SUPPLY OF WATER IN URBAN CITIES OF NAMIBIA: THE CASE OF WINDHOEK.

A Research Paper submitted in partial fulfillment of the requirements for the degree of Master of Public Policy and Administration

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ABSTRACT

The study seeks to examine the interface between the urban expansion and the water supply and demand in Windhoek. Against this background, the study elaborates prospects relating to the provision and supply of water to the capital. The city's population is estimated at 300 000 inhabitants (Windhoek Urbanization Report 2001/2002), experiencing an annually population growth rate of 4.4 % and urbanization rate of 4.4%. The arid climate, the low precipitation per year, the enormous evaporation rate (on average 30% of surface water) and the rural urban migration makes it a difficult task to supply water to the city. This study employs secondary research methods, including the economic approach of demand and supply applied in the market theory of economics. This is complemented by data relating to water supply, consumption, population growth and water supply policy including case study findings from Botswana and Mozambique. This study has not only focused on the water supply and distribution situation in Windhoek but also creates an opportunity for academic intervention, creating a policy scenario that might serve as a basis for policy review and formulation. This study found that a positive relationship exists between water supply and urban expansion. This relationship is cemented by the analysis of the trend observed between population growth, water demand, consumption and supply. It is evident in this study that the three indicators mentioned above are positively linked. In order to upset the trend observed, a number of policy alternatives have to be applied in order to strike the balance between water supply and urbanization as a function of population growth.

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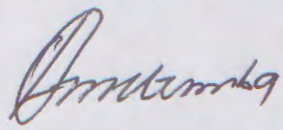
My word of thanks should also be extended to my brothers Borniface, Jerome, Humphery, Musa, my sister Namasiku, my parents Lunza Mutumba and David Mutumba for encouraging and supporting me through the duration of my study.

DEDICATION

This thesis is dedicated to my parents Lunza Mutumba and David Mutumba who have contributed enormously to my academic attainments. I thank you for the everlasting love you are giving me. Secondly, to all my brothers and sisters for the emotional support that they are giving me.

DECLARATIONS

I declare this thesis as my own, unaided work. It is being submitted for the degree of Master in Public Policy and Administration, Faculty of Economics and Management Science, University of Namibia/ ISS. I further testify that it has never been submitted for any other degree or to any other institution of higher learning.



LIST OF GRAPHS AND TABLES

ACRONYMS

AIC	Average Incremental Cost
C	The Intercept
D	Water Demand
EP	Estimated Price
JOA	Joint Operating Authority
JPWTC	Joint Permanent Water Technical Commision
LID	Low Impact Development
M	Multiplier or Gradient
NAMWATER	A State Owned Commercialized Public Water Provider.
P	Current Population
R	Rate of Population Growth
S	Water Supply

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Windhoek is the national capital of Namibia. Although Walvis Bay is categorized as part one municipality, the city of Windhoek is by far the largest urban center in Namibia. In accordance to the city of Windhoek urbanization report of 2001/2002, Windhoek has a population of approximately 300 000 inhabitants. The population is higher than all urban centers in Namibia.

Knowing the regions it is important to note that the size of the population has a direct relationship with the cost of providing utility services within a proclaimed local authority area. Although utility services referred to in this case include drinking water, electricity and other utilities, the focus is mainly on water supply which entails supply of drinking water and sewer.

The supply of water is funded through user charges comprising water consumption and service charges. This means that the inhabitants within the city are dependent directly on the city council for the supply of water where as the sustainability from the side of the city council is dependent on the ability of inhabitants to pay for their water consumption.

Although it is mandatory for the city council in terms of section 30 (2) (a) of the Local Authority Act to supply water to its inhabitants for household, business and industrial purposes, they can only sustain that if inhabitants pay for the water consumed.

The city's inhabitants have increased significantly since independence in 1990. This is linked to the level of development in the city in relation to other towns in the country.

The disparity observed in the context of development is attributed to the fact that the South African colonial regime focused more on a centralized system of government. The tendencies lead to the concentrations of most economically important activities in Windhoek. Resulting from this, a significant number of people began to migrate to the city since independence in 1990 in search for better opportunities.

The influx combined with the city's population growth results in urban growth. Urbanization leads to the challenge to supply basic needs to the inhabitants of the city. The city of Windhoek under the umbrella of the city's vision to remain one of the urban prime service centers in all aspects of living, has tasked itself to insure the smooth and sufficient provision of water to all citizens within the city boundaries, irrespective of whether they are duly registered or squatting.

This aspect of facilitating portable water to the consumers individually brings to the fore, the logistic challenge of negotiating water supply with the bulky water producer of Namibia, NAMWATER. With this statement it is clear that the research investigates the relationship between bulky water supply and demand, on assumption that the relationship to some extent is dependent on urbanization and population growth.

1.2 STATEMENT OF THE PROBLEM, HYPOTHESIS, OBJECTIVE AND RESEARCH METHOD.

The issue of water scarcity is not only a Windhoek situation. It is a global phenomenon because most countries are faced with a similar problem. For example, during the water resource conference held in December 20 to 21, 1997 the prime minister of India emphasized the need to create consciousness for the preservation of water. This was mentioned. He further emphasized the need for proper population planning as vitally important to attain sustainable utilization of water.

Since independence in 1990 the city of Windhoek has undergone a rapid expansion. The city's population has been growing at a rate of five percent annually. It has an urbanization rate of close of close to five percent a year. The concern in terms of availability of water is viewed based on its climatic nature especially the amount of precipitation received annually, which is very low. The rate of evaporation is 30 % of surface water which is associated with persistent drought occurrence.

Given that, the main sources of supply are the dams, underground water and water reclamation from treated sewage. These sources are mainly supplemented by precipitation. The outlined conditions do not positively relate to the current level of growth in the size of the city.

HYPOTHESIS: A positive linear relationship exists between urban expansion, water supply and demand. This relationship is influenced by the linear function or relationship of urban growth.

OBJECTIVE OF THE STUDY

The researcher undertakes to verify or falsify the assumption underlying the hypothesis.

RESEARCH METHODOLOGY

The study uses secondary data research or 'desk-top' research. The use of already provided sources is prominent in this study, municipal policies, population statistics, water supply, consumption and expenditure. Literature search was conducted to solicit information on what other countries are doing on the subject.

This is mainly on other authors' views on the subject. Comparative cases are Mozambique, South Africa and Botswana, which are countries with similar background in terms of population, urbanization and climate. Data from statistical information are collected over a period of ten years, on water supply, consumption, water tariffs, and population growth. Policy documents were reviewed to provide information on the efforts in place. The data are collected mainly from the city of Windhoek and state owned public water provider NAM WATER

In this study a systematic sample is used to select data on population growth, water consumption and supply. The sample is based on a time frame from 1995 to 2005. This is collected distinctively per variable. The data are used to determine trend and relationship between population growth, water supply and demand.

Data collected on the various variables are interpreted based on tables and graphs which are used to determine trend and relationship between the said variables. Content analysis or documentary analysis is used to gather alternative views on the subject.

The examination employs Bostock, Chandler, Shepherd and Smith (1997) mathematical linear model and the economics demand and supply model developed the classical economists such as Keynes and Marx. The linear model gives the relationship between two variables where one variable depends on the other one (independent variable). This relationship is defined by the function (D/S= MP-C) which is further derived as D= 1.4P-63. In this model demand (D), supply (S) and population (P) are variable while gradient (M) and intercept (C) are constant. In order to enter the process of verification or falsification the model is tested by changing the variable population (P) which changes over time.

The demand and supply theory argues for a market approach where the forces of demand and supply determine the output and the price at which the given good is provided in relation to the units of that good provided. In this case the consumable in question is water. This theory continues to be prominent in the modern writings of recent economic writers such as Wilson and Clark (1988). In this study the same theory is used to examine the demand and supply of water in Windhoek.

1.3 SIGNIFICANCE OF THE STUDY

By focusing on the assessment of water supply in Windhoek, this study creates opportunities for academic intervention. Through this study a policy scenario can serve as a basis for policy review and formulation. The findings of the study will serve as reference or learning experience for other towns in the country in terms of planning for water provision. Depending on the depth of the study, a case for government intervention may be created.

1.4 SCOPE AND LIMITATION OF THE STUDY

This study mainly focuses on Windhoek, specifically on water supply. The analysis of the study is based on the sequence or pattern of change over a period of ten years from 1995 to 2005. This is due to limited availability of data in terms of statistics.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter gives a brief review of the literature presented on the subject. The literature brings out important issues relating the problem in question. In this case the literature is broken down into water supply situation in Windhoek, Urban expansion and water supply and case study of Gaborone, Botswana and Maputo, Mozambique.

2.2 Theory

It is important in this study that, arguments are drawn from theories, this aids research (Knowles 1986: 3). "The research worker needs a set of assumptions as a starting point to guide what he does, to be tested by experiment or to serve as a check on observations and insights. Without any theory his activities may be as aimless as wasteful as the wondering of the explorers in North America.... Some knowledge of theory always aids practice".

In the case of this study the theory that captures the essence of water supply is the demand and supply approach of economics developed by traditional economists such as the Classical and Keynesian economists. The theory recognizes the positive link that exists between demand and supply. It gives a positive relationship between quantity supplied and the price at which the quantity is supplied, the negative relationship between the price and the quantity demanded.

The use of this theory is phenomenal in water supply policies. For example the City of Windhoek applies the same theory in its water supply policy. This application is observed in terms of the supply and demand side policies of the City. The use of this theory also extends to the pricing strategies of water service provision. A good example is that of the Average Incremental Cost Pricing (AIC).

The theory recommends the setting of the prices or user fees for infrastructure services equal to marginal supply cost. If the current infrastructure is not sufficient to cover future service levels, marginal supply cost must reflect cost to expansion of capacity as well as the marginal cost of operation.

2.3 Background on water supply in Windhoek

The supply of water to the City of Windhoek is jointly made by the City Council and NAMWATER, a state owned cooperative operating commercially. NAMWATER took over the responsibility of supplying water nationally from the Ministry of Water and Agriculture in 1997. Its establishment followed after the introduction of the NAMWATER act of 1997. This act stipulates the operational frame work of the said cooperative.

The commercialization of water supply was made to insure effective and efficient provision of water. This followed shortly after the implementation of the decentralization act of 1992. The act allowed for the proclamation of villages, towns and cities. The NAMWATER act allows NAMWATER to operate on a full cost recovery basis as to allow it to cover its cost

and to insure sustainable provision of water to the respective town, municipal and village councils. This makes the cost of water supply to gradually escalate with time.
NAMWATER supplies bulk water to the city of Windhoek. This bulk water supplied is mainly obtained from the Von Bach, Omatako and Swakoppoort dams.

This supply is complemented by the City of Windhoek through surface water, reclaimed treated sewage sources and underground water sources (bore holes). With reference to the latest hydrology report of the City of Windhoek of 2002-2003, 49% of the city-produced water is from underground water (bore holes), 43% is from surface water and 8% is from reclaimed sources (water from treated sewage).

In Namibia the main sources of water are the exterior and interior river basins. These include the Zambezi river basin in the north east part of the country. This forms the border between Namibia, Zimbabwe and Zambia. The river has an area of 17426 km^2 and is the country's richest source. It has a mean flow of 40 cubic km^3 a year.

The Okavango river basin in the north east has an area of 106798 km^2 in Namibia. This borders Namibia with Angola and Botswana through its spiral into the Okavango swamps. The river has a mean flow of 10 km^3 a year.

The Kunene river basin in the south west part of the country has an area of 17549 km^2. Rainfall over the kunene is very unreliable and variable. It has a mean flow of five km^3 a year. The river is always dry at the end of the dry season. This is because it has a relatively

small catchment's area and steep sided in the upper section which makes the flow to run quickly to the cost. This is the main source of supply to the four northern regions of the country, where approximately more than a third of the population live. Demand for water usually picks up in October which is the period of minimum flow.

The Orange river basin in the south of the country has an area of 219 249 km^2 in Namibia. The river forms the southern border with South Africa. It has a mean flow of about eleven km^3 a year. The major Namibian tributary, the Fish River, has a mean flow of about 0.48 km^3 a year at its confluence with the Orange River.

The Orange river project which started 35 years ago in South Africa has cut the flow of water in the lower part of the river by almost two thirds. The project transfers water from the Caledon and the Orange River to rivers outside the basin which flows to the Eastern Cape Province in South Africa. The project operates with dozen dams with a combined capacity of 8.3 km^3 a year.

The interior basins including the Cuvelai River enters Namibia as an ephemeral delta of 130 km width known as the Oshanas. These converge towards the Etosha pan. The runoff within the interior basins has been observed to vary from zero to 0.1 kilometers a year.

In order to have a clear picture of other variables that influence the supply of water in Windhoek, one has to look at the relationship between water supply and climate in the City. The climate variables are temperature and rainfall. These two variables play an important role

in water supply. Windhoek as a city located in Southern Africa, is characterized by a strong latitudinal and longitudinal gradients (Tyson 1986).

The major latitudinal gradient is in temperature and longitudinal gradient is in rainfall (Davies and Day 1998). Windhoek receives an average rainfall of 250-300mm a year. The rainfall in the City is seasonal, unpredictable and episodic, which means it has no rainfall in most months of the year. Therefore water has to be stored for use in dry months. The situation is particularly crucial in the supply of water in the city.

In terms of temperature the City has an annual average temperature of 37 degree Celsius. This is associated with an annual evaporation rate of 30% of surface water. In Namibia the summer drought coincides with the hottest time of the year. This combined with the high inter-annual variability in rainfall, means more water has to be stored to insure sufficient supply in dry years. This will lead to a serious water deficit in the City.

This means the supply of water in Windhoek is likely to decrease over time. Overall the effects are as follows. First, when annual rainfall received is lower the level of surface water decreases which means there will be less water in dams. Second, low levels lead to an increase in the depth at which the water table is reached beneath the surface ground. This makes the drawing of water from beneath the surface difficult, and causes a drop in the amount of water drawn from the underground by means of boreholes. This causes, in turn, the reduction in the proportion of water provided by underground sources. Third, daily average temperature increase alters the rate of evaporation from surface water. This leads to more water been lost from the surface and, in turn, reduces the amount of water in dams. Fourth,

the comprehensive effects of both reduced rainfall and high temperature lead to high evaporation rates and therefore to massive reduction in water supply.

The city of Windhoek has put in place several policies to regulate and control the supply of water to the residents and the entire business community. The establishment of such policies was based on equitable and affordable service delivery, sustainable supply of water, cost effectiveness and recovery. The policies are divided into the following:
Supply policy is aimed at increasing the amount of water supplied to the City and to insure future availability. The policy requires huge amount of capital in order to implement it effectively. It also requires an extension in the resource base to enable a huge investment in technology and infrastructure capacity to draw water from far distant sources.

The financing of such projects requires a rise in the tariff base, which in turn will mean a rise in the water bills. This is seen as a means for effective cost recovery and sustainable development. In this case the increase in supply will mean an investment in water supply infrastructure in terms of water-drawing pipes. This is required to supplement to the current supply sources and is also needed in order to expand on water reclamation and purification capacity to enhance supply. In return, such measures require tremendous capital in order to implement them. In view of such a possibility the financing of such investment will mean an increase in the user charges in the city. This is a particular water service charge caused by escalating demand of such services.

Demand Policy is aimed at the regulation of demand and water consumption in the City. The demand policy aims at reducing the consumption level of water by both residents and the business community. The policy is divided into two components. Restrictive policy uses

water tariff differential as a policy tool to control consumption. Persuasive policy uses education in terms of creating awareness for the need to conserve water as a scarce resource. A number of campaigns have been launched to create awareness for sustainable consumption of water as a means to conservation.

The policy measures in place are:

(1) Education- this creates an awareness of the importance of water in Windhoek and what makes this case unique in terms of scarcity. It emphasizes the need for water conservation.

(2) Limits on high water consumption activities such as car washing, garden irrigation, industrial usage and swimming pools. This is controlled by a cost differentiated mechanism where a different high cost is charged in the cases of consumption rates. This mechanism is employed to discourage high consumption of water.

(3) The use of surplus consumption rates for domestic water consumption where a flat tariff is charged when a particular household consumes within the average limit set by the municipality. This reduces unnecessary consumption of water in the city.

The existing policy on cost recovery is basically on the regulation of the payment of outstanding debts on water bills by both residents and the business community. This policy provides a regulatory framework in terms of the handling of such cases. The policy has the following stipulations. (1) The city cuts down the supply of water to individual residents whose bills for water is not paid to date this also apply to businesses. (2) In cases of debts accumulated and not settled for over a length period of time, the city opts to sale the housing property in an attempt to recover the debts outstanding. This is more prominent to residents.

(3) In addition to the existing policy the city has introduced a revised credit control policy that offers a more convenient and flexible means of payment for the settlement of debts as compared to the old one. The new policy was implemented in 2005. The policy has also been complemented by the recent incentive scheme which was introduced to motivate individuals to pay their water bills. This is operated through the carrying out of monthly and quarterly draws. The incentive benefits both individuals and businesses.

In addition the government of the Republic of Namibia entered into international agreements with its neighbours as an effort to secure water supply for the future. These agreements include a number of water commissions, protocols and conventions on the sharing of water sources and its use. This is mainly water sources such as rivers that are shared with other countries (FAO 2005).

The agreements include the permanent joint technical commission on the Kunene River (1990), which was signed between Namibia and Angola on the use of the water resources from the said river. This also paved way for a Joint Operating Authority (JOA) between the two countries. Its current major priority is the development of hydro electric power scheme on the lower Kunene River.

Joint Operating Authority between Angola and Namibia was reinstated in 1990. It deals specifically with operation of the regulations of regulating the dam on the Kunnene River at Gove (Angola), and with infrastructure for the Ruacana hydro power station on the same river in Namibia. The power station itself is in Namibia but, parts of the infrastructure (diversion weir, intakes) are situated in Angola.

The Permanent Water Commission on the Orange River (1992) was signed between Namibia, Botswana, South Africa and Lesotho. It provides the regulatory framework that governs the use of the shared source by the signatory countries. The Permanent Water Commission was established to deal with water matters of mutual concern, since the reintegration of Walvis Bay into Namibia in 1994. The commission concentrates its activities on the Orange River Basin.

Joint Permanent Water Technical Commission (JPWTC) between Botswana and Namibia concerning the development and utilization of water resources of common interest was established in 1990, after countries had cooperated in 1980s. It has jurisdiction over the activities in the Kuando –Linyanti-Chobe system in the Zambezi River basin and had jurisdiction over the Okavango river basin before OKACOM was formed.

Permanent Okavango River Basin Commission (OKACOM) (1994) was signed by Namibia and Botswana. This necessitates the equal access to water resources of the said river, stipulating further the basis of benefit for the two countries.

SADC Protocol on Shared Water Sources (1995) expanded on the existing agreements by further cementing the existing regulations to make the accessing of shared water resources convenient for the respective countries.

The treaty of the Viools drift and Noordoewer joint irrigation scheme between Namibia and South Africa was also signed in 1992, establishing parastatal authority to operate the irrigation project located on both sides of the orange river at Viools Drift and Nooroewer.

2.4 Urban expansion and water supply

The rapid development of cities influences rapid growth of population, causing a rise in the demand for water. This impacts both the quality and cost of water supply in cities (Davis 1999). The Low Impact Development concept (LID) was thus advocated in order to integrate environmental concerns with land development, focusing on water and pollutant balances.

In fundamental sense the concept of LID represents the application of pollution prevention and waste minimization concepts to land development (McDonough etal. 2003). Other authors like Rushiton (2001) advocate the concept of green revolution incorporated with biological retention strategies. This is a vegetated management practice designed to collect, store, infiltrate and treat runoff. The biological retention areas (also known as rain gardens) may help to improve of the quality of water in cities.

There is a need for a fundamental change in the way residential, commercial and industrial properties are developed. This is required to minimize water demand and consumption. This should be done in terms of quality control measures. Therefore the manner in which land is developed requires increased attention.

Given the arid nature of most countries in southern Africa, as urbanization continues on an increase in most cities of southern Africa, there will be a time when demand will outstrip water supply. This is because of the continuous occurrence of draught over time.

One of the problems associated with development is increased surface water runoff. Rapid development leads to the replacement of natural permeable surfaces with permanent impermeable surface structures such as roads, car parks, sidewalks, Rooftops and driveways. This leads to massive pollution of water sources when the runoff mixes with or reaches the water supply sources (Daniel 2001).It is also noted that sacrificing open land for impervious surfaces alters the water balance by promoting polluted runoff at the expense of infiltration.

Development negatively impacts water in two ways. First, many of the new materials and components used in land development contribute to high pollutant loads during rainfall and subsequent water runoff. Second, natural filtering by natural vegetation is replaced by concrete and rooftops which offer little means of water quality improvement (Davis and Burns 1999).

Urbanization continues to be a problem in most cities in Southern Africa. In Gaborone Botswana, the problem is noticeable as the city authority continues to battle with the problems that has resulted from expansion of the city. Several studies have shown that the city continues to grow in size as population growth and rural urban migration takes its tall. Water supply is a problem currently with projection of the city being water stressed by 2021 (International Institute for Applied Systems Analysis 2001). The city is one of the arid places in southern Africa.

According to the study carried out by the Institute for Applied Systems Analysis in 2001, Maputo is hard stricken by the same problem of water shortage which has resulted from rapid urbanization. The city's population has grown significantly in the last few years. The city is currently unable to meet the combined demand of its population, industry and agriculture.

Only 29 percent of population in Maputo has water in their homes. 21 percent takes water from public taps while half of its population does not have piped water. It is projected in the same study that if 80 percent of the population was to be connected in 2021, there would be a water deficit in the next ten years.

The sustainable management of water resources is not possible without a relatively permanent population living within the carrying capacity of land. Unless overpopulation is slowed, any attempts to plan for population development are more likely to fail. In this case the capacity of land is measured in terms of its available water resources.

As the effects of urbanization takes its tall on water supply, most countries resorts to drawing of large quantities of water from far distant shared sources such as rivers. The quantities of water are drawn towards domestic reservoirs such dams. In some cases the countries resort to the damming of such sources. Such measures are resorted to in effort to sustain water supply in relation to demand. Other studies have found that conflicts are more likely to result where countries shares water resources.

A study conducted at Origon University in 2001, found that the likelihood of conflicts results when two factors come to play. First, large or rapid changes occur in the basin physical setting. Second, existing institutions are unable to absorb and effectively manage change. For example, when there is no treaty spelling out each nation's responsibilities with regard to the shared river or any implicit agreement.

2.5 SUMMARY

The literature looks at water supply situation in Windhoek and the nature of the problem in other cities. This is looked at based on the case of Gaborone, Botswana and Maputo, Mozambique. The chapter further gives the broader scenario of the problem in context by highlighting the environmental and socio-political aspects of the problem.

CHAPTER THREE

URBAN EXPANSION AND WATER SUPPLY

3.1 Introduction

The preceding chapter looked at the water situation in Windhoek. This chapter examines the link between urban expansion and water supply by focusing specifically to what happens to water supply as the City expands in size. The main indicators are population growth, water demand, consumption and supply.

3.2 Urban expansion

In a number of cities in the world and in Windhoek in particular, urban expansion is on a rise. In the context of this study, urban expansion is viewed in terms of urbanization. This refers to the growth in the size of the city caused by the increased movement of people from rural to towns and cities.

In Windhoek, rural urban migration has been on an increase since independence in 1990. There are several reasons why people move from rural areas to cities. In Namibia in particular the following push and pull factors account for such movement.

- Lack of proper services in rural areas. The services referred to in this case are education, health and commercial. Most of these services are very limited in rural areas and in some parts they are none existent. Most of these services are concentrated in towns and cities. Windhoek has the most of all services mentioned above. This makes it more attractive for people to come to the city.

Education for example, the best secondary schools and teachers are found in Windhoek and it is where most institutions of higher learning are.

- Poor living conditions in rural areas. Here the conditions of living are described in terms of basic needs water, electricity, housing and sanitation. This has resulted in most people preferring to stay in towns and cities compared to rural areas.

- Lack of employment opportunities in rural areas. This is based on the fact that urban areas are more developed than rural areas. In Namibia Windhoek is the most developed urban center among others. This makes it more attractive for investment. As a result, it leads to increase in economic activities. This is evident by looking at the level of industrial development taking place within the city. This results in more jobs being created. In return, more people are pulled towards the city.

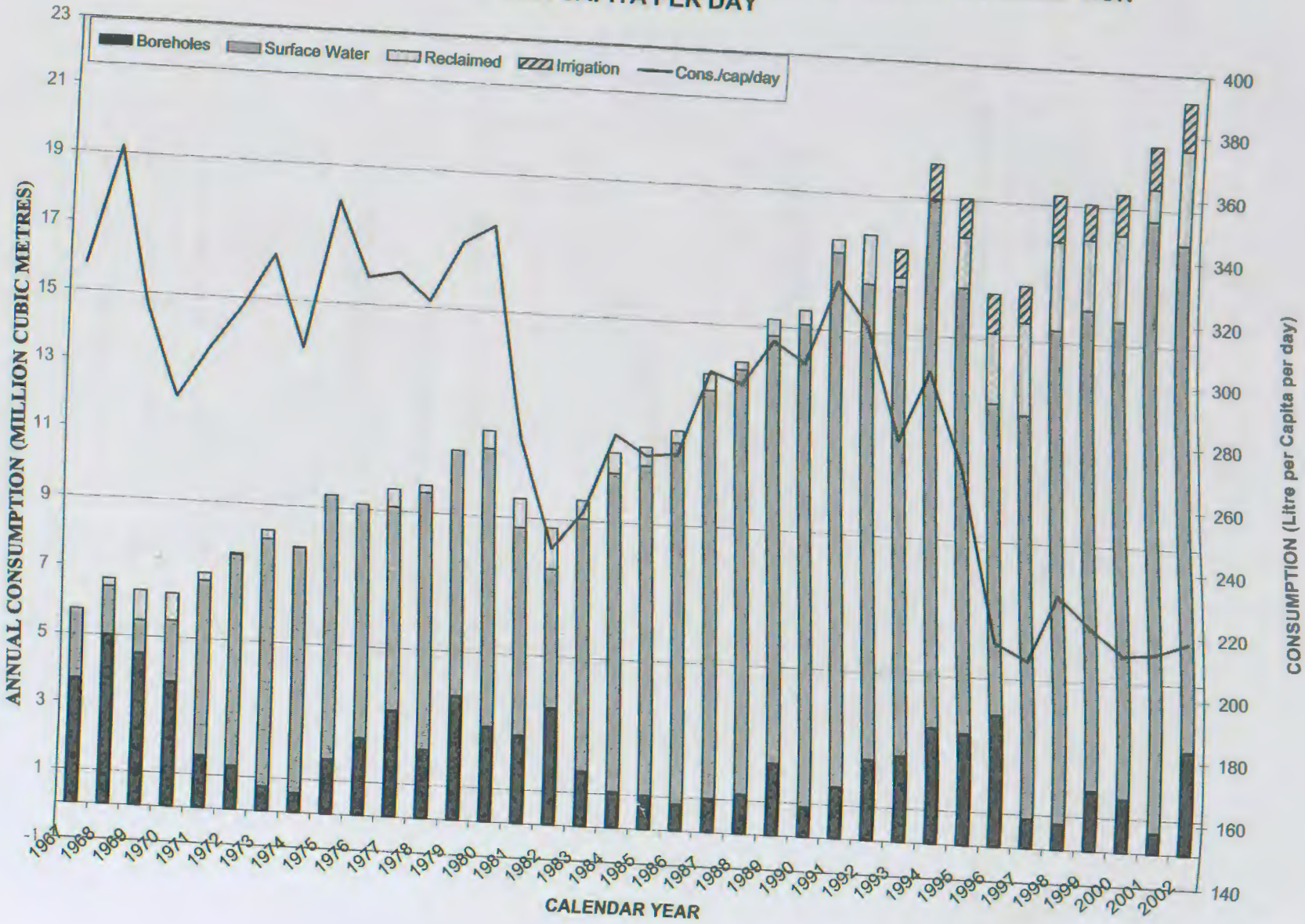
- Reduction in agricultural productivity. Agricultural productivity has gone down over time in Namibia. It follows the persistent draught occurrence in the country. Being the main source of employment and income in Namibia, a reduction in agricultural productivity means a reduction in employment as well as income. Due to this, most people are forced to move to the city in search for employment.

Beside the effect of rural urban migration, population growth plays a major role in urbanization. Even though the city's urban growth rate of 4.4% (City of Windhoek urbanization Report 2001/2002) is viewed low in comparison to other towns in the country. It is more prominent because Windhoek has the highest population. Population growth fuels expansion because more people mean more services.

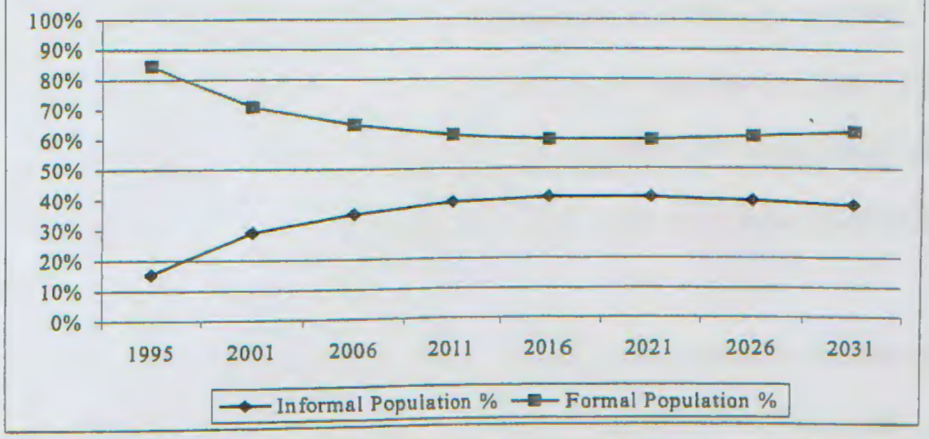
As cited earlier, the level of economic activity has increased over time. This means that the city's industrial base has also increased. When this is combined with population growth, rural urban migration and development, it results in urban growth. This is because more space is created to cater for growth in infrastructure. Which will in turn, lead to increase in the demand for water supply services. This pattern will continue in the next years to come as long as the development gap between Windhoek and other towns continues to broaden.

In examining the relationship between urbanization as a function of population and water supply, the following statistical information are looked at, next page 23 and 24.

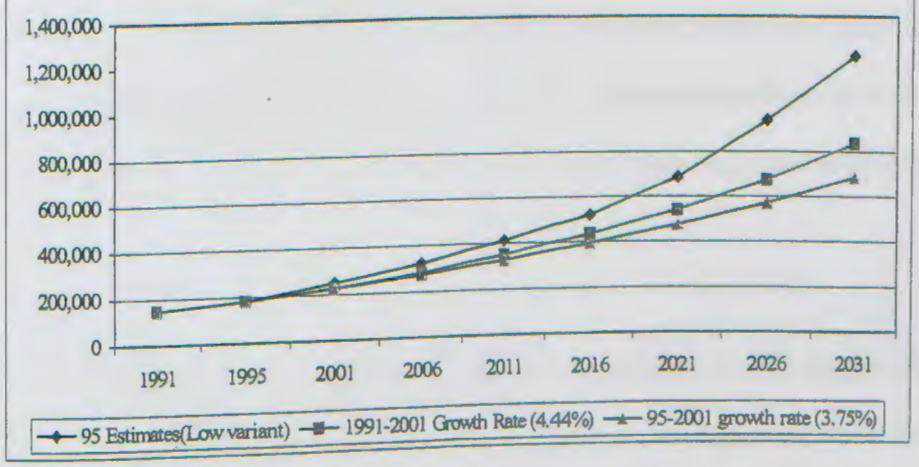
Graph 3.2.1: WATER PRODUCTION FROM DIFFERENT SOURCES AND DAILY WATER CONSUMPTION PER CAPITA PER DAY



Graph 3.2.2: Informal Population as a Proportion of Total Population



Graph 3.2.3: Windhoek Population Growth



Surce: Windhoek Urbanization Report 2001/2002

Graph 3.2.4: Windhoek population as a Proportion of National Population

	1991	2001	2006	2011	2020	2030
National Growth rate	3.60%	2.60%	*1.50%	*1.50%	*1.50%	*1.50%
Windhoek Growth rate	4.35%	4.44%	4.44%	4.44%	4.44%	4.44%
National (mil)	1,4	1,8	2	2.7	2.8	3.2
Windhoek (Thousands)	147	227	282	351	518	800
WHK as a % of National	10.43%	12.43%	13.58%	14.54%	18.80%	25.02%

Note: * Source: Human Development Report, UNDP

Based on the information on page 23 and 24, the following is observed. Rural urban migration significantly increased from independence in 1990 up to 2006. From 2006 migration is estimated to continue increasing on a more constant rate and by 2021 it will slowly begin to decrease. Taking migration as an indicator of urbanization, one can then describe its trend based on the trend observed in terms of the rural urban migration.

However the city's population as observed on graph 2 has continued to increase from 1991 to 2001. The population since then has been increasing at a rate of 4.3% annually. From 2001 the population has been estimated to have continued increasing at rate of 4.44% annually showing an increase in the level of growth. This trend is estimated to increase significantly from the year 2016. Given the trend in population growth observed above, it is evident to note that the city's population continues to broaden in relation to the national population as shown in table 3.3.4.

In comparison to water supply, graph 3.2.1 shows an increase in the supply from 1992 to 2002. Even though there has been a noticeable decrease in supply of water from 1994 to 1996, on average the supply continued to increase. Consumption at the other hand shows a more zigzag trend. It has been increasing and decreasing over time and it is more likely to follow the same trend in future.

Following the interpretation above, the following models are used for the analysis. (1) For population the model EP= R (P) + P is used. Here estimated population (EP) is a function of population growth rate (R) which is a constant and current population (P) plus the current population (P). This module is applied as follows:

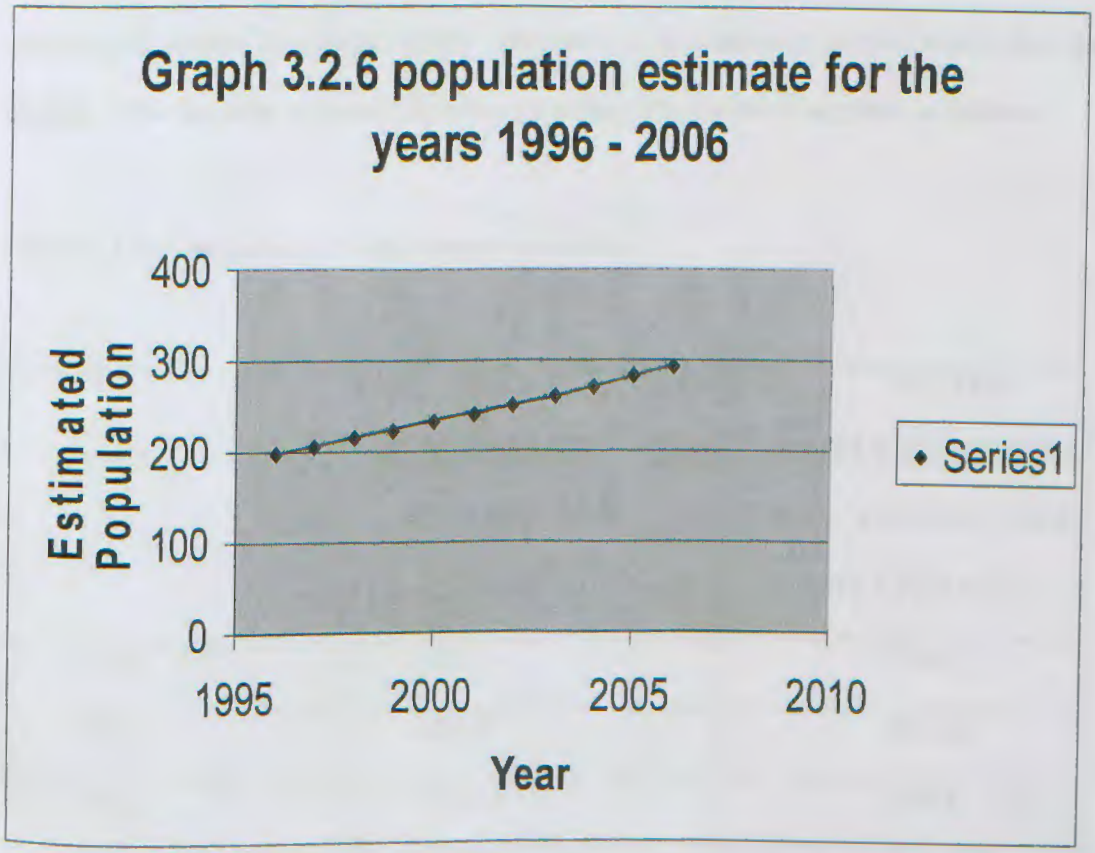
The values of the different year's population are obtained by substituting in the given function. Population growth rate is fixed at 4 % as provided in the statistics. The following estimates are obtained using the model. In this analysis, 1996 is taken as the initial year. The population value for this year is estimated from the provided statistics.

Table 3.2.5: Computing of population estimates

YEAR	ESTIMATED POPULATION (1000'S)
1996	198
1997	205.9
1998	214.14
1999	222.71
2000	231.62
2001	240.88
2002	250.52
2003	260.54
2004	270.96
2005	281.79
2006	293.06

Source: Windhoek urbanization report 2001/2002.

This information is graphically represented below.



Source: O. Mutumba (2007).

(2) In examining the relationship between water supply and population growth, the model S=MP-C is used. This model is derived as S= 1.4 P -63 using the population growth rate of 4% and an estimated consumption rate of 6%. In this model water supply (S) is dependent on population growth (P) and the two are variable over time. The multiplier or gradient (M) and the intercept (C) are constant over time.

The values of the estimated population obtained using the first model, are substituted in the function to obtain the water supply estimates. It is assumed in this model that the water supply is the function of the outlined relationship. The model is applied as follows.

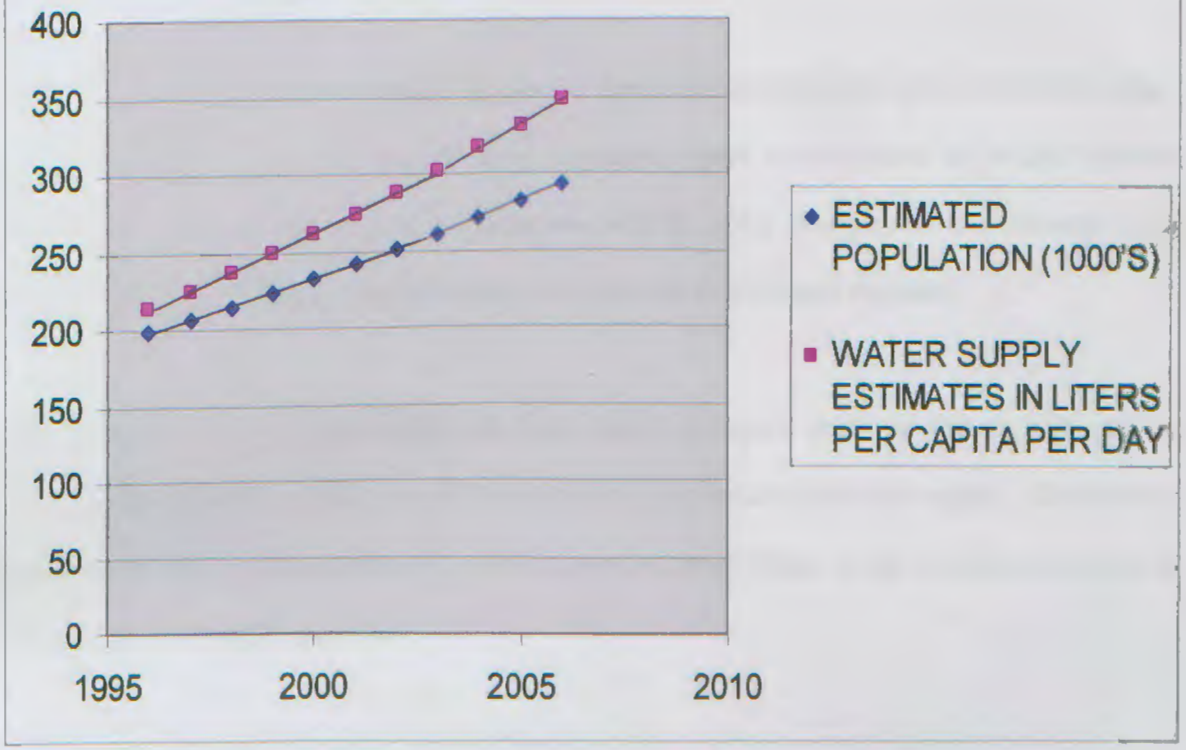
Table 3.2.7: Computing of water supply estimates

YEAR	ESTIMATED POPULATION (1000'S)	WATER SUPPLY ESTIMATES IN LITERS PER CAPITA PER DAY
1996	198	214.2
1997	205.9	225.26
1998	214.14	236.8
1999	222.71	248.79
2000	231.71	261.27
2001	240.88	274.23
2002	250.52	287.73
2003	260.54	301.756
2004	270.96	316.34
2005	281.79	331.51
2006	293.06	347.28

Source: City of Windhoek Urbanization Report 2001/2002

The data above is translated into a graph on page 29.

Graph 3.2.8 The relationship between population growth and water supply



Source: O. Mutumba (2007)

As shown above, the increase in population leads to increase in water supply. It is also important to remember the fact that, population increases over time so will the supply for water. We can now conclude from the analysis above that urban expansion has the following effects on water supply.

- Urban expansion leads to an increase in the supply of water in the city.
- Since increasing supply means expanding capacity, this will also increase city's expenditure on water supply and distribution in the City.

- Even though, changes in population lead to changes in water supply, supply does not change proportional to population change. The relationship exhibited above is not of a linear nature.

Other effects of urbanization may be in form of economic growth leading to an increase in per capita income of people in turn, lead to increased water consumption as people become wealthier. In general the overall consequence will be water scarcity, as the resource from which water is drawn from gets depleted over time due to increased demand.

The analysis of the models used in this study shows the same observed pattern reflected by the statistics provided by the city of Windhoek on population and water supply. The models employed in this study can be used in this case to estimate future trend in population growth as well as water supply patterns.

However the analysis of the linear models was carried out assuming other factors do not influence demand and supply of water in the city. In this case the researcher is aware of the fact that his approach works with the principle of 'exclusion,' rather than inclusion. This statement means that factors such as climate and precipitation underlying the estimates possibly by the water supplier (NAMWATER) are not considered. Similarly, variables such as consumer behavior underlying demand estimates conducted by the city of Windhoek are excluded as well.

Such aspects of crucial importance to water provision have been deliberately set aside as they are set aside for the purpose of not interfering with the analysis of the linear model as exercised in the thesis.

3.3 SUMMARY

This chapter looked at urban expansion and water supply/demand. In this chapter the causes of urban expansion are looked at. The chapter further looked at the relationship between water supply/demand and population growth as the function of urbanization. A closer analysis was done to give the basis of the existence of the said relationship. This is discussed in the next chapter.

CHAPTER FOUR

WATER SUPPLY AND DEMAND

4.1 INTRODUCTION

This chapter gives a background on the nature of supply and demand for water. An economic approach is used in this chapter to give a trend analysis of both demand and supply over time. The factors influencing the two variables are also briefly examined in an effort to show their effects on the said variables.

4.2 Water supply

Looking at the statistical information provided on graph 3.2.1, water production by the city of Windhoek has been maintained above 320 liters per capita per day. The water production in the city has been characterized by an upward, downward trend from 1992 to 2002. The production of water decreased slightly from 1992 to 1993. From 1993 to 1994, the amount of water produced increased remarkably. As from 1994 to 1996, water production decreased significantly and then continuously increased from 1997 to 2002.

Economic theory of supply (Wilson and Clark 1988: 129) states that, the increase in the amount of an economic good produced, in this case water, will lead to the increase in the cost (price) of providing such an amount. It is important to understand in this case that, the supply of water is influenced by a number factors, price included.

The effects of these factors can be both positive leading to an increase in supply or, negative, leading to a decrease in quantity of water supplied. In addition to these factors, the water resource capacity dictates the amount of water that can be produced at a time.

In order to account for the trend in the production of water reflected on graph 3.1, one needs to examine the effect of the following factors on water supply:

(1) Change in climatic conditions

Climate in this context is measured in terms precipitation and temperature. With reference to rainfall the city receives an average annual rainfall of 300 mm. The average summer temperature may rise to 37 degrees on a normal hot day. These two climatic variables play a very significant role in water supply.

When the amount of rainfall received annually drops below average, the level of water in dams drops down and the depth at which the water table is reached increases. This leads to a decrease in the amount of water supplied. Temperature changes, alters change in the rate at which evaporation take place. When the average temperature increases, the rate of evaporation of surface water also increases. This leads to a reduction in the amount of water in surface sources such as dams.

(2) The level of infrastructure capacity

The capacity of infrastructure available is suited to the current level of supply. Taking this fact into consideration, it is clear that any increase in supply has to be linked to an increase in infrastructure.

Taking into account the cost involved in the maintenance and improvement of infrastructure, one has to look at the available financial resources before opting for an expansion.

(2) Financing

A more prominent factor in water supply is the cost implication of providing water. There are two types of costs. Full supply cost, includes all expenditure related to the supply of water to the consumers. These are maintenance costs, costs of acquiring infrastructure, inflation and the production cost. Full economic cost includes management operational costs, opportunity cost and externalities.

Given the fact that water supply expansion is more of a medium to long term venture, the costs involved in this case are quite high. A large financial base in this case is required to sustain such a project. By looking at the financial status of the city of Windhoek, one wonders whether such an option is feasible. The role of other stake holders is important in this regard as to assist in the financing of such projects.

(3) Population growth

The city of Windhoek has shown a significant growth since independence. The City's population is projected to continue growing at the current rate of 4.4% a year. At this rate the population is bound to double in the next 15 years. In order to sustain the supply of water to meet the growing need, there has to be a significant increase in the amount of potable water provided.

(4) Technological advancement

This is viewed in terms of the improved machinery and equipments required to increase the amount of water produced. Investment in technology is always expensive. It requires tremendous amount of capital. However, the long run benefits of such investment will be reduced cost of production as more water is produced at minimized costs. This is an effective move that leads to economies of scale.

Based on the facts presented in the analysis of supply, the prediction of water supply trend over time can be done based on the elasticity theory of economics.

This will help to measure the responsiveness of supply in relation to cost. The

Analysis uses figures which were obtained from the projections made in the UNDP Water Supply and Sanitation Sector Assessment for Namibia 2000.

4.2.1 Population estimates for Windhoek in the year 2000

Population (thousands) estimates	Population growth per year
271	5%/year

Water production in the year 2000 was 14 l/cap/day.

Source: UNDP Water Supply and Sanitation Sector Assessment 2000

Costs and Investment

4.2.2 Costs and tariffs (N$/m^3) in the year 2000

Average water production cost	N$ 2.22
Average water tariff	N$ 1.74
Average sewage tariff	N$ 2.46
Total	N$ 6.42

Source: UNDP Water Supply and Sanitation Sector Assessment 2000

4.2.3 Construction costs (N$/m^3) in the year 2000

Water supply	Average charge	Sanitation	Average charge
House connections	N$ 13.26	Sewage	N$ 36.48
Other public	N$ 2.64	On-site disposal	N$ 2.64

Source: UNDP Water Supply and Sanitation Sector Assessment 2000

4.2.4 Construction costs (N$/capita) in the year 2000

Water supply	cost	Sanitation	cost
Piped system with house connections	N$1116	Sewage with ld connection	N$ 912
Public stand posts	N$ 402		
Bore holes Protected dug wells	N$ 120 N$ 60		

Source: UNDP Water supply and Sanitation Sector Assessment 2000

The given population in 2000 is 270 000 inhabitants. The current population in 2006 is approximately 300 000 inhabitants. Over a period of six years, the population increased by 30 000 which amounts to 11% increase. Assuming supply also increased by 11% this will result in an increase in water to15.4 l/cap/day. The total cost of water provision in 2000 was N$ 2671.44 /m³/cap. However taking into consideration the current interest rate of 6% charged by NAMWATER and an approximate 4% inflation rate a year, a total make up of 10% annually on the cost of water supply is assumed in this case. Estimating water supply level of 14 l/cap/day, the cost over a period of six years at this rate of ten percent a year will be N$ 4737 as an estimate in 2006.

Therefore Price Elasticity of Supply (PES)

$$PES = \frac{\%\text{ change in Quantity Supplied}}{\%\text{ Change in Price}}$$

$$= \frac{11.1\%}{77.32\%}$$

= 0.14 less than 1 (inelastic)

This clearly shows that, a small increase in the supply of water will lead to a larger increase in the cost of water supply. This analysis clearly shows that, a significant increase in population will lead to water scarcity as water supply does not increase proportional to increase in population.

4.3 Water demand

In order to understand the concept of demand, it is important to look at the economics law of demand. The law states that as the price of an economic good in this case, water increases

the amount that people are willing to consume decreases at that given price. Price changes can be used as a mechanism to control water consumption as well as a tool for water utility administrators.

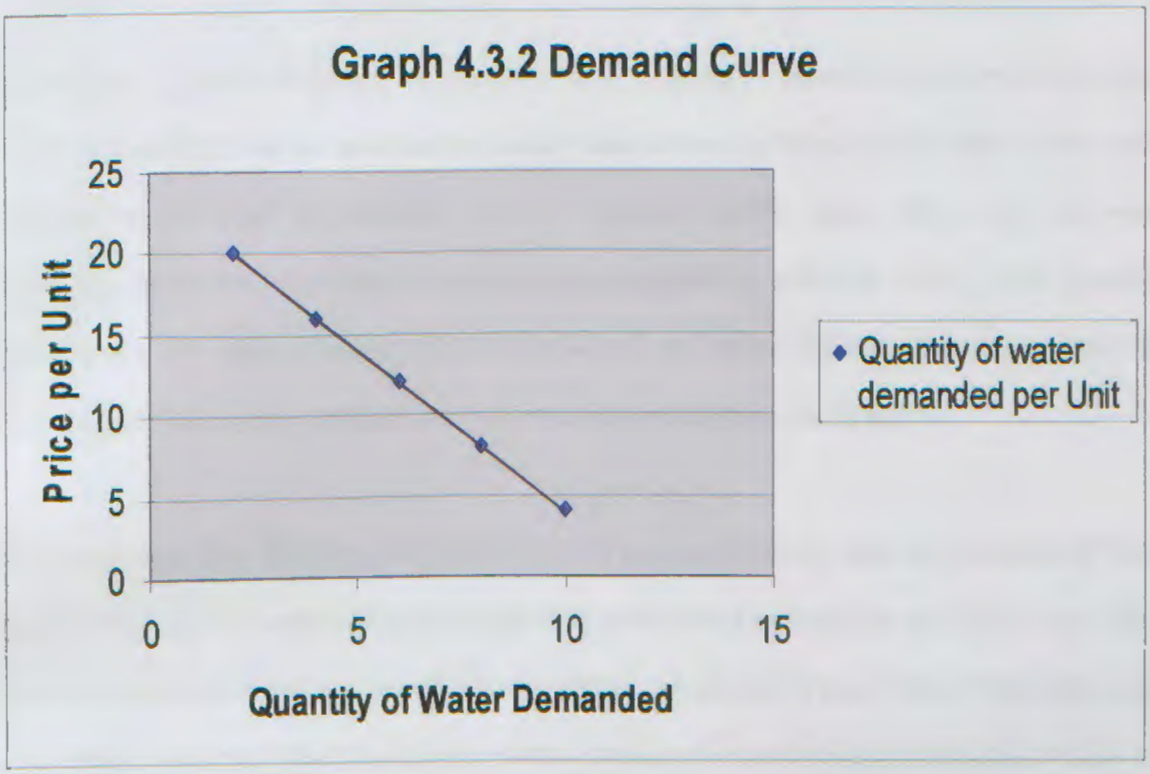
A simple illustration below can be used to demonstrate the application of the law of demand. Assuming water is quantified in units in this case. An individual's demand will be influenced as follows: table below.

4.3.1 Relationship between price and quantity demanded

Price per unit (N$/unit)	Quantity of water demanded per Unit
2	20
4	16
6	12
8	8
10	4

The information above is translated into a demand graph shown on page 38.

The price of water in this case is plotted on the vertical axis and quantity demanded on the horizontal axis. It is assumed in this case that the price depends on the quantity of water demanded. Quantity of water demanded is an independent variable. As shown on the graph, a negative relationship exists between the price as a cost and the quantity of water people are willing to consume at a given price.



Source: O. Mutumba (2007).

This curve shows a linear relationship between price and quantity demanded. In reality the curve is not linear especial when demand for the group of people or the market in general is taken into account. This follows the fact that there are three sets of consumers; the poorer, middle income and the higher income earners. These set of consumers demand water at various levels in relation to their wealth.

As the population continues to grow, it becomes increasingly difficult to meet the demand for water in the city. The cost of developing new supplies is increasing rapidly. Water management in the city has concentrated to date on increasing supply of water in response to

increase in demand without paying attention to conservation, demand management and prevention of pollution of water sources.

It is evident in terms of the city of Windhoek that majority of its residents are not encouraged to use water efficiently by any measure rather than increasing block tariffs. This is a common trend in most cities of southern Africa. Rothert (2000) agues that very few water consumption demand measures have been implemented in southern Africa. Less than one third of the 40 million urban water users served by urban developed water system, are encouraged to use water efficiently by any measure rather than block tariffs.

He further ague that although this economic tool can be effective, other components of water consumption and demand management such as educational campaigns, will have little effect. The consumption of water in relation to growth in population is more likely to double in the next fifteen years to come, if effective water consumption and demand management are not implemented future supply of water is not guaranteed.

The supply of water is increasing slow in comparison to population and growth in the size of the city. This raises high possibility of water stress and scarcity. There are several factors that influence the demand for water:

(1) Price, in the context of water refers to the cost of consumption. As state earlier, a negative relationship exists between price and quantity. Changes in price in this case will affect quantity consumed negatively.

(2) People income, income is seen as the measure of individual wealth. As the people become wealthier they tend to consume more water. This can be consequent of economic growth.

(3) Education and awareness, this aspect links to consumer behavioral change. It is believed that education provided through massive campaigns can create a change in the pattern of consumption. This is due to the fact that most people become aware of the need to preserve and conserve water. In return begin to consume water wisely to avoid wastage.

(4) Industrial growth, growth in industry usually occurs as more people turn to invest in the production sector of the economy. The impact of growth in industry is measured in terms of vital water. This refers to the volume of water that is needed to produce a given amount of a good or service (Turton 1998).

In terms of water demand management, four categories are identified. These are economic, institutional, technical and behavioural. Specific examples include escalating block tariff rates, promotion of water wise industries, water auditing, water loss management, retrofitting with serving devices, informative billing and water wise gardening.

In Windhoek more water is lost through inefficiency, water leaks and illegal connections. The effective implementation of water consumption demand measures will lead to massive water servings as consumption falls over time. This will in turn lead to a reduction in future water supply in the city. The demand of water is escalated by new water connections for household, business and industry. There are several constraints to effective implementation of water consumption and demand management which includes the following:

(1) Financial implications

Financing of projects relating to water supply is more easily compared to consumption and water demand strategies. Loans can be obtained easily to build dams as means to increase water supply. Respectively financing of expansion of infrastructure and existing capacity can be more easily obtained in the same manner. While implementation of most water consumption and demand management measures requires the involvement of the end users in this case the customers for it to be effective. This may come in terms of financing for the device required to minimize losses of water by individual household, businesses and industry.

(2) Technical constraints

The successful implementation of water consumption and demand management require an effective policy and legislative framework. The absence of this leads to failure in the implementation of such measures. There is difficult in capturing and understanding of consumer behavior and patterns. The lack of skills and know-how also plays a role in effecting and initiating of such measures. The existence of lack of cooperation among local authorities may hamper such initiative.

(3) Public perception and ideology

Water demand management strategies are viewed by many as measures required only in times of draught. Many view the measures relating to water demand management as punishments. There is a wide spread fear by most consumers that, water conservation measures may result in poor service delivery.

(4) Lack of competition for service delivery

In the context of Namibia, the public water utility NAMWATER has a monopoly advantage over supply of water. The fact that there are no other provider makes it difficult to implement certain measures aimed at controlling water consumption/demand. This may be perceived by the cooperative as means to reduce its profit. This is because its profit depends highly on the amount of water it supplies to its customers. A reduced profit in this case will lead to failure to cover operational costs of supplying water. In most cases infrastructure for water supply and distribution is owned by the same institution, this in itself is a shortcoming.

Even though, the efforts of implementing water consumption and demand management have its shortcomings, compared to supply side policies it is found to be cheaper and more viable. In order to capture the effectiveness of its application the following analysis is carried out. If we assume the current water supply is 20 l/cap/day. Assuming that effective implementation of demand side policies lead to a decrease in liters/cap/day of water consumed by 10%. This means a reduction of 2 l/cap/day will be obtained in this case. This effort leads to an equal water savings of 2l/cap/day. As this trend continues over time, less water will be required to supply a given amount of people in the city. In return this will reduce future supply of water to the city.

4.3 SUMMARY

This chapter looked at water supply and demand, the analysis undertaken in this chapter in relation to the variables stated followed a more economic approach. Here the economic theory of demand and supply was applied in determining the future trends in both water demand and supply. The chapter further applies the concept of elasticity in relation to changes in supply and cost of water supply over time.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter gives the conclusions drawn from the study. Here the conclusion is based on the study findings and analysis. The chapter further provides recommendations that are aimed at providing possible solutions that are required for the efficient provision of water for domestic and industrial consumption within the City of Windhoek.

5.2 CONCLUSIONS DRAWN FROM THE STUDY ANALYSIS

Following the previous discussions, the following conclusions can be drawn based on the analysis of the water supply situation in Windhoek.

A positive relationship exists between water supply, demand and urban growth (urbanization) as a function of population growth. This relationship leads to influence of population growth on water supply and demand. It is found in this study that supply does not change proportional to changes in population. A large change in population leads to a smaller change in supply. Therefore a linear relationship does not exist between urban expansion, population and water supply.

However, the relationship shows a positive trend and a strong correlation between water supply and population growth. It is true also in the case of urbanization that, as the city grows

in size over time the amount of water supplied also increases. Following the analysis in chapter four, it has been found that, demand for water may not necessarily change positively in relation to increase in population and the effect of urbanization. This is because demand is affected by a number of factors which may influence it negatively.

In this case it has been observed in chapter four that, the effective implementation of water consumption and demand side policies may lead to a decrease in the demand for water. Therefore a positive relationship may not exist between population growth, urbanization and water demand. Since change in demand is not proportional to changes in both urbanization and population growth, a linear relationship does not exist between the two variables.

Based on this conclusions the stated hypothesis is rejected on the basis of the conditions underlying the application of the assumptions of the model D/S= 1.4 P -63. Therefore a positive relationship does not usually exist between urban expansion and water demand and both water demand and supply are not influenced by the linear function or relationship of urban growth.

The assumptions of the models may change when other factors excluded are considered in the analysis. In terms of water supply, climatic factors such as temperature and precipitation may influence the amount supplied as shown earlier in the study. The demand for water may also be influenced by the changes in consumer behavior. As shown earlier in the study, the behavior of consumers may positively change when their income increases and they may turn to consume more water likewise increase the demand for water. Policy may influence demand as well. When the demand management strategies are effective, consumers may turn to

consume less water in response to the measures in place. In this case demand for water will decrease.

Even though such factors may exert influence on demand and supply, it is important to note that their effect can be minimal. This is due to the fact that, water is a basic need which most people are not willing to compromise on.

It is also evident in this study that, the use of shared water resources is prominent as countries struggle to sustain the supply of water to its nationals. This is particular to intentions related to drawing of water in larger quantities aimed at supplementing domestic water needs. This if not handled properly may spark conflicts among neighbors. It is important to always study the stipulations governing the use of such resources before opting for such choices.

Water scarcity is a global phenomenon and most crucial to the arid regions of the world, a closer look at what others are doing in relation to water supply provides valuable lessons to improve the situation in the country and the city of Windhoek in particular. A number of possible policy alternatives have been cited in this study. The possible alternatives cited are based closely on the situation at hand. However, an important aspect to consider will be the viability of the options to opt for. This is in view of the various short comings that exist in the form of resources from financial to water.

It is evident based on the analysis and the arguments presented in this study that the situation in Windhoek is of a serious nature and if not strategically attended to, it may result into a critical crisis in a very near future. The need to look at policy alternatives is necessary to

provide benefits to the City of Windhoek, restrict the unnecessary wastage of water, to enable sustainable water supply and to mobilize support from the private agencies.

5.3 RECOMMENDATIONS

From the conclusions drawn the following recommendations are made to improve on the situation of water supply in Windhoek.

- Having looked at the relationship between water supply , demand and urban expansion/growth, there is need to examine possible alternatives to address policy matters relating to urbanization, population growth and water demand management strategies.
- There is a need to regulate population movements by discouraging the movement of people into the city. This can be done by implementing a standard fee for squatters based on a square meter area. This fee should vary according to the size of household, where larger households pay more for the occupied piece of land.
- Introduce effective population control measures, which are aimed at reducing the size per family. This can be done through extensive educational campaigns. It can be done in partnership with the Ministry of Health and Social Services.
- Strengthen the existing demand management strategies by lobbying for private sector assistance in the funding of educational awareness campaigns, which are aimed at creating awareness of the need to preserve and conserve water in the city. Forster joint ventures with the private agencies, especially the media industry, to allow for a wider coverage for such campaigns. This is one of the strategies the city of Gaborone in Botswana have employed to cultivate the culture of conservation.

- Refine the already existing differentiated billing system in place. This is so as to capture effective cost of providing water services to the people. This can be done by

- (1) Introduce an effective surplus consumption billing system that is differentiated according to levels i.e., different rates for business entities, high-income residents, middle income and lower income respectively. (2) Set the prices or user fees for infrastructure services equal to marginal supply costs as suggested by the economic price theory. The essence of economic analysis is captured in this case by the Average Incremental Cost (AIC) Pricing system. This system identifies the cost that will be incurred to extend capacity over some planning period and converts it to per unit output.
- Promote integrated water resource management.
- Create incentives and regulations that will insure conservation and sustainable use of water resources.
- Strengthen monitoring, legislative frame work and institutional capacity.
- Prevent pollution of water sources by setting up strict guidelines, in terms of industrial operations. This will help to control industrial activities and in turn limit the possibility of pollution of water sources by industrial waste disposal.
- Create a national fund aimed at assisting the water providing institutions to subsidize the supply of water to the poor. This will enable the suppliers to cover the cost of providing water to such residents.
- There is a need to look at the role of small and micro enterprises. These enterprises can perform various selected service delivery functions at local level, either contracted out by the community, community based organizations, or water supply and sanitation utility serving the consumers. The local entrepreneurs can operate water kiosks,

perform maintenance functions and construct facilities for the water supply utility, or operate the entire local system under the management, lease or concession contract.

- Continue to promote research on water supply sources and its sustainable use. This will enable the city authority to sustain the future water needs of its inhabitants.

APPENDIX

Demand: total amount of water that people are willing to consume in liters at a given price per capita per day.

Supply: Total amount of water provide in litres per capita per day at a given price.

Demand side policy: type of policy that is aimed at controlling and regulating the amount of water consumed by cutting down on water wastage.

Supply side policy: type of policy that aims at increasing water supply as means of insuring sustainable provision of water.

Development: the increase in the amount in economic activities caused by the increase in the demand for goods and services.

Policy: a regulatory framework of guidelines on how activities should be carried out in terms of what to do and how to do it.

Policy Strategy or Instrument: a measure of how to bring about change among affected groups or for delivering services to segments of the society, entails choices about the means of intervention (May 2003).

Urban Expansion: the growth in the size of the City caused by an increase in population and development.

Rural urban migration: movement of people from rural areas to cities and towns.

Virtual water: the concept that was developed by Prof. Tony Allan that refers to the amount of water needed to produce a commodity or service (Turton 1998).

Water security: a situation where countries have physical, economic and environmentally sustainable access to adequate water now and in the future (Engelman and Leroy 1993).

Aridity: is a condition that results from a permanent situation of low rainfall and evaporation rates (Pallet 1997: 18).

Draught: refers to less rainfall received over one year or few years (Pallet 1997:18).

Water demand management: the adaptation and implementation of a strategy by a water institution to influence the water usage in order to meet any of the following objectives: economic efficiency, social development, social equity, environmental protection, sustainable supply and service (Rother 2000:5).

Water conservation: 'Minimization' of loss or waste, the preservation, care and protection of water resources and the efficient and effective use of water.

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