RESEARCH PROJECT REPORT

DOMESTIC WATER CONSUMPTION PER CAPITA: A CASE STUDY OF SELECTED HOUSEHOLDS IN NAIROBI.

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GEOGRAPHY DEPARMENT
UNIVERSITY OF NAIROBI

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DECLARATION

I declare that this research project is my own original work, and that it has not been presented in any other academic institution for examination purposes.

Otieno, A. ______________

This research paper has been submitted for examination with my approval as University supervisor.

Dr. OGEMBO, W.O. ______________

08/09/05

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List of acronyms and abbreviations

DC's	Developed Countries
LDC's	Least Developed Countries
GOK	Government of Kenya
MOWRMD	Ministry of Water Resources Management and Development
NAWASCO	Nairobi Water and Sewerage Company
NCC	Nairobi City Council
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund

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ABSTRACT

Global freshwater consumption has increased six fold between 1990 and 1999; this is more than twice the population growth. These statistics indicate that population alone cannot account for all the increase in water consumption. There are other interlinked variables that need to be analyzed and verified by research. Freshwater use by continents is partly based on several socio-economic development factors, including population and climatic characteristics (Chalecki, 2002).

Global efforts to manage and utilize freshwater resources in a sustainable manner have been hampered chiefly by lack of accurate information on water use for human needs in quantitative terms.

This research project investigated the per capita consumption of residents of Prudential and Umoja II estates of Nairobi. The relationship between water consumption patterns and the socio-economic status of the respondents was investigated. The results showed that the socio-economic status of consumers had a significant impact on water consumption per capita.

The per capita consumption in Prudential estate was found to be 119 Litres per day. The per capita consumption in Umoja II estate was found to be 58.8 Litres per day.

The study also examined the role played by the size of urban households in determining the per capita domestic water consumption. This attribute of population was found to exert an insignificant influence on per capita domestic water consumption.

Finally, the role that seasonal climatic changes play in determining the water consumption of city residents was analyzed. The results demonstrate that seasonal climatic changes play a critical role in domestic water consumption. This led to the conclusion that global climate change could have a significant impact on water availability and on domestic water consumption patterns.

1.1 INTRODUCTION

This study investigated and determined the per capita water consumption of residents from selected households in the city of Nairobi.

Primary data was obtained from the households selected to comprise samples for the research. The source of secondary data was the Nairobi Water and Sewerage Company water-metering depot situated at Kariobangi Estate.

Nairobi has been classified as follows:

A. Upper Nairobi is an area of low density with high-income population, lying to the West and North of the central business district (CBD).

B. Eastlands is the marginalized urban fringe to the East of and away from the CBD. It has low and middle-income groups and is densely populated (Lillis, 1991).

The area of research was based in the Eastlands area of Nairobi. The Eastlands area falls within the administrative region known as Embakasi constituency of Nairobi province. This area has residential housing estates that indicate the different socio-economic profiles of the population.

Study sites

a) Prudential Estate,
b) Umoja II Estate.

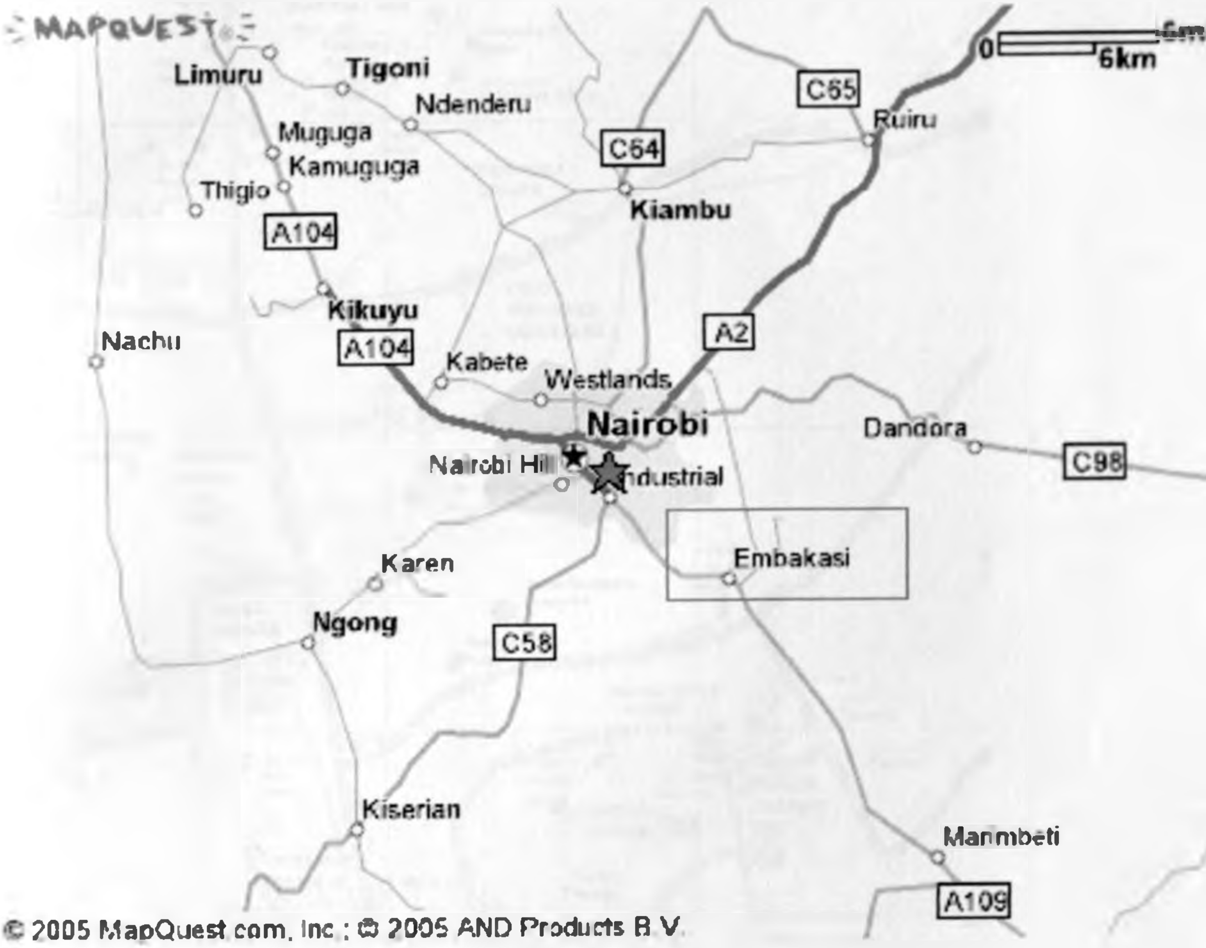
Prudential estate represents the high-income population in this socio-economic profile. Umoja II represents the population of low socio-economic status in this relative scale.

MAPS OF STUDY AREAS

MAP.A. LOCATION OF NAIROBI IN KENYA

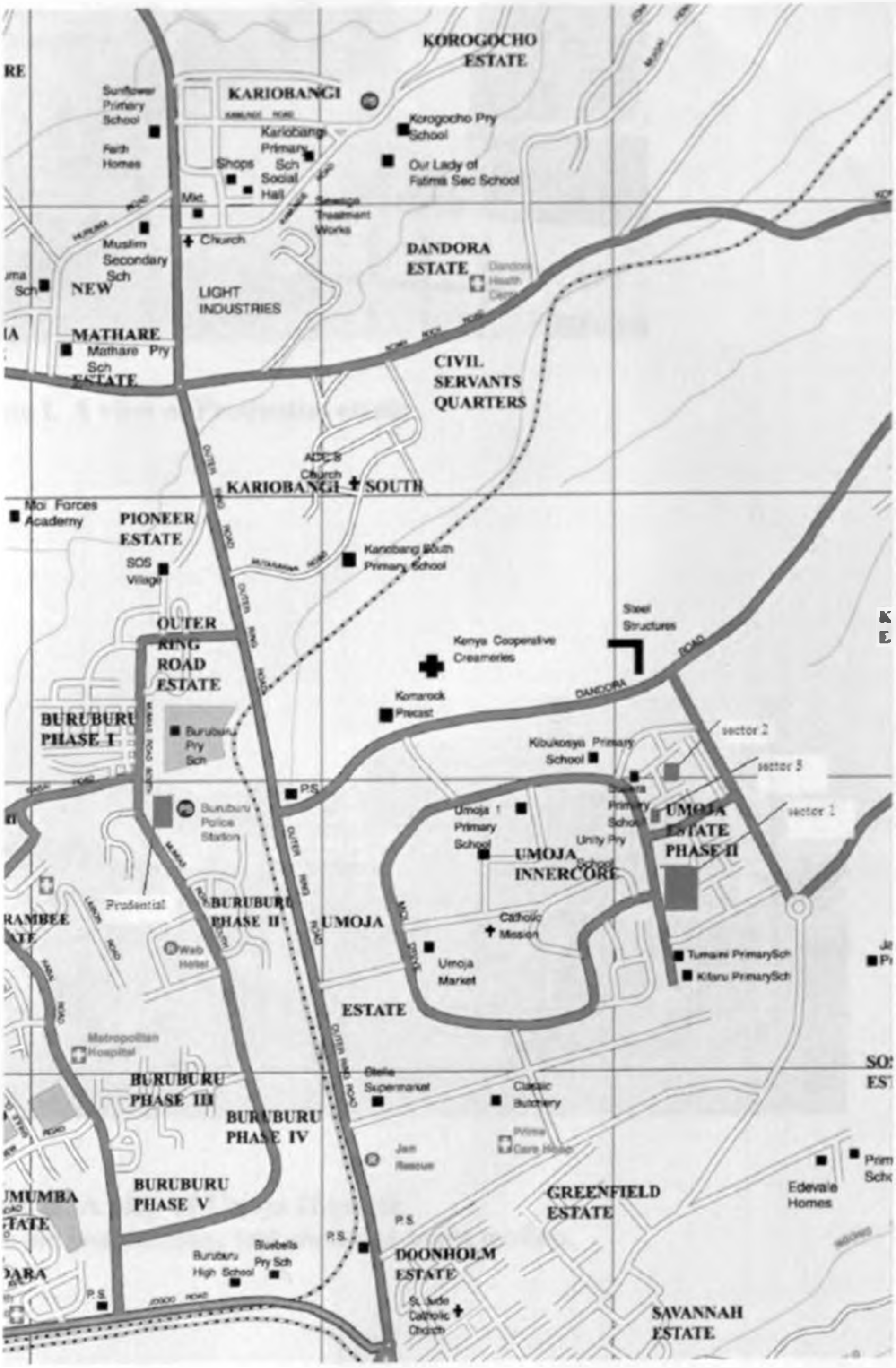
Source: CIA world fact book-Kenya

MAP B. LOCATION OF EMBAKASI CONSTITUENCY IN NAIROBI



Source: www.mapquest.com

MAP.C LOCATION OF PRUDENTIAL AND UMOJA II ESTATES IN EMBAKASI CONSTITUENCY Scale. 1:20000



Source:www.hassconsult.co.ke

Photo I. A view of Prudential estate

Photo II. A view of Umoja II estate
Note the water storage tank mounted on the rooftop.

1.2 BACKGROUND

Domestic water consumption in Kenya accounts for 20% of all water use. Agriculture accounts for 76% while industrial use accounts for 4%. This distribution is common in developing states, which rely heavily on agriculture. In most of the developed states the trends are reversed. For example Holland uses 34% of her water resources for agriculture, 5% for domestic purposes, and 61% for industrial activities. On average, the world uses 70% of fresh water for irrigation 20% for industrial purposes and 10% for domestic use (Gleick et al, 2002).

In Kenya, the estimates of per capita water availability have been provided by various sources with varying degrees of accuracy and reliability.

According to the Kenya Ministry of Water Resources Management and Development, the country's per capita water supply per annum stands at $647m^3$. This is projected to fall to $235m^3$ by the year 2025 if the current state persists in terms of climate and population growth. This estimate of 647 m^3 is much higher than the World Resources Institute (WRI) estimate made in 1990. The per capita water availability was $590m^3$ according to the WRI. Critical areas of disagreement therefore occur in the estimates of water resource quantities as done by national agencies, United Nations bodies and professional groups. Some of the differences arise from periodical variations in precipitation experienced in the country. On the global scene, data for small countries and countries in arid and semi arid zones are less reliable than are those for larger and wetter countries.

The major area of agreement, however, is that water resource availability per capita is likely to diminish in the future. There is also agreement among the scientific community that per capita consumption is a reliable indicator of water resource utilization. This indicator allows for comparison with other countries. To make the comparison possible, the sources of data, the methods of data collection, and the periods used for measurement must be described in detail.

The methodology for determining per capita fresh water availability in a country relies on population estimates and an estimate of the country's internal renewable water resources. The water resource available is then divided by the total population. The results are given in cubic metres per capita per year. A similar methodological approach was followed in this research. However, this research was mainly concerned with providing precise figures on domestic water consumption per capita, and not estimates of available freshwater resources. The research was particularly focused on per capita water consumption of individuals in selected urban households.

Application of per capita measurement

Water consumption per capita is a widely used environmental indicator of the state of water resource use in any given geographical area. The per capita consumption is developed from statistical parameters, but it has additional characteristics. It provides a simpler and more readily understood form of information compared to complex data and statistics. The per capita indicator has the potential of reducing the uncertainty level associated with decision making for environmental planning. The per capita consumption is an indicator that relates environmental aspects to socio-economic factors. In similar studies, the level of consumption of water resources has been found to be directly dependent upon the socio-economic status of the consumers (Postel, 1993).

1.3 THE PROBLEM STATEMENT

What is the per capita water consumption of residents in Nairobi households? This research seeks to provide an answer to this question. The research problem is to determine the current per capita domestic water consumption level.

Reliable information on the condition and trends in a country's water resources in respect of quantity is required for such purposes as assessing the resources, and for determining their potential for supplying the current and foreseeable demand.

Human population increase is related to increasing pressure on the water resource. Nairobi has a growing water supply problem, which is linked to the original choice of site. The city was not originally planned to be a large densely populated urban area, and the available water resources are only sufficient for a smaller population. To meet this high and growing demand water has to be pumped from locations outside Nairobi.

Table 1.Population growth in Nairobi

Census Year	Population
1969	509,256
1979	822,775
1989	1,600,000
1999	2,143,254

Source: republic of Kenya, population and housing census reports.

Water scarcity is an ultimate constraint in the world's least developed countries (LDC's) development, and hence environmental and development issues must be considered together. There is a sharp distinction between water capabilities in developed countries and LDC's. Many LDC's happen to be located in the arid and semi arid tropics. About ¾ of the bottom 44 countries on the UNDP Human Development Index can be found in Sub Saharan Africa

It has been projected that by 2025, about 1 billion people will be living in cities experiencing regular water stress, and possibly chronic water scarcity. The critical issue will not only be deficiencies in the supply of drinking water, but also the pollution of water from human activities. Water supply and demand sets upper limits on human carrying capacity, and human activities can contribute to even greater scarcity. It has been documented that larger metropolitan areas and mid sized cities in LDC's are barely coping with rapid urbanization. This urbanization linked with rapid population growth is expected to continue in LDC's. Some projections suggest that population in LDC cities will reach 4 billion people by 2025. Some higher estimates reach 5 billion, which would be 60% of the projected future world population. Urban domestic consumers are using even larger shares of available water resources and are at the same time degrading these resources with their wastes. Rapid urban population increase is putting severe strains on water resources and environment protection capabilities of many cities.

Causes of water scarcity

During the last national census carried out in 1999, the city of Nairobi had a population of 2,143,254 people. Kenya's total population stood at 28,686,607 people during that period. The unprecedented growth in urban areas of developing countries has been called over-urbanization. This means that they have a higher level of urbanization relative to the level of industrial growth. Rapid population growth and rural-urban migration are the major causes of water supply problems in cities. Between 1950 and 1980, cities in Latin America such as Bogotá, Mexico City, and Sao Paolo quadrupled in population. In Africa, cities like Nairobi, Dar es Salaam, Lagos, and Kinshasa increased in population at least seven fold during the same period.

The existence of these urban centres is threatened by one critical problem: How to acquire an adequate supply of water.

Due to this inadequacy of water, efforts for water conservation and proper management of the resource are imperative. However, decision makers may not be well informed without recent indicators of water consumption levels per capita; coupled with knowledge of the current numbers of the population, and their water consumption patterns.

The main question is to what extent can water demand be met and under what conditions; and how will the quality and quantity of water be affected when the upper limits of human population size are reached?

Despite the modern technology advancements, water demand in growing urban areas cannot be indefinitely satisfied. Environmental damages are increasingly being caused by the over exploitation of freshwater sources. Urban growth is ultimately self-limiting, and therefore urban planners and decision-makers must carefully consider how to make long-range plans. These plans must be holistic, and should be in harmony with demands for sustainable socio-economic development at the national, as well as a global level. A determination of the present water demand per capita of urban populations is the first and most logical step forward in solving this problem. This particular study is of importance as it seeks to provide answers to these very questions.

Knowledge gaps

The benefits and costs of providing a safe, convenient, and reliable water supply to households in the developing world have been subject to vast and wide-ranging research. Most of this research has focused on:

a. The relationship between water and disease,
b. The efficacy of water supply projects in improving health,
c. The causes and consequences of rigid control of water resources by individual classes of society without the consideration of gender,
d. The financing of water supply infrastructure.

Despite this plethora of research, relatively little is known about a number of key aspects of domestic water use. In particular, knowledge is scarce about the long-term trends and changes in household water use in any part of the world. This is because of the lack of quality baseline information and because of the cost and complexity of undertaking longitudinal and repeat studies.

Thus most research on household water use is limited to one season or year, or is carried out within the narrow confines of a donor-funded project or programme. Where studies have attempted to examine changes over time, they have tended to be limited in scope, frequently concentrating on a single locality. Consequently, the dynamics and determinants of domestic water consumption remain only partly understood. Among the regions of the world, these research gaps are most acute for sub-Saharan Africa, the region whose population has the least access to improved water supplies (Thompson et al, 2000).

1.4 RATIONALE/JUSTIFICATION OF THE PROBLEM

The U.N. programme of action (Agenda 21) proposes that countries should focus, inter alia, on: a) Water and sustainable urban development,

b) Impacts of climate change on water resources.

Scarcity of fresh water resources and the escalating costs of developing new resources have a considerable impact on all forms of national development and economic growth. Urgent action is needed to improve the effectiveness of the use of water resources if their contribution to human welfare and productivity is to be sustained. Special attention needs to be given to the growing effects of urbanization on water resource usage and to the critical role played by local authorities and municipal authorities in managing the supply, use and overall treatment of water.

Better management of urban water resources, including the elimination of unsustainable consumption patterns, can make a substantial contribution to the alleviation of poverty and improvement of the health and quality of life for the urban population.

Easy access to adequate water is a necessary condition for societal development, and where water is scarce, human health and economic welfare suffer. These impacts of water scarcity are often more severe in urban areas with dense populations, such as Nairobi's Eastlands region.

In the early stages of a nation's development, the quantity of water is seen as the most pertinent factor. In a country that is yet to industrialize such as Kenya, water quantity management is of the utmost importance (UN-HABITAT, 2003).

This study hopes to produce accurate data concerning the water consumption patterns of urban households in the study area. It is hoped that this data will enhance the discipline of planning and management of urban water resources.

1.5 ASSUMPTIONS AND VARIABLES

Per capita water consumption

The primary assumption in calculating the per capita water consumption is that each household member has equal water needs. There is no distinction among the household members on the basis of age, sex, race or body size. It is assumed that the water resource is shared equitably within the household; hence total consumption per household is divided by the number of individuals to derive the per capita consumption.

The calculation of per capita consumption over a prolonged period, such as consumption per year or per month, is based on the assumption that there is no significant variation in the day-by-day consumption patterns of the individuals. Any changes in consumption that may arise from one day to the next are all reflected in the total consumption figure at the end of the period under investigation. On this basis, the total consumption per year may be subdivided further to consumption per month, per week or per day according to the objectives of the researcher.

Variables

There are three important variables in domestic water consumption that are the subject of this research. They are:

a) Household size,

b) Socio-economic status,

c) Seasonal climatic changes.

According to Ehrlich's equation, Population, Affluence and Technology are critical variables in determining people's consumption of natural resources .The equation is expressed as follows:

I = P x A x T, where the impact on any natural resource is dependent on population, affluence and technology factors. This formula has often been used to discuss the connections between these variables. It has the appearance of a mathematical model that may be revised to achieve greater precision as follows.

P-Population

The population dynamic that has been considered for investigation is the number of individuals per household. Much of the debate on the impact of population on the environment has been conducted in an unscientific manner. But things become clearer when they are looked at quantitatively and in terms of physical mechanisms. Then population tends to take its proper place as one of the key factors (Harrison, 1992).

The first assumption concerning population is that the greater the number of individuals, the greater their impact. Statistical methods are used to test this hypothesis in the course this research. The data on household sizes and corresponding water consumption allows for the quantitative analysis.

The second population assumption is that whenever common resources are shared within a household setting, it leads to lower per capita consumption. This assumption is also subjected to statistical investigation in this research project.

A-Affluence

It is the welfare status of the population. It is assumed that the more affluent the population, the more water they will consume for domestic purposes.

The poor often spend a higher percentage of their incomes on water than the affluent do (UN-HABITAT, 2003). For purposes of this research, the term affluence is replaced by socio-economic status. This research investigates the impact of socio-economic status on domestic water consumption.

T-Technology

This is the technological choice of the population. In this research, the technology used to obtain water is the same for all the samples. They are using piped water, which is distributed directly to the respective households by the Nairobi Water and Sewerage Company. The Company measures the volume of water consumed by each household. The rates are based on a volumetric charging system. The pricing rates of water are the same for all the households sampled in this research.

1.6 AIMS AND OBJECTIVES

The aim of this research project is to determine the per capita water consumption of selected Nairobi households. The study set out to generate new data concerning the water consumption patterns of these households. This information will be useful as a tool for policy formulation and in supporting the management decisions of planners and other stakeholders in the Kenyan water sector. It is hoped that the results from this research will also provide baseline data that may enhance further research possibilities on the Kenyan freshwater resources. For example, similar research may be done periodically to establish the trends in water consumption in the research areas.

In this way, it is hoped that the research will contribute towards sustainable water resource management in urban areas of Kenya.

Objectives

1) To compute the correlation between household size and per capita water consumption.
2) To investigate the impact of socio-economic status on per capita domestic water consumption.
3) To examine the impact of climatic variations on domestic water consumption per capita.

1.7 HYPOTHESES

1) **H_0** The household size has no significant impact on the per capita water consumption.

   H_1 The household size has a significant impact on the per capita water consumption.

2) **H_0** The socio-economic status of consumers has no significant impact on per capita water consumption.

   H_1 The Socio-economic status of consumers has a significant impact on per capita water consumption.

3) **H_0** Climatic variations have no significant impact on domestic water consumption.

   H_1 Climatic variations have a significant impact on domestic water consumption.

2.0 LITERATURE REVIEW

2.1.WORLD WATER

Table.2 The Distribution of Water across the Globe

Location	Volume ($10^3 km^3$)	Total Vol. in Hydrosphere -ere (%)	Fresh water (%)	Annual Vol. recycled in km^3	Renewal period years
Ocean	1,338,000	96.5	-	505,000	2,500
Groundwater (gravity & capillary)	23,400*	1.7	-	16,700	1,400
Predominantly fresh ground water	10,530	0.76	30.1	-	-
Soil moisture	16.5	0.001	0.05	16,500	1
Glaciers & permanent snow cover	24,064	1.74	68.7	-	-
Ground ice (Permafrost)	300	0.022	0.86	30	10,000
Water in lakes (Total)	176.4	0.013	-	10,376	17
Fresh water lakes	91.0	0.007	0.26	-	-
Salt water lakes	85.4	0.006	-	-	-
Marshes & swamps	11.5	0.0008	0.03	2,294	5
River water	2.12	0.0002	0.006	43,000	16 days
Biological water	1.12	0.0001	0.003	-	-
Water in atmosphere	12.9	0.001	0.04	600,000	8 days
Total V. in hydrosphere	1,386,000	100	-	-	-
Total freshwater	35,029.2	2.53	100%	-	-

*Excluding groundwater in the Antarctic, estimated at 2,000,000 km^3 and including predominantly freshwater of 1,000,000 km^3 (UNESCO, 2003).

The availability of freshwater across the globe is a critical factor for human development. About 71% of the earth's surface is made up of water. However, less than 3% of this is freshwater. Most of this water is inaccessible because it is either frozen as glaciers in the Polar Regions, or it may be held within deep underground aquifers.
This table shows great disparities: Between the huge volume of saltwater and the tiny fraction of freshwater; between the large volume contained by the glaciers and groundwater as opposed to the small volumes of water in rivers, lakes and reservoirs.

As population increases, freshwater demand increases, and supplies per capita inevitably decline. Per capita water supplies in the world decreased by a third (⅓) from 1970 to 1990. There is little doubt that population growth has been and will continue to be one of the main drivers of changes to patterns of water resource use. If present consumption patterns continue, two out of every three persons on earth will live under water stressed conditions by the year 2025.A total of 25 African countries will experience either water stress alone or additionally face water scarcity by the same period. Future projections of worldwide population growth have been revised downwards in recent years, but most projections expect the world population to stabilize at about 9.3 billion people in 2050. This is still over 50% higher than the 2001 population of 6.1 billion. Thus the increase in numbers of people will still be a major driver of water resources management for at least another 50 years (UNESCO/UN, 2003).

Table.3 World water availability versus population (as percentages)

	Water resources	Population
North Central America	15%	8%
South America	26%	6%
Europe	8%	12.5%
Africa	10%	12.5%
Asia	36%	60%
Australia	5%	1%

Source: (UNESCO/UN, 2003).

The global overview of water availability versus the population stresses the continental disparity. Asia supports more than half the world population with only 36% of the world's freshwater resources.

The world pattern of precipitation shows large annual totals in the tropics (2400 mm and more), in the mid latitudes and where there are high mountain ranges (Jones 1997). Small annual precipitation totals (200 mm and less) occur in the subtropics. The world's deserts and semi-deserts are located in these areas. Differences within the African continent are particularly significant.

Table.4 Water withdrawals by sector and region

Region	Withdrawals km³ per year	Agriculture (%)	Industry (%)	Domestic (%)
Africa	152	85	6	9
Asia -Pacific	1850	86	8	6
S. America- Caribbean	263	73	9	18
North America	512	39	47	13
West Asia	84	90	4	6
Europe	456	36	49	15
Total	**3317**	**70**	**20**	**10**

Source: (UNESCO/UN, 2003).

2.2 AFRICA

The African continent occupies an area of 30.1 million km^2. It has a rapidly growing human population that is well over 700 million, many living in the world's least developed countries.

During the decade from 1990 to 2000, Africa suffered a third of the world's water related disaster events (floods and droughts), with nearly 135 million people affected. About 80% of these are affected by drought and the unavailability of water. Moreover, the increasing frequency of floods and droughts will exert greater pressure on freshwater ecosystems and on the freshwater provision networks and infrastructure. All the above factors will act together to pose enormous difficulties in the storage, provision and distribution of water, as well as water treatment (water purity and purification of used water).

Freshwater availability in Africa

The availability of freshwater in Africa is one of the most critical factors governing development in the continent. The mean water availability per capita in Africa is about 5,720 cubic metres per year. This is lower than the global average of 7,600 cubic metres per capita per year. There are, however, large disparities in the world's sub-regions.

The intergovernmental group of experts on climate change anticipates a decline in stream flows and mean availability of freshwater in African countries, mainly in the North and South. These changes are expected to impact the freshwater ecosystems negatively.

Access to freshwater resources

Major difficulties of water provision have been observed in countries that have less than 1700 m^3 per capita per year. Water stress of less than 1000 m^3 per capita per year has been observed in 14 of 53 African countries with available data.

The access to water resources is therefore a priority question for African countries, together with concerns over decreasing water quality due to excessive withdrawals, the declines in reservoirs and pollution from various sources. Due to these circumstances, 25 African countries will experience either water stress or water scarcity, and difficulties in water supply within the 2020 to 2030 decade (UNEP, 2002).

Domestic water consumption

By comparison to the other regions in the world, the African domestic sector is a moderate consumer of water. For example, in Europe, the domestic sector represents about 13% of withdrawals, which is at least twice higher than the African level. The per capita domestic consumption in Africa is 47 Litres per day. This is much lower than the consumption of the other countries and regions as shown in the following table.

Table.5 Domestic water consumption by region

Region	Daily consumption per capita
Africa	47 Litres
Asia	85 Litres
United Kingdom	334 Litres
United States	578 Litres

Source: (Jones, 1997).

The water consumption level of populations varies equally according to the access to water. Generally, the more accessible the resource, the more consumption becomes important. On the other hand, individuals who have to spend much time in search of water and in transporting it are more moderate in their consumption. A study in East Africa revealed that urban populations use more water than the rural domestic households. Households with direct access to piped water consumed 3 times more water than those not connected to the municipal system. These disparities need to be addressed, as the poor end up paying more money for water than their rich counterparts. This happens when they have no choice but to purchase water from private vendors. The populations that are deprived of sufficient water due to prohibitively high costs are also more prone to disease from the unsanitary conditions that they live in.

In Southern Africa, the disparities between diverse groups of the population are extreme. Urban households in low income areas use about 50 Litres per capita per day, while the middle and high-income sections may use up to 750 Litres per person per day, which is about 13-15 times more water on average (Saghir et al, 1997).

2.3 KENYA

The republic of Kenya is positioned across the equator, and has geographical diversity in terms of climate, physiography and geology. It has a surface area of 583,000 km^2, of which 569,000 km^2 is land surface while the remaining 14,000 km^2 portion is water.

Most rains occur from May to August. Months with the highest rates of potential evapotranspiration are the ones with least rainfall. The geographical distribution of surface water resources in Kenya is varied. Severe droughts occur in more than ⅔ of the country, one in every 5 years because of failure of rains. More than 63% of the total area of Kenya receives only 500 mm rainfall per year. However, the well-watered parts of the country support nearly 80% of the population through agriculture and related activities (Khroda, 1988).

Drainage systems of Kenya

There are three major drainage systems in Kenya.

- The Nile basin system. This drains the western flank of the Rift valley into the Mediterranean Sea.
- The internal drainage, which comprise the great Rift valley with many lakes and rivers draining into them, Chalbi desert and the lake Amboseli.
- The Indian Ocean drainage system. This includes rivers Athi, Tana, Voi, Ewaso Ngiro (North) and other smaller streams.

The characteristics of the Kenya rivers are adduced from the annual distribution of the river run-off (stream flow). The typical feature of the duration period of the surface run-off (flood) of the Kenya rivers dominating most of the territory is about 2-3 months and 8-9 moths in the South-western Kenya.

Some of the major perennial rivers in Kenya are Tana, Nzoia, Athi, Sondu, Ewaso Ngiro (North), Ewaso Ngiro (South), Yala, Nyando and Mara. However, water shortage is one of the features covering the greater territory of the country, with the exception of the South-western Kenya (Ogembo, 1980).

Table.6 Estimated water withdrawals in Kenya (1990).

Withdrawal per year	Cubic metres per capita
Domestic	13
Industrial	3
Agricultural	52
Total withdrawal	**68**

Source: (Gleick et al, 2002).

Estimated population: 30.34 million.

Estimated Total withdrawal: 2.05 cubic kilometers.

Table.7 Freshwater resources of Kenya in 2000

Land area	569,140 km²
Population in 2000	36,699,000 people
Population density per km²	54
Total internal* freshwater	20.20 km³
Groundwater produced internally	3 km³ per annum
Surface water produced internally	17.20 km³ per annum
Dependency ratio	33% inflows from other countries
Total renewable water resources	30.20 km³ per annum
Total renewable water resources per capita	985 m³ per annum

Source: (Gleick et al, 2002).

*Aggregation of world water data can only be done for internal renewable water resources, and not the total renewable water resources, as that would result in double counting of shared water resources.

2.4 NAIROBI

Climatic characteristics of Nairobi

The city of Nairobi is about 40 km South of the Equator, but the temperatures are altitude – modified. This is because it is found at a fairly high altitude, of between 1650 up to 1800 metres above sea level. The mean annual temperature in the city is 17°C. The mean daily maximum temperature is 23°C and the mean minimum daily temperature is 12°C. The month of mean maximum temperature is usually February, and the month of mean minimum temperatures is usually July. The mean monthly evaporation rates vary as the mean monthly temperatures vary.

The mean annual rainfall is 1,080 mm. This rainfall is experienced in two seasons. The long rains are usually from March to May, while the short rains are from mid-October to December. Fifty percent of the rainfall is experienced between March and May.

Human population Characteristics of Nairobi

Nairobi is the capital city of Kenya. The city had a population of 2,143,254 people according to the census carried out in August 1999. The population in Nairobi was estimated to have reached 2.5 million in 2003.

The total number of households in Nairobi was 649,426 in 1999, and the mean density was 3,079 people per square kilometre. A closer examination of the spatial distribution reveals that there are areas of low-density population and areas of high-density population. The majority of Nairobi residents occupy the high-density residential areas to the East and Northeast of the Central area. There are some medium -density housing units to the North and West of the Central area. The low-density residential units are to be found in the extreme Northwest, and include Karen and some parts of Langata constituency. A sprawling area of informal settlements called Kibera slums has developed within Langata.

Eighty percent of the Nairobi land area supports 20% of the high-income groups in suburban planned residential developments. The low-income group, constituting 80% of the population, are sprawled in the remaining 20% residential land, contributing to high population density and water supply difficulties. These low-income areas experience the highest rate of population growth due to rural-urban migration and natural increase (Khroda, 1988).

Water demand in Nairobi

In Nairobi, the total demand for water in 1990 was about 50 million cubic metres per year. The Tana and Athi Rivers have met much of this need. The Tana supplied 81% while Athi River supplied 19% of the water (40.5 million cubic metres and 9.5 million cubic metres per year respectively). When rainfall is inadequate, some parts of Nairobi City face water shortages and the normal production is disrupted. In the year 2000, this was the scenario at Nairobi's water sources.

Table.8 Nairobi water demand and supply in 2000

Source	Normal production capacity	Supply in 2000	
	m^3/day	m^3/day	Shortfall per day
Kikuyu springs	4,000	4,000	Nil
Ruiru dam	12,000	11,700	300
Sasumua dam	40,850	19,200	21,650
Ngethu/Thika Dam	289,750	240,000	49,750
Total	**346,600**	**274,900**	**71,700**

Source: (Makuro, 2000).

Some changes are evident in the ten-year period between 1990 and 2000. From a demand of 50 million cubic metres a year, the demand in 2000 had increased to about 126 million cubic metres per year. This is about 2.5 times increase in demand over a ten-year period. The drought conditions in 2000 had a severe impact on the water supply situation. Among the factors cited as key to this shortfall in supply was destruction of forests and degradation of water catchment areas, leading to changed hydrologic conditions and adverse weather patterns. Consequently this degradation leads to increased runoffs that are short-lived, with resultant siltation problems in dams and intakes. The concept is that the management of land and its cover affects the water quantity, duration of river flows and amount of sediment contained in the water (Tebbutt, 1990).

2.5 THEORETICAL FRAMEWORK

Freshwater-population interaction

It is important to analyze demographic features in Africa in order to help demonstrate their interaction with freshwater resources, systems and management. As a monolithic concept, 'population' in relation to physical and socio-economic phenomena remains vague, and its popularly advocated effects and how it is affected by these phenomena lacks strong empirical evidence. In Africa, what should concern the scientific community is how much research, if any, has explored the freshwater- population dynamics relationship.

The concept of 'population dynamics' relates strictly to the three components of population, namely: fertility, mortality and migration, which determine the population change and structure. Population change in urban areas is due to both natural increase and migration. The natural increase is simplified as births minus deaths within the population. 'Population structure', on the other hand, denotes innate attributes of the population such as gender and age. The population structure also denotes the acquired socio-economic attributes such as economic activity, educational attainment, language group and marital status. Freshwater management must take cognizance of community population dynamics, the primary factor being household size (Oucho, 2001).

The following three issues help to illustrate some pertinent aspects of the freshwater – population dynamics.

1) Freshwater resources and withdrawals.
2) Population and annual renewable freshwater availability in the past, present and future years.
3) The proportion of population without access to safe water.

Freshwater resources and withdrawals

There are three features of freshwater resources and withdrawals that are listed below as:

i) Annual river flows
ii) Annual withdrawals
iii) Withdrawals by different sectors (domestic, agricultural and industrial sectors).

These features deserve analysis and research (UNEP/HABITAT, 1999).

Huge capital and recurrent expenses are needed particularly to meet energy, chemical and labour requirements of urban water schemes. The planner's task is, therefore, to determine what should be the optimum size of a water supply scheme within some financial and environmental constraints (So et al, 1982). The ultimate capacity of a water supply scheme is usually considered in relation to three crucial variables.

These are:

- The ultimate extent of the service area,
- The ultimate service population, and
- The projected per capita water consumption per unit time (Iteke, 1980).

It is thus not practical for a water supply system to strive to meet the demand of an ever-expanding population spread over an unlimited service area. It is also unreasonable to expect a water supply system to meet unrestricted demand per capita per unit time. It becomes apparent that the planning for city water resources cannot be successful without the availability of regularly updated per capita water consumption data.

Water stress

Unlike water quality standards for which there are accepted guidelines and specific targets, there are no universally agreed standards that have been established for water quantity. As such, there is no precise universal minimum daily water allowance or requirement per capita stipulated by the W.H.O or any other international body. At the second world water forum and inter-ministerial meeting held in March 2000 in the Netherlands, there was a failure to address this issue of quantity. The amount available per capita for most cities in developing states frequently remains well below the minimum standards suggested by national governments and international bodies. Although 20 litres per person per day is currently the standard for household water consumption, it has been estimated that 30 to 40 Litres a day are the minimum needed per person if drinking, cooking, laundry and basic hygiene are all taken into consideration (Thompson et al, 2000).

It is possible to make a quantitative comparison between a country's water availability per capita to the per capita demand. Once the per capita demand has been established, mathematical projections may be made for a future situation where a better quality of life has been attained. Such projections are based on the observation that economic development is often accompanied by increased water consumption per capita. The population changes must also be taken into account. This, however, is only possible in countries that have the relevant water consumption statistics (Shiklomanov, 1993).

Economic development and natural resource consumption.

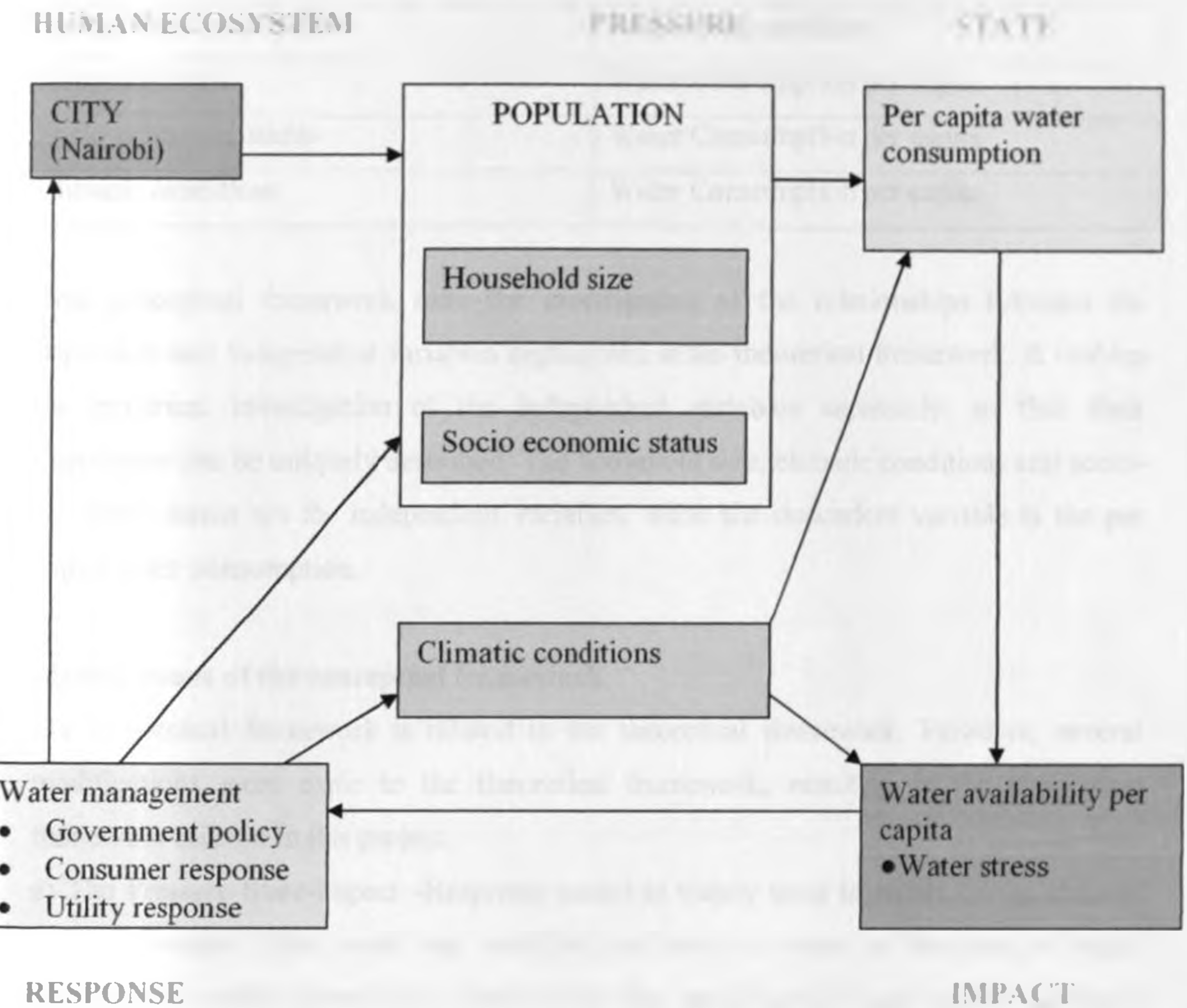
Various researchers have described the connection between economic development and the consumption of natural resources. In our focus on the natural resource of freshwater, the economic system is dealt with insofar as it generates both the demand and the means for freshwater resource exploitation (de Vries et al, 1997).

The increasing pressure on the regional and global freshwater environment is caused not only by the growing population, but also by the ever-large thoroughput of materials associated with the life-styles of more affluent regions. These larger thoroughputs are directly associated with increasing human welfare, in the form of dwellings and household activities. It has become evident that they cause various undesirable side effects, among which is environmental degradation and natural resource depletion. Such externalities, as they are called in economic literature, tend to offset part of the gains in welfare. However, both welfare and the perceived loss of welfare through environmental degradation are difficult, or even impossible to quantify in unambiguous and non-controversial terms (Rotmans et al, 1995).

For these reasons, population and economic development are related to the rate of consumption of freshwater resource in the conceptual framework of this project. Economic development is a strong factor in domestic water consumption. The UNDP Human Development Report (1998) highlights disparities in freshwater use based not on accessibility, but on economic development. The report found that a new born baby in the

North could consume 40-70 times more water than a new born baby in the South who has equal access to water. It is therefore critical to examine the roles of population size and economic development in a conceptual framework that establishes their respective impacts on domestic freshwater consumption. The impact of climatic conditions on water consumption patterns must also be investigated in the same framework.

2.6 CONCEPTUAL FRAMEWORK



Adapted and modified from: (Rotmans et al, 1995)

(De Vries et al. 1997)

Table.9 Variables in the conceptual framework

Independent variables	Dependent variable
Household size	Water Consumption per capita
Socio-economic status	Water Consumption per capita
Climatic conditions	Water Consumption per capita

This conceptual framework suits the investigation of the relationships between the dependent and independent variables highlighted in the theoretical framework. It enables the empirical investigation of the independent variables separately, so that their importance can be uniquely described. The household size, climatic conditions and socio-economic status are the independent variables, while the dependent variable is the per capita water consumption.

Modifications of the conceptual framework

The conceptual framework is related to the theoretical framework. However, several modifications were made to the theoretical framework, resulting in the conceptual framework utilized in this project.

a) The Pressure-State-Impact –Response model is widely used to report on the state of the environment. This model was modified and used to report on the state of water consumption within households. That is the first modification made in this project's conceptual framework.

b) The impact of climatic conditions on domestic water consumption was a modification of the conceptual framework. Previous models did not account for this impact of climatic conditions on domestic water consumption patterns. According to earlier models, climatic conditions are better known to impact on water availability than on domestic water consumption.

c) The socio-economic status of water consumers was incorporated into this conceptual framework. The importance of the socio-economic status is that prosperity levels provide the demand for, and means of sustaining high domestic water consumption.

2.7 LIMITATIONS OF THE STUDY

The study is limited to the middle-income and high-income groups within the Eastlands area of Nairobi. The study does not cover the low-income groups that reside in informal settlements because they lack individual water meters in their households.

Delimitations of the study

The computed results concerning the correlation between household size and per capita water consumption may safely be generalized to comparable urban households with piped water supplies.

The results on the impact of socio-economic status on per capita water consumption may safely be generalized to comparable urban households that have the same water tariffs, and the same level of service from the water utility.

The findings on the impact of climatic conditions on domestic water consumption may safely be generalized to comparable urban households.

2.8 DEFINITION OF TERMS

Per capita: The term per capita literally means per person. This is regardless of the age and gender of the person.

The per capita water consumption is expressed as litres consumed per person per day (l/p/d).

Per capita consumption may be calculated per day, per month or per year, and these different time periods were specified in this research where necessary.

The units of water consumption are in cubic metres (m^3). 1 m^3 is equivalent to 1000 litres of water.

Household size: The total number of individuals being served by a single water meter in a household constitutes the household size. 'Piped' households are those with access to direct and functional water connections within the house or immediate compound. A functional piped system is one from which a household could satisfy its basic water needs throughout the year.

Domestic water consumption: This refers to the total and combined amount of water that is used for drinking, cooking, washing and sanitation in the house. It also includes water used in watering plants in household gardens.

Table 10.Water stress levels

Water availability

m^3 per capita per year	Level of water stress
Over 1700	Occasional or local water stress
1000-1700	Regular water stress
500-1000	Chronic water scarcity
Below 500	Absolute water scarcity

Source: Gleick et al (2002) pg 99

At the level of chronic water scarcity, the lack of water begins to hamper economic development, human health and well-being.

CHAPTER 3
METHODOLOGY

3.1 Introduction

In this research project, Nairobi is defined as the *universe* of interest. Prudential and Umoja II estates are defined as two distinct *populations* within Nairobi

Prudential estate is a homogeneous population based on the type of housing and water facilities. By the same token Umoja II estate is homogeneous based on the type of housing and water facilities available to the population.

The samples for this research were drawn from the populations in these two residential estates. The main distinction between the two estates was the difference in socio-economic status

3.2 Socio-economic status

There are various indicators of socio-economic status. These include income levels, type and location of housing, and house rent.

People are often elusive to questions concerning their incomes. It calls for the exercise of dictatorial powers on the part of the researcher to get accurate details on respondent's incomes (Boreham & Semple, 1976). For this reason, details on income levels of respondents were not required in this research. The following indicators of socio-economic status were used instead.

a) The location and quality of urban housing tends to reflect socio- economic status (Peil, 1983)

Prudential estate consists of spacious maisonettes, each having four bedrooms. Each maisonette has a servant's quarter and a lawn. The houses sampled in Umoja II estate were less spacious, and each house had a single bedroom.

b) House rent

The house rent required for the houses was used as an indicator of the socio-economic status of the residents. In Prudential estate, the house rent per month was 25,000 shillings. In Umoja II estate the households sampled were rented at the sum of 5,000 shillings per month.

From the house rents, it was clear that Prudential estate represents the population of high socio-economic status. Umoja II estate represents the population of low socio-economic status in this comparative scheme.

Photo III. Houses in Prudential estate

Photo IV. A Street and houses in Umoja II estate

3.3 Prudential estate

First a letter was written to the security chairman of Prudential estate stating the intent to conduct research in the estate. Unfortunately, this was the period in which some University of Nairobi students had been involved in armed robberies and a cache of weapons had been found in the University's Mamlaka hostels. Due to this negative publicity, the Prudential Estate security chairman gave strict conditions. The researcher was not allowed to personally enter into any of the households, but was to conduct investigations from outside the gates. For this reason, questionnaires were used in Prudential estate. The questionnaires were issued to the respondents under the supervision of the security personnel of Prudential estate.

3.3 a) Sampling methodology in Prudential Estate

Prudential estate has a total of 88 house units. However, the total number of residential houses was only 74 at the time of this research. This is because some of the units were unoccupied at the time of research, while other units were used for commercial purposes. Some examples of commercial purposes were a pre-school, Prudential farmers co-operative society offices, and a shopping centre within the estate. Due to the presence of residential and non-residential units, stratified sampling was done. One stratum was made up of the 14 non-residential houses, and the other stratum comprised the residential units. Only the 74 residential units formed the target population.

Photo V. A house in Prudential estate

A preliminary or test questionnaire was formulated and issued to 30 households. Their responses would indicate whether the questionnaire had been well formulated. After receiving the responses, the questionnaire was modified to make it easy to use, and to capture the precise information required. It was also discovered that the residents preferred a questionnaire giving them a deadline as to when the researcher would collect the results. In this regard the final questionnaire stipulated the exact time when the questionnaires would be collected. This would facilitate the quick collection of data and ensure a high percentage of returned questionnaires.

The modified questionnaires were then issued to all the 74 residential households in Prudential estate. Thus the entire target population was issued with questionnaires. A period of one week was given as the deadline for the collection of all the questionnaires, but it was later extended to the second week. The issuance and collection of questionnaires was done in the early evening during the weekends. At the end of this period, a total of 37 duly completed questionnaires were recovered. One questionnaire among the 37 was disregarded because the occupant had moved into the estate only two months prior to the research. It is only the respondents who had lived in the same house, for more than one year prior to the research that could give the required information. This is because their water consumption during the previous one-year was the subject of investigation.

3.3 b) Data evaluation

The consumption data for each household was obtained from the meter readings at the Nairobi Water and Sewerage Company depot at Kariobangi. The meter readings consist the raw data that the utility uses to produce consumer water bills.

First the ***House numbers*** in the questionnaires were matched with the utility's meter card readings. There was no inconsistency between the house numbers as given by the respondents and the ones in the meter cards. The meter card that has Prudential estate data is number '37-16'. The figure '37' represents the area number, while '16' is the specific meter card for Prudential estate.

However, there were various reasons that led to the disuse of some questionnaires. The main reasons why some households were not included in the final sample for research were as follows.

- **Inconsistent meter readings and estimates.**

Data from houses that had inconsistent meter readings and estimated water consumption readings were not processed any further. The meter readers marked the initials (lkd) in some of the meter cards, and these initials indicated the houses that were locked at the time of meter reading. All such houses were eliminated from the sample because accurate meter readings are imperative for water consumption research.

Photo VI. Position of water meter within a compound in Prudential estate

Note. The blue water meter is nearly overgrown with weeds. The meter is inaccessible to meter readers when the gate is locked.

- **Spoilt meters**

Any households that had spoilt water meters at any time during the year under investigation were removed from the sample. The initials in the meter readings at the depot were marked (m/s) to indicate spoilt meters. Consequently, all houses that had their water meters replaced during the period of interest were not included in the final sample of prudential estate.

After these processes of data evaluation, the total sample in Prudential estate was reduced to 29 households out of a total of 37 households that initially had returned the questionnaires. The final sample size from Prudential estate was 39 % of the total population. This sample size was representative of the population in Prudential estate.

3.4 Umoja II estate.

Umoja II estate was stratified on the basis of residential and non-residential houses. The owners had converted some of the houses into business premises. The most common commercial uses were retail shops, beauty salons, food kiosks, butcheries, grocery shops, video arcades, medical clinics and laboratories; tailoring shops, clothing stores, communications bureaus, bars, churches and hardware stores. All of these non-residential houses were not part of the sample. It is only the stratum consisting of residential houses that was sampled for research

Photo VII. Umoja II estate.

Note the upward extensions on the left, and original houses on the right.

3.4 a) Sampling procedure.

The total number of houses in Umoja II estate is difficult to determine because new houses and extensions are being constructed continuously. (View photo VII). From the records at the City Council water department, the original plots were 1104 in number. The research was restricted to original houses and did not include any of the extensions.

Questionnaires were distributed randomly to the original residential households. The total number of questionnaires issued was 250.In Umoja II estate, unlike Prudential estate, the residents were interviewed based on the questionnaires. The respondents were more open and even allowed the researcher into some of their houses. The respondents were assured that their house numbers would not be revealed to third parties to protect their privacy. This same protection of privacy was accorded to the Prudential estate residents.

Furthermore, the Nairobi Water Company does not allow the publication of private account details of water consumers.

The areas that were surveyed in Umoja II were area '31', (meter cards 9 and 10). The other area was '32', (meter cards 18 and 19). The terms area '31' and area '32' refer to administrative regions as demarcated by the Nairobi Water Company.

Photo VIII. Original Umoja II houses.

Samples were drawn from original houses only. Note the school gate on the right. Such non-residential houses were not part of the sample.

Random sampling of the residential households was determined by the following factors.

a) Presence in the house at the time of sampling.

If a house had no occupant at the time of the sampling, the questionnaire would be slipped under the door. Whenever only juveniles were found in the house at the time of sampling, the questionnaires were given to such children. The children were duly instructed to give the questionnaires to their parents. The time of return for the questionnaire was indicated in the form. The house numbers of each sampled house were recorded in a field notebook as well as on the questionnaires .If on the day of return the occupants were still unseen, then that house would be struck off the samples list. No further attempts were made to recover the questionnaires from such households.

In some of the houses the completed questionnaires were found upon returning. Some of the respondents also left their completed questionnaires with neighbours. This happened in cases where the respondents knew they would be absent on the appointed questionnaire collection day. The accuracy of the information on each of the questionnaires was checked, and upon satisfaction, the form was filed among the other usable questionnaires that comprised the sample.

b) Willingness to be interviewed

Some respondents preferred to answer the questionnaire with the help of the researcher and their wishes were obliged. Some of the respondents preferred to fill the forms themselves and they were free to do so. In some houses, the residents were unwilling to be interviewed based on the questionnaires and disqualified themselves from participation in the research. Their wishes were also granted. It emerged that friends and neighbours had a big influence on each other. In any plot where the first person met was willing to participate, the rest of the neighbours were more likely to participate. Whenever the first person approached turned away the researcher and suggested he interviews the neighbours instead, the other neighbours were equally unwilling to participate in the research.

The refusal to be interviewed or to fill the questionnaire was one of the problems encountered. Some of the respondents were also afraid that they could be incriminating themselves by giving the research information, and they had to be reassured that their names and house numbers would not be published. Upon such reassurance, many respondents then became willing to participate in the research.

c) Period of residence in the same house

Some of the questionnaires were discarded even after they were properly filled whenever it emerged that the respondents had not lived in their current house for a period of at least one year. It was apparent that in Umoja II estate there were more frequent cases of movement from other houses than in Prudential estate. This elimination based on duration of stay in the house led to a further reduction in the sample size.

3.4 b) Data evaluation

All the households that had not yet been eliminated from the sample were then carried to the Nairobi Water company depot at Kariobangi for further analysis. First the house numbers were matched with the numbers in the meter records. In Umoja II the house numbers were a combination of numerals and letters, and these had to match perfectly. An example would be such as Plot 001 door 1- C. All the letters and numerals designating a residence were counterchecked for accuracy. The three parameters precisely locating a household had to match, and any inconsistently numbered questionnaires were discarded from the final sample.

The other criteria for eliminating further households from the sample were the same as in Prudential estate. Any houses that had spoilt meters, inaccessible meters at the time of meter reading, and estimated consumption readings were eliminated. Houses that had new meters installed during the previous year either as a result of theft or other causes were also eliminated from the sample. After this evaluation process, the total number of households that had reliable data to form the sample in Umoja II estate was reduced to 62 households.

3.5 DATA ANALYSIS

3.5 a) Water consumption analysis

The Nairobi Water Company strives to make meter readings on a monthly basis. However, some readings were done after periods that were longer or shorter than the calendar months. The meter readings were therefore analyzed as follows.

It was necessary to first establish the time that had elapsed between the meter readings. This was done by counting the number of days between the dates of meter readings. These *elapsed periods* were recorded. The next step was to determine the water consumption during each of these elapsed periods.

The water company meter readers usually record the final four digits of the meters. Each time a new reading is made it is called the *Current reading*. After duration of approximately one month, the same meter is read again and a new *current reading* is obtained. The new *current reading* minus the previous reading gives the consumption during the *elapsed period*. The following is an illustration from a house in Umoja II estate.

The meter reading on 11.6.2003 was 4586 m^3. The subsequent reading was 4590 ^{3} made on 11.7.2003.The consumption for the *elapsed period* becomes

4590 - 4586 = 4 m^3.

A period of 30 days had elapsed between the previous and current reading. Thus the consumption of that particular household was 4 cubic metres, consumed over a period of 30 days.

The 4 cubic metres was the *derived consumption*. This procedure to determine the derived consumption was repeated for all the meter readings and for all the households sampled. This is the process by which the raw data tables on water consumption were generated. The source of primary data used to generate the raw data tables was the meter readings from the Kariobangi depot of the Nairobi water company.

3.5 b) Creation of raw data tables

The derived consumption for each household and for every elapsed period was manually calculated as shown above. The derived consumption figures were then entered into the computer. Microsoft Excel programme was chosen for this task. This made the subsequent generation of graphs and analysis of the data easier and quicker.

The periods of the meter readings were recorded at the top of columns in an Excel worksheet. Below each period was the derived consumption. The house numbers were displayed on each specific row. However, the column with house numbers was hidden before printing the raw data tables to protect the privacy of the consumers.

Each row also had the number of individuals for each house called the *Household size.* The summation of consumption for all the periods in a single row gave the total consumption of the household during the one-year period. The total consumption in a row divided by the household size gave the per capita consumption for that particular household.

A sample of the raw data tables.

17/1-6/3/03	6/3-8/4	8/4-22/5	22/5-20/6	20/6-28/7	28/7-10/9	10/9-13/10	13/10-1/12	1/12-15/1/04	total m^3	size
40	12	20	13	12	23	25	26	25	196	6
22	18	24	18	31	15	6	14	9	157	4

3.6 SPECIFIC AIM OF THE STUDY

Determination of per capita consumption

The aim of this research was to determine the per capita water consumption of the respondents from the two sampled residential estates of Nairobi.

The total water consumed by the respondents during a one-year period was first determined. This was done using data from the water utility and the respondents as described in previous sections of methodology. This total water consumption was divided by the total number of individuals within the sampled households. The result is the per capita consumption of the respondents. The samples from Umoja II and Prudential estates were investigated separately.

The total water consumption of Prudential estate respondents is presented in table B1 in the appendix section. The total number of respondents was 192 individuals from the 29 households that formed the sample. The total consumption of the respondents for a 363-day period of investigation was 8340 m^3. The per capita consumption is obtained when the total water consumed is divided by the total number of respondents. The calculated results are contained in the fourth chapter of this report.

The total water consumption data for Umoja II respondents are tabulated in the appendix B section, under the tables marked as B2, B3 and B4.The total water consumption for the year was 6287 m^3. The total number of respondents was 293 individuals in Umoja II estate. The per capita consumption was obtained after dividing 6287 m^3 by the 293 respondents. This number of respondents was the total population from the sample of 62 households in Umoja II estate. The sampling section covered earlier provides the details on how the sample sizes were arrived at. The detailed results of per capita consumption are found in the results chapter of this report.

3.7 SPECIFIC OBJECTIVES OF THE STUDY

3.7 A. Impact of climatic changes on water consumption

The temperature and rainfall data was obtained from the Kenya meteorological department situated at Dagoretti. The particular data relevant to this research was from the Jomo Kenyatta International Airport- Embakasi weather station. This is the weather station of closest proximity to the study areas.

The objective was to examine the impact of seasonal climatic changes on domestic water consumption .The climatic conditions under investigation were temperature and rainfall. The climatic conditions were the independent variables while domestic water consumption was the dependent variable. Separate statistical tests were done for temperature and rainfall variables, so that the impact of each respective variable could be determined.

The seasonal differences were first demonstrated. and then the impact of these seasonal changes on consumption was examined. The following methodology was used to demonstrate seasonal differences.

Seasonal differences

The relative temperature difference between any two periods was the basis for designating one period as the ***Cool*** season and the other period as the ***Hot*** season. The period of relatively higher temperature was termed Hot season, and the period of relatively lower temperature was termed Cool season. The difference in temperature between the periods was given in degrees centigrade.

A similar approach was used in designating one period as Wet season and the other as Dry season, based on the relative rainfall amount experienced in each respective period. The period of relatively more rain was termed ***Wet*** season and that of relatively less or no rain was termed ***Dry*** season. The difference in rainfall amounts experienced between the seasons was expressed in terms of millimetres.

Adjustment of elapsed periods in seasonal consumption

One of the data limitations was that water meter consumption readings were made on diverse dates. Hence the elapsed period between subsequent meter readings often differed. This made it necessary to adjust one period to make it comparable to the other. An additional challenge is that the seasons do not strictly follow the calendar monthly patterns. neither do they relate to the time of water meter reading.

It was important to keep the *elapsed periods* for the seasons equal. The duration, in terms of days in the wet season, must be made equal to the duration of the dry season before comparison of the water consumption during the different seasons is made.

For example in Prudential estate, the cool season was the duration from 20.6.2003 to 28.7.2003.This is a time period of 38 days. The derived consumption of this particular household was 12 cubic metres during this time. The mean temperature was 17° centigrade. For this same household, the hot season was the duration from 17.1.2003 to 6.3.2003.This is a time period of 48 days, which is ten days longer than the cool season period. The derived consumption for this household was 40 cubic metres in the hot season. The mean temperature was 20.5°centigrade. To make the durations of the seasons comparable, the number of days in the hot season must be reduced to 38 days. When a reduction of the number of days is made, the derived consumption must also be reduced accordingly.

The following formula was used to reduce the period of consumption from 48 days to 38 days for the hot season.

$38/48 \times 40\ m^3 = 31.6\ m^3$.

To the nearest cubic metre = $32\ m^3$.

The derived consumption of this household in the hot season after 38 days is 32 cubic metres. This is reduced from the 40 cubic metres that was the derived consumption for the household over a 48-day period.

In summary, the consumption in this household was $12\ m^3$ after 38 days during the cool season, and $32\ m^3$ after an equivalent period of 38 days during the hot season. The comparison of consumption between the two seasons is now justified because the durations of the two seasons are equivalent. The household size also remains unchanged during the seasons.

A similar approach was followed for all the households in the samples to make the elapsed periods equivalent for the different seasons. This is how the data analysis tables A1 to A8 were generated. In each sample the durations of the seasons were made equivalent, and the derived consumptions were calculated accordingly. After this procedure, it became possible to compare the consumption of the selected households during the different seasons.

Analysis of seasonal impact on consumption

After the generation of data analysis tables A1-A8, the mean consumption of the households during a particular season was compared to the mean consumption of the same households during a different season.

The mean consumption in the hot season was compared to the mean consumption in the cool season. This was done to determine the impact of temperature changes on water consumption.

The mean consumption in the wet season was then compared to the mean consumption during the dry season. This was done to determine the impact of rainfall on water consumption.

The seasonal water consumption data of Umoja II and Prudential estate consumers were analyzed separately. This is because they are two distinct populations with different water consumption characteristics.

The null hypothesis was formulated, stating that there is no significant difference in mean consumption between the seasons. Since the important variables of household size and socio-economic status had been controlled for these households, any differences in mean water consumption would be attributed to the changes in climatic conditions. The t-test was utilized in the statistical test for the difference between the means.

3.7 B. Impact of household size on consumption

The data on ***household sizes*** was obtained from the questionnaires and interviews of respondents.

Urban household sizes may be indeterminate, with members coming and going, while some may be away on a temporary or longer-term basis, or recently arrived on a visit. The distinction between ***de facto*** (those actually in) and ***de jure*** population (those who are usually in) is important (Peil, 1983). This research was based on the ***de jure*** population of households. The de jure population is appropriate for planning purposes.

The quantity of water consumed for domestic purposes varies with household size, sources and price (UNICEF/G.O.K, 1990). In order to determine the impact of household size on consumption, the variables of source and price have to be controlled. In this research, the water source is the Nairobi Water and Sewerage Company. The water pricing rates in the study areas, namely Prudential and Umoja II estates are the same.

Analysis of the impact of household size on consumption.

The correlation between ***household size*** and per capita water consumption was computed in this section. During data analysis, the houses were first grouped according to the total number of individuals in each house. In Prudential the minimum household size observed was 4, while the maximum household size consisted of ten residents. In Umoja II estate the household sizes ranged from 2 to 9 people per house. The corresponding per capita consumption for each group of households was then calculated. The results were presented in the form of graphs. That is how the graph series labeled graph 1 up to graph 4 were generated. The Y-axis represented the water consumption per capita, and the X-axis represented the household sizes.

The interpretation of data by use of the graphs data was inconclusive. The graphs alone could not be used to accurately determine the correlation between household size and water consumption per capita. This led to the application of additional statistical methods as follows.

The correlation between household size and per capita water consumption was computed. The correlation coefficient(r) was computed to determine the correlation between per capita water consumption and *household size*. The strength of the correlation was tested using the t-test. The coefficient of Determination (r^2) was used to describe the percentage of consumption that is accounted for by household size. The results were then published in the results section.

The independent variable that was not controlled in this section of analysis was the ***household size.*** The per capita consumption was the dependent variable.

The analysis of the data was done separately for Prudential and Umoja II estates since they are distinct populations. This was done to control the socio-economic variables.

The consumption data covered a period of exactly one year, hence the climatic changes experienced by the households were also taken into account.

3.7 C. Impact of socio-economic status on consumption

The objective in this section was to determine the impact of socio-econoic status on per capita water consumption.The difference in socio-economic status between Umoja II and Prudential estates was established as explained in earlier sections.What remained was to determine the difference in water consumption between the two populations.

The period investigated was approximately one year, which was precisely 363 days for Prudential estate households and 366 days for Umoja II households.

The total water consumption of a single individual from each of the sampled households was the subject of investigation. The sample size in Umoja II consisted of 62 individuals, since now only one individual from each household was required as the sample. The sample from Prudential estate consisted of 29 individuals. This is because only one individual per household was chosen from the already established larger sample of 29 households in Prudential estate.

The per capita consumption for each individual from a house was obtained after dividing the total water consumed per household, by the total number of residents in each respective household. The data on per capita consumption was tabulated as shown in table A9 in the appendix section.

The tabulated data was then subjected to statistical analysis using the t-test. The results were recorded in the results chapter of this report.

CHAPTER 4
RESULTS

4.1 PER CAPITA CONSUMPTION OF SELECTED HOUSEHOLDS IN NAIROBI

Results

The per capita consumption in Prudential estate was higher than the per capita consumption in Umoja II. This difference in per capita consumption was attributed to their differences in socio-economic status.

Table.11

PER CAPITA CONSUMPTION IN PRUDENTIAL ESTATE

	Litres	m^3
Consumption per Day	119	0.119
Consumption per Month	3,620	3.62
Consumption per Year	43,437	43.44

Table.12

PER CAPITA CONSUMPTION IN UMOJA II ESTATE

	Litres	m^3
Consumption per Day	58.8	0.058
Consumption per Month	1,790	1.79
Consumption per Year	21,457	21.46

4.2 HOUSEHOLD SIZE AND PER CAPITA CONSUMPTION

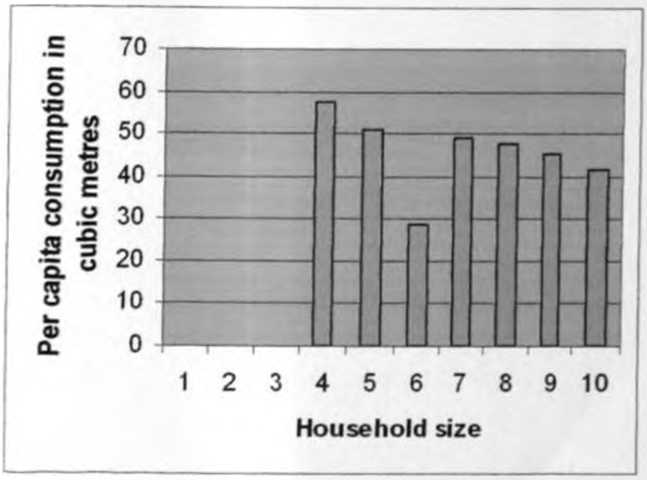
4.2 a] PRUDENTIAL ESTATE

Table.13

Household size and per capita consumption

Household size	Per capita consumption
4	57.4 m^3
5	51.2 m^3
6	28.8 m^3
7	49.1 m^3
8	47.9 m^3
9	45.2 m^3
10	41.8 m^3

Graph 1. Per capita consumption and household size



Prudential estate: Table of correlation analysis
X= household size
Y=per capita consumption per year in m^3

X	X^2	Y	Y^2	XY
4	16	57.4	3294.76	229.6
5	25	51.2	2621.44	256
6	36	28.8	829.44	172.8
7	49	49.1	2410.81	343.7
8	64	47.9	2294.41	383.2
9	91	45.2	2043.04	406.8
10	100	41.8	1747.24	418
∑49	**371**	**321.4**	**15241.14**	**2210.1**

Hypotheses

H_0 There is no significant correlation between household size and per capita Consumption of the residents.

H_1 There is a significant correlation between household size and per capita consumption of the residents.

Prudential Estate

Correlation coefficient, (r) =

$$r = \frac{2210.1 - \frac{(49)(321.4)}{7}}{\sqrt{\left[371 - \frac{(49)^2}{7}\right]\left[15241.1 - \frac{(321.4)^2}{7}\right]}} \quad = -39.7$$

$$= \sqrt{(371 - 343)} \quad (15241.1 - 14756.9)$$

$$= \sqrt{28x484.2}$$

$$= \sqrt{13557.6}$$

$$= 116.4$$

$$r = \frac{-39.7}{116.4} = -0.3411$$

$$r^2 = 0.1163$$

$$r^2 x100 = 11.63\%$$

$$H0r = 0$$

$$H1r \neq 0$$

$$t = \left|0.3411x\frac{\sqrt{7-2}}{1-0.1163}\right|$$

$$= 0.3411x\left(\frac{2.2361}{0.8837}\right)$$

$$t = 0.86$$

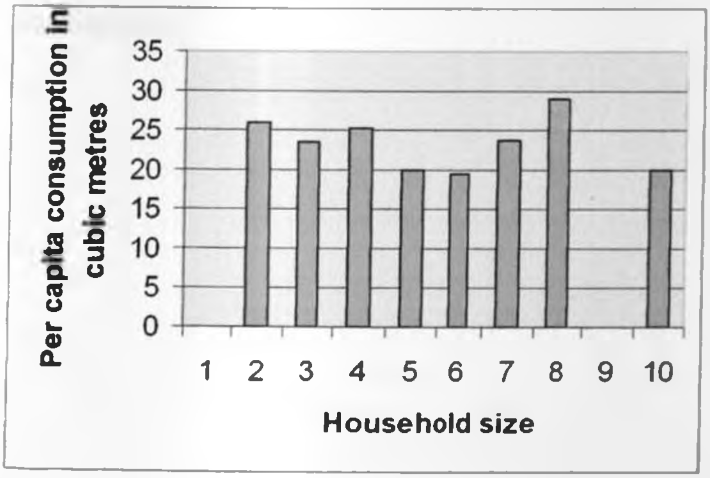
Critical t at α 0.05 and 5 degrees of freedom is 2.57. Calculated t, 0.86 is less than critical t. The null hypothesis is adopted that there is no significant correlation between household size and per capita water consumption.

4.2 b] UMOJA II SECTOR 1

Table 14. Household size and per capita consumption

Household Size	Per capita consumption
2	25.9 m^3
3	23.6 m^3
4	25.3 m^3
5	20.1 m^3
6	19.6 m^3
7	23.8 m^3
8	28.9 m^3
10	20.1 m^3

Graph 2. Per capita consumption and household size



Umoja II Estate: Sector 1(N=40 households)
Correlation of household size and consumption per capita
X= household
size
Y= Consumption per capita per year in m^3

X	X^2	XY	Y	Y^2
2	4	51.8	25.9	670.81
3	9	70.8	23.6	556.96
4	16	101.2	25.3	640.09
5	25	100.5	20.1	404.01
6	36	117.6	19.6	384.16
7	49	166.6	23.8	566.44
8	64	231.2	28.9	835.21
10	100	201	20.1	404.01
∑45	**303**	**1040.7**	**187.3**	**4461.69**

Hypotheses

H_0 There is no significant correlation between household size and per capita water consumption.

H_1 There is a significant correlation between household size and per capita water consumption.

Correlation coefficient, (r) =

$$r = \frac{1040.7 - \frac{(45)(187.3)}{8}}{\sqrt{303 - \frac{(45)^2}{8}} x 4461.7 - \frac{(187.3)^2}{8}} = 1040.7 - 1053.6 = -12.9$$

$$= \sqrt{[\,303 - 253.1\,]x[4461.7 - 4385.2]}$$

$$= \sqrt{[49.9 x 76.5]}$$

$$= \sqrt{3817.35}$$

$$= 61.8$$

$$r = \frac{-12.9}{61.8} = -0.2087$$

$$r^2 = 0.0435$$

r^2 x 100 = 4.35% of consumption is accounted for by Household size.

Significance test or r

H_0 r = 0

H_1 r ≠ 0

$$t = \left| r \frac{\sqrt{n-2}}{1-r^2} \right|$$

$$t = 0.2087 \; X \; \frac{\sqrt{6}}{1 - 0.0435} = (0.2087)\left[\frac{2.4495}{0.9565}\right]$$

$$= 0.2087 \; x \, 2.5609$$

$$t = 0.53$$

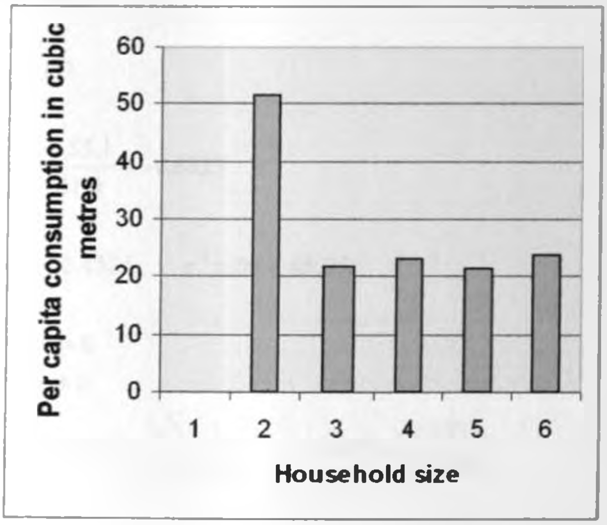
Critical t at α 0.05 and 6 degrees of freedom is 2.45.Calculated t, 0.53 is less than critical t, 2.45.The null hypothesis,H_0 is adopted that there is no significant correlation between household size and per capita water consumption.

4.2 c] UMOJA II ESTATE SECTOR 2.

Table 15. Household size and per capita consumption

Household size	Per capita consumption
2	51.5 m^3
3	21.7 m^3
4	23.3 m^3
5	21.6 m^3
6	24 m^3

Graph 3. Per capita consumption and Household size



Umoja II Estate sector 2.(N=13 households)
Table of correlation analysis
X= household size
Y= per capita consumption per year in m^3

X	X^2	Y	Y^2	XY
2	4	51.5	2652.25	103
3	9	21.7	470.89	65.1
4	16	23.3	542.89	93.2
5	25	21.6	466.56	108
6	36	24	576	144
∑20	**90**	**142.1**	**4708.6**	**513.3**

Correlation coefficient r =

$$\frac{513.3-\frac{(20)(142.1)}{5} = 513.3-568.4 = -55.1}{\sqrt{\left[90-\frac{(20)^2}{5}\right]\left[4708.6-\frac{(142.1)^2}{5}\right]}}$$

$$=\sqrt{(90-80)(4708.6-4038.5)}$$

$$=\sqrt{6701}$$

$$=81.9$$

$$r=\frac{-55.1}{81.9}=-0.6727$$

$$r^2=0.4525 \qquad r^2 x100=45.25$$

$$H0r=0$$
$$H1r\neq 0$$

$$t=\left|0.6727x\frac{\sqrt{5}-2}{1-0.4525}\right| \qquad =0.6727x\frac{1.7321}{0.5475}$$

$$t=2.13$$

Critical t at α 0.05 and 3 degrees of freedom is 3.18. Calculated t, 2.13 is less than critical t. The null hypothesis is adopted that there is no significant correlation between household size and per capita water consumption.

4.2 d] UMOJA II SECTOR 3

Table 16: Household size and per capita consumption

Household size	Per capita consumption
2	49.5 m^3
3	25 m^3
5	12 m^3
7	9.9 m^3
9	17.1 m^3
10	16.5 m^3

Graph 4. Per capita consumption and Household size

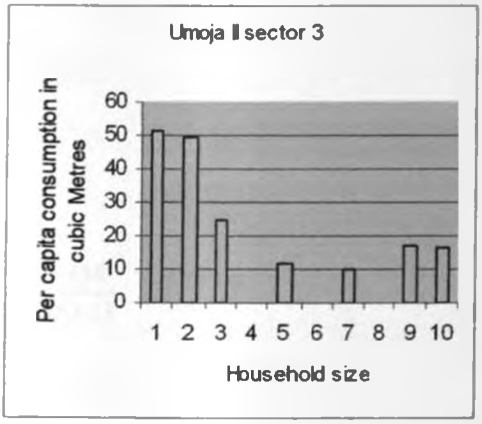


Table of correlation analysis

X= household size   Y= per capita consumption per year in m^3

X	X^2	Y	Y^2	XY
2	4	49.5	2450.3	99
3	9	25	625	75
5	25	12	144	60
7	49	9.9	98.01	69.3
9	81	17.1	292.41	153.9
10	100	16.5	272.25	165
∑36	**268**	**130**	**3881.6**	**622.1**

Correlation coefficient (r) =

$$r = 622 - \frac{(36)(130)}{6} = 622 - 780 = -158$$

$$\sqrt{\left[268 - \frac{(36)^2}{6}\right]\left[3882 - \frac{(130)^2}{6}\right]}$$

$$\sqrt{[268 - 216]\ [3882 - 2817]} = \sqrt{52x1065}$$

$$= \sqrt{55380}$$

$$= 253.33$$

$$r = \frac{-158}{253.33}$$

$$r = -0.6237$$

$$r^2 = 0.389 \qquad r^2 x100 = 38.9\%$$

$$H_0 \quad r = 0$$
$$H_1 \quad r \neq 0$$

$$t = -0.6237x\frac{\sqrt{4}}{1-0.389} \qquad = 0.6237x\frac{2}{0.611}$$

$$t = 2.04$$

Critical t at α 0.05, and 4 degrees of freedom is 2.78.Calculated t , 2.04 is less than critical t. The null hypothesis is adopted that there is no significant correlation between household size and per capita water consumption.

4.3 CLIMATE CHANGE AND WATER CONSUMPTION

4.3 a] PRUDENTIAL ESTATE

i) COOL AND HOT SEASON CONSUMPTION

Hypotheses

H_0 There is no significant difference in mean domestic water consumption between the cool and hot season.

H_1 There is a significant difference in mean domestic water consumption between the cool and hot season.

Summary data (from table A1)

Cool Season	Hot Season
$\bar{x} = 28.8m^3$	$\bar{y} = 31.1m^3$
$\sum x = 835m^3$	$\sum y = 902m^3$
$\sum(x-\bar{x})^2 = 7932.8$	$\sum(y-\bar{y})^2 = 5876.7$
n = 29 households	n = 29 households
17.0 ° Centigrade	20.5 ° Centigrade
20.6.2003 - 28.7.2003	17.1.2003 - 6.3.2003

Best pooled estimator σ =

$$\sigma = \frac{\sqrt{7932.8 + 5876.7}}{(29+29)-2} \qquad = \frac{\sqrt{13809.5}}{56}$$

$$= \sqrt{246.6}$$

$$= 15.7$$

$$SE\overline{X} = \frac{15.7}{\sqrt{29}} = \frac{15.7}{5.4} = 2.9$$

$$SE\overline{y} = \frac{15.7}{\sqrt{29}} = \frac{15.7}{5.4} = 2.9$$

$$SE(\overline{x} - \overline{y}) = \sqrt{(2.9)^2 + (2.9)^2} = \sqrt{8.41} + 8.41 = \sqrt{16.82}$$

$$= 4.1$$

$$t = \left|\frac{28.8 - 31.1}{4.1}\right| = \frac{2.3}{4.1} = 0.56$$

Critical t at α0.05, 56 degrees of freedom lies between 2.02≤(t) ≥2.00. Calculated t, 0.56 is less than critical t.

The null hypothesis, H_0 is adopted that there is no significant difference in mean domestic water consumption between the Cool and Hot seasons in Prudential estate.

The table of analysis (A1) on water consumption during the Cool and Hot seasons was based on data calculated to cover a time frame of 38 days for each respective season. The temperature difference was 3.5 ° Centigrade between the cool and hot seasons.

ii) DRY AND WET SEASON CONSUMPTION

Hypotheses

H_0 There is no significant difference in mean domestic water consumption between the wet and dry season.

H_1 There is a significant difference in mean domestic water consumption between the wet and dry season.

Summary Data (from table A2)

Dry Season	**Wet Season**
$\bar{x} = 36.2m^3$	$\bar{y} = 32.1m^3$
$\sum x = 1050m^3$	$\sum y = 930m^3$
$\sum(x-\bar{x})^2 = 7844.8$	$\sum(y-\bar{y})^2 = 11191.9$
n = 29 households	n = 29 households
Rainfall: 26.4-43.3 mm	Rainfall: 154.6-384.4 mm
17.1.2003 - 6.3.2003	8.4.2003 - 22.5.2003

Best pooled estimator σ =

$$\sigma = \frac{\sqrt{7844.8 + 11191.9}}{(29+29)-2} = \frac{\sqrt{19036.7}}{56} = \sqrt{339.9}$$

$$= 18.4$$

$$SE\overline{X} = \frac{18.4}{\sqrt{29}} = \frac{18.4}{5.4} = 3.4$$

$$SE\overline{y} = \frac{18.4}{\sqrt{29}} = \frac{18.4}{5.4} = 3.4$$

$$SE(\bar{x} - \bar{y}) = \sqrt{(3.4)^2 + (3.4)^2} = \sqrt{11.56} + 11.56 = \sqrt{23.12}$$

$$= 4.8$$

$$t = \left| \frac{36.2 - 32.1}{4.8} \right| = \frac{4.1}{4.8} = 0.85$$

Critical t at α 0.05 and 56 degrees of freedom lies between 2.02≤(t) ≥2.00. Calculated t, 0.85 is less than critical t.

The null hypothesis, H_0 is adopted. There is no significant difference in mean domestic water consumption between the Wet and Dry seasons in Prudential estate.

The table of data analysis (A2) was based on data calculated to cover a time frame of 44 days of water consumption during both the Wet and Dry seasons.

4.3 b] UMOJA II ESTATE SECTOR 1

i) WET AND DRY SEASON CONSUMPTION.

Hypotheses

H_0 There is no significant difference in mean domestic water consumption between the wet and dry season.

H_1 There is a significant difference in mean domestic water consumption between the wet and dry season.

Summary data (from table A3)

Wet Season	Dry Season
$\bar{x} = 8.5m^3$	$\bar{y} = 15.1m^3$
$\sum x = 341m^3$	$\sum y = 605m^3$
$\sum(x-\bar{x})^2 = 810$	$\sum(y-\bar{y})^2 = 4498.4$
n= 40 households	n= 40 households
Rainfall: 154.6 -384.4 mm	Rainfall: 16.9 -26.4 mm
27.3.2003 -14.5.2003	3.1.2003 -19.2.2003

Best pooled estimator σ =

$$\sigma = \frac{\sqrt{810 + 4498.4}}{(40+40)-2}$$

$$= \frac{\sqrt{5308.4}}{78}$$

$$= \sqrt{68.06}$$

$$= 8.25$$

$$SE\bar{X} = \frac{8.25}{\sqrt{40}} = \frac{8.25}{6.32} = 1.31$$

$$SE\bar{Y} = \frac{8.25}{\sqrt{40}} = \frac{8.25}{6.32} = 1.31$$

$$SE(\bar{x} - \bar{y}) = \sqrt{(1.31)^2 + (1.31)^2}$$

$$= \sqrt{1.72 + 1.72} = \sqrt{3.44}$$

$$= 1.85$$

$$t = \left| \frac{8.5 - 15.1}{1.85} \right|$$

$$= \frac{6.6}{1.85} = 3.57$$

$$t = 3.57$$

Critical t at α 0.05 and 78 degrees of freedom is between 2.00 ≤ (t) ≥ 1.98. Calculated t, 3.57 is greater than critical t. The null hypothesis is rejected. The alternative is adopted that there is a significant difference in domestic water consumption between the Wet and Dry seasons in Umoja II estate.

The table of analysis (A3) on water consumption during the Wet and Dry seasons was based on data calculated to cover a time frame of 47 days for each respective season.

ii) COOL AND HOT SEASON CONSUMPTION

Hypotheses

H_0 There is no significant difference in domestic water consumption between the cool and hot season.

H_1 There is a significant difference in domestic water consumption between the cool and hot season.

Summary Data (from table A4)

Hot season	**Cool Season**
$\bar{x} = 15.1m^3$	$\bar{y} = 9.3m^3$
$\varepsilon x = 605m^3$	$\varepsilon y = 370m^3$
$\sum(x-\bar{x})^2 = 4498.4$	$\sum(x-\bar{x})^2 = 1513.6$
n = 40 households	n = 40 households
20.5 ° Centigrade	17.3 ° Centigrade
3.1.2003 -19.2.2003	11.7.2003 -1.9.2003

Best pooled estimator σ =

$$\sigma = \frac{\sqrt{4498.4 + 1513.6}}{(40+40)-2}$$

$$= \frac{\sqrt{6012}}{78} = \sqrt{77.07} = 8.78$$

$$SE\bar{X} = \frac{8.78}{\sqrt{40}} = 1.39$$

$$SE\bar{Y} = \frac{8.78}{\sqrt{40}} = 1.39$$

$$SE(\bar{x}-\bar{y}) = \sqrt{(1.39)^2 + (1.39)^2}$$

$$= \sqrt{3.86}$$

$$= 1.96$$

$$t = \frac{15.1 - 9.3}{1.96} = \frac{5.8}{1.96} \quad t = 2.96$$

Critical t at α 0.05 and 78 degrees of freedom is between 2.00 ≤ (t) ≥ 1.98. Calculated t, 2.96 is greater than critical t. The null hypothesis is rejected. The alternative is adopted that there is a significant difference in domestic water consumption between the Cool and Hot seasons in Umoja II estate.

The table of analysis (A4) on water consumption during the Cool and Hot seasons was based on data calculated to cover a time frame of 47 days for each season respectively.

4.3 c] UMOJA II ESTATE SECTOR 2

i) COOL AND HOT SEASON CONSUMPTION

Hypotheses

H_0 There is no significant difference in domestic water consumption between the cool and hot season.

H_1 There is a significant difference in domestic water consumption between the cool and hot season.

Summary data (from table A5)

Hot Season	Cool Season
$\bar{x} = 13.4m^3$	$\bar{y} = 4.5.m^3$
$\sum x = 174m^3$	$\sum y = 58m^3$
$\sum(x-\bar{x})^2 = 241.1$	$\sum(y-\bar{y})^2 = 29.3$
n = 13 households	n = 13 households
20.5 ° Centigrade	17.6 ° Centigrade
8.1.2003 -26.2.2003	13.6.2003 -21.7.2003

Best pooled estimator σ =

$$\sigma = \frac{\sqrt{241.1+29.3}}{(13+13)-2} \qquad = \frac{\sqrt{270.4}}{24}$$

$= 3.36$

$$SE\overline{X} = \frac{3.36}{\sqrt{13}} = \frac{3.36}{3.61} = 0.93$$

$$SE\overline{Y} = \frac{3.36}{\sqrt{13}} = \frac{3.36}{3.61} = 0.93$$

$$SE(\bar{x} - \bar{y}) = \sqrt{(0.93)^2 + (0.93)^2}$$

$= \sqrt{1.73}$

$= 1.32$

$$t = \left|\frac{13.4 - 4.5}{1.32}\right| = \frac{8.9}{1.32} = 6.74$$

$t = 6.74$

Critical t at α 0.05 and 24 degrees of freedom is 2.06. Calculated t, 6.74 is greater than critical t. The null hypothesis is rejected. The alternative is adopted that there is a significant difference in domestic water consumption between the Cool and Hot seasons in Umoja II estate.

The table of analysis (A5) on water consumption during the Cool and Hot seasons was based on data calculated to cover a time frame of 38 days for each season respectively.

ii) WET AND DRY SEASON CONSUMPTION

Hypotheses

H_0 There is no significant difference in domestic water consumption between the Dry and Wet seasons.

H_1 There is a significant difference in domestic water consumption between the Dry and Wet seasons.

Summary data (from table A6)

Dry Season	**Wet Season**
$\bar{x} = 16.2m^3$	$\bar{y} = 5.2m^3$
$\sum x = 210M^3$	$\sum y = 68m^3$
$\sum(x-\bar{x})^2 = 347.7$	$\sum(y-\bar{y})^2 = 40.3$
n = 13 households	n = 13 households
Rainfall: 9.5-26.4 mm	Rainfall: 384.4- 391.2 mm
8.1.2003 -26.2.2003	31.3.2003 -16.5.2003

Best pooled estimator σ =

$$\sigma = \frac{\sqrt{347.7 + 40.3}}{(13+13)-2} \quad = \frac{\sqrt{388}}{24} = \sqrt{16.17}$$

= 4.02

$$SE\overline{X} = \frac{4.02}{\sqrt{13}} = \frac{4.02}{3.61} = 1.11$$

$$SE\overline{Y} = \frac{4.02}{\sqrt{13}} = \frac{4.02}{3.61} = 1.11$$

$$SE(\bar{x} - \bar{y}) = \sqrt{(1.11)^2 + (1.11)^2}$$

$$= \sqrt{2.46}$$

$$= 1.57$$

$$t = \left| \frac{16.2 - 5.2}{1.57} \right| = \frac{11}{1.57}$$

$$t = 7.01$$

Critical t at α 0.05 and 24 degrees of freedom is 2.06. Calculated t, 7.01 is greater than critical t. The null hypothesis is rejected. The alternative is adopted that there is a significant difference in domestic water consumption between the Wet and Dry seasons in Umoja II estate.

The table of analysis (A6) on water consumption during the Wet and Dry seasons was based on data calculated to cover a time frame of 46 days for each season respectively.

4.3 d] UMOJA II ESTATE SECTOR 3

i) HOT AND COOL SEASON CONSUMPTION

Hypotheses

H_0 There is no significant difference in domestic water consumption between the Hot and Cool seasons.

H_1 There is a significant difference in domestic water consumption between the Hot and Cool seasons.

Summary data (from table A7)

Hot Season	**Cool Season**
$\bar{x} = 30.8m^3$	$\bar{y} = 7.7m^3$
$\sum x = 277m^3$	$\sum y = 69m^3$
$\sum(x-\bar{x})^2 = 3353.6$	$\sum(y-\bar{y})^2 = 180$
n = 9 households	n = 9 households
20.5 ° Centigrade	17.3 ° Centigrade
8.1.2003 -28.2.2003	17.7.2003 -4.9.2003

Best pooled estimator σ =

$$\sigma = \frac{\sqrt{3353.6+180}}{(9+9)-2} = \frac{\sqrt{3533.6}}{16} = \sqrt{220.85}$$

$$= 14.86$$

$$SE\overline{X} = \frac{14.86}{\sqrt{9}} = \frac{14.86}{3} = 4.95$$

$$SE\overline{y} = \frac{14.86}{\sqrt{9}} = \frac{14.86}{3} = 4.95$$

$$SE(\bar{x}-\bar{y}) = \sqrt{(4.95)^2 + (4.95)^2}$$

$$= \sqrt{24.5} + 24.5 \quad = \sqrt{49}$$

$$= 7$$

$$t = \left|\frac{30.8-7.7}{7}\right| = \frac{23.1}{7}$$

$$t = 3.3$$

Critical t at α 0.05 and 16 degrees of freedom is 2.12. Calculated t, 3.3 is greater than critical t. The null hypothesis is rejected. The alternative is adopted that there is a significant difference in domestic water consumption between the Cool and Hot seasons in Umoja II estate. The table of analysis (A7) on water consumption during the Hot and

Cool seasons was based on data calculated to cover a time frame of 49 days for each season respectively.

ii) WET AND DRY SEASON CONSUMPTION

Hypotheses

H_0 There is no significant difference in domestic water consumption between the Dry and Wet seasons.

H_1 There is a significant difference in domestic water consumption between the Dry and Wet seasons.

Summary data (from table A8)

Dry Season	**Wet Season**
$\bar{x} = 32.1m^3$	$\bar{y} = 9.8m^3$
$\sum x = 289m^3$	$\sum y = 88m^3$
$\sum(x-\bar{x})^2 = 3574.9$	$\sum(y-\bar{y})^2 = 185.6$
n = 9 households	n = 9 households
Rainfall: 16.9 -26.4 mm	Rainfall: 384.4 -391.2 mm
8.1.2003 -28.2.2003	31.3.2002 -12.6.2003

Best pooled estimator σ =

$$\sigma = \frac{\sqrt{3574.9+185.6}}{(9+9)-2} = \frac{\sqrt{3760.5}}{16} = \sqrt{253.03}$$

$= 15.91$

$$SE\overline{X} = \frac{15.91}{\sqrt{9}} = \frac{15.91}{3} = 5.3$$

$$SE\overline{Y} = \frac{15.91}{\sqrt{9}} = \frac{15.91}{3} = 5.3$$

$$SE(\bar{x} - \bar{y}) = \sqrt{(5.3)^2 + (5.3)^2}$$

$$= \sqrt{56.18}$$

$$= 7.5$$

$$t = \left| \frac{32.1 - 9.8}{7.5} \right| = \frac{22.3}{7.5}$$

$$t = 2.97$$

Critical t at α 0.05 and 16 degrees of freedom is 2.12. Calculated t, 2.97 is greater than critical t. The null hypothesis is rejected. The alternative is adopted that there is a significant difference in domestic water consumption between the Wet and Dry seasons in Umoja II estate.

The table of analysis (A8) on water consumption during the Wet and Dry seasons was based on data calculated to cover a time frame of 51 days for each season respectively.

4.4 IMPACT OF SOCIO-ECONOMIC STATUS ON CONSUMPTION

Hypotheses

H_0 There is no significant difference in per capita water consumption between the residents of Prudential and Umoja II estates.

H_1 There is a significant difference in per capita water consumption between the residents of Prudential and Umoja II estates.

Summary data (from table A9)

Prudential Estate	**Umoja II Estate**
$\bar{X} = 43.2$ m³	$\bar{Y} = 23$ m³
$\sum X = 1253.4$	$\sum Y = 1426.1$
$\sum (x-\bar{x})^2 = 11801.24$	$\sum (y-\bar{y})^2 = 7090.85$
n = 29 residents	n = 62 residents

Best pooled estimator σ =

$$\sigma = \frac{\sqrt{11801.24+7090.85}}{(29+62)-2} = \sqrt{212.27} = 14.57$$

$$SE\bar{X} = \frac{14.57}{\sqrt{29}} = \frac{14.57}{5.38 = 2.7} \qquad SE\bar{y} = \frac{14.57}{\sqrt{62} = 1.85}$$

$$SE(\bar{x}-\bar{y}) = \sqrt{(2.7)^2 + (1.85)^2} = \sqrt{10.71} = 3.27$$

$$t = \frac{43.2-23}{3.27} = 6.17$$

Critical t at α 0.05, 89 degrees of freedom lies between $2.00 \leq (t) \geq 1.98$.

Calculated t, 6.17, is greater than critical t.

H_0 is rejected and the alternative is adopted that there is a significant difference in per capita water consumption between residents of Prudential and Umoja II estates.

CHAPTER V

5.0 DISCUSSION OF RESULTS

Three important variables affecting water consumption were investigated. These variables were Household size, Socio-economic status and Climate change. The results show that there is an order of relative importance of the variables. Household size had least importance in terms of determining the water consumption per capita. The socio-economic status and climate change were important variables. The climatic changes resulted in significant changes in per capita consumption in Umoja II estate. This means that in order to plan properly and to effectively manage the water resource in cities, seasonal and long-term climatic changes must be taken into account. The impact of socio-economic status on domestic water consumption was also found to be significant.

5.1.a) SEASONAL CHANGES AND DOMESTIC WATER CONSUMPTION

Table 17. Water consumption per household in Wet and Dry seasons

	wet season consumption	Dry season consumption	Increment
Prudential estate	32.1 m^3	36.2 m^3	4.1 m^3
Umoja II sector 1	8.5 m^3	15.1 m^3	6.6 m^3
Umoja II sector 2	5.2 m^3	16.2 m^3	11 m^3
Umoja II sector 3	9.8 m^3	32.1 m^3	22.3 m^3

Table 18. Water consumption per household in Cool and Hot seasons

	Cool season consumption	Hot season consumption	Increment
Prudential estate	28.8 m^3	31.1 m^3	2.3 m^3
Umoja II sector 1	9.3 m^3	15.1 m^3	5.8 m^3
Umoja II sector 2	4.5 m^3	13.4 m^3	8.9 m^3
Umoja II sector 3	7.7 m^3	30.8 m^3	23.1 m^3

After statistical analysis, it emerged that seasonal changes had an impact on the mean water consumption of households in all the samples. However, it was noted that the impact of seasonal changes was not statistically significant in Prudential estate. The data from table 19 shows that there was an increase in consumption of 4.1 cubic metres between the wet and dry seasons in Prudential. Although this was a clear increase due to changes in climatic conditions, it was not statistically significant when subjected to the t-test. Nevertheless, the fact was established that indeed a difference in mean household consumption had occurred. The consumption in the dry season was higher than that of the wet season. The consumption in the cool season was also found to be lower than the consumption during the hot season.

In general, the changes observed between the *Wet* and *Dry* season were higher than the consumption changes between the *Cool* and *Hot* seasons. In prudential estate, the percentage increase in consumption due to variation in rainfall was 12.8%, whereas the changes in consumption due to temperature increase were 8%. In Umoja II estate sector 1, the consumption increased by 77.6% from the wet to the dry season. The consumption increased by 62.4% when the temperatures changed between the cool and hot seasons.

In Umoja II estate samples, it emerged that the changes in consumption that are attributed to seasonal variations were statistically significant. At the end of this discussion there is a theory put forward to explain this differential impact of seasonal changes. This is the phenomenon whereby seasonal changes had a greater impact in consumption in Umoja II estate than in Prudential estate.

In all the 3 sectors sampled in Umoja II, the climatic changes were found to exert a significant change in consumption of households. The differences in mean consumption of the households were found to be statistically significant when subjected to the t-test. The variations in climatic conditions caused changes in mean consumption of households of such magnitude that these households behaved like entirely different populations based on the prevailing climatic conditions. These changes were remarkable in that the sampled households were in actual fact the same households, and that only the seasons had changed. The seasonal changes in Umoja II resulted in the households acquiring entirely different consumption characteristics. Since these differences were statistically significant, the hypothesis stating that climatic changes have a significant impact on domestic water consumption was adopted in Umoja II estate.

The alternative to this hypothesis had earlier been adopted in Prudential estate. In Prudential estate the climatic changes had no significant impact on the mean consumption of the sampled households. The differences in the way Umoja II households and the ones in Prudential estate reacted to climatic changes suggests that domestic water consumers will react differently to changes in climatic conditions based on their socio-economic status. The reason why prudential estate consumption was only slightly altered by seasonal changes, whereas the consumption in Umoja II was significantly altered is explained in the theory put forward as follows.

5.1.b) IMPACT OF CLIMATIC CHANGES ON WATER CONSUMPTION

From the results, it was apparent that households of relatively higher socio-economic status, represented here by Prudential estate, are likely to experience insignificant changes in consumption due to variations in climatic conditions.
On the other hand, it became apparent that climatic variations have a significant impact the domestic water consumption of households of lower socio-economic status. The following is an explanation for these observations.

The theory is that all species within the animal kingdom are sensitive to climatic conditions, and that they respond to climatic changes primarily in one of the following two ways.
Response by;
a) Adaptation to climatic conditions, or
b) Modification of climatic conditions

What sets us apart from other animals is that as human beings, we are so greatly concerned about the climatic conditions to the extent we monitor the climatic conditions in the science of Metreology.

a) Adaptation to climatic conditions

Adaptation: **These are the changes in established behaviour patterns of animals in response to changes in climatic conditions.**

Animals may adapt to climatic changes by migration, for example. Other animals may adapt physiologically by aestivation and hibernation. Moreover, these physiological changes are accompanied by behavioural changes, as the affected animals usually adopt a sedentary lifestyle during the adverse climatic conditions. Adaptation to climatic changes thus involves changes in the behaviour of animals. Humans can also adapt to environmental conditions by making behavioural changes. Any significant changes in human behaviour in order to accommodate climatic changes invariably lead to changes in domestic water consumption. Thus when human beings adapt to climatic changes, their consumption patterns are inevitably altered.

b) Modification of climatic conditions.

Modification: **This is the response to climatic changes by use of technologies that alter adverse climatic conditions to suitable conditions.**

Modification of climatic conditions must involve the use of technologies that alter climatic conditions that are considered adverse into suitable climatic conditions.

Although the modification of environmental conditions is chiefly the preserve of human beings, it is not limited to humans alone. A few animals are also able to modify their immediate environments by use of simple technologies such as the weaving of nests by some birds.

Modification of the environment is done by humans due to their sensitivity to changes in climatic conditions. There is a vast array of technologies that can be used to modify climatic conditions. For example, most humans live in constructed housing shelters. The reason we live in constructed houses is principally to modify the climatic conditions to suitable parameters. Homelessness among some people is a direct result of human poverty, where the homeless cannot afford the high price of building technology. In some houses we have insulation, central heating and air conditioning systems to modify the interior microclimatic conditions. The clothes we wear also modify the immediate environment. Although whenever we dress up we may do it subconsciously, it is really a modification of climatic conditions. That is why we have winter and summer clothing for example.

In order to modify the properties of water, we have hot baths and instant hot showers for example. Some technologies such as washing machines and dishwashers altogether remove the need to make contact with water when washing clothes and dishes. The use of technology to modify climatic conditions implies that human water consumption potential remains unaffected by climatic conditions. However, all persons who cannot afford such technologies have to adapt to adverse climatic conditions, and their water consumption patterns are altered as a result.

It becomes apparent that in order to modify the immediate environment of man, there is always an economic cost involved. Usually this cost is incurred in purchasing the item that modifies the environment. For example, in order to modify the temperature of cold water in the house, one may opt to use an instant hot shower system. This will be costly in terms of initial purchase price and energy consumption. In the event a consumer uses renewable energy such as solar energy, then only the initial purchase cost will be incurred.

The consumer incurs an economic cost in order to modify the environment. The involvement of economic cost is the main criterion for the distinction between modification and adaptation to environmental changes. Adaptation to environmental conditions usually involves behaviour change, and does not necessarily involve economic cost. In many cases adaptation to the climatic conditions is the cheaper option.

Since modification of the environment involves economic cost, it follows that having a higher income makes a consumer better placed to modify his or her environment. Since modification of the environment does not necessitate significant behaviour changes, the water consumption in households that can afford to modify their environments is not significantly influenced by climatic changes.

On the other hand, the persons with low socio-economic status are more likely to react to climatic changes by adaptation. Adaptation to the environmental conditions results in behavioural changes. Adaptation is a lifestyle change.

Since Prudential estate residents represent a high-income population, they react to changes in climatic conditions primarily by modification. That is the reason why the consumption in Prudential estate was not significantly affected by the changes in climatic conditions. Whenever the climatic conditions are modified, there is little need for significant changes of behaviour. The changes in behavior are in turn responsible for the changes in consumption patterns, and so there is no expectation of significant changes in consumption in the absence of behaviour change.

In Umoja II estate, the socio-economic status was relatively low compared to Prudential estate. The changes in consumption in Umoja II were found to be statistically significant. It is apparent that the Umoja II residents were more likely to adapt to changes in climatic conditions than their Prudential estate counterparts. These changes in behaviour patterns in turn resulted in a significant change in the water consumption patterns of Umoja II residents.

The socio-economic status determines the technological choices and behaviour of consumers. The respondents were asked whether they boiled their tap water before drinking to eliminate harmful microbes. The concerns on the safety of tap water arise from the fact that the utility has been guilty of providing untreated water to consumers on several occasions in the past. As a result, 49% of respondents believed tap water was unfit for direct consumption.

In prudential estate, 89 % of the respondents boiled their water to improve its quality. In Umoja II estate, only 63% of the respondents boiled their water. Although they had concerns about the quality of water, some of the Umoja II residents cited the cost involved in boiling water as the reason for their failure to boil water.

Monthly consumption trends

The water consumption data was rearranged into total consumption on a month-by-month basis for analysis. It became clear that there were large variations in consumption from one month to the next month in Umoja II estate. The month of highest consumption was 563 m^3 and that of least consumption was 226 m^3. This is a difference of 337 m^3 in Umoja II.

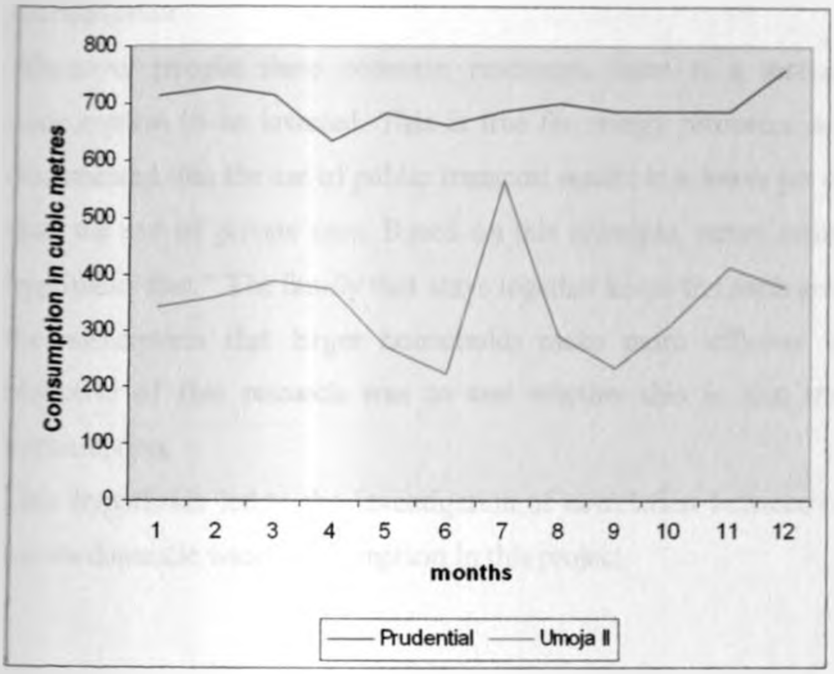
The consumption in Prudential showed less variation from one month to the next. The highest consumption was 758 m^3 and the least was 701 m^3. The difference was only 57 m^3 between the highest and lowest consumption figure. This implies that the consumption in low-income estates is radically influenced by climatic changes, while in high-income areas the consumption is not very sensitive to climatic changes. This illustrates the difference in response to climatic changes by Adaptation and Modification respectively.

The socio-economic status of households will determine their mode of reaction to climatic changes. The socio-economic status dictates whether they will adapt to or modify the climatic conditions.

Climatic changes clearly have an impact on domestic water consumption patterns. The degree or strength of impact depends on the socio-economic status of the consumers. The consumption patterns of low-income groups are more sensitive to changes in climatic conditions.

The following chart illustrates that the consumption in Prudential estate, due to modification responses, was less erratic when compared to the consumption in Umoja II where the residents largely respond to climatic changes by adaptation.

Graph .5 Month-by-month consumption trends



Summary on climatic changes and water consumption

It has been demonstrated that climatic changes not only impact on the availability of surface water supplies, but that these climatic changes equally have an impact on domestic water consumption.

It has also been demonstrated that households of higher socio-economic status will experience insignificant changes in consumption patterns due to climatic changes. On the other hand, households of lower socio-economic status are significantly impacted by climatic changes.

The poor are thus more vulnerable to climatic changes. This means that cities with large proportions of poor households are likely to have erratic domestic water consumption patterns as dictated by the prevailing climatic conditions. This further contributes to the seasonal difficulties in provision of water services in such cities. Thus some of the seasonal shortfalls in water supply are not only due to physical water scarcity, but the situation may be aggravated by the increased demand by vulnerable households during the hot and dry seasons. The hot and dry seasons are notably the peak water consumption seasons.

5.2 CORRELATION BETWEEN HOUSEHOLD SIZE AND PER CAPITA CONSUMPTION

Introduction

Whenever people share common resources, there is a tendency of the per capita consumption to be lowered. This is true for energy resources such as fossil fuels. It is documented that the use of public transport results in a lower per capita fuel consumption than the use of private cars. Based on this principle, many authors have advanced this hypothesis that " The family that stays together keeps the earth greener". This is based on the assumption that larger households make more efficient use of resources. The objective of this research was to test whether this is also true for domestic water consumption.

This hypothesis led to the investigation of correlation between household size and per capita domestic water consumption in this project.

Correlation tests.

The significance of the correlation coefficient (r) was investigated using the t-test. The results showed that there was a weak correlation between household size and per capita water consumption. In both Prudential and Umoja II estate samples, the null hypothesis was adopted that there is no significant correlation between household size and per capita water consumption. The coefficient of determination, (r^2) calculated for the samples showed that the percentage or proportion of water consumption accounted for by household size was low.

Summary on household size and per capita water consumption

In all the sampled households in Prudential and Umoja II estates, it emerged that there was no significant correlation between household size and per capita water consumption. The adoption of the null hypothesis provides evidence that the water resource is unique from other resources such as land and energy resources.

It was therefore concluded that water is a unique resource. It is unique from other resources such as energy resources where sharing the resource at the household level often leads to lower consumption per capita. For the water resource, individual needs are not significantly lowered by virtue of sharing the resource in a household setting.

The water consumption by one household member does not reduce the potential for consumption by any other household members provided the level of water supply is sustained.

5.3 IMPACT OF SOCIO-ECONOMIC STATUS ON DOMESTIC WATER CONSUMPTION

Introduction

Disparities on domestic water consumption are based on socio-economic status. It was hypothesized in this research that the households of higher socio-economic status would consume more water than their counterparts with a lower socio-economic status. Prudential estate represented the higher socio-economic status and Umoja II represented the lower socio-economic status population.

Results

When the t- test was applied to the water consumption results, it was concluded that the difference in per capita consumption between the two estates was statistically significant. The null hypothesis was rejected and the alternative was adopted that there is a significant difference in consumption between Prudential and Umoja II estates. This significant difference in water consumption per capita was attributed to the difference in socio-economic status between the two populations.

Summary

The socio-economic status determines the consumption patterns of consumers as well as the technological choices that they make in their houses. Some technologies may result in water use efficiency while others may not. In Prudential estate, 59% of the respondents made use of showers for personal hygiene, while 41% used basins to bathe themselves. In Umoja II estate, the choice of technologies was different. Only 23.5% of the respondents made use of showers .The majority of respondents, 76.5% used basins to wash their bodies. In Umoja II, one of the reasons given for low usage of showers was that some of their bathrooms were not fitted with shower facilities.

Another reason given for widespread use of basins in Umoja II was lack of sufficient water pressure in the showers. This low pressure may be due to inefficiency on the part of the water utility company, coupled with a high demand from a large population that exceeds the infrastructure capacity.

Factors contributing to per capita water consumption

a) Total living space

b) Income levels

c) Water pricing policy

- Houses with larger total living spaces require larger amounts of water to maintain the houses. Small-sized houses require less water for general house maintenance. A house with many rooms and a sizeable garden or lawn requires more water. In this research, Prudential estate houses have 4 bedrooms and a servant's quarter. The gardens in Prudential were also well watered. The expansive living space contributed to the high water consumption in Prudential estate.

- Income levels contribute to the per capita water consumption of individuals. High income creates additional demands for water, and determines the means by which water is made available to consumers. For example, the economically poor populations that live in Nairobi's informal settlements do not have piped water supplies. They mostly obtain their water from vendors. On the other hand, the wealthy have a ready supply of piped water that is directly accessible within their houses. In addition, the large total living space, and various household goods acquired as a result of wealth create greater demand for water.

- Pricing policies also determine the water consumption patterns of consumers. For instance, the water for Prudential and Umoja II estates was priced at the same rate by the utility. This gives little or no incentive to the high-income households to use water resources conservatively. The pricing of water has political and economic implications. As a result, the water resource is often under-priced for political reasons. When water is not priced on sound economic basis, there is little motivation for the consumers to conserve water. Thus poor pricing policies contribute to high water consumption

The three factors discussed above all contributed to the higher water consumption in Prudential estate than in Umoja II estate.

Coping with water shortages

The residents of Nairobi cope with water shortage by stockpiling water. Some of the houses have inbuilt tanks that act as water reservoirs. Some of the residents buy additional large capacity tanks and water containers to store water. The following is a picture of a water storage tank in Umoja II estate.

Photo IX. Water storage tank in a house compound Umoja II

The stockpile of water in each house ensures there is little disruption to normal water consumption in periods of water shortage. Water shortages are usually experienced whenever there are repairs and maintenance of works, and also during severely dry seasons. The ability to stockpile water in households renders any water rationing activities by the utility futile (Budds and Mc Granahan, 2003). The consumers over abstract water when it is available, and later use these reserves during the period of water shortage. These are the mechanisms by which the city residents cope with water shortages.

Water conservation ethics.

There was no clear evidence of water conservation ethics in any of the sampled households in Prudential and Umoja II estates.

In Prudential estate, 49 % of the respondents felt water was expensively priced. They however did not make any notable efforts to conserve water.

The practice of watering lawns using hosepipes directly was observed in Prudential estate, and it results in water wastage. The better practice would be to attach water sprinklers to the hosepipes.

Many leaking taps were observed in Umoja II estate, and this leads to massive losses of water.

There is therefore a great need to improve the water conservation practices of residents in both of the estates that were sampled

Corrupt practices

Corrupt practices result in poor service delivery. Some of these practices include illegal water connections made by consumers, and misappropriation of water revenues by the water service providers. Illegal water connections often sabotage the water supply to the legally connected consumers. There was evidence of illegal connections in Umoja II estate, captured in the following picture

Photo X. Illegal water connections in Umoja II estate.

Note the leakage that results from the poorly connected hosepipes. There is a huge loss of revenue to the utility as a result of these illegal connections. There is often collusion between the culprits and the utility personnel in these corrupt practices. As a result, the legally connected neighbours have become complacent, and rarely report the illegal connections to the utility.

Water management in Kenya

In Kenya the body responsible for management of water is known as the Water Resource Management Authority (WRMA). This body was constituted by the water act (2002). The WRMA is charged with the responsibility, inter alia, of ensuring that all catchment areas within the country are protected. This is to be achieved by the constitution of catchment protection committees in all water catchment areas. Catchment protection activities include the control of vegetation, soil conservation and forest preservation. The main objective of protecting catchment areas is to preserve the quality and quantity of water.

Other civil society groups and relevant government agencies are also involved in catchment protection. An example of a successful group is the Green Belt Movement. This group is led by the 2004 Nobel peace prize laureate, Professor Wangari Maathai.The Green Belt Movement is involved in tree planting exercises across the country. They also play the role of a watchdog body that sounds the alarm on environmentally destructive practices that may be condoned by the political leadership in Kenya. The group also focuses on ways to ensure local communities are involved in conservation of forests.

Areas for further research

- This research did not investigate the particular behaviour changes that result in lower consumption in cool seasons when compared to the hot season. These behaviour changes are subtle and may not be easily noticed. However, it has been established that these subtle behaviour changes can become statistically significant between one season and the next.

- Another area for further research is to look into the possibility of quantifying and determining the strength of correlation between climatic changes and consumption changes. It was not possible to determine the precise increase in consumption brought about by a single degree's increase in temperature. It would be desirable if the data could allow for the calculation of how much change in consumption can be attributed to a degree increase in temperature and to an increase in rainfall. Such information could be useful in the preparation of future water consumption models. One of the conditions for achieving this is through making data on climatic conditions available on a day-to-day basis. Such data was not accessible from the Metreology department during the course of this research. For example, the data they presented had a total number of rainy days in a month, but the particular dates of the rainy days were not provided in their compiled data. It was not possible to gain access to the raw data during the course of this research. Such raw data needs to be made easily accessible to researchers in future.

- It was apparent from the results that temperature changes played a lesser role in determining water consumption when compared to rainfall changes. It may thus be concluded that rainfall is a slightly more important factor of climate change in determining water consumption than temperature changes. However, this is an area that requires further research, as often rainfall and temperature act synergistically, and it is difficult to describe the impact of the two factors separately.

- The aspect of gender of the respondents was not investigated due to the primary assumption of the per capita water consumption. It was assumed that there is no difference in consumption based on age, size and gender. However, further research is needed to determine the role of gender in water consumption. The results of such investigations could lead to the development a gender- based water consumption indicator.

5.4 a) Practical and academic significance of the study

Contribution to the discipline

- The methodology used to determine the impact of climatic conditions on domestic water consumption was new to the field. The research clarified the importance of climate change in domestic water consumption.
- The research affirms previous results that report a difference in water consumption based on socio-economic status of consumers. It was affirmed that per capita water consumption is high in high-income estates, and the per capita water consumption is lower in low-income estates.
- In the course of the work, it was clarified that response to climatic changes are based on socio-economic status of a population. It is clarified that consumer response to climatic changes is by either ***Adaptation*** or by ***Modification***. It was further clarified that modification of climatic conditions is the likely response for affluent populations. Less affluent populations respond to climatic changes primarily by adaptation.
- In the course of the research, new data was produced regarding water consumption in Nairobi. This new data fills some of the knowledge gaps left by previous researchers.

5.4 b) Practical and academic recommendations of the study.

Role of the Government

- Government development policy should focus on sustainable development. The government should fully participate in initiatives to manage human induced climate change. The Kenyan commitment to the Kyoto protocol should be sustained. Clear policies should be formulated and fully implemented to curb production of Green house gases. This is because climate change could have a severe impact on both water consumption patterns and on water availability. The implications of climate change on natural systems sustaining humanity may be more serious than previously thought (Ong'wenyi, 2000).
- The policy makers should involve local participation from city residents, and adopt the bottom-up management approach. This is because water management is more than a

scientific and engineering issue, but one that extends to include community empowerment and organizational restructuring (Syed & Nickum, 2002).

- The forest cover of the country should be increased, and water catchments conserved. The government should pay due attention to these sectors in its development plans.

Role of consumers

- Consumers should be encouraged to conserve water in their households. This conservation can be achieved by reusing water and prompt replacement of leaking taps.
- Consumers should be encouraged to report corrupt water practices such as illegal connections to the authorities.

Domestic water conservation measures

The following measures can help consumers in reducing the amount of water required for general household activities.

- ➢ Retrofitting of houses is the process of replacing old systems with modern water efficient devices that lead to lower water consumption. Low capacity cisterns are available and should be used to replace wasteful high capacity cisterns.
- ➢ Consumers are encouraged to reuse water in the houses. Brown water is water that has been use for laundry, and may be reused to flush cisterns instead of being poured down the drain.
- ➢ Consumers who wash their cars using water poured directly from hosepipes ought to use basins instead so as to conserve water. Consumers with gardens and lawns have the option of using efficient sprinklers to water their lawns instead of direct hosepipes. Another option is for residents to grow drought resistant plants in their gardens. There are various species of plants that have a high ornamental value and low water requirements.
- ➢ The use of showers instead of basins and bathtubs for personal hygiene lowers the water consumption per capita. Consumers should be encouraged to use shower facilities.

Role of water service providers

- The water service providers should reduce leakages in their water storage and distribution network. It has been estimated that a 20% - 25 % reduction of current water losses (unaccounted for water) could eliminate water shortage problems in Nairobi (UNESCO/UN, 2003).
- The water service providers should be actively involved in the protection of catchment areas.
- The pricing policies should be reviewed constantly by the utility in consultation with lead government agencies and all stakeholders.
- There is need to invest in technologies relating to water reuse and recycling of water. Research should be intensified in non-conventional sources of water such as desalinization.

5.4 c) Conclusion

Domestic water needs of a growing city population in Nairobi can be met in a sustainable manner if these recommended measures are implemented, and if the water resource is given a priority in government planning. Proper water management often results in better quality of life, and leads to the achievement of the ultimate goals of sustainable socio-economic growth.

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APPENDIX A

DATA ANALYSIS TABLES

Table A1

Prudential Estate (N=29 households)
Consumption in the Cool and Hot season

Cool Season			Hot Season		
X	(X-X̄)	(X-X̄)²	Y	(Y-Ȳ)	(Y-Ȳ)²
12	-16.8	282.24	32	0.9	0.81
31	2.2	4.84	17	-14.1	198.81
43	14.2	201.64	36	4.9	24.01
26	-2.8	7.84	26	-5.1	26.01
8	-20.8	432.64	13	-18.1	327.61
22	-6.8	46.24	21	-10.1	102.01
36	7.2	51.84	35	3.9	15.21
65	36.2	1310.44	63	31.9	1017.61
20	-8.8	77.44	23	-8.1	65.61
31	2.2	4.84	36	4.9	24.01
43	14.2	201.64	46	14.9	222.01
43	14.2	201.64	29	-2.1	4.41
25	-3.8	14.44	48	16.9	285.61
52	23.2	538.24	62	30.9	954.81
57	28.2	795.24	49	17.9	320.41
42	13.2	174.24	40	8.9	79.21
22	-6.8	46.24	27	-4.1	16.81
13	-15.8	249.64	18	-13.1	171.61
9	-19.8	392.04	35	3.9	15.21
62	33.2	1102.24	47	15.9	252.81
17	-11.8	139.24	27	-4.1	16.81
21	-7.8	60.84	32	0.9	0.81
5	-23.8	566.44	2	-29.1	846.81
14	-14.8	219.04	13	-18.1	327.61
28	-0.8	0.64	31	-0.1	0.01
10	-18.8	353.44	21	-10.1	102.01
34	5.2	27.04	34	2.9	8.41
9	-19.8	392.04	10	-21.1	445.21
35	6.2	38.44	29	-2.1	4.41
∑835		**7932.76**	**902**		**5876.69**

Table.A2

Prudential Estate (N=29 households)
Consumption in Dry and Wet season

Dry season			Wet season		
X	(X-X̄)	(X-X̄)²	Y	(Y-Ȳ)	(Y-Ȳ)²
37	0.8	0.64	20	-12.1	146.41
20	-16.2	262.44	24	-8.1	65.61
42	5.8	33.64	40	7.9	62.41
30	-6.2	38.44	38	5.9	34.81
16	-20.2	408.04	10	-22.1	488.41
25	-11.2	125.44	20	-12.1	146.41
40	3.8	14.44	43	10.9	118.81
74	37.8	1428.84	65	32.9	1082.41
27	-9.2	84.64	26	-6.1	37.21
42	5.8	33.64	36	3.9	15.21
53	16.8	282.24	56	23.9	571.21
33	-3.2	10.24	47	14.9	222.01
56	19.8	392.04	19	-13.1	171.61
72	35.8	1281.64	73	40.9	1672.81
57	20.8	432.64	69	36.9	1361.61
47	10.8	116.64	11	-21.1	445.21
31	-5.2	27.04	30	-2.1	4.41
21	-15.2	231.04	17	-15.1	228.01
40	3.8	14.44	39	6.9	47.61
54	17.8	316.84	72	39.9	1592.01
31	-5.2	27.04	33	0.9	0.81
37	0.8	0.64	28	-4.1	16.81
3	-33.2	1102.24	3	-29.1	846.81
15	-21.2	449.44	10	-22.1	488.41
36	-0.2	0.04	30	-2.1	4.41
25	-11.2	125.44	12	-20.1	404.01
40	3.8	14.44	10	-22.1	488.41
12	-24.2	585.64	12	-20.1	404.01
34	-2.2	4.84	37	4.9	24.01
∑1050		**7844.76**	**930**		**11191.89**

X= Wet season consumption in cubic metres

Y= Dry season consumption in cubic metres

Table A3

Umoja II Estate Sector 1:Consumption of the Wet and Dry seasons

Wet season			Dry season		
X	(X-X̄)	(X-X̄) ²	Y	(Y-Ȳ)	(Y-Ȳ) ²
0	-8.5	72.25	1	-14.1	198.81
5	-3.5	12.25	13	-2.1	4.41
4	-4.5	20.25	3	-12.1	146.41
8	-0.5	0.25	9	-6.1	37.21
5	-3.5	12.25	9	-6.1	37.21
11	2.5	6.25	19	3.9	15.21
5	-3.5	12.25	14	-1.1	1.21
7	-1.5	2.25	5	-10.1	102.01
11	2.5	6.25	7	-8.1	65.61
5	-3.5	12.25	8	-7.1	50.41
3	-5.5	30.25	2	-13.1	171.61
5	-3.5	12.25	10	-5.1	26.01
9	0.5	0.25	18	2.9	8.41
8	-0.5	0.25	22	6.9	47.61
8	-0.5	0.25	9	-6.1	37.21
5	-3.5	12.25	7	-8.1	65.61
8	-0.5	0.25	37	21.9	479.61
11	2.5	6.25	30	14.9	222.01
10	1.5	2.25	15	-0.1	0.01
11	2.5	6.25	7	-8.1	65.61
5	-3.5	12.25	6	-9.1	82.81
5	-3.5	12.25	16	0.9	0.81
12	3.5	12.25	38	22.9	524.41
11	2.5	6.25	23	7.9	62.41
10	1.5	2.25	15	-0.1	0.01
11	2.5	6.25	15	-0.1	0.01
3	-5.5	30.25	7	-8.1	65.61
13	4.5	20.25	14	-1.1	1.21
5	-3.5	12.25	24	8.9	79.21
10	1.5	2.25	18	2.9	8.41
7	-1.5	2.25	4	-11.1	123.21
8	-0.5	0.25	6	-9.1	82.81
13	4.5	20.25	18	2.9	8.41
12	3.5	12.25	10	-5.1	26.01
5	-3.5	12.25	9	-6.1	37.21
12	3.5	12.25	25	9.9	98.01
13	4.5	20.25	18	2.9	8.41
28	19.5	380.25	53	37.9	1436.41
11	2.5	6.25	23	7.9	62.41
8	-0.5	0.25	18	2.9	8.41
341		**810**	**605**		**4498.4**

Table A4

Umoja II Estate sector 1: Consumption of Hot and Cool season

Hot season			Cool season		
X	(X-X̄)	(X-X̄) ²	Y	(Y-Ȳ)	(Y-Ȳ) ²
1	-14.1	198.81	4	-5.3	28.09
13	-2.1	4.41	7	-2.3	5.29
3	-12.1	146.41	1	-8.3	68.89
9	-6.1	37.21	5	-4.3	18.49
9	-6.1	37.21	9	-0.3	0.09
19	3.9	15.21	11	1.7	2.89
14	-1.1	1.21	8	-1.3	1.69
5	-10.1	102.01	2	-7.3	53.29
7	-8.1	65.61	11	1.7	2.89
8	-7.1	50.41	6	-3.3	10.89
2	-13.1	171.61	2	-7.3	53.29
10	-5.1	26.01	6	-3.3	10.89
18	2.9	8.41	14	4.7	22.09
22	6.9	47.61	21	11.7	136.89
9	-6.1	37.21	9	-0.3	0.09
7	-8.1	65.61	4	-5.3	28.09
37	21.9	479.61	14	4.7	22.09
30	14.9	222.01	30	20.7	428.49
15	-0.1	0.01	25	15.7	246.49
7	-8.1	65.61	11	1.7	2.89
6	-9.1	82.81	7	-2.3	5.29
16	0.9	0.81	14	4.7	22.09
38	22.9	524.41	7	-2.3	5.29
23	7.9	62.41	7	-2.3	5.29
15	-0.1	0.01	4	-5.3	28.09
15	-0.1	0.01	8	-1.3	1.69
7	-8.1	65.61	1	-8.3	68.89
14	-1.1	1.21	8	-1.3	1.69
24	8.9	79.21	16	6.7	44.89
18	2.9	8.41	6	-3.3	10.89
4	-11.1	123.21	5	-4.3	18.49
6	-9.1	82.81	11	1.7	2.89
18	2.9	8.41	10	0.7	0.49
10	-5.1	26.01	11	1.7	2.89
9	-6.1	37.21	1	-8.3	68.89
25	9.9	98.01	10	0.7	0.49
18	2.9	8.41	10	0.7	0.49
53	37.9	1436.41	18	8.7	75.69
23	7.9	62.41	7	-2.3	5.29
18	2.9	8.41	9	-0.3	0.09
∑605		**4498.4**	**370**		**1513.6**

Table A5

Umoja II sector 2(N=13 households)
Hot and Cool season consumption

Hot season			Cool season		
X	(X-X̄)	(X-X̄) ²	Y	(Y-Ȳ)	(Y-Ȳ) ²
11	-2.4	5.76	6	1.5	2.25
12	-1.4	1.96	4	-0.5	0.25
12	-1.4	1.96	5	0.5	0.25
19	5.6	31.36	4	-0.5	0.25
12	-1.4	1.96	5	0.5	0.25
22	8.6	73.96	6	1.5	2.25
17	3.6	12.96	6	1.5	2.25
9	-4.4	19.36	3	-1.5	2.25
14	0.6	0.36	4	-0.5	0.25
15	1.6	2.56	4	-0.5	0.25
16	2.6	6.76	7	2.5	6.25
5	-8.4	70.56	2	-2.5	6.25
10	-3.4	11.56	2	-2.5	6.25
174		**241.08**	**58**		**29.25**

Table A6

Umoja II Sector 2 (N= 13 households)
Dry and Wet season consumption

Dry season			Wet season		
X	(X-X̄)	(X-X̄) ²	Y	(Y-Ȳ)	(Y-Ȳ) ²
13	-3.2	10.24	3	-2.2	4.84
14	-2.2	4.84	3	-2.2	4.84
15	-1.2	1.44	6	0.8	0.64
23	6.8	46.24	7	1.8	3.24
14	-2.2	4.84	4	-1.2	1.44
26	9.8	96.04	6	0.8	0.64
21	4.8	23.04	4	-1.2	1.44
10	-6.2	38.44	8	2.8	7.84
17	0.8	0.64	6	0.8	0.64
18	1.8	3.24	4	-1.2	1.44
20	3.8	14.44	8	2.8	7.84
7	-9.2	86.64	6	0.8	0.64
12	-4.2	17.64	3	-2.2	4.84
210		**347.72**	**68**		**40.32**

Table A7

Umoja II sector 3 (N=9 households)
Hot and Cool season comparison

Hot season X	$(X-\bar{X})$	$(X-\bar{X})^2$	Cool season Y	$(Y-\bar{Y})$	$(Y-\bar{Y})^2$
13	-17.8	316.84	4	-3.7	13.69
29	-1.8	3.24	7	-0.7	0.49
25	-5.8	33.64	3	-4.7	22.09
23	-7.8	60.84	3	-4.7	22.09
73	42.2	1780.84	16	8.3	68.89
55	24.2	585.64	13	5.3	28.09
12	-18.8	353.44	4	-3.7	13.69
31	0.2	0.04	11	3.3	10.89
16	-14.8	219.04	8	0.3	0.09
277		**3353.56**	**69**		**180.01**

Table A8

Umoja II Estate sector 3(N=9 households)
Dry and Wet season consumption

Dry season X	$(X-\bar{X})$	$(X-\bar{X})^2$	Wet season Y	$(Y-\bar{Y})$	$(Y-\bar{Y})^2$
14	-18.1	327.61	6	-3.8	14.44
30	-2.1	4.41	10	0.2	0.04
26	-6.1	37.21	8	-1.8	3.24
24	-8.1	65.61	6	-3.8	14.44
76	43.9	1927.21	19	9.2	84.64
57	24.9	620.01	14	4.2	17.64
13	-19.1	364.81	3	-6.8	46.24
32	-0.1	0.01	12	2.2	4.84
17	-15.1	228.01	10	0.2	0.04
289		**3574.89**	**88**		**185.56**

Table A9

X= Prudential per capita consumption in cubic metres. n X = 29 residents

Y= Umoja II per capita consumption in cubic metres. n Y = 62 residents

Prudential estate			Umoja II estate		
X	$(X-\bar{X})$	$(X-\bar{X})^2$	Y	$(Y-\bar{Y})$	$(Y-\bar{Y})^2$
32.7	-10.5	110.25	51	28	784
39.3	-3.9	15.21	49.5	26.5	702.25
33.9	-9.3	86.49	9.9	-13.1	171.61
38.6	-4.6	21.16	25	2	4
16	-27.2	739.84	21	-2	4
28.6	-14.6	213.16	17.1	-5.9	34.81
65.8	22.6	510.76	8	-15	225
86.3	43.1	1857.61	12	-11	122
29.5	-13.7	187.69	16	-7	49
82	38.8	1505.44	13	-10	100
37.2	-6	36	37	14	196
50	6.8	46.24	6.2	-16.8	282.24
61.1	17.9	320.41	14.6	-8.4	70.56
69.7	26.5	702.25	19.7	-3.3	10.89
33.7	-9.5	90.25	34	11	121
47.8	4.6	21.16	13.7	-9.3	86.49
16.6	-26.6	707.56	28.7	5.7	32.49
75.5	32.3	1043.29	16.7	-6.3	39.69
54.3	11.1	123.21	8.5	-14.5	210.25
30.1	-13.1	171.61	36	13	169
8	-35.2	1239.04	23.8	0.8	0.64
19.8	-23.4	547.56	29.5	6.5	42.25
54.6	11.4	129.96	13.8	-9.2	84.64
22.2	-21	441	8	-15	225
43	-0.2	0.04	28.9	5.9	34.81
20.5	-22.7	515.29	20.1	-2.9	8.41
60	16.8	282.24	25.2	2.2	4.84
41.8	-1.4	1.96	19.3	-3.7	13.69
54.8	11.6	134.56	14	-9	81
			38.3	15.3	234.09
∑1253.4		**11801.24**	22.8	-0.2	0.04
			20.8	-2.2	4.84
			17.2	-5.8	33.64
			19.6	-3.4	11.56
			10.7	-12.3	151.29
			17.5	-5.5	30.25
			43	20	400
			21.4	-1.6	2.56
			18.5	-4.5	20.25
			21.6	-1.4	1.96
			27.4	4.4	19.36

24	1	1
7.7	-15.3	234.09
33.2	10.2	104.04
19.9	-3.1	9.61
43.4	20.4	416.16
38.3	15.3	234.09
21.2	-1.8	3.24
22	-1	1
23	0	0
23.4	0.4	0.16
33	10	100
20.8	-2.2	4.84
23.3	0.3	0.09
30.5	7.5	56.25
17.5	-5.5	30.25
20.7	-2.3	5.29
51.5	28.5	812.25
19	-4	16
29	6	36
12.7	-10.3	106.09
13	-10	100
∑1426.1		**7090.85**

APPENDIX B

RAW DATA TABLES ON WATER CONSUMPTION

Note: Each row represents a single household and its total consumption for the stipulated period. The house numbers were not disclosed here to protect the privacy of the consumers. The *size* column is the household size for each respective house.

Table B1

Prudential estate water consumption data: covering 363 days

17/1-6/3/03	6/3-8/4	8/4-22/5	22/5-20/6	20/6-28/7	28/7-10/9	10/9-13/10	13/10-1/12	1/12-15/1/04	total m³	size
40	12	20	13	12	23	25	26	25	196	6
22	18	24	18	31	15	6	14	9	157	4
46	30	40	27	43	43	29	54	27	339	10
33	22	38	18	26	37	24	36	36	270	7
17	8	10	7	8	11	8	8	19	96	6
27	22	20	14	22	25	19	30	21	200	7
44	31	43	28	36	66	49	126	103	526	8
80	50	65	42	65	69	53	86	94	604	7
29	24	26	14	20	17	15	18	14	177	6
46	30	36	20	31	40	37	50	39	329	6
58	44	56	30	43	44	37	53	45	410	5
36	30	47	32	43	49	42	60	33	372	10
61	21	19	23	25	24	23	20	34	250	5
78	51	73	39	52	70	45	73	69	550	9
62	136	69	48	57	70	47	69	69	627	9
51	30	11	47	42	45	23	28	26	303	9
34	24	30	16	22	28	23	35	27	239	5
23	17	17	11	13	18	14	20	16	149	9
44	30	39	27	9	61	29	34	29	302	4
59	36	72	48	62	76	47	75	68	543	10
34	23	33	14	17	22	18	18	30	209	5
40	17	28	16	21	27	21	27	44	241	8
3	1	3	2	5	1	1	3	5	24	3
16	11	10	8	14	14	14	15	17	119	6
39	31	30	19	28	29	26	37	34	273	5
27	12	12	6	10	12	11	9	12	111	5
43	28	10	45	34	36	23	40	42	301	7
13	9	12	7	9	18	13	22	20	123	6
37	25	37	30	35	43	32	35	26	300	5
									8340	
1142	**823**	**930**	**669**	**835**	**1033**	**754**	**1121**	**1033**	**8340**	**192**

Table B2

Umoja II Estate consumption data: Covering 366 days Sector 1

16/11/02- 3/1/2003	3/1- to 19/2	19/2- to 27/3	27/3- to 14/5	14/5- to 11-Jun	11/6- to 11-Jul	11/7- to 1-Sep	1/9- to 6-Oct	6/10-to 17 Nov.03	Total m³	Household size
20	1	0	0	2	4	4	5	3	39	3
10	13	7	5	11	5	8	6	9	74	2
8	3	3	4	1	1	1	5	5	31	5
9	9	9	8	6	9	6	10	7	73	5
8	9	6	5	6	4	10	6	5	59	3
20	19	14	11	16	15	12	12	17	136	4
9	14	12	5	14	6	9	6	7	82	6
5	5	9	7	4	2	2	4	6	44	2
3	7	9	11	9	6	12	13	16	86	3
7	8	6	5	4	4	7	4	5	50	3
2	2	1	3	1	2	2	2	2	17	2
10	10	8	5	13	4	7	7	8	72	2
18	18	11	9	15	8	15	11	14	119	5
29	22	15	8	34	11	23	16	19	177	6
11	9	8	8	6	4	10	7	6	69	5
6	7	7	5	5	7	4	9	6	56	7
45	37	31	8	7	35	15	8	45	231	8
31	30	18	11	30	15	33	15	18	201	10
16	15	11	10	21	11	28	19	20	151	6
6	7	10	11	8	5	12	8	10	77	4
7	6	7	5	7	6	8	5	5	56	4
17	16	11	5	17	8	16	11	14	115	3
9	38	11	12	4	2	8	4	3	91	4
9	23	14	11	14	6	8	12	7	104	5
12	15	14	10	14	5	4	7	5	86	5
16	15	8	11	14	3	9	13	9	98	5
4	7	5	3	3	2	1	2	5	32	3
14	14	3	13	21	4	9	16	11	105	6
18	24	25	5	32	9	18	29	12	172	4
15	18	15	10	16	5	7	12	9	107	5
6	4	3	7	12	6	6	16	14	74	4
12	6	13	8	16	10	12	23	8	108	5
15	18	18	13	16	9	11	21	16	137	5
10	10	9	12	27	11	12	43	10	144	6
13	9	3	5	3	6	1	3	3	46	6
25	25	14	12	20	9	11	27	23	166	5
6	18	18	13	34	8	11	17	14	139	7
42	53	36	28	42	16	20	41	26	304	7
12	23	14	11	14	7	8	16	10	115	3
13	18	11	8	14	8	10	16	8	106	5
									4149	
548	**605**	**447**	**341**	**553**	**298**	**410**	**507**	**440**	**4149**	188

Table B3

Umoja II Estate consumption data: Covering 365 days sector2

8/1/03 to 26-Feb	26/2 to 31-Mar	31/3 to 16/5	16/5 to 13/6	13/6 to 21/7	21/7 to 4-Sep	4/9 to 8-Oct	8/10 to 24-Nov	24/11 to 8-Jan-04	Total m³	Household size
14	2	3	26	6	19	13	15	17	115	5
15	12	3	14	4	26	11	13	19	117	5
16	13	6	23	5	14	9	6	7	99	3
25	2	7	13	4	21	10	10	12	104	5
15	8	4	12	5	17	10	10	12	93	4
28	17	6	25	6	35	12	23	31	183	6
22	15	4	16	6	15	10	9	8	105	6
11	9	8	1	3	10	6	7	7	62	3
18	11	6	16	4	17	8	12	11	103	2
19	11	4	16	4	14	9	10	8	95	5
21	21	8	6	7	6	6	7	5	87	3
7	3	6	1	2	5	5	3	6	38	3
13	2	3	1	2	5	2	5	6	39	3
									1240	53
224	**126**	**68**	**170**	**58**	**204**	**111**	**130**	**149**	**1240**	

ble B4

ıoja II Households consumption data: covering 366 days. (Sector 3)

0- /03	8/1-28/2	28/2-31/3	31/3-12/6	12/6-17/7	17/7-4/9	4/9-7/10/03	total in m³	Household size
5	14	9	9	3	4	7	51	1
11	30	11	15	7	7	18	99	2
13	26	8	11	5	3	3	69	7
31	24	1	9	5	3	2	75	3
24	76	21	27	13	16	33	210	10
27	57	21	20	12	13	4	154	9
5	13	4	5	3	4	6	40	5
15	32	13	17	8	11	24	120	10
9	17	11	14	7	8	14	80	5
							898	
140	**289**	**99**	**127**	**63**	**69**	**111**	**898**	**52**

NAIROBI CLIMATIC DATA

JOMO KENYATTA METEOROLOGICAL STATION

ALTITUDE: 5329 FEET — LATITUDE: 01 19' SOUTH

1624 METRES — LONGITUDE: 36 55'EAST

	Temperature			Rainfall
2002	MAX	MIN	AVERAGE	TOTAL RAIN (mm)
JULY	24.3	11.3	17.8	0.2
AUGUST	22.9	12.9	17.9	3.9
SEPTEMBER	26.0	12.8	19.4	54.5
OCTOBER	26.8	14.3	20.6	48.7
NOVEMBER	25.5	15.5	20.5	115.1
DECEMBER	25.1	15.3	20.2	331.2
JANUARY 2003	26.5	13.9	20.2	16.9
FEBRUARY	28.2	13.4	20.8	9.5
MARCH	30.1	14.7	22.4	22.1
APRIL	28.0	15.7	21.9	154.6
MAY	24.3	15.2	19.7	229.8
JUNE	23.2	13.1	18.1	6.8
JULY	22.4	11.6	17.0	1.6
AUGUST	23.4	11.9	17.5	47.8
SEPTEMBER	25.2	13.4	19.3	40.8
OCTOBER	27.0	14.4	20.7	52.3
NOVEMBER	24.9	15.2	20.1	119.8
DECEMBER	25.9	14.1	20.0	25.2
JANUARY 2004	27.4	14.8	21.1	95.3

QUESTIONNAIRE

This research concerns the water consumption of households in Nairobi.Your answers will be useful in planning for future water provision.Please answer the following questions as accurately as possible.

1. House Number__________

2. What name appears on your water bill_________________________

3. How long has your family lived in this house(Tick one below)

For more than two years _______

For less than two years _______

4. How many people usually live in your house (Including those who may be in boarding schools,etc)

____

5. Has this usual number of residents been the same since 2002 (tick one)
Yes______ No______

6.Among the methods given below, which one do you often use to take a bath (tick one)

a) A basin/ bucket _______

b)A Shower _______

c) A bathtub _______

7.Do you usually drink water directly from the tap without boiling it first ? (tick one)

Yes______ No______

8. Given the choices below,how would you describe the costs of your water bills? (tick one)

a) Expensive______

b) Fair ______

c) Cheap ______

9. Given the two choices below,what problem would you like the Nairobi Water and Sewerage Company to solve first? (tick one)

a) Improve water quality _______

b)Reduce water shortages _______

Thank you very Much.

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