.2
2002	5,600.800	48,862.412	4.5
2003	5,894.726	66,157.700	5.2
2004	6,223.525	79,887.394	5.6
2005	6,588.733	96,944.853	5.9
2006	7,000.502	114,812.640	6.2

Appendix 2b

Projected GDP Growth (Source: World Bank World Development indicators, adjusted to 2000 base and estimated and projected values developed by the Economic Research Service ; updated: 12/19/06)

Country /Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Angola	3.14	14.35	3.45	11.10	15.70	27.29	20.50	11.70	7.80	6.20	6.44	6.22	6.22	6.22	5.92	5.82	5.72
Burundi	3.20	4.50	-1.20	5.50	5.00	5.00	4.95	4.85	4.75	4.66	4.57	4.47	4.38	4.30	4.21	4.13	4.04
Benin	5.02	6.00	3.90	2.70	4.80	5.20	5.11	5.01	4.92	4.84	4.75	4.66	4.58	4.50	4.42	4.34	4.26
Botswana	5.16	4.96	6.72	4.89	4.80	5.00	5.00	4.96	4.87	4.37	4.44	4.39	4.33	4.28	4.23	4.17	4.12
Burkina	5.90	4.40	6.50	3.90	7.09	4.10	4.02	3.94	3.86	3.78	3.71	3.63	3.56	3.49	3.42	3.35	3.28
Cameroon	5.30	4.20	4.50	4.30	2.60	4.10	4.30	4.36	4.32	4.29	4.25	4.22	4.18	4.15	4.12	4.08	4.05
Cape Verde Islands	3.80	4.60	5.00	5.50	6.30	6.20	6.11	6.02	5.93	5.84	5.75	5.66	5.58	5.49	5.41	5.33	5.25
Central African Republic	1.50	-0.80	-7.60	1.30	2.80	3.00	3.20	3.15	3.10	3.06	3.01	2.97	2.92	2.88	2.84	2.79	2.75
Chad	9.90	9.90	11.30	29.80	10.10	6.00	4.70	3.60	3.53	3.46	3.39	3.32	3.25	3.19	3.18	3.18	3.17
Comoros Islands	2.33	2.32	2.10	1.91	2.80	3.07	3.36	3.68	3.58	3.48	3.39	3.29	3.21	3.12	3.04	2.95	2.87
Congo Combined	0.48	3.99	3.47	5.13	6.80	6.50	6.20	6.08	5.80	5.50	4.50	4.30	4.00	4.00	3.70	3.50	3.40
Cote D Ivoire	0.10	-1.63	-1.66	1.64	0.60	2.40	2.70	3.63	3.57	3.52	3.46	3.41	3.36	3.31	3.26	3.21	3.16
Djibouti	1.86	2.55	3.53	3.00	3.30	3.50	3.47	3.43	3.40	3.36	3.33	3.30	3.26	3.23	3.20	3.17	3.13
Equatorial Guinea	1.45	17.62	14.70	9.98	9.20	6.70	6.50	6.00	5.60	5.20	5.00	4.50	4.20	4.00	3.80	3.50	3.20
Eritrea	9.23	0.66	3.00	1.77	0.50	0.83	2.50	2.46	2.41	2.37	2.33	2.29	2.25	2.21	2.17	2.13	2.10
Ethiopia	8.81	2.00	-3.86	13.11	8.60	5.37	5.61	5.82	6.06	4.60	5.50	5.40	5.40	5.30	5.20	5.20	5.10
Gabon	2.50	0.00	2.60	1.40	2.70	2.90	3.00	2.90	3.00	3.20	3.30	3.50	3.50	3.50	3.60	3.60	3.60
Gambia	5.80	-3.20	6.70	8.30	4.50	4.70	4.63	4.56	4.50	4.43	4.37	4.31	4.24	4.18	4.12	4.06	4.00
Ghana	4.20	4.50	5.20	5.80	5.80	5.80	5.90	5.96	6.02	5.90	5.72	5.55	5.44	5.33	5.22	5.12	5.02
Guinea	3.80	4.20	1.20	2.60	3.00	4.40	4.80	4.82	4.85	4.87	4.85	4.82	4.78	4.73	4.68	4.63	4.59
Guinea Bissau	0.20	-7.20	0.60	4.30	2.30	2.80	2.70	2.50	2.48	2.46	2.44	2.43	2.41	2.39	2.37	2.35	2.34
Kenya	4.38	0.40	2.77	4.34	5.00	4.80	4.53	4.35	4.50	4.30	4.10	3.90	3.70	3.50	3.30	3.30	3.30
Liberia	2.90	3.70	-31.30	2.40	7.50	6.80	7.00	6.50	6.30	4.50	4.20	4.12	4.03	3.95	3.87	3.80	3.72
Lesotho	3.21	3.50	3.28	2.34	1.20	1.70	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.94	1.90	1.86	1.82
Madagascar	6.00	-12.70	9.79	5.25	5.50	6.50	5.80	5.67	5.55	5.43	5.31	5.20	5.08	4.97	4.86	4.76	4.66
Malawi	-4.97	2.86	6.07	6.71	2.00	5.50	5.43	5.36	5.30	5.23	5.16	5.10	5.04	4.97	4.91	4.85	4.79
Mali	12.10	4.15	7.44	2.19	5.40	5.50	5.60	5.70	5.59	5.47	5.36	5.26	5.10	4.95	4.80	4.77	4.75
Mauritania	3.65	2.32	6.38	6.86	5.50	17.90	12.20	10.20	7.40	6.90	6.68	6.46	6.25	6.05	5.85	5.66	5.48
Mauritius	6.70	4.40	3.10	4.20	3.00	2.60	2.80	3.00	3.70	4.33	4.20	4.18	4.16	4.15	4.13	4.12	4.10
Mozembique	13.10	8.16	7.80	7.20	7.70	7.50	7.24	5.76	5.52	5.51	5.40	5.32	5.28	5.17	5.28	5.05	4.57
Namibia	2.40	6.67	3.48	5.95	3.80	3.67	3.70	4.00	4.00	4.00	4.00	4.50	4.50	4.50	4.50	4.50	4.50
Niger	7.10	3.00	5.32	0.90	3.50	3.80	3.70	3.70	3.50	3.48	3.45	3.43	3.41	3.39	3.37	3.34	3.32
Nigeria	3.10	1.55	10.69	6.00	6.90	6.86	6.60	6.80	7.00	6.70	6.50	6.00	5.80	5.20	4.80	4.90	5.00
Rwanda	6.72	9.38	0.96	4.00	3.22	3.46	3.40	3.35	3.29	3.24	3.19	3.14	3.09	3.04	2.99	2.94	2.90
Sao Tome and Principe	4.00	4.10	4.50	4.50	3.80	5.50	7.00	8.50	15.00	27.00	13.00	6.70	5.40	5.30	4.85	4.50	4.34
Senegal	4.69	1.14	6.45	6.16	6.20	5.20	5.12	5.27	5.21	5.15	5.08	5.02	4.96	4.90	4.84	4.79	4.73
Seychelles	-2.21	0.31	-6.30	-2.00	1.00	2.60	3.30	3.30	3.27	3.23	3.20	3.17	3.14	3.11	3.08	3.05	3.01
Sierra Leone	5.41	6.30	9.20	7.40	7.53	6.90	6.30	6.17	6.05	5.93	5.81	5.69	5.58	5.47	5.36	5.25	5.15
Sudan	6.10	6.00	6.00	6.00	8.01	6.60	6.25	6.49	5.66	6.38	5.90	5.46	5.05	4.91	4.77	4.64	4.51
Swaziland	1.79	2.80	2.40	2.12	1.75	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.80	1.80	1.50	1.50
Tanzania	6.24	7.24	7.10	6.28	6.80	5.70	6.80	6.00	5.70	4.50	4.20	4.10	4.00	3.90	3.89	3.88	3.87
Togo	-0.18	4.14	2.70	3.00	2.80	3.50	3.47	3.43	3.40	3.20	3.17	3.14	3.10	3.07	3.04	3.01	2.98
Uganda	6.10	6.84	4.73	5.73	5.50	5.70	5.90	4.80	4.50	4.50	4.40	4.20	4.00	4.00	3.90	3.90	3.90
Zaire (Congo, Democratic Republic)	4.56	3.93	3.14	2.70	8.50	4.60	4.21	3.39	3.36	3.34	3.31	3.29	3.26	3.24	3.21	3.19	3.16
Zambia	4.89	3.30	5.10	4.65	4.30	6.04	6.64	5.97	5.27	5.69	5.96	5.49	5.49	5.63	5.68	5.58	5.79
Zimbabwe	-2.70	-4.40	-10.40	-4.20	-10.33	-5.23	3.58	4.06	3.98	3.34	3.59	1.65	3.70	3.78	2.99	3.06	2.91

Appendix 3

MLR Analysis

Constants	45362.7	a
	26.1	b
	-5.2	c
	2989.0	d
	6189.7	e

Year	water supply	projected supply	Population	rainfall	GDP	Rationing
	1000m3/yr	1000m3/yr	1000	mm/yr	%	Yes/No
1986	91880	90844	1254	545.2	5.2	0.0
1987	90456	90445	1304	640.3	4.8	0.0
1988	90907	94246	1356	988.9	6.2	0.0
1989	95328	92247	1410	656.7	4.5	0.0
1990	93239	90666	1466	568.6	3.3	0.0
1991	95419	95797	1524	1008.0	5.3	0.0
1992	98916	95539	1585	557.0	3.9	0.0
1993	93772	97813	1648	509.3	4.0	0.0
1994	94742	97063	1714	547.9	3.3	0.0
1995	92745	104784	1782	1029.8	4.0	1.0
1996	117286	109975	1853	716.6	4.6	1.0
1997	114216	108077	1926	1223.5	4.2	1.0
1998	112742	115249	2003	513.6	4.7	1.0
1999	119473	115871	2083	641.8	4.4	1.0
2000	113571	116640	2165	512.2	3.7	1.0
2001	115598	118533	2251	837.6	4.2	1.0
2002	125883	121071	2341	1010.0	4.5	1.0
2003	126000	126235	2434	887.0	5.2	1.0
2004	131796	131376	2531	574.2	5.6	1.0
2005	132315	133816	2632	777.9	5.9	1.0
2006		131758	2736	700.0	6.20	0.0
2007		133705	2845	700.0	5.90	0.0
2008		136841	2958	700.0	5.96	0.0
2009		140095	3076	700.0	6.02	0.0
2010		142933	3198	700.0	5.90	0.0
2011		145719	3325	700.0	5.72	0.0
2012		148667	3458	700.0	5.55	0.0
2013		151932	3595	700.0	5.44	0.0
2014		155340	3738	700.0	5.33	0.0
2015		158897	3887	700.0	5.22	0.0
2016		162638	4042	700.0	5.12	0.0
2017		166539	4202	700.0	5.02	0.0
2018		172425	4369	700.0	5.53	0.0
2019		176966	4543	700.0	5.53	0.0
2020		181688	4724	700.0	5.53	0.0
2021		186598	4912	700.0	5.53	0.0
2022		191703	5107	700.0	5.53	0.0
2023		197011	5310	700.0	5.53	0.0
2024		202530	5522	700.0	5.53	0.0
2025		208269	5741	700.0	5.53	0.0

Output result of Regression

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.956633628
R Square	0.915147899
Adjusted R	0.892520672
Standard E	4903.008953
Observatior	20

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	3889066044	972266511	40.44454504	7.25423E-08
Residual	15	360592452	24039496.8		
Total	19	4249658496			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	45362.71911	9820.459114	4.619205537	0.000334023	24430.90609	66294.53213	24430.90609	66294.5321
X Variable ·	26.13039342	5.184777923	5.039828862	0.000146621	15.07930092	37.18148592	15.07930092	37.1814859
X Variable :	-5.195724142	5.810011612	-0.894270871	0.385301525	-17.5794707	7.18802241	-17.57947069	7.18802241
X Variable :	2989.016116	1512.537	1.97616066	0.066825256	-234.88017	6212.912402	-234.8801703	6212.9124
X Variable ‹	6189.707749	4455.542063	1.389215422	0.185047062	-3307.05531	15686.47081	-3307.055313	15686.4708

Appendix 4a

Data of monthly water consumption by walk

Consumption by walk for the month of November 2005

CYCLE	WALK	CONSUMPTION	N
13	5	1825	
13	10	3655	
13	15	2607	
[illegible]	[illegible]	[illegible]	199
13	25	1279	106
13	30	1753	196
13	35	209	77
13	40	482	81
14	5	2193	193
14	10	423	92
14	15	70	154
14	20	20	73
14	25	1902	181
14	30	574	182
14	35	1226	219
15	5	3198	
15	[illegible]	[illegible]	122
15	15	1379	152
15	20	1349	124
15	25	3851	
15	30	4454	
15	35	2510	
15	40	9526	394
15	45	6620	
15	50	3537	145
15	55	5971	149
15	60	2092	
15	65	5497	
15	70	5583	266

CYCLE	WALK	CONSUMPTION	N
[illegible]	5	[illegible]	112
[illegible]	10	4300	128
[illegible]	15	3844	77
[illegible]	20	[illegible]	386
16	25	5423	237
16	30	6778	
16	35	48579	
16	40	14896	
1	45	7552	
16	50	9149	
16	55	7294	
16	58	0	
16	60	9663	
16	65	11187	337
16	70	2797	130
16	75	7795	

Affluent Areas	Consumption	N
[illegible]	[illegible]	703
Roman Ridge	5423	237
Abelemkpe	24617	954
Dworwulu	13984	467

Non-affluent Areas	Consumption	N
Nima	5643	659
Mamobi	3702	582
Newtown	3418	634
Kotobabi	2728	276

Consumption by walk for the month of December 2005

CYCLE	WALK	CONSUMPTION	N
13	5	1866	
13	10	3682	
13	15	3295	
13	20	1823	199
13	25	1189	106
13	30	1508	196
13	35	90	78
13	40	261	80
14	5	1375	195
14	10	195	92
14	15	73	154
14	20	20	73
14	25	1662	182
14	30	450	182
[redacted]	35	938	219
15	[illegible]	[illegible]	
15	10	539	122
[illegible]	[illegible]	1370	152
15	20	1109	124
15	25	3327	
15	30	3974	
15	35	2565	
15	40	9723	394
15	45	6833	
15	50	2980	145
15	55	6756	149
15	60	2203	
15	65	5971	
15	70	5573	266

CYCLE	WALK	CONSUMPTION	N
[redacted]			111
16	10	4211	128
16	15	4356	77
16	20	17432	386
16	[illegible]	5569	238
16	30	7118	
16	35	49907	
16	40	14366	
16	45	8837	
16	50	8270	
16	55	8786	
16	58	0	
16	60	9864	
16	65	11946	337
16	70	3538	130
16	75	7054	

Affluent Areas	Consumption	N
Airpo[redacted]		702
Roman Ridge	5569	238
Abelemkpe	25032	954
Dworwulu	15484	467

Non-affluent Areas	Consumption	N
Nima	48[redacted]	659
Mamobi	30[redacted]	583
Newtown	2202	636
Kotobabi	2479	276

Consumption by walk for the month of January 2006

CYCLE	WALK	CONSUMPTION	N
13	5	1145	
13	10	3532	
13	15	3248	
13	20	1776	199
13	25	1002	106
13	30	795	196
13	35	121	79
13	40	186	80
14	5	1024	195
14	10	68	92
14	15	13	154
14	20	20	73
14	25	1508	182
14	30	391	182
14	35	663	219
[illegible]	[illegible]	[illegible]	
15	10	402	122
15	[illegible]	[illegible]389	152
15	20	1031	124
15	25	3032	
15	30	4078	
15	35	2462	
15	40	9489	396
15	45	6625	
15	50	2939	145
15	55	6000	149
15	60	2144	
15	65	6059	
15	70	5784	266

CYCLE	WALK	CONSUMPTION	N
[redacted]			
[illegible]	10	4681	[illegible]
[illegible]	15	3432	[illegible]
[illegible]	20	[illegible]	[illegible]
16	25	5226	238
16	30	6329	
16	35	43919	
16	40	13974	
16	45	7374	
16	50	9059	
16	55	8386	
16	58	0	
16	60	11256	
16	65	10992	338
16	70	3956	130

Affluent Areas	Consumption	N
[redacted]	[redacted]	704
Roman Ridge	522	238
Abelemkpe	24212	956
Dworwulu	14948	468

Non-affluent Areas	Consumption	N
Nima	3880	660
Mamobi	256	583
Newtown	1527	636
Kotobabi	2420	276

Consumption by walk for the month of February 2006

CYCLE	WALK	CONSUMPTION	N
13	5	1261	
13	10	4096	
13	15	3012	
13	20	1507	199
13	25	767	106
13	30	1027	195
13	35	84	78
13	40	276	79
14	5	1100	195
14	10	27	92
14	15	134	154
14	20	20	73
14	25	1677	183
14	30	457	182
14	35	616	219
15	5	2560	
[illegible]	[illegible]	[illegible]	122
[illegible]	[illegible]	1420	152
15	20	1273	124
15	25	3304	
15	30	4399	
15	35	2746	
15	40	9383	396
15	45	7149	
15	50	3039	145
15	55	8054	149
15	60	2108	
15	65	5535	
15	70	5438	266

CYCLE	WALK	CONSUMPTION	
[illegible]	[illegible]	[illegible]	111
16	10	4581	129
16	15	4122	78
16	20	12853	383
[illegible]	25	5444	238
16	30	5925	
16	35	48638	
16	40	12650	
16	45	8710	
16	50	9884	
16	55	10513	
16	58	0	
16	60	12457	
16	65	14110	338
16	70	3041	130
16	75	7742	

Affluent Areas	Consumption	N
Airport Residential	[illegible]	701
Roman Ridge	5444	238
Abelemkpe	25914	956
Dworwulu	17151	468

Non-affluent Areas	Consumption	
Nima	3661	657
Mamobi	2750	584
Newtown	1678	636
Kotobabi	2693	276

Consumption by walk for the month of March 2006

CYCLE	WALK	CONSUMPTION	N
13	5	1408	
13	10	3431	
13	15	3239	
13	20	1686	199
13	25	677	107
13	30	1179	196
13	35	193	78
13	40	330	79
14	5	1282	195
14	10	49	92
14	15	133	154
14	20	20	73
14	25	2013	183
14	30	410	182
14	35	556	219
1[illegible]	5	[illegible]71	
15	10	203	122
15	15	1347	152
15	20	1096	124
15	25	2464	
15	30	4120	
15	35	2426	
15	40	9015	396
15	45	6142	
15	50	3045	145
15	55	7658	150
15	60	2239	
15	65	5831	
15	70	5446	266

CYCLE	WALK	CONSUMPTION	N
[illegible]	[illegible]	[illegible]	116
[illegible]	10	5626	129
[illegible]	15	3965	78
[illegible]	20	15555	382
16	25	5351	238
16	30	7001	
16	35	47902	
16	40	10453	
16	45	9806	
16	50	8756	
16	55	9749	
16	58	0	
16	60	11771	
16	65	12581	336
16	70	3309	129
16	75	5602	

Affluent Areas	Consumption	N
[illegible]	2971[illegible]	705
Roman Ridge	5351	238
Abelemkpe	25164	957
Dworwulu	15890	465

Non-affluent Areas	Consumption	
Nima	4065	659
[illegible]amobi	2979	584
[illegible]ewtown	1687	636
Kotobabi	2443	276

Consumption by walk for the month of April 2006

CYCLE	WALK	CONSUMPTION	N
13	5	1266	
13	10	3600	
13	15	3199	
13	20	1814	199
13	25	648	107
13	30	1478	195
13	35	257	78
13	40	437	79
14	5	1381	195
14	10	94	92
14	15	141	154
14	20	20	73
14	25	1927	184
14	30	416	182
14	35	721	219
[illegible]	[illegible]	[illegible]	
15	10	72	113
15	15	1305	152
15	20	1066	124
15	25	2944	
15	30	3882	
15	35	2489	
15	40	7789	392
15	45	6836	
15	50	2808	146
15	55	6965	151
15	60	2303	
15	65	5590	
15	70	4981	264

CYCLE	WALK	CONSUMPTION	N
[illegible]	[illegible]	[illegible]	116
16	10	3869	119
16	15	3818	76
16	20	[illegible]235	383
16	25	5584	238
16	30	6851	
16	35	46752	
16	40	12655	
16	45	9093	
16	50	10525	
16	55	8456	
16	58	0	
16	60	11397	
16	65	11775	336
16	70	2162	129
16	75	5410	

Affluent Areas	Consumption	N
Airport Residential	2876[illegible]	694
Roman Ridge	558[illegible]	238
Abelemkpe	22[illegible]43	953
Dworwulu	13937	465

Non-affluent Areas	Consumption	N
Nima	4634	658
Mamobi	3064	585
Newtown	1708	627
Kotobabi	2371	276

Consumption by walk for the month of May 2006

CYCLE	WALK	CONSUMPTION	N
13	5	1021	
13	10	3381	
13	15	2657	
13	20	1469	199
13	25	613	105
13	30	1749	196
13	35	337	78
13	40	433	79
14	5	1296	195
14	10	84	92
14	15	290	154
14	20	60	73
14	25	2138	188
14	30	469	181
14	35	850	221
15	[illegible]	[illegible]	
15	10	92	113
15	[illegible]	1415	152
15	20	1046	124
15	25	2612	
15	30	4259	
15	35	2716	
15	40	8593	392
15	45	6473	
15	50	3154	147
15	55	5718	152
15	60	2385	
15	65	6026	
15	70	5362	264

CYCLE	WALK	CONSUMPTION	N
[illegible]	[illegible]	[illegible]	116
[illegible]	10	4687	119
[illegible]	15	3881	76
[illegible]	20	[illegible]	383
16	25	5781	238
16	30	6338	
16	35	48373	
16	40	11633	
16	45	8457	
16	50	8300	
16	55	9115	
16	58	0	
16	60	11114	
16	65	12607	336
16	70	3502	130
16	75	6418	

Affluent Areas	Consumption	N
[illegible]	[illegible]	694
Roman Ridge	5781	238
Abelemkpe	22827	955
Dworwulu	16109	466

Non-affluent Areas	Consumption	N
Nima	4601	657
Mamobi	3457	590
Newtown	1822	627
Kotobabi	2465	276

Consumption by walk for the month of June 2006

CYCLE	WALK	CONSUMPTION	N
13	5	1493	
13	10	3567	
13	15	3029	
13	20	1906	197
13	25	928	104
13	30	2077	196
13	35	368	78
13	40	718	77
14	5	1566	195
14	10	48	92
14	15	364	153
14	20	60	73
14	25	2494	188
14	30	443	182
14	35	902	221
[illegible]	[illegible]	[illegible]	
15	10	128	113
15	15	1292	153
15	20	970	124
15	25	2550	
15	30	4433	
15	35	2693	
15	40	8381	389
15	45	6452	
15	50	2499	147
15	55	5979	151
15	60	2305	
15	65	5131	
15	70	5315	260

CYCLE	WALK	CONSUMPTION	N
[illegible]	[illegible]	[illegible]	116
16	10	4281	125
16	15	[illegible]755	76
16	20	12904	384
16	2	6257	238
16	30	7178	
16	35	45349	
16	40	12467	
16	45	7101	
16	50	6629	
16	55	7445	
16	58	0	
16	60	10206	
16	65	10324	334
16	70	3292	124
16	75	6083	

Affluent Areas	Consumption	N
Airport Residential	[illegible]	701
Roman Ridge	[illegible]57	238
Abelemkpe	22174	947
Dworwulu	13616	458

Non-affluent Areas	Consumption	N
Nima	5997	652
Mamobi	383[illegible]	591
Newtown	2166	626
Kotobabi	2262	277

Consumption by walk for the month of July 2006

CYCLE	WALK	CONSUMPTION	N
13	5	1054	
13	10	3596	
13	15	2906	
13	20	2047	197
13	25	937	105
13	30	2538	196
13	35	427	78
13	40	752	77
14	5	1866	195
14	10	34	92
14	15	319	153
14	20	40	73
14	25	2589	188
14	30	472	182
14	35	[illegible]	221
15	5	3129	
15	10	155	113
15	15	1554	155
15	20	1171	124
15	25	3642	
15	30	4842	
15	35	2745	
15	40	8517	389
15	45	6154	
15	50	3456	147
15	55	5448	151
15	60	2571	
15	65	6509	
15	70	5449	260

CYCLE	WALK	CONSUMPTION	N
[illegible]	[illegible]	[illegible]	116
[illegible]	10	4455	125
[illegible]	15	2927	76
[illegible]	20	[illegible]	381
16	25	6231	238
16	30	6761	
16	35	60316	
16	40	15090	
16	45	5869	
16	50	9107	
16	55	7273	
16	58	0	
16	60	10696	
16	65	12514	334
16	70	2666	124
16	75	8315	

Affluent Areas	Consumption	N
[illegible]	2562	698
Roman Ridge	6231	238
Abelemkpe	22870	947
Dworwulu	15180	458

Non-affluent Areas	Consumption	N
Nima	6701	653
Mamobi	412	591
Newtown	2414	626
Kotobabi	2725	279

Consumption by walk for the month of August 2006

CYCLE	WALK	CONSUMPTION	N
13	5	1049	
13	10	3425	
13	15	2702	
13	20	1743	198
13	25	954	106
13	30	2399	198
13	35	439	78
13	40	714	77
14	5	1794	195
14	10	17	92
14	15	326	152
14	20	40	73
14	25	2504	186
14	30	540	182
[illegible]	[illegible]	[illegible]	221
15	5	2449	
15	10	232	113
15	15	443	155
15	20	1041	124
15	25	3116	
15	30	4805	
15	35	2508	
15	40	9375	390
15	45	6287	
15	50	2793	147
15	55	5938	151
15	60	2418	
15	65	5999	
15	70	6121	260

CYCLE	WALK	CONSUMPTION	N
[illegible]	[illegible]	[illegible]	116
16	10	4348	122
16	15	4385	76
16	20	16103	381
16	25	5242	239
16	30	5747	
16	35	45928	
16	40	13166	
16	45	8555	
16	50	7109	
16	55	7086	
16	58	0	
16	60	10749	
16	65	9080	334
16	70	2521	125
16	75	6746	

Affluent Areas	Consumption	N
[illegible]esidential	[illegible]	695
[illegible]oman Ridge	5242	239
Abelemkpe	24227	948
Dworwulu	11601	459

Non-affluent Areas	Consumption	N
[illegible]	[illegible]	657
[illegible]amobi	4117	589
[illegible]ewtown	2409	625
Kotobabi	2484	279

Consumption by walk for the month of September 2006

CYCLE	WALK	CONSUMPTION	N
13	5	1203	
13	10	3320	
13	15	3117	
13	20	2083	198
13	25	988	106
13	30	1863	198
13	35	360	78
13	40	738	77
14	5	1892	195
14	10	78	92
14	15	288	152
14	20	40	73
14	25	2295	185
14	30	553	183
14	35	574	221
15	5	3141	
15	10	182	113
15	15	1615	155
15	20	1189	124
15	25	3111	
15	30	4848	
15	35	2790	
15	40	9538	391
15	45	6895	
15	50	3002	147
15	55	5138	151
15	60	2583	
15	65	6275	
15	70	5637	261

CYCLE	WALK	CONSUMPTION	N
[illegible]	5	[illegible]	115
[illegible]	10	4401	122
[illegible]	15	3224	76
[illegible]	20	[illegible]	381
16	25	5504	239
16	30	6098	
16	35	50200	
16	40	12063	
16	45	8521	
16	50	8761	
16	55	8029	
16	58	0	
16	60	11387	
16	65	11155	334
16	70	2380	125
16	75	7428	
Consumption on city basis			
Affluent Areas	**Consumption**	**N**	
[illegible]	[illegible]	694	
Roman Ridge	5504	239	
Abelemkpe	23315	950	
Dworwulu	13535	459	
Non-affluent Areas	**Consumption**	**N**	
Nima	6032	657	
Mamobi	342[illegible]	589	
Newtown	2480	625	
Kotobabi	2804	279	

Consumption by walk for the month of October 2006

CYCLE	WALK	CONSUMPTION	N
13	5	1105	
13	10	3834	
13	15	2949	
[redacted]	20	1991	198
13	25	1221	106
13	30	1414	198
13	35	629	78
13	40	662	77
14	5	1659	196
14	10	15	92
14	15	458	152
14	20	20	73
14	25	1935	185
14	30	455	183
14	35	617	221
15	5	2453	
15	10	173	113
15	15	1572	115
15	20	1387	127
15	25	2993	
15	30	5069	
15	35	2693	
15	40	9202	391
[illegible]	45	6514	
15	50	3229	147
15	55	5197	151
15	60	2504	
15	65	6175	
15	70	5440	261

CYCLE	WALK	CONSUMPTION	N
[redacted]			115
16	10	4889	123
16	15	3348	76
16	20	14137	381
16	25	5656	239
16	30	6460	
16	35	52195	
16	40	10726	
16	45	8919	
16	50	7670	
16	55	7789	
16	58	0	
16	60	12043	
16	65	9038	335
16	70	2326	125
16	75	8469	

Consumption on city basis

Affluent Areas	Consumption	N
[redacted]		695
Roman Ridge	5656	239
Abelemkpe	23068	950
Dworwulu	11364	460

Non-affluent Areas	Consumption	N
Nima	5917	657
Mamobi	3007	589
Newtown	2325	626
Kotobabi	2959	242

Appendix 4c

UNESCO-IHE Institute for Water Education **QUESTIONAIRE FOR HOUSEHOLDS INTERVIEW**

CITY............... INTERVIEWER.................... CUSTOMER NUMBER........................

1. How many people living in the house use the water? ....
2. Is the quantity of water adequate for you? Yes ☐ No ☐
3. Do you have a swimming pool? Yes ☐ No ☐
4. Do you have a garden (lawn)? Yes ☐ No ☐
5. Are you using your water for any retail business? Yes ☐ No ☐
6. Are you aware of any method for saving water? Yes ☐ No ☐
   a. If yes from where? a. TV b. Radio c. Meeting d. Others......................
7. What do you use for bathing? a. Bucket b. Bathtubs c. Shower d. Others..........
8. Do you brush your teeth from a cup or from the tap? a. Cup b. Tap
9. Which of the ff. is your first priority of water use?
   a. Cooking b. Drinking c. Bathing d. Gardening e. Others.............
10. Do you have an alternative source to tap water? Yes ☐ No ☐
    If yes, what is the source?..
11. Is your connection equipped with water meter? Yes ☐ No ☐
    If yes, is the meter working? Yes ☐ No ☐
12. Is your meter reading done every month? Yes ☐ No ☐
13. For how many hours do you have access to water? ....
14. Do you have an installed booster for sucking water to your home Yes ☐ No ☐
    If No, does an individual's booster deprive you of access to water? Yes ☐ No ☐
15. Do you experience water leakages? Yes ☐ No ☐
16. Do you report any water leakages or pipe bursts? Yes ☐ No ☐
    If yes, how long does it take to be repaired? ....
17. Is there a possibility of using less water than currently used? Yes ☐ No ☐
    If yes, how...

Comments:

Appendix 4c

Summary of Questionnaire Data

	Airport Residential	%	Dzorwulu	%	Newtown	%	Mamobi	%	Nima	%
Total Samples	15	100	15	100	15	100	15	100	15	100
Perception on adequacy of water										
Adequate	7	47	15	100	0	0	1	7	4	27
Not adequate	8	53	0	0	15	100	14	93	11	73
Priority of Water										
Cooking	9	60	0	0	3	20	5	33	1	7
Drinking	0	0	1	7	8	53	8	53	12	80
Bathing	6	40	10	67	4	27	2	13	2	13
Others	0		4	27	0	0	0	0	0	0
Source of Eduaction on Water use										
Television	5	33	13	87	5	33	0	0	0	0
Radio	10	67	1	7	0	0	7	47	0	0
Meeting	0	0	0	0	0	0	4	27	0	0
Others	0	0	1	7	0	0	4	27	0	0
None	0	0	0	0	10	67	0	0	15	100
Meter Status										
Not metered	1	7	0	0	13	87	8	53	10	67
Metered Connection	14	93	15	100	2	13	7	47	5	33
Condition of Meter				0				0		
Working	14	93	14	93	2	13	7	47	5	33
Not working	0	0	1	7	0	0	0	0	0	0
Experience of leakage at home								0		
Yes	15	100	0	0	9	60	0	0	13	87
No	0	0	15	100	6	40	15	100	2	13
Mode of brushing teeth						0		0		
Cup	7	47	10	67	15	100	15	100	14	93
Tap	8	53	5	33	0	0	0	0	1	7
Swimming Pool								0		
Yes	0	0	0	0	0	0	0	0	0	0
No	15	100	15	100	15	100	15	100	15	100
Garden										
Yes	2	13	0	0	0	0	0	0	0	0
No	13	87	15	100	15	100	15	100	15	100
What is use for bathing										
Bucket	2	13	1	7	15	100	14	93	15	100
Bathtubs	2	13	0	0	0	0	0	0	0	0
Showers	11	73	14	93	0	0	1	7	0	0