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SCHOOL OF ECONOMICS

THE ECONOMICS OF WATER IN BOTSWANA
Water Use and Affordability in Urban Areas

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DEDICATION

To Andrew and Matlhogonolo.

ABBREVIATIONS USED

BCL	Bamangwato Concessions Limited
BMC	Botswana Meat Commission
BNWMP	Botswana National Water Master Plan
CPI	Consumer Price Index (Urban)
CSO	Central Statistics Office
DC	District Council
DM	Demand Management
DWA	Department of Water Affairs
FAP	Financial Assistance Policy
GDP	Gross Domestic Product
GNP	Gross National Product
LRMC	Long Run Marginal Cost
m	Meters
m^3	Cubic Meters
MCM	Million Cubic Meters
MMEWA	Ministry of Minerals, Energy and Water Affairs
NDP 8	National Development Plan 8
NSCWP	North South Carrier Water Project
O&M	Operation and Management
P	Pula (Botswana Currency)
$	US Dollars
SMEC	Snowy Mountains Engineering Corporation
WUC	Water Utilities Corporation
USA / US	United States of America
°C	Degrees Celsius

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ABSTRACT

This study discusses urban water use and affordability by different consumers in Botswana. It outlines the potential urban water requirements that are expected to accompany the continuing economic developments in the country. Water demand for various uses has been increasing rapidly in recent years because of the development in industries and institutions, let alone an increase in population and hence an increase in domestic use due to changes in living standards.

Chapter 1 presents the background information, which entails the general characteristics and economic development of Botswana, and a brief description of the nature of the problem, and how it should be addressed.

Chapter 2 outlines the main objectives, which summarises what should be achieved by the study at the end.

Chapter 3 presents some literature on urban water use and affordability. It focuses on issues such as water supplies and demands, the relative importance of demand management versus supply augmentation, water conservation and protection, and water prices and pricing systems practised in Botswana and other countries. It also discusses the empirical findings by other studies, and uses price and income elasticities to determine the significance of water use and affordability in urban areas for different consumers.

Chapter 4 discusses the methodology to be adopted so as to meet the set objectives of the study.

Chapter 5 examines the factors which appear to influence the quantity of water used for various purposes and the ways in which water consumption behaviour is expected to change over time in response to changes in economic activities and development. By using the available literature and the limited data analysis, it was discovered that factors such as population, rainfall, construction and price of water (tariffs) result in some variations in the quantity of water consumed by different consumers over time.

Finally, chapter 6 concludes the discussions and examines the policy implications of urban water demand, supplies and management in Botswana.

CHAPTER ONE
Introduction

1.1 Background Information

Botswana is a landlocked country and it shares its borders with Zimbabwe, Zambia, Namibia and South Africa. It is situated close to the subtropical high-pressure belt of the Southern Hemisphere. The mean altitude above sea level is approximately 1000 metres and the total land area is 582, 000 square kilometres, which is about the size of Kenya or France.

Due to its location, the country is largely arid or semi-arid and is characterised by:

a) Severe and often prolonged drought conditions
b) Average daily temperatures ranging from a minimum of 5°C in winter to a maximum of 43°C in summer.
c) High evaporation rates, which range from 1.8 m to over 2.2 m annually for surface water.
d) Highly variable rainfall combined with high evapo-transpiration rates.

All these factors result in that result in shortage of water in the country and brings about uncertainty as to how long into the future this pattern would last as human activities are altering the chemical composition of the atmosphere which may lead to global warming and cause regional changes in the climate.

e) Two main land systems of hardveld(which covers about 20%) and sandveld(which covers about 80%). The hardveld system is characterised by loamy sandy soils and the sandveld is characterised by poor sandy soils(Kgathi, 1998)

The enumerated defacto population was 1,326,796 in August 1991. This was about 41.0 % higher than the enumerated population at the 1981 census. The annual population growth rate between 1981 and 1991 was 3.5%. According to the 1991 census, 45.7% of the country's population was living in urban areas. This is an increase of 17.7% over the 1981 census figure of people living in urban areas by then. Whilst this growth is partly due to substantial population growth in urban areas like Gaborone, Francistown etc, most of the growth is attributed to the re-classification of many villages from rural to urban (e.g. Tlokweng and Palapye). Based on the 1991 population and housing census, the defacto population is projected to increase from 1,323,796 in 1991 to 1,693,970 in 2001. This is a 27.96% increase over the total enumerated population in 1991. The population is estimated to grow at an annual average rate of 2.5% during the period 1991-2001. (CSO statistical bulletin, 1999). Population density is low in the country and most of the population is concentrated in the eastern part of the country i.e. along the railway line.

Table 1.1 Growth of Population in Urban Areas, 1971-2003 ('000)

	1971	1981	1991	Estimated 1997	Estimated 2003
Gaborone	17,7	59,7	133,5	183,8	246,8
Francistown	18,6	31,1	65,2	88,3	116,6
Lobatse	11,9	19,0	26,0	29,9	34,5
Selebi-Phikwe	4,9	29,5	39,8	45,6	5,7
Jwaneng	-	5,6	11,2	14,9	19,4
Orapa	1,2	5,2	8,8	10,3	11,7
Sowa Town	-	-	2,2	3,2	4,4

Source: National Development Plan 8

The economic growth has been generally rapid in Botswana since the 1970s. The gross domestic product (GDP) is estimated to have grown from P17, 502.9 million in 1996/97 to P20, 428.3 million in 1997/98 representing an increase of 16.7%. The sectors that contributed more to this growth were: General Government (19.2%), Mining (18.8%), Trade, Hotel and Restaurants (16.8%), Water and Electricity (15.9%), Transport (15.3%) and manufacturing (14.1%). The Agricultural sector on the other hand, grew by 5.4% in 1997/98 compared to 9.6% in 1996/97, mainly due to low and erratic rainfall during the year. The GDP by type of expenditure in current prices shows a decline in the share of consumption by both government and households. The share of Government consumption decreased from 30.6% in 1998/99 to 29.9% in 1999/2000, while that of households decreased from 32.2% in 1998/99 to 31.0% in 1999/2000 (Economic Report, 2001).

The Ministry of Minerals, Energy and Water Affairs (MMEWA) is responsible for the national water policy in the Botswana. There are two main institutions/authorities responsible for water supply and these are:

- Department of Water Affairs (DWA), which is responsible for supplying water to major villages (which have district administrative headquarters or had more than 5000 people in 1975).
- Water Utilities Corporation (WUC), which is a government owned enterprise incorporated through an Act of parliament known as WUC Act of 1970 (revised in 1978). It supplies potable water to urban areas of Gaborone, Francistown, Lobatse, Selebi-Phikwe, Jwaneng and Sowa Town. It also provides water to the peri-urban areas and villages close to urban centres through bulk supplies to the Department of Water affairs. Since its inception, it has retained its business focus, which is to plan for and provide adequate supplies of potable water in these areas on an economically viable manner and in the spirit of good public utility practice.

In 1970, the total population supplied by the Corporation was approximately 30,000 with water consumption averaging 5 mega-litres per day. In contrast, the 1998 statistics reflect the total population supplied at 330,000 with an average of 84 mega-litres daily consumption. This substantial increase in demand over the years has required the continual development of infrastructure (WUC information booklet, 1998). The business of running water supplies is quite onerous and complex given the high variable and erratic rainfall, high temperature and evapotranspiration which are responsible for replenishment of surface water, impounding reservoirs and recharge of groundwater acquifers. Therefore, as an increase in demand outstrips supply it calls for the identification and development of new and distant water sources to augment the existing ones which exercise is not only prohibitively expensive but also has serious water tariff implications to the consumer.

The setting of the water tariff governed by the WUC Act, stipulates that the Utility has to be commercial and viable, and has to contribute to the expansion of the supply system. This implies that the tariff rates have to be set in line with the Long Run Marginal Cost (LRMC) of water supply system in urban areas. Although the Corporation increased its efficiency and kept the cost increases far below the rate of inflation, these adjustments were not enough to meet the requirements of the Act. Therefore, the Corporation found it fit to implement the largest project ever in the country i.e. the 1,2 billion Pula, North South Carrier Water Project (NSCWP). This project is complete and is still waiting commissioning. The second phase will realise the construction of another dam on the Lower Shashe River to be known as Polometsi to deliver water through the initial pipeline before it is duplicated. This project is still at detailed design stage.

There are two main sources of water in the country and these are groundwater and surface water. The development of surface water is constrained by low and erratic run-off, lack of the availability of suitable dam sites and high rates of evaporation (Krook, 1994). The Botswana National Water Master Plan (BNWMP) study revealed that 35% of the total water supply is from surface water whereas 65% is from groundwater. It is worth noting that surface water accounts for 90% of the total supply of water in urban areas.

Table 1.2 Corporation's raw water abstracted from major dams

Name of Dam	Capacity (MCM)	Capacity Utilization(%) as at 31st March 1999	Location
Gaborone	141.4	81.32	Gaborone
Bokaa	18.5	41.35	Bokaa
Nnywane	2.3	83.04	Lobatse
Shashe	85.0	97.18	Tonota
Letsibogo	100.0	8.90	Mmadinare
Molatedi	201.0	81.00	South Africa

Source: WUC information booklet, 1998

The Gaborone, Bokaa and Molatedi dams supply Gaborone while Nnywane supplies Lobatse and it is also a standby source. Lobatse also gets up to 100% of its supply from Gaborone Treatment Works. WUC is entitled to 7.3 MCM of water transfers from Molatedi dam, if the dam is over 26% full and half that allocation if the dam is below 26% full. Jwaneng is supplied by ground water from the boreholes in the Magagarape wellfields. Shashe dam is supplying Francistown and Selebi-Phikwe. Letsibogo dam, which was commissioned in June 1997 supplies Selebi-Phikwe and augment supplies to greater Gaborone after completion of the NSCWP. Sowa town is supplied by underground water from Dukwe Wellfields.

Groundwater resources are the main source of water for most of the urban villages, rural villages and some of the mining centres. They also provide water to wildlife and livestock. Groundwater is supplied through boreholes, which are drilled from acquifers. About 15000 boreholes are scattered in various parts of the country. The quality of groundwater is threatened by pollution especially in areas which are densely populated such as the South Eastern Botswana. An analysis of water samples taken from about 2000 boreholes by DWA revealed that 34 boreholes had a nitrate pollution which is above the Government recommended level of 100 mg/l (Kgathi, 1998). The possible causes of nitrate water pollution are organic wastes from pit latrines and septic tanks. The number of pit latrines has been increasing over the years to improve sanitation, in response to the educational programs by the Ministry of Health.

1.2 Statement of the problem

There are some good reasons for researching the demand and utilisation of water that includes:

i) The need to ensure wastage is kept to a minimum.

ii) Equitable use of the available supply of water.

iii) To gauge the appropriate balance to be struck between the scale of investment into water supply and the requirements of consumers.

iv) To help with risk analysis particularly at times when supply is restricted through drought.

Available literature suggests that there are several indicators or parameters, which influence/ determine/ measure water use and affordability in urban areas. These include quantity consumed, price of water (tariffs), rainfall, temperature, evapotranspiration, construction (as a proxy for economic growth), population growth, drought, per capita income, etc.

Studies conducted by Arup Botswana (1991) and Snowy Mountain Engineering Corporation (1991) have so far not been comprehensive in that such consultancies have confined their analysis on annual data. The former used a six-year period (1985-1990) while the latter used a ten-year period (1980-1989). Both studies used relatively small samples weakening any inferences drawn from them. For example, in the Arup Botswana study, price of water had no significant association with the quantity of water consumed during that period. Therefore, there is need for further empirical and analytical work on the water use and affordability in urban areas. The study will however use the 15-year period that is disaggregated into quarterly data (i.e. from 1st quarter 1984 to 4th quarter 1998. More variables will be incorporated in the models used by the above-mentioned consultancies.

This study will also generate a stock of information necessary for decision making on various economic issues including:

- A focus on water demand rather than water supply (i.e. adoption of water demand management strategies to reduce demand).
- Measures of water conservation and protection etc.

CHAPTER TWO

Objectives of the Study

2.1 General Objective

The study addresses itself to the establishment of how water is used by urban consumers and assesses the impact of water tariffs on consumer affordability over time.

2.2 Specific Objectives

i) To establish the factors that influence the quantity of water which is consumed and how tariffs are perceived by consumers and influence the consumption behaviour.

ii) To establish the composition of water demand i.e. ways that different consumers use water, at what times, in which locations and for what purposes.

iii) To examine the present tariffs system and assess the benefits of changes to the consumer.

iv) To establish the most effective means by which the escalation in demand for water may be reduced without detrimental effect on economic development and community needs.

v) To assess the impact of present tariffs on consumers' affordability and to forecast the effects of increasing tariffs on consumers' affordability and water demand within the various use categories.

vi) To identify and analyse measures that are put in place and that could be introduced to conserve water.

vii) To establish the relationship between the level of tariffs and consumers affordability and their willingness to pay for water.

viii) To determine the price and income elasticities of demand for urban water.

ix) To establish demand models of water utilisation (quantity consumed) with key independent variables such as tariffs (price of water), rainfall, population, and construction (as a proxy for economic growth) etc. over time.

x) To draw conclusions and make policy recommendations on the basis of the findings of the study.

CHAPTER THREE

Literature Review

3.1 Theoretical Literature Review

Water is becoming one of the largest and certainly the most universal of problems facing mankind as the earth moves into the twenty-first century. The tasks of supplying enough water of required quality to growing populations and the safe disposal of wastewater are straining many authorities to the limit. Although the problem varies in type and intensity, it is challenging governments of countries at all stages of development in most parts of the world. (Winpenny, 1994).

Pearce et al (1994) alleged that there are two rules of sustainability, which are relevant to the water sector. These are; Quantity and Quality Sustainability Rules. The quantity rule states that the quantity of water resources should not decline overtime as this may reduce its total supply. It requires that the demand for water should be met by effective run-off, and such a demand for water should not deplete groundwater resources. Resources that are used at a rate that exceeds their rate of replenishment are known as finite resources. The quality rule states that the quality of water should not decline over time as this may reduce the total supply of water. If the quality of water resources declines, heavy economic costs are imposed on future generations, as they will inherit polluted waters.

One of the factors that threaten the sustainability of water resources, particularly in semi-arids and arid environments is population growth. As population increases, the demand for water increases and this may lead to water depletion if the rate of its replenishment is lower than the rate of use. The effect of population growth on water resources also depends on population density. Areas with high population density tend to be associated with the mining of groundwater resources. The need to conserve and allocate water to socially more valuable uses has not always been evident. In some societies water has long been treated as a scarce and valuable resource. But in many countries, water has been treated as though it was available in unlimited quantities, and supplied at zero or low cost to consumers who resent the idea of water as an economic resource.

3.1.1 Water supplies and use

According to Young et al (1985), fresh water for human use is found in surface water or groundwater. Water is generally categorised among the renewable (flow) resources, although certain groundwater deposits are more usefully analysed with concepts applicable to the non-renewable (stock) resource case. In most countries, easily accessible water sources have already been tapped, supplies are approaching their physical limits and new supplies for growing populations and rising consumption levels are only available at increasing cost. It has been argued that societies suffer water stress when annual renewable supplies fall below approximately 2 kilolitres per person at a time when demands for water are increasing in the process of development (Falkenmark, 1989).

The environmental costs of water supply schemes are becoming less acceptable as they become greater and as they are increasingly measured in economic terms. These costs arise both in supply (e.g. depleting acquifers, damming rivers, destroying wetlands) and in disposal of waste water (run off, effluent and sewage) (Winpenny, 1994).

Water Utilities and their governmental sponsors in many countries, are in no position to bear the increasing capital, operating and maintenance costs catering for the projected growth of water requirements. Their poor financial position is partly due to failures in pricing and cost recovery. Other factors leading to poor financial performance are high proportion of leaks and wastage, weak billing and collection systems, erratic payments by large consumers. As a result, they are depleted of funds necessary to maintain, repair and expand systems. As consumers suffer reduced levels of service, their willingness to pay existing bills, let alone increased tariffs, starts to wilt.

According to a World Bank Policy Paper (1993), there are four types of contracting arrangements that are used in urban water systems and these:

(a) Service contracts: whereby a public water company hires a private firm to provide specific services such as meter reading, billing and collecting, and operating production facilities.

(b) Management contracts: whereby a contractor assumes overall responsibility for operating and maintaining the water supply system with freedom to make day to day management decisions.

(c) Concessionaire contracts: whereby a private firm finances investments in fixed assets in addition to working capital. Assets are however owned by the firm for the period of the concession and are transferred back to the public authority at the end of the period.

(d) Lease contracts: whereby a private firm rents the facilities from a public authority and assumes responsibility for operation and management (O & M). The lessee finances working capital and replacement of capital components with a limited economic life while public authority is responsible for fixed assets.

3.1.2 Water demands

i) The link between economic growth and urban water demand.

Eberhardt et al (1983) argued that there are a number of important links between the pace of economic activity and water requirements, where water requirements are water demands at a given real price. For household water requirements there is a direct and indirect relationship. Firstly, household requirements are positively related to real income per head, so that we would expect household demand to be lower in a lower income head scenario. Secondly, the faster economic growth is likely to be associated with higher levels of net immigration and hence higher population growth. For industrial water demand, with a given industrial composition and technical change with repeat to the intensity of water use, water requirements are likely to increase at a parallel pace with industrial output. Commercial water requirements are related to the level of commercial employment, they therefore rise faster, the greater the rate of economic growth. Public water demands are likely to increase in line with general growth, and could accelerate with rising standards of living as income rise.

ii) Household water demand

a) The influence of household size and dwelling type.

There are opportunities for economies of scale in residential water use; garden water use is perhaps the most obvious example, and in-house water applications such as dish washing and laundry are also examples of water uses which may not increase in direct proportion with family or household size.

b) The influence of income

Household income is a significant determinant of both in-house and garden water use. The lower responsiveness of in-house use than of garden water use to changes in income may be explained on the grounds that expenditure on in-house water is of a less discretionary nature than on garden water. Channels through which increased income could lead to increased in-house water use could be increased ownership of water using appliances such as automatic washing machines, dishwashers, garbage disposal units etc. Eberhardt et al (1983) argued that income elasticity of in-house water demand varied little with location, climatic conditions etc., and the water response to income changes is likely to be greater where incomes are relatively low than where incomes are relatively high. This consideration may be of particular importance in those regions where major resource developments are projected to occur and if such developments result in a rapid rise in incomes from relatively low levels, then the impact of such income changes on residential water requirements could be larger than otherwise.

c) The influence of the weather

Weather conditions, in particular rainfall and temperatures can be expected to influence total residential water demand. Garden use is likely to be influenced by the average levels and patterns of rainfall and temperature. Urban water consumption varies directly with maximum temperatures and inversely with level of rainfall. As temperature rises, people tend to use more water by watering their gardens and taking several showers a day. Weather patterns influence the size of water storage required to meet adopted targets for water supply reliability and in this respect they have potential impacts on both demand projections and the supply decisions of the relevant authorities.

d) The influence of water price

Allowance for possible price effects on the level of water use of households or communities is a central characteristic which distinguishes the process of forecasting water demands from that of forecasting water requirements. There is much evidence that for water, like other goods, the quantity for which consumers are able and willing to pay will decline as the price increases. For the purpose of forecasting water demands, qualification of the link between water price and quantity demanded is necessary. Under a pricing system that imposes a charge for each additional unit of water, the consumption of an additional unit of water requires that the purchase of some other goods be foregone. Water use behaviour is modified under such pricing systems, and that price changes bring about adjustments in quantities of water demanded (Eberhardt et al, 1983).

iii) Industrial water demand

a) Industrial water requirements

Industry water is used as a factor of production. At any given real price of water, the amount of water used in a particular establishment will depend on its level of output, the price of inputs other than water, the price of waste-water disposal and the opportunities for substitution between water and other inputs such as labour, materials or capital. The opportunities for substitution between inputs will be greater in the long run than in the short run, for in the short run the capital stock of the firm is given. The composition of aggregate output and the level of aggregate output will determine industrial water use. If we were to assume no change in the composition of industrial output over time, and no change in technology, then changes in industrial water requirements will reflect changes in the level of industrial output.

It is argued that there is no clear evidence on the relationship between industrial water use and the level of industrial activity overtime. Even with a given real price for industrial water, the rate of growth of industrial water use may not mirror the rate of growth of industrial activity if changes occur in the composition of output towards or away from water-intensive industries, if technological change is such as to favour the introduction of more or less water-intensive capital equipment, and if changes in waste-water charges affect least-cost production etc.

b) The influence of water price

Water is generally a minor input in industrial processes, and the cost of water represents a minor cost in relation to the total market value of the product even in industries that are water intensive. Given that water is generally a minor input in an industry and that its inputs are at least partly determined by the characteristics of the capital equipment employed, the elasticity of industrial water use with respect to price can be expected to be low in the short-run. In the long run, we would expect that industrial use of water would respond to changes in the relative price of water.

For an existing industrial enterprise, with a given production technology, changes in water use practices induced by changes in water prices are likely to be very minor; for new and existing enterprises expanding or replacing capital equipment, the price of water may be an influence on the choice of technology and where alternative technological possibilities embody different water use characteristics, on the level of water demand.

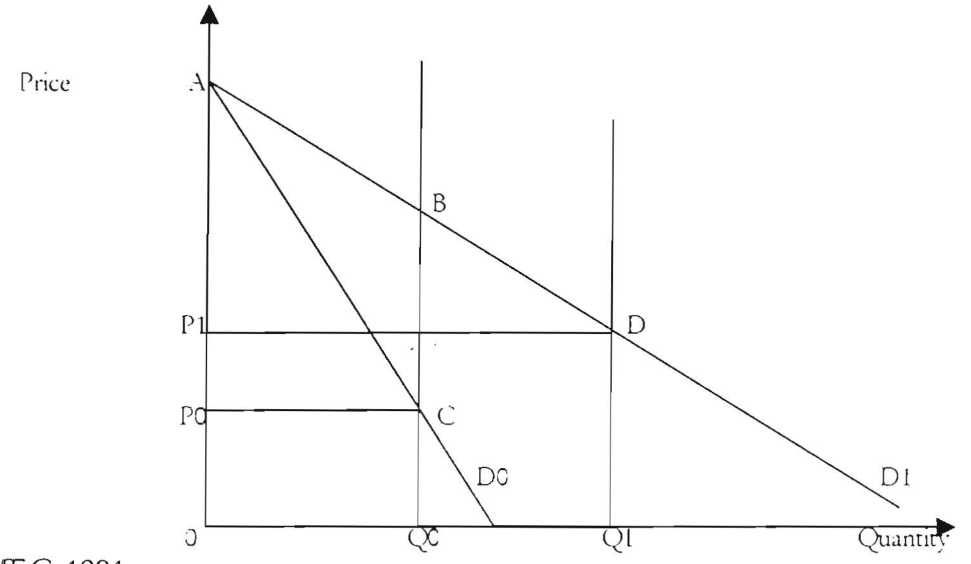
iv) Commercial water demand

On the assumption that the use of water in commercial enterprises is principally for staff amenities, we would expect a close relationship between movements in commercial sector employment and commercial use. We would further expect that commercial water use per employee would increase with rising levels of real activity in the economy, for at high income levels staff amenities could be extended to include such relatively water-using facilities as showers, gymnasiums, etc. more especially in mining towns.

3.1.3 Demand and Economic Benefits

Economic demand for water is expressed in terms of the relationship between price and the quantity of water that consumers wish to take. Like any other commodity, a higher (or lower) price will discourage (or encourage) water use. The economic demand curve describes this price-quantity relationship. Growth in demand for water implies shift in the position of the demand curve. This is illustrated in the following diagram:

Figure 3.1. The relationship between demand, supply and benefits as population and income increases.



Source: SMEC, 1991

The demand curve in the initial situation is Do and the prevailing price of water, Po, equates current supply with demand. The position of the demand curve changes in response to population growth from Do to D1. At any given price level, other things being equal, it is assumed that consumption will increase with population growth. A lot of literature argues that water demand has demonstrated that growth in real per capita income shifts the demand curve outwards to the right of D1.

By using the total area under the curve even without augmentation, there is a small increase in welfare shown as area ABC. This reflects an increase in the absolute value of water in conditions of scarcity and demand growth. If the augmentation increase supply from Q0 to

Q1 with the new price of P1, then there will be an increase in consumer benefits of area ADQ1Q0. Even if demand is increasing, development will be delayed if the costs of the system augmentation exceed benefits. If so, it was assumed in measuring benefits and computing their distribution between consumers and producers that pricing, water allocation and demand management would be adjusted to the static supply situation.

3.1.4 Demand Management for efficient and equitable water use

Demand management (DM) is a policy for the water sector that stresses making better use of the existing water supplies, rather than developing new ones. One way of visualising DM is to compare it with its alternative, supply augmentation, that was the prevailing policy in many countries until recently. (Kay et al, 1997).

Demand management stresses waste reduction, the development of water- efficient methods and appliances, creation of incentives for more and careful use for both suppliers and users, improved cost recovery, reallocation from low to high value uses, a role of private sector, greater devolution of water management to consumers and user groups, and greater use of economic instruments (prices, markets) alongside other methods of matching supply and demand. DM includes measures to relate the value of water to its cost of provision and motivate consumers to adjust their usage in the light of those costs. It also entails treating water more like an economic resource as opposed to a public service.

DM may be exercised either through the price system or through non-price controls such as quantitative water restrictions, education campaigns aimed at limiting water wastage etc. We consider that DM through the price system where prices are set at levels to reflect true real costs will lead to the more efficient and equitable allocation of resources. It promotes efficient use of water by discouraging waste and seeking to increase value-added from existing supplies.

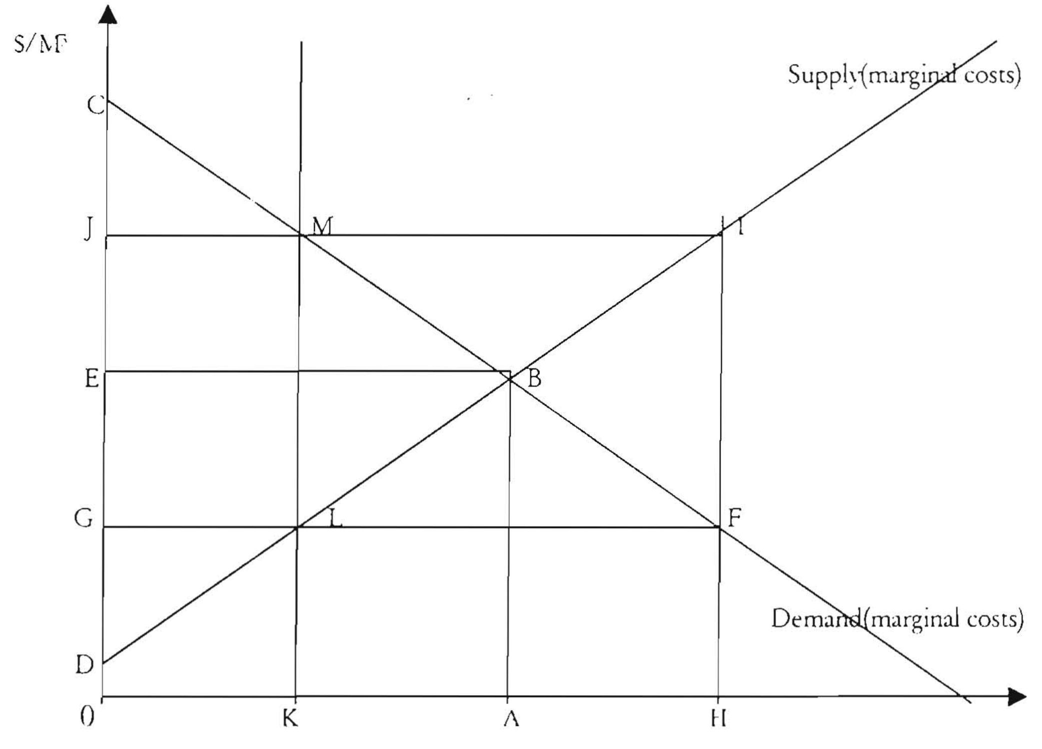
Supply augmentation stresses the development of more water resources to meet the water demand. These resources have higher financial and environmental costs and marginal costs pricing have to be imposed to recover the implementation costs (e.g. dam construction, pipeline, borehole drilling, treatment works etc).

Marginal cost pricing implies allocative efficiency, but may imply a loss while average cost pricing allows water sales revenue to cover costs. Therefore, marginal costs pricing works well with supply augmentation while average costs pricing works well with demand management.

3.1.5 Economic Efficiency

Economic efficiency would be obtained by setting water charges equal to opportunity cost of water. The following diagram is useful in approaching water conservation:

Figure 3.2 Supply and demand for water.



Source:Herrington, 1987

The demand curve relates the consumers' willingness to pay for the amount of water consumed. This would normally be downward sloping from left to right reflecting the diminishing utility derived from successive increments of water. The supply curve slopes upward to reflect the fact those increments of supply can be provided only at rising cost to the water system.

According to this diagram, net benefits are maximised when OA units of water are produced with price of OE. Net benefits, which are depicted by the excess of the area under the demand curve over that under the supply curve are represented by area CBD. If consumption is higher than this, say OH, the costs ABIH of supplying the increment AH exceed benefits ABFH by BIF. But if consumption is restricted to OK, by excessive prices, the loss of consumer benefits KMBA exceeds the supply cost savings by KLBA.

Water conservation: An important element of any strategy designed to deal with water is incentives for adopting technologies and management approaches to make use, allocation and distribution of water more efficient. Increased efficiency in use, measured as the amount of water saved in providing a given level of services. Such measures as reduced leakage from customers' taps and pipes, more efficient toilet flushes etc. need to entail any loss of consumers' surplus. As water scarcity and waste disposal problems become more acute, it will become increasingly important to adopt and improve water conservation practices, desalination and wastewater reuse systems, and overall pollution reduction approaches.

Historically, the standard technique for evaluating public investments and policies in the water resources area has been the benefit cost analysis. This approach assumes that economic efficiency is a relevant objective for public water interventions. Procedures for estimating the benefits and costs of a marketed commodity such as water can be interpreted as efforts to stimulate hypothetical market outcomes. Benefit refers to the amount that a rational user of a publicly supplied good would be willing to pay for it while costs represent the foregone value of goods and services displaced by a project.

3.1.6 Water prices and pricing systems

The importance of pricing and other incentives that encourage consumers to adopt efficient water use practices depends on the relative value of water. When good quality water is plentiful and cheap, it does not pay to invest in costly monitoring devices and pricing systems. However, demand is responsive to price and it becomes increasingly worthwhile to measure, monitor and price water carefully as it becomes scarce.

According to Winpenny(1997), the metering of domestic water supplies is fairly common in developing countries, though the charge rates tent to be well below the level necessary to cover operation and maintenance costs and investment outlays. He argues that it is more realistic to ask authorities to raise prices to the economic cost recovery level before taking further steps to marginal cost covering. In practice the water tariff can be structured so as to relieve small or poor consumers though equity and poverty concerns are often cited as arguments against more rigorous pricing.

In Botswana, the water pricing policy is based on the principles of equity, efficiency and affordability. Equity implies that all citizens of Botswana should have access to safe water whereas efficiency implies that an attempt should be made to ensure that the economic cost of water supply is met by consumers whenever is possible. Affordability implies that those who do not have the ability to pay for water should not be denied access to it (Thema,1997).

The tariff structure adopted by WUC involves rising block or slab rates, which is similar to that being used in most of the countries in the world. This system provides for concessionary rates to meet basic needs at low levels of consumption whilst charging at an increasing rate at higher levels of consumption to cover the costs of supply. Recommendations made by the BNWMP study were that, all consumption above the concessionary level should be charged for at least at the LRMC of supply. This tariff structure has a dual benefit of providing a service to the poor whilst offering the incentive to avoid wasteful consumption by larger consumers. This is generally regarded as equitable and efficient.

Block tariffs were restructured in 1992 to more closely reflect water scarcity. The quantity of water eligible for the lowest tariff was reduced from the first 15 m^3 to the first 10 m^3 per month whilst the quantity at which the highest tariff was introduced fell from 40 m^3 to 25 m^3 per month (Thema, 1997).

The water tariffs were reviewed in 1993,1996,1998,1999 and 2000 in order to achieve efficiency. The following tables depict the prevailing tariffs and standard charges for the year 1998/99:

Table 3.1 Tariffs for domestic and business consumers (1998/99)

Tariff band	Consumption Per month (cubic meter)	Gaborone/ Lobatse	Jwaneng	F/town	Sowa Town	Selebi-Phikwe
		Thebe per	cubic	Meter		
1	0 – 10	115	115	115	115	115
2	11 – 15	352	227	281	259	182
3	16 – 25	448	297	408	376	227
4	Above 25	618	343	449	414	285
5	Raw water (untreated)	197	-	105	-	-
6	Raw water BCL	-	-	-	-	special tariff

Source: WUC Supplementary Report, 1998/99

Table 3.2 Tariffs for Government/town and District Council

Tariff Band	Consumption per month	Gaborone/ Lobatse	Jwaneng	Francistown	Sowa Town	Selebi-Phikwe
		Thebe per	cubic	meter		
1	0 – 10	160	115	160	115	115
2	11 – 15	465	227	373	259	182
3	16 – 25	597	297	540	376	227
	Above 25	818	343	597	414	285
	Stand pipe (council)	717	297	466	-	242
	Bulk water treated (DWA & District Council	717	297	466	-	-
	Bulk water untreated (DWA and District Council	261	-	-	-	141

Source: WUC Supplementary Report, 1998/99

Table 3.3 Standard Charges

Minimum charge	P9.00
Reconnection fee	P40.00
Meter Test fee	P30.00

Source: WUC Supplementary Report, 1998/99

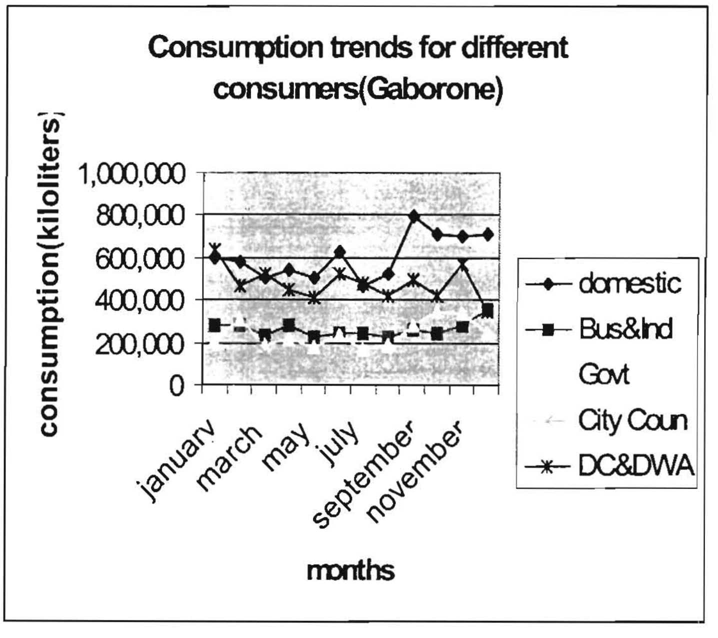
3.1.7 Trends of water consumption by customers supplied by WUC

Water Utilities Corporation supplies the following users with water:

- Domestic consumers
- Business and industrial consumers
- The Government
- City Council
- District Councils and DWA - bulk water
- BCL special tariff

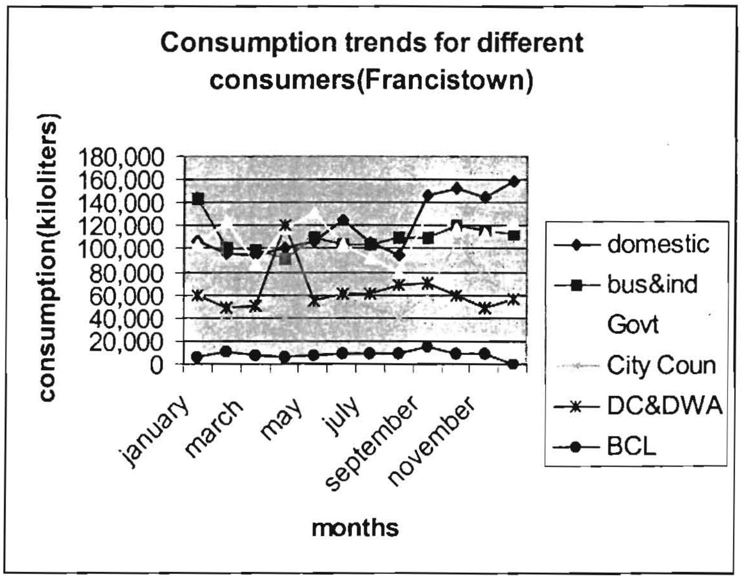
The trend will be observed for the year 2000 and data is on monthly basis. This year experienced high rainfall and almost all the dams in the country were 100% full.

Figure 3.3



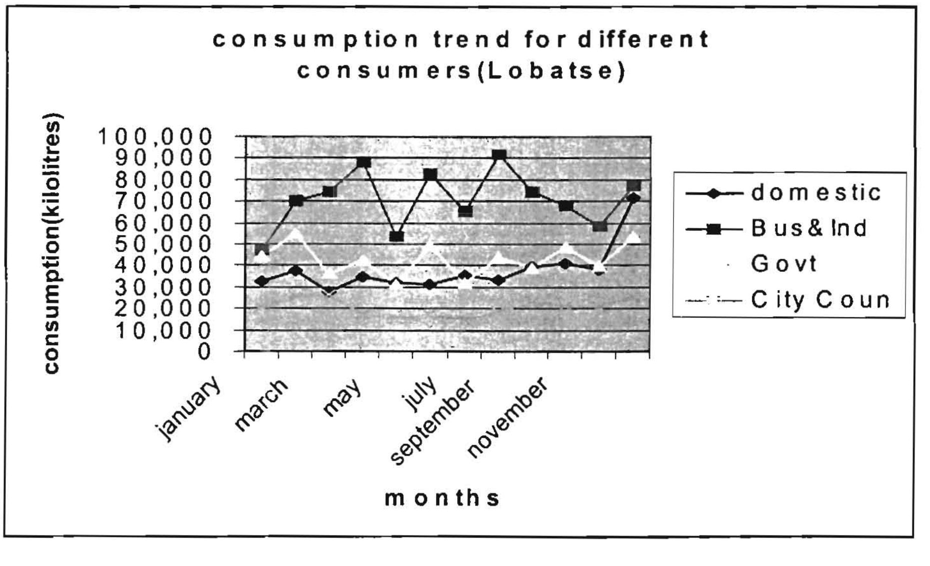
Water consumption by domestic customers is high between October and February due to the hot season and as a result more water is used for watering gardens, showering etc. This tendency is also observed in District Council and DWA which supply villages. The least consuming customer is City Council which supply among other things urban stand pipes.

Figure 3.4



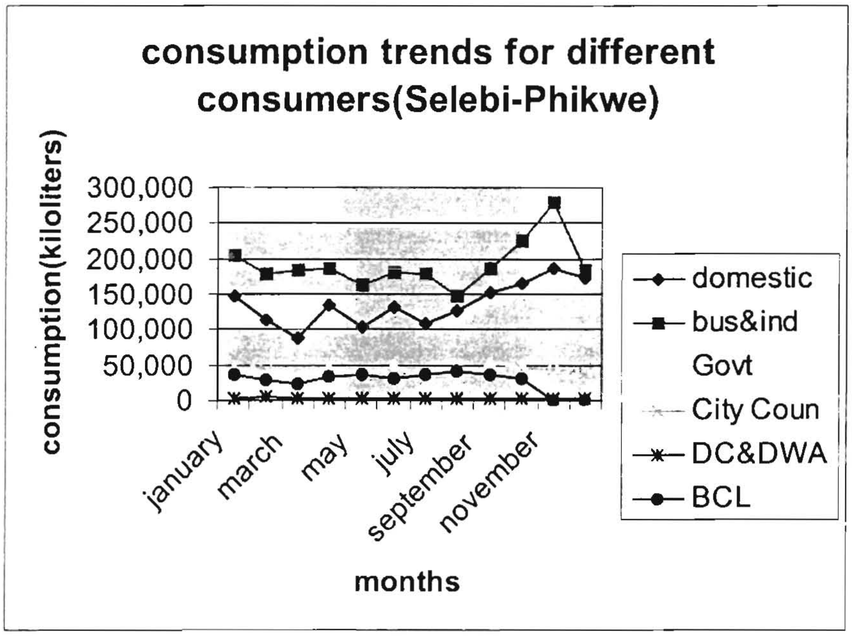
In Francistown, the highest consumers are domestic customers, followed by business & industry then Government institutions. The least consumer, is BCL which has a special tariff from WUC since is a highly subsidised mine in Botswana. There is a Nickel mine in Francistown, which uses this subsidised water. There was a tremendous increase in water consumption by DC and DWA and this could have been due to shortage of water in some villages in the North East District. Economic activities such as construction, expansion of roads and Botswana Meat Commission lead to an increase in demand for water.

Figure 3.5



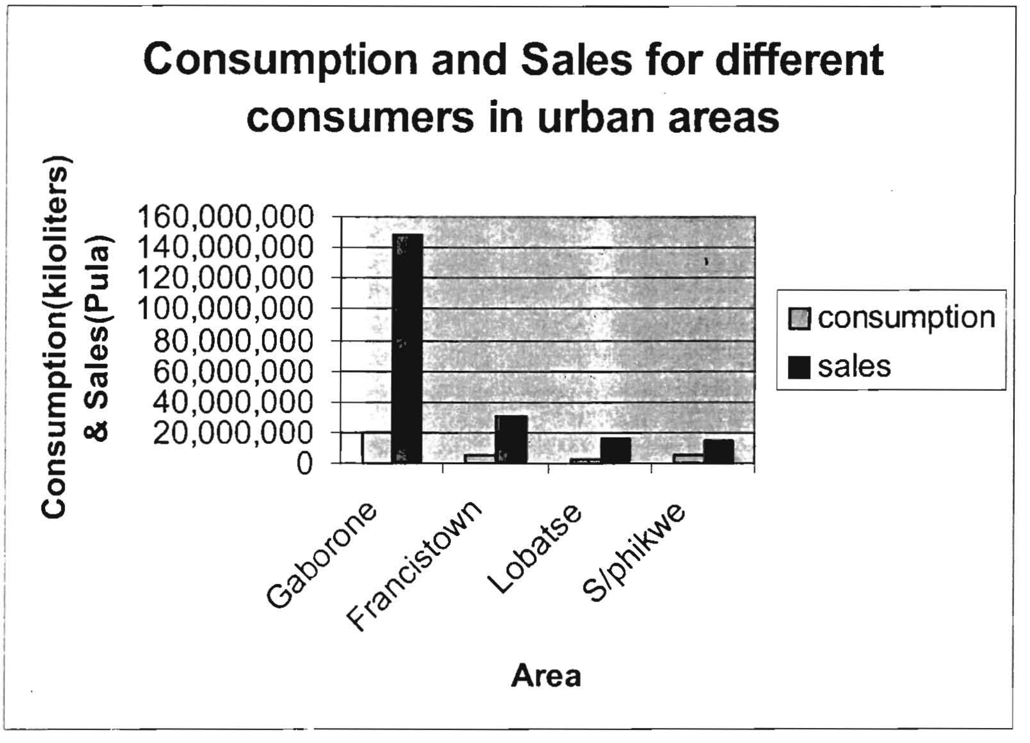
In Lobatse, the largest consumer is the business and industry and this mainly due to Botswana Meat Commission (BMC) where a lot of water is used during cattle slaughtering and meat processing. The smallest consumer is the City Council and this implies that less water is being consumed from standpipes. There was an increase in water consumption for all the customers and this mainly due to high temperatures experienced in November and December. When horticultural demand is high, more water is used during this period unless there is rain.

Figure 3.6



In Selebi-Phikwe, there exist a Copper and Nickel mine that is largely subsidised by the government because of its unsustainability. This mine has employed a lot of mine workers and as a result more water is being consumed. Business, industry and domestic customers are the largest consumers of water. This town also has a lot of small, medium and large-scale industries and firms that employed a large number of people. As a result more water is being used in production of goods and consumption. Most of these firms are financed through the Government aiding policies such as Financial Assistance Policy (FAP) etc. There was a tremendous decrease in water consumption in business and industry. This was due to the fact that most industries had been closed for Christmas and New Year holidays. This occurs in other towns but it is more significant in Phikwe since the town is heavily industrialised.

Figure 3.7



According to this figure, more water is consumed in Gaborone with the highest sales, followed by Francistown. The bulk of the population is situated in these two cities as a result of rural urban migration. Economic activities such as construction, road expansion and BMC in Francistown result in large quantities being consumed. The least consumers are found in Selebi Phikwe and Lobatse.

3.2 Empirical Literature Review

This section addresses empirical findings reported in the literature on water use and affordability in urban areas.

3.2.1 Price elasticities of demand for water

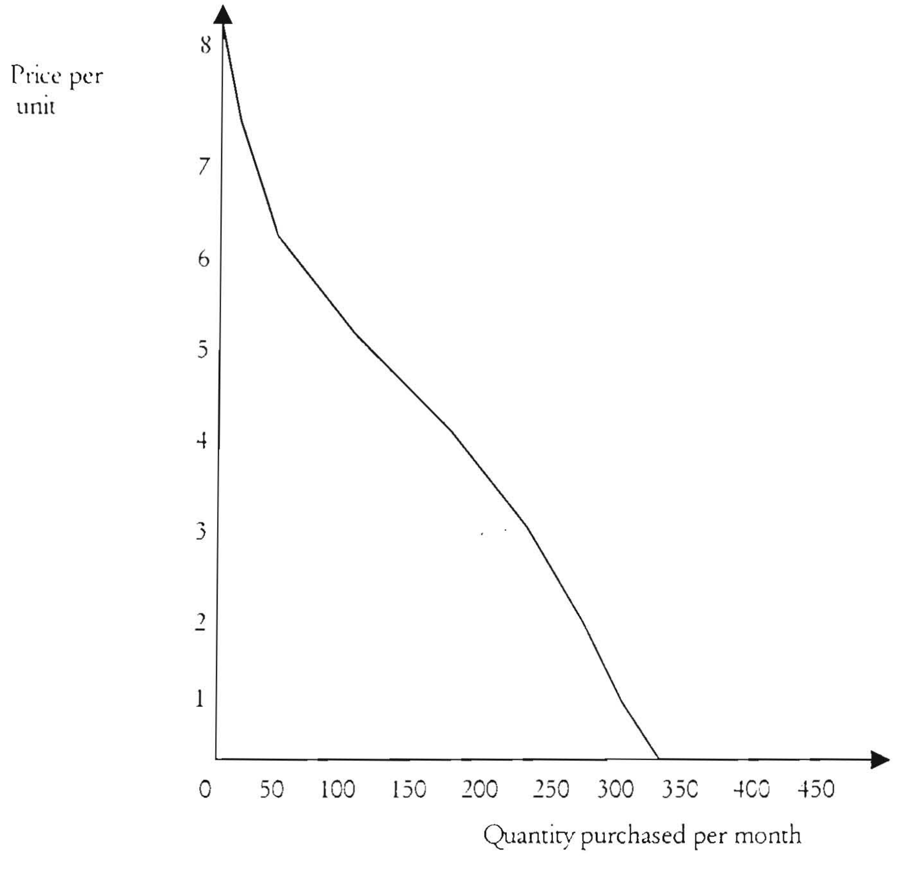
Merrett(1997) presents a theory which deals with domestic consumers' price elasticities of demand for water. This refers to the relationship between water consumption (i.e. quantity consumed) and the level of tariffs.

Price elasticity can be used, as a way of predicting the consumption response that changes in tariffs would most likely induce. The main factors including price elasticities outlined by Eberhard(1995) are as follows:

(a) Nature of use: different uses of water have different price elasticities, discretionary use (e.g. gardening) has much greater price elasticity than non-discretionary use (e.g. cooking).
(b) Current consumption levels: consumers using only a basic amount of water will have much lower price elasticities than consumers using large amounts.
(c) Season conditions: price elasticities are typically higher in summer. This is because summer usage includes a larger proportion of outdoor use, which is more elastic thus making overall use more elastic than in winter.
(d) Water bills: consumers that have water bills that represent higher proportions of their incomes have higher price elasticities.

The cultural and economic context of any demand function is referred to as the conditions of demand. The first condition is the tastes and habits of consumers, (i.e. the nature of the need for the community). The second is the price, quality and availability of commodities that consumers consider to the substitutes for the product. These two together should account for the consumers' willingness to purchase. The third condition is the incomes, assets and access to credit of consumers, which account for the ability to purchase. Where the conditions of demand are stable, the graphical function can be used to represent not only the price and quality differences within a given time period, but also price and quality changes in successive time periods. We should note that higher prices are associated with lower quantities and so the demand function slopes downwards from left to right.

Figure 3.8 A cubic demand curve for water



Source: Merrett,1997

The general hypothesis adopted by Merrett about the shape of the demand curve for water is that it takes the form of a cubic function, where:

$$P = aQ^3 + bQ^2 + cQ + d \qquad (1)$$

This function is illustrated in figure 3.8. At low quantities purchased, a higher price brings little reduction in the absolute quantity purchased because of the intensity of the need for the product. At the middle of the range quantities, a price difference brings a clear shift in the quantity purchased. At high quantities, a lower price eventually brings no increase in the quantity purchased because the consumer is satiated with water.

Table 3.4 Price elasticity of demand for water.

Price per m^3	Quantity purchased (m^3 per month)	Value of sales (column 1 X col.2)	Elasticity
6	700	4200	
			-1.80
5	1000	5000	
			-1.67
4	1500	6000	
			-1.00
3	2000	6000	
			-0.60
2	2500	5000	
			-0.21
1	2800	2800	

Source: Merrett, 1997

According to these findings, there is an implication that low prices are always associated with low elasticities and high with high. These relationships can be of great importance in shaping the consumers' behaviour.

- Where e lies between 0 and -1, demand is inelastic and a lower price brings a greater quantity purchased but with lower value of sales.

- Where e =-1, a lower price brings a greater quantity purchased, but with no change in the value of sales.
- Where e lies between -1 and negative infinity, a lower price brings a greater quantity purchased and with a higher value of sales.

More empirical work by Winpenny(1994) on price elasticity of water demand states that in-house domestic water consumption appears to be inelastic whereas outdoor use is much more elastic. The greater the demand elasticity of outdoor use also explains some of the seasonal and regional differences evident in table 3.5.

Table 3.5 Consensus estimates of price elasticity of water demand in USA

	Short Run Elasticity	Long Run Elasticity
Residential Use		
Indoor use	0.0	0.0 to -0.10
Outdoor use-Eastern US	N/a	-1.30 to -1.60
-Western US	N/a	-0.70 to -0.90
Commercial & Institutional Use		
Individual categories	N/a	-0.20 to -1.40
Industrial Use		
Individual categories	N/a	-0.30 to -6.71
Aggregate industrial	N/a	-0.50 to -0.80

Source: Winpenny, 1994

3.2.2 Income elasticities of demand for water

The Arup Botswana (1991) study estimated the income elasticity of demand (i.e. the relationship between household income and consumption of water). It is argued that as income rise, households consume more water, although for WUC's consumers, the income effect leading to increased consumption is partially offset by the price effect of rising tariffs which lead to reduced consumption. It should be noted that the income elasticity of demand could be estimated only at a given structure of tariffs.

Table 3.6 Estimates of domestic consumers' income elasticities of demand for water.

	Average	Income	Elasticities		
Monthly Income(Pula)	Gaborone	Lobatse	S/Phikwe	Jwaneng	F/Town
<600	0.20	0.33	-0.77	-0.16	0.73
601-1000	0.71	-0.22	0.13	0.55	-0.39
1001-1500	-0.41	0.71	1.71	0.06	2.10
1501-2000	0.80	2.28	0.21	0.69	-0.06
2001-4000	-0.28	0.31	1.24	-0.67	-0.18
4001+	N/a	N/a	N/a	N/a	N/a
Average	0.20	0.68	0.51	0.09	0.44

Source: Arup Botswana, 1991

Note that, figures are the ratios of the proportionate change in average consumption to proportionate change in income between the midpoints of the class intervals for tariff structures and consumption levels.

The above table illustrates that as incomes rise, the propensity of domestic consumers to consume water, at any rate for the principal income bands, also rise. At about above P2000 income per month there is a little relationship between income and water consumption. Since these estimates are made at a point in time, with a given tariff structure, it is not possible to be precise about how income growth in the future will affect consumption if, at the same time as income changes, there is also a change in the structure of tariffs. These results seem to be awkward in the sense that negative elasticities imply that as income increases less water is consumed and this is not true in reality. Therefore, these results may be influenced by free water obtained from public standpipes.

Apart from using the income and price elasticities, this study will employ the multiple regression analysis to test for the significance of water use and affordability in urban areas.

3.2.3 Arup Botswana Model

Arup Botswana conducted a study and came up with this model:

$$Q = f(P, s, e) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where: Q = quantity of water consumed.

P = price of water

s = vector of other factors which may influence consumption

e = stochastic error term

This multiple regression analysis has been run for each of the market areas using monthly time series data. The following detailed model was used:

$$Q = b_0 + b_1 P + b_2 R + b_3 E + b_4 T + e \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where: b_0 = intercept

b_1- b_4 = elasticity coefficients

R = rainfall

E = evaporation

T = time trend

e = stochastic error term

Table 3.7 Multiple regression analysis results using WUC monthly time series, Gaborone domestic 1985-1990

Independent Variables	Dependent Variable *Proportionate change in quantity consumed per m³ monthly, based on 4 month moving average*	Dependent Variable *Quantity consumed per m³, monthly, based on 4 month moving average*
Proportionate change in price (band average)	Beta coefficient = 0.132 (t significance = 0.2772)	n/a
Price (band average)	n/a	Beta coefficient = 0.025 (t significance = 0.853)
Rainfall	Beta coefficient = -0.238 (t significance = 0.057)	Beta coefficient = 1.432 (t significance = 0.157)
Evaporation	Beta coefficient = 0.102 (t significance = 0.838)	Beta coefficient = 0.248 (t significance = 0.0102)
Time trend	Beta coefficient = -0.108 (t significance = 0.373)	Beta coefficient = 0.561 (t significance = 0.001)
Adjusted R^2	0.450	0.425
Standard Error	4.92	3.65
Significance of F-Ratio	0.1439	0.00000

Source: Arup Botswana, 1991

According to Arup Botswana (1991), these results imply that amongst the range of variation of the real price of water experienced over the past five years, there has been no significant association with quantity of water consumed. The finding is of zero price elasticity of demand for water; i.e. there is no effect on quantity consumed as a result of changes in price.

The results also reveal that the quantity consumed is statistically related to weather conditions. Rainfall variable was significant whilst evaporation variable provided a better statistical association. The weather condition variables had the correct sign and were highly significant. Therefore, the higher the rainfall the lower the quantity consumed, other things being equal.

3.2.4 SMEC Model

The National Water Master Plan study that was conducted in Botswana by SMEC in 1991 established the relationship between the price of water and quantity consumed in the South East District. The price-quantity relationship is said to be dependent upon wider social and economic context: the size of the population, its income level, technology of water use and such factors as consumer behaviour in drought periods, lifestyles, or social structure.

Estimation of the price effect requires simultaneous estimation of these other influences of water use. This was done econometrically by estimating an empirical demand function:

$$Qd = f(P, I, T, S, D) \quad \ldots\ldots (4)$$

Where: Qd = amount of water demanded

P = price of water

I = consumer income

T = technology of water use

S = social factors affecting water use

D = drought behaviour

The price-quantity relationship can be derived from the demand function and expressed in the form of an economic demand curve.

According to this study, possible explanatory variables for water use were taken to be the average price (total water sales value divided by volume), gross domestic product per capita (an index of economic growth) and a dummy variable denoting the incidence of drought years (0 if no drought and 1 if drought). The two monetary variables were expressed at 1990 constant prices, using the explicit price deflator for gross national product (GNP), from the national accounts. The use of the top marginal price in WUC's standing tariff was also investigated. It was found that the top marginal price was strongly correlated with average price. Since average price more accurately reflects supply price to all consumers, including non-domestic consumers, it was preferred as an explanatory variable.

The following demand functions were estimated:

$$Qd1 = 2206 - 344\,D - 695\,P \quad \ldots\ldots(5)$$
$$SE = (44) \quad (38) \quad (52) \qquad R^2 = 0.97$$

$$Qd2 = 153.9 - 23.1\,D - 41.2\,P \quad \ldots\ldots(6)$$
$$SE = (1.9) \quad (1.6) \quad (1.9) \qquad R^2 = 0.99$$

In equation 5, Qd is the amount of water used per metered service connection (in m^3) per annum and in equation 6, it is the amount of water used per head of population. P is the average price of water (Pula/m^3) and D is the dummy variable for drought. The figures in brackets show standard errors (SE) of the estimated coefficients, and in this case are encouragingly small suggesting a high degree of significance. The value of R^2 shows that the estimated demand function produces a close fit to the data. The overall result suggests that the dominant influences on water use in the period studied were the price of water and drought. Note that, in regressions where per capita income was tried as an explanatory variable, it was not significant and had an invalid sign.

CHAPTER FOUR

Methodology

During this study, data collection and analysis will be organised to meet the objectives. First of all, there will be a review of existing billing data to extract evidence of consumption and tariffs. Secondly, a field survey will be conducted on domestic consumers, duly stratified by market areas then clustered by type of housing (e.g. low, medium and high cost housing etc.), household income and household type to reflect their type and significance, and an analysis will be made on their consumption behaviour. This will specifically be done to acquire more detailed information about their consumption patterns and to explore their nature of their demands and behaviour patterns.

Both primary and secondary data will be used in domestic category while secondary data will be used for commercial, industrial and institutional (Government) categories for the established demand models for water utilisation and affordability. However, this study will emphasize more on secondary data. Primary data will be used specifically on affordability analysis and conservation measures.

This study will cover four market/ urban areas:

i) Gaborone

ii) Francistown

iii) Lobatse

iv) Selebi-Phikwe

Demand elasticities (i.e. price and income) will be estimated. Ideally, these should suggest the impacts of changes to the present tariff system on consumption, affordability and the types of consumers most directly affected. Separate multiple regression analyses will be undertaken for each urban area to determine the significance of water use and affordability in these areas.

4.1 Hypotheses

This study will test the following hypotheses:

(a) Price of water is insignificant in explaining trends in water utilisation in the period of study.

(b) Arguments of the demand function stand in linear relation to the quantity of water consumed.

4.2 Model specification

In order to achieve the objectives of this study, models by Arup Botswana (1991), and Merrett(1997) will be used to estimate the income and price elasticities of demand for water in all market areas.

Furthermore, models engaged by Arup Botswana (1991) and SMEC (1991) will be used to test the significance of water use and affordability in urban areas. Adding more variables such as rainfall and population will modify these empirical models. The modified model is specified as follows:

$$\ln Qc = b_0 + b_1 \ln Pop - b_2 \ln R - b_3 \ln P + e \quad (7)$$

Where: Qc = Quantity consumed

P = Price of water

Pop = Population

R = Rainfall

e = stochastic error term

b_0 = intercept

$b_1 - b_3$ = elasticity coefficients

ln = proportionate change

4.3 Study Variables

i) Dependent variable - Quantity consumed

The dependent variable from the model is the quantity consumed which is measured in kiloliters. Its quantitative behaviour will be influenced by the behaviour of the independent variables as they change over time.

ii) Independent variables

The variables used to explain the significance of water use and affordability in urban areas over time are as follows:

- Price of water (average band tariff)
- Rainfall (in millimetres)
- Population

4.4 Expected Signs of Parameter Estimates

It is assumed that for efficiency, equity and affordability to occur, Quantity consumed (Qc), must have an indirect relationship with price of water (P). Therefore the value of the coefficient $b_3 < 0$ indicating that it will have a negative impact on the dependent variable. This implies that as price of water increases, quantity consumed will decrease. Rainfall coefficient is expected to have a negative sign implying that more rain will lead to a decrease in water consumption (i.e. $b_2 < 0$). Population coefficient is expected to have a positive sign implying that an increase in population results in an increase in water consumption ($b_1 > 0$).

4.5 Estimation Method and Data Analysis

Since the study will examine the significance of water use and affordability in urban areas over a period of 15 years, cross sectional and time series data become necessary. It should be observed that one major characteristic is that cross-sectional parameters (e.g. population) may shift over the years under consideration while simultaneously time series related explanatory variables such as prices may vary over the cross section of different market areas. The difficulty that such a situation poses lies in the fact that the disturbance term is likely to consist of the time series related perturbations, cross sectional perturbations and a combination of both.

In order to account for the fact that the error term may be correlated over time and over cross sectional units, the error component must be tested for autocorrelation and heteroscedasticity during regression analysis. This procedure is useful because it uses a form of generalised least- square regression that is more efficient than other approaches which use ordinary least square. The econometric package, E-Views was adopted to run the regression.

4.6 Data Types and Sources

This study uses primary data that was collected by means of interviews (or questionnaires) from domestic consumers, and secondary data that was obtained from the following sources:

- Botswana National Development Plans
- WUC annual reports
- Central Statistics Office bulletins
- Annual Economic reports etc.

Quarterly data was used in the regression analysis (from 1st quarter 1984 to 4th quarter 1998).

4.7 Limitations of the model

The econometric model adopted for this study, like any other econometric models, is based on assumptions and is also subjected to errors at data collection level, model specification and estimation levels in a research process. Secondly, being more of a mathematical or statistical tool, it may not be able to capture certain aspects such as socio-economic factors that cannot be quantified but yet affects the significance of water use and affordability in urban areas.

4.8 Qualitative Assessment

A qualitative assessment is necessary to supplement the econometric assessment and is justifiable considering the limitations already cited above. A questionnaire was used to collect information on the social objectives of water policy and their achievements (water conservation etc.), the problems being encountered and the strategies put in place, finance issues and technological advancement etc. This assessment was intended to address qualitative factors and to provide a second opinion about the econometric model findings (Refer to Appendix 1.1).

CHAPTER FIVE

Empirical Analysis

5.1 Analysis of the questionnaire results

One hundred and twenty households were interviewed during the survey. Thirty households were interviewed from each area. These households were randomly selected by skipping two to three households in between. Data collected during the survey revealed that domestic water use varied with the household type, size and income. The domestic consumers receive their water from their private connections and public standpipes. It also revealed that the majority of the respondents with private connections are of the opinion that water prices are still affordable though tariffs are adjusted almost annually. Reference is made to appendix 1.1.

5.1.1 Domestic/Household use of water in urban areas (as at February 2001)

This section depicts the survey findings for the domestic consumers in all market areas.

Table 5.1 Results for domestic consumers

	Private	Connections			Stand	Pipes		
	Gabs	F/town	Lob	Phikwe	Gabs	F/town	Lob	Phikwe
H/hold income(P)								
<500	0	0	0	0	1	2	3	3
501 - 1000	3	1	0	0	1	1	1	2
1001 - 2000	9	6	4	10	0	0	1	2
2001 - 3000	7	9	8	6	0	0	0	0
3001 - 4000	4	8	9	5	0	0	0	0
4001 - 5000	3	2	4	2	0	0	0	0
>5000	2	1	0	0	0	0	0	0

Total	28	27	25	23	2	3	5	7
House Type								
Low cost	8	7	5	3	2	3	5	7
Mediumcost	10	10	10	10	0	0	0	0
High cost	10	10	10	10	0	0	0	0
Total	28	27	25	23	2	3	5	7
H/hold Size								
1 - 3	12	10	7	5	0	0	0	0
4 - 6	10	9	11	8	0	0	1	0
7 - 9	4	5	2	8	1	1	1	3
9+	2	3	5	2	1	2	2	4
Total	28	27	25	23	2	3	4	7

These results show that a lot of consumers connect water pipes to their yards as their income rise. As income rise, people tend to move from low cost housing to medium and high cost housing. As a result, the number of private connections increases.

Several types of water use were identified during the survey and these were:

- Washing clothes (both hand wash and machine wash)
- Car wash
- Swimming pools
- Showering and bathing
- Watering gardens
- Cooking and dish washing
- House cleaning

Domestic consumers were also interviewed about some water saving techniques and almost all of them knew how to save water in the house and outside. They responded by saying "Close the tap tightly" and "Repair the leaks on time". Other techniques of saving water were as follows:

- Re-use water for watering plants
- Take shorter showers instead of bathing
- Reduce watering and water in the mornings and very late in the afternoons
- Reduce the number of times for washing cars in a week
- Reduce the number of times for washing clothes in a week
- Not leave water running when brushing teeth

One of the principal ways that the domestic consumers claimed they save water is by repairing leaks as at when they occur.

Table 5.2 Number of days taken by domestic consumers to repair leaks

Leaks	Gaborone	Francistown	Selebi-Phikwe	Lobatse
Same day	18	15	16	12
2 – 7 days	6	7	6	4
8 - 14 days	2	3	2	3
15 - 21 days	0	3	1	4
22 - 31 days	0	0	0	0
31+	0	0	0	0
Total	28	27	25	23

n =120 (N.B. the difference is for those who use public standpipes)

These results imply that consumers respond and repair leaks very fast to save water and avoid high bills.

Table 5.3 Type of toilet system used by households

Type	Gaborone	Francistown	Lobatse	Selebi-Phikwe
Low Cost				
Pit-latrine	6	6	7	8
Water system	4	4	3	2
Medium Cost				
Pit-latrine	0	1	3	2
Water system	10	9	7	8
High Cost				
Pit-latrine	0	0	0	0
Water system	10	10	10	10
Total	30	30	30	30

These results show that a lot of consumers use water system toilets. As their income rise they tend to move away from pitlatrines.

5.1.2 Affordability Analysis

Affordability of water is determined by consumers' income and the analysis is based on the income of consumer groups. The following table provides average water consumption by income.

Table 5.4 Average water consumption for private connection consumers, m^3 for December 2000.

Household income(P)	Gaborone	Francistown	Lobatse	Selebi-Phikwe
<500(1)	0	0	0	0
501 - 1000	18.3	16.6	0	0
1001 - 2000	26.4	28.6	22.4	24.5
2001 - 3000	21.9	20.0	16.8	18.2
3001 - 4000	32.8	30.1	28.6	32.5
4001 - 5000	34.6	32.5	27.0	36.0
>5000(2)	28.8	30.4	n/a	n/a

Notes: (1) There is zero consumption for people earning less than P500 because they do not have

private connections.
(2) n/a depicts that non of the consumers in these areas interviewed earned more than P5000.

These results depict that domestic consumers in Selebi Phikwe use more water on average compared to other areas. This is due to the fact that they do a lot of garden watering since the growth of their plants is deterred by the sulphuric acid from BCL (copper and nickel) mine.

Income elasticities for domestic consumers with private connections were calculated from survey results/findings. The midpoints of the income groups and average water consumption were used to compute these elasticities.

Table 5.5 Average income elasticities for domestic consumers for December 2000

Monthly income(P)	Gaborone	Francistown	Lobatse	Selebi-Phikwe
<500	-	-	-	-
501 - 1000	0.5	0.5	0.5	0.5
1001 - 2000	0.3	0.42	0.29	-0.01
2001 - 3000	-0.31	-0.65	-0.5	-0.52
3001 - 4000	0.83	0.84	1.03	1.1
4001 - 5000	0.18	0.25	-0.21	0.34
>5000	-0.9	-0.31	n/a	n/a

These results reveal that at income levels below P2000, consumers use reasonable amount of water and this may be due to the fact that some of them get water from stand pipes whilst others fall in the lowest tariff band. As a result, they conserve water because they do not want to pay high bills, as their income is low. But at income levels between P3000 and P4000, consumers tend to use more water as they move from say, low cost housing to medium or high cost housing. They start using domestic appliances such as washing machines, dish washers, water system toilets, plant lawns and flowers etc. This is depicted by a tremendous increase in their income elasticities and this is so in almost all towns. But as income increases further to above P4000, consumers tend to reduce their consumption as they get used to these appliances and start engaging in water conserving measures or practices.

Affordability is also determined by households' payment for water bills per month. It was discovered that most of the consumers do not receive their bills at all from the Corporation. Instead they go to WUC revenue offices on monthly basis to request for their bills and pay right away. Data on how is paid on monthly basis for water by households was not available because most of the consumers could not produce their receipts, reasons being; misplaced or lost. WUC could not assist because the information required was already deleted from the computer system. However, it was found that the significant numbers of households were paying less than 5% of their income on monthly basis. It was also discovered that all the households interviewed were paying water bills by themselves and none of the bills were paid by someone else.

The results show that all the consumers interviewed afforded water as compared to other utilities such as telephones and electricity since water bills are very low.

Table 5.6 The estimates of average price elasticities for water consumers (1990-1997)

Year	Gaborone	Francistown	Lobatse	S/Phikwe
1990	0.38	0.50	0.12	-0.07
1991	0.67	0.71	1.04	0.53
1992	0.14	0.11	-0.03	-0.03
1993	0.60	0.14	0.23	-0.04
1994	0.39	0.29	0.95	1.22
1995	-0.83	-2.05	-5.75	4.84
1996	-2.81	-2.34	-0.31	-2.52
1997	3.51	1.58	0.88	4.68

Notes:-average band tariff is used for price of water

-Overall consumption is used to compute these elasticities

In economics, price elasticity of demand is expected to have a negative sign since the demand curve is always sloping downwards. These results show that the elasticities are negative where demand has decreased with an increase in price as expected. As price of water increases, quantity consumed (demanded) is expected to decrease, other things being equal. In most cases, it may take some time for consumers to adjust their consumption to the new prices following tariff changes and also the awareness of the tariff change may not be immediately apparent. These low average price elasticities imply that consumption is inelastic and therefore consumers can still afford water charges with the current trend of tariff adjustments.

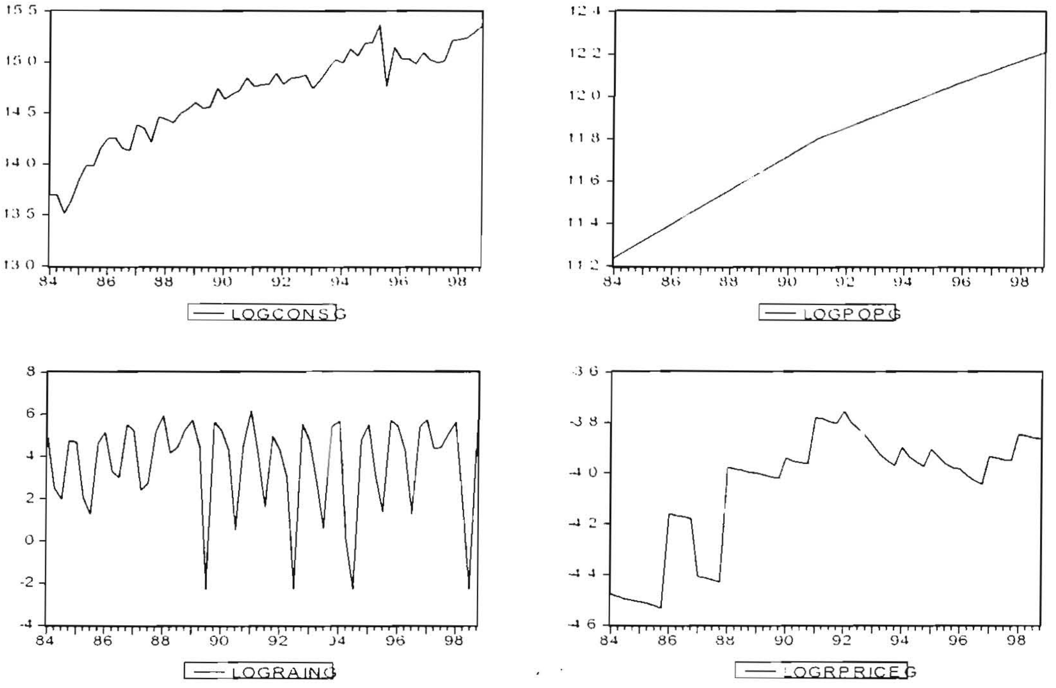
5.2 Regression Analysis Results and Interpretation

This section presents and discusses the regression results of the equation as specified under chapter four. At this stage we do not only estimate and determine the signs of the elasticity coefficients (parameters), but also test the statistical significance of the model we have adopted for this study. Logarithmic transformations (logs) are being used to allow the regression coefficients to be interpreted as elasticities and to reduce heteroscedasticity in the cross sectional data.

The transformed indicators yield good series that compare very well with the dependent variable. Each explanatory variable was graphed against the dependent variable to see the trend they follow over time. The results show that there was an increase in consumption from 1992 to 1994 and this was due to drought experienced over that period. The other reason was that loss of other alternatives such as water from wells and streams etc. caused a rise in purchases of municipal and state owned water.

5.2.1 Regression results for Gaborone

Figure 5.1 The trend of the indicators over the sample period



This figure shows the behaviour or the trend followed by these indicators over the study period. This shows that quantity of water consumed increased with time. There was an increase in consumption between 1992 and 1995 and this was mainly due to droughts experienced in the country. After the droughts, there was rain and consumption decreased between 1995 and 1996. The rainfall trend shows that there are serious fluctuations because of the four seasons experienced in the country. There are more rains in summer than in other seasons and winter is dry with little or no rain. Population trend is increasing with time and prices are also increasing with time.

Table 5.7 Regression results for Gaborone

Dependent Variable: LOGCONSG
Method: Least Squares
Date: 03/31/01 Time: 11:57
Sample: 1984:1 1998:4
Included observations: 60

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPOPG	1.303914	0.094061	13.86249	0.0000
LOGRAING	0.005206	0.007501	0.694099	0.4905
LOGRPRICEG	0.359827	0.116312	3.093632	0.0031
C	0.759493	1.508138	0.503596	0.6165

R-squared	0.925754	Mean dependent var	14.67465
Adjusted R-squared	0.921777	S.D. dependent var	0.461960
S.E. of regression	0.129203	Akaike info criterion	-1.190529
Sum squared resid	0.934826	Schwarz criterion	-1.050906
Log likelihood	39.71586	F-statistic	232.7513
Durbin-Watson stat	1.260602	Prob(F-statistic)	0.000000

LOGCONSG = + 0.759492803 + 1.303913753LOGPOPG + 0.005206189099LOGRAING +

0.3598270682LOGRPRICEG ---(8)

These results suggest that the dominant indicators that influence the quantity of water consumed for this area are price of water, population and rainfall. Population and quantity consumed have a direct relationship, which conform to economic theory. An increase in population growth leads to an increase in the amount of water consumed. Price of water and rainfall coefficients has positive signs, which imply that, an increase in price of water and rainfall result in an increase in water consumption and this does not conform to economic theory. In the case of Botswana, consumers are not that sensitive to price changes and rainfall because they continue on keeping their trends of water usage.

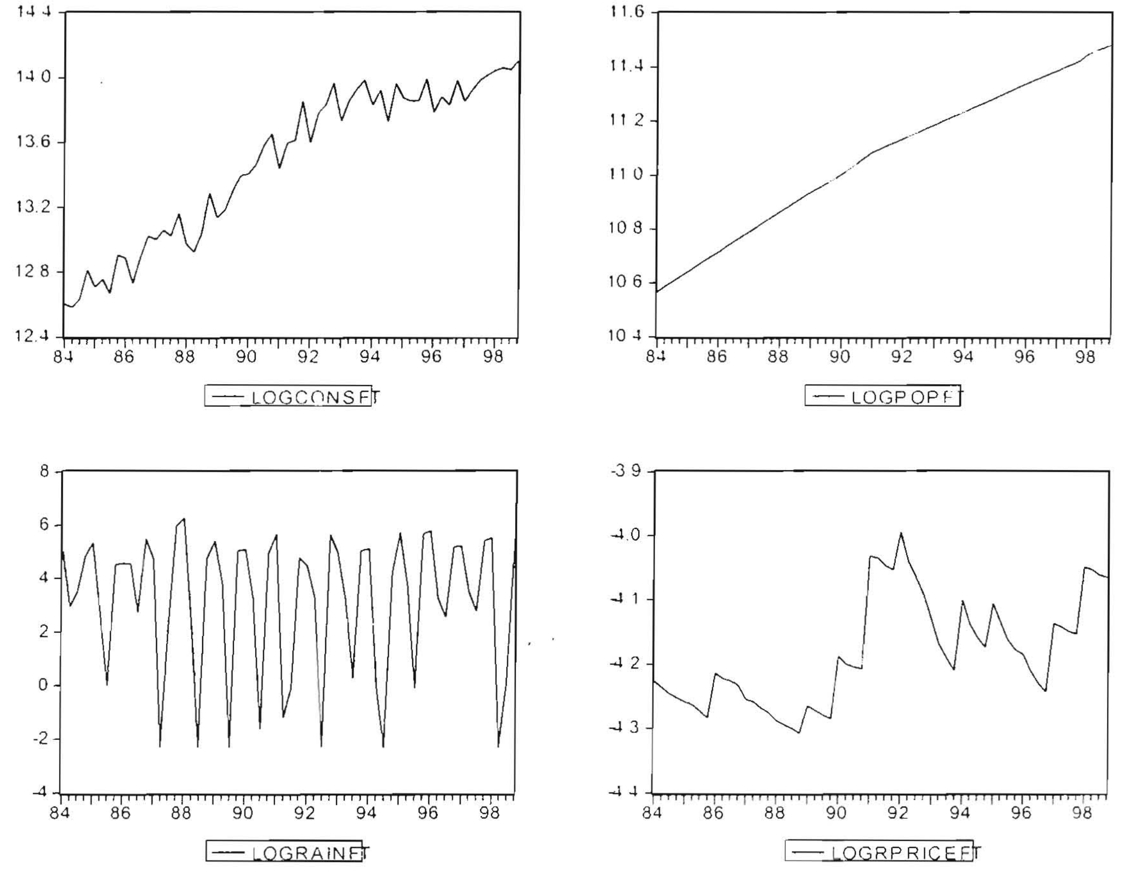
The coefficients of the population and price are significant since the computed t-value of 13.86249 and 3.093632 respectively far exceeds the critical value of 2.021 with 56 degrees of freedom at the 0.05 level of significance. This implies that these variables significantly influence the quantity consumed over time. The p-values and standard errors are encouragingly small, suggesting a high degree of significance. The rainfall coefficient is insignificant since the computed t-value of 0.694099 is less than the critical value of 2.021 at the 0.05 level of significance. Therefore, the rainfall variable insignificantly influences the quantity of water consumed over time.

The coefficient of population is 1.303914 and it implies that a 1 % increase in population will lead to about 1.30% increase in quantity of water consumed over time. The coefficient for rainfall is 0.005206 and this implies that a 1 % increase in rainfall will lead to almost no change in water consumption over time. The coefficient of real price of water is 0.359827 implying that a 1 % increase in price of water will result in about 0.36% increase in water consumption over time.

The coefficient of determination, $\bar{R}^2$ of 0.921777 implies that the selected indicators can only explain 92% of the changes in quantity of water consumed overtime, which depict a good model. About 92% of the variations in proportionate change in water consumption in Gaborone were due to changes in proportionate change in population, proportionate change in rainfall and proportionate change in price of water over the study period.

5.2.2 Regression results for Francistown

Figure 5.2 The trend of the indicators over the study period.



According to these results, the explanatory variable trends tend to follow that of the dependent variable. There exists a direct relationship between the quantity of water consumed and the explanatory variables. The observations tend to oscillate about the trend line and the trend seems to follow the same pattern with the highest peak in 1992/1993. This is mainly due to the fact that the country was hit by a serious drought in those years and as a result, more water was consumed at high price. After these drought years, the trend tend to be more gentle and this is due to increased rainfall, which filled up water sources and as a result price of water decreased followed by a decrease in consumption.

Table 5.8 Regression results for Francistown

Dependent Variable: LOGCONSFT
Method: Least Squares
Date: 03/30/01 Time: 16:18
Sample: 1984:1 1998:4
Included observations: 60

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPOPFT	1.621206	0.073074	22.18571	0.0000
LOGRAINFT	0.001726	0.005804	0.297356	0.7673
LOGRPRICEFT	0.526465	0.233196	2.257608	0.0279
C	-2.265492	1.608038	-1.408855	0.1644

R-squared	0.942314	Mean dependent var	13.47641
Adjusted R-squared	0.939223	S.D. dependent var	0.480732
S.E. of regression	0.118515	Akaike info criterion	-1.363221
Sum squared resid	0.786560	Schwarz criterion	-1.223598
Log likelihood	44.89663	F-statistic	304.9220
Durbin-Watson stat	1.394671	Prob(F-statistic)	0.000000

LOGCONSFT = - 2.2654923342 + 1.621206479LOGPOPFT + 0.00172594595LOGRAINFT +

0.52646536643LOGRPRICEFT --(9)

These results suggest that the dominant indicators that influence the quantity of water consumed for this area are price of water, population and rainfall. According to these results, the population variable has the correct sign as expected except for price of water and rainfall. Population and quantity consumed have a direct relationship, which conforms to economic theory. An increase in population growth leads to an increase in the amount of water consumed. Price of water and rainfall coefficients have positive signs, which imply that increases in price of water and in rainfall result in an increase in water consumption and this does not conform to economic theory. Due to factors such as drought, price of water increases with increases in consumption. As rainfall decrease the price of water goes up and people tend to consume more water. This is shown by a low rainfall t-statistic of 0.297356, which implies that rainfall is not significant in this model. In Francistown, consumers are not that sensitive to price changes and rainfall because they continue on keeping their increasing trends of water usage. Therefore, rainfall is an insignificant factor in water consumption over time.

The coefficients of the population and price are significant since the computed t-value of 22.185711 and 2.257608 respectively far exceeds the critical value of 2.021 with 56 degrees of freedom at the 0.05 level of significance. This implies that these variables significantly influence the quantity consumed over time. The p-values and standard errors are encouragingly small, suggesting a high degree of significance. The rainfall coefficient is insignificant since the computed t-value of 0.297356 is less than the critical value of 2.021 at the 0.05 level of significance. Therefore, the rainfall variable insignificantly influences the quantity of water consumed over time.

The coefficient of population is 1.621206 and it implies that a 1 % increase in population leads to about 1.62% increase in quantity of water consumed over time. The coefficient for rainfall is 0.001726 and this implies that a 1 % increase in rainfall will lead to almost no changes in water consumption over time. The coefficient of real price of water is 0.526465 implying that a 1 % increase in price of water will result in about 0.53% increase in water consumption over time.

The coefficient of determination, $\bar{R}^2$ of 0.939223 implies that the selected indicators can only explain 94% of the changes in quantity of water consumed overtime, which depict a good model. About 94% of the variations in proportionate change in water consumption in Francistown were due to proportionate changes in population, rainfall and price of water over the study period.

5.2.3 Regression results for Lobatse

Figure 5.3 Trends of indicators over time (Lobatse)

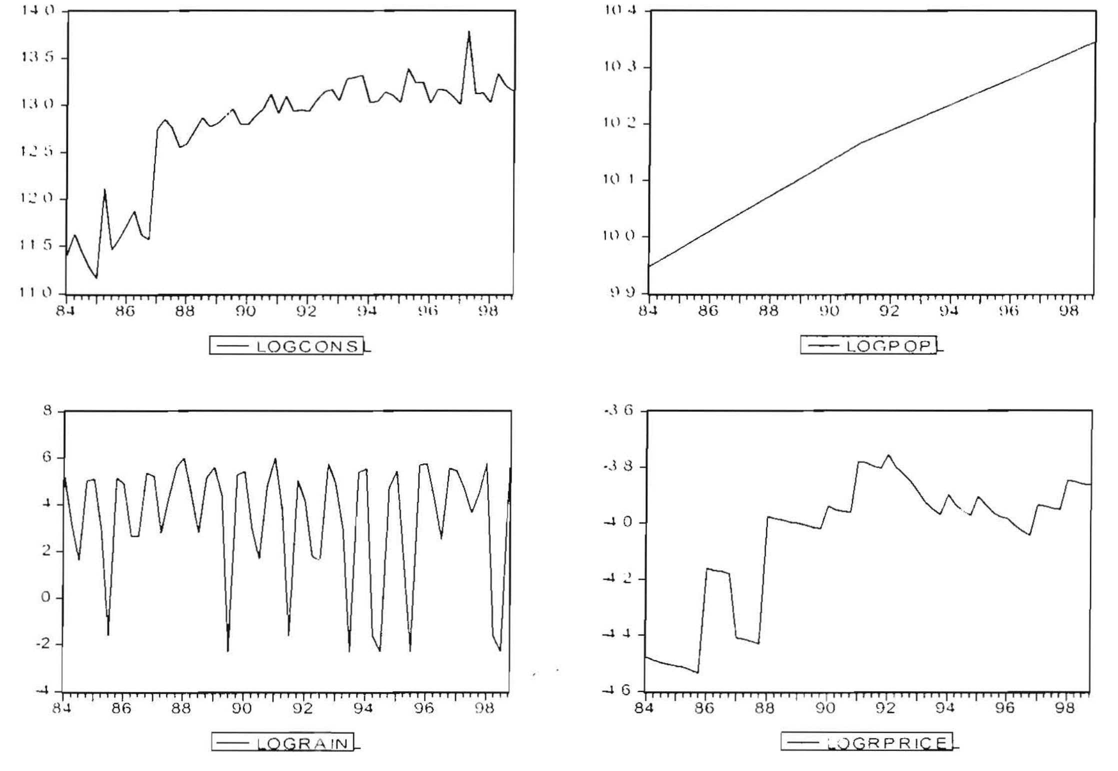


Table 5.9 Regression results for Lobatse

Dependent Variable: LOGCONSL
Method: Least Squares
Date: 03/30/01 Time: 16:30
Sample: 1984:1 1998:4
Included observations: 60

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPOPL	3.217506	0.553362	5.814465	0.0000
LOGRAINL	-0.005409	0.015871	-0.340801	0.7345
LOGRPRICEL	0.882943	0.277700	3.179489	0.0024
C	-16.35601	6.533666	-2.503343	0.0152

R-squared	0.763721	Mean dependent var	12.74410
Adjusted R-squared	0.751063	S.D. dependent var	0.633545
S.E. of regression	0.316098	Akaike info criterion	0.598811
Sum squared resid	5.595402	Schwarz criterion	0.738434
Log likelihood	-13.96433	F-statistic	60.33602
Durbin-Watson stat	1.032552	Prob(F-statistic)	0.000000

$$LOGCONSL = - 16.35601034 + 3.217505584LOGPOPL - 0.005408995052LOGRAINL + 0.8829429202LOGRPRICEL \quad (10)$$

These results suggest that the dominant indicators that influence the quantity of water consumed for this area are price of water, population and rainfall. According to these results, the population and rainfall variables have the correct sign as expected except for price of water. Population and quantity consumed have a direct relationship, which conform to economic theory. An increase in population leads to an increase in the amount of water consumed. Price of water coefficient has positive sign, which imply that, an increase in price of water results in an increase in water consumption and this does not conform to economic theory. This implies that in Lobatse, consumers are not that sensitive to price changes and because they continue on keeping the upward trend of water usage. Rainfall coefficient has an indirect relationship with the quantity of water consumed implying that as it rain people tend to reduce their water consumption.

The coefficients of the population and price are significant since the computed t-value of 5.814465 and 3.179489 respectively far exceeds the critical value of 2.021 with 56 degrees of freedom at the 0.05 level of significance. This implies that these variables significantly influence the quantity consumed over time. The p-values and standard errors are encouragingly small, suggesting a high degree of significance. The rainfall coefficient is insignificant since the computed t-value of -0.340801 is less than the critical value of 2.021 at the 0.05 level of significance. Therefore, the rainfall variable insignificantly influences the quantity of water consumed over time though it has a correct sign.

The coefficient of population is 3.217506 and it implies that a 1 % increase in population growth will lead to about 3.22% increase in quantity of water consumed over time. The coefficient for rainfall is -0.005409 and this implies that a 1 % increase in rainfall will lead to almost no change in water consumption over time. The coefficient of real price of water is 0.882943 implying that a 1 % increase in price of water will result in about 0.88% increase in water consumption over time. This implies that consumers in Lobatse are not that sensitive to water price increase and they maintain or even increase their consumption trend with time.

The coefficient of determination, $\bar{R}^2$ of 0.751063 implies that the selected indicators explain 75% of the changes in quantity of water consumed overtime, which depict a good model. About 75% of the variations in proportionate change in water consumption in Lobatse were due to proportionate changes in population, rainfall, and price of water over the study period.

5.2.4 Regression results for Selebi-Phikwe

Figure 5.4 Trend of the indicators series over time.

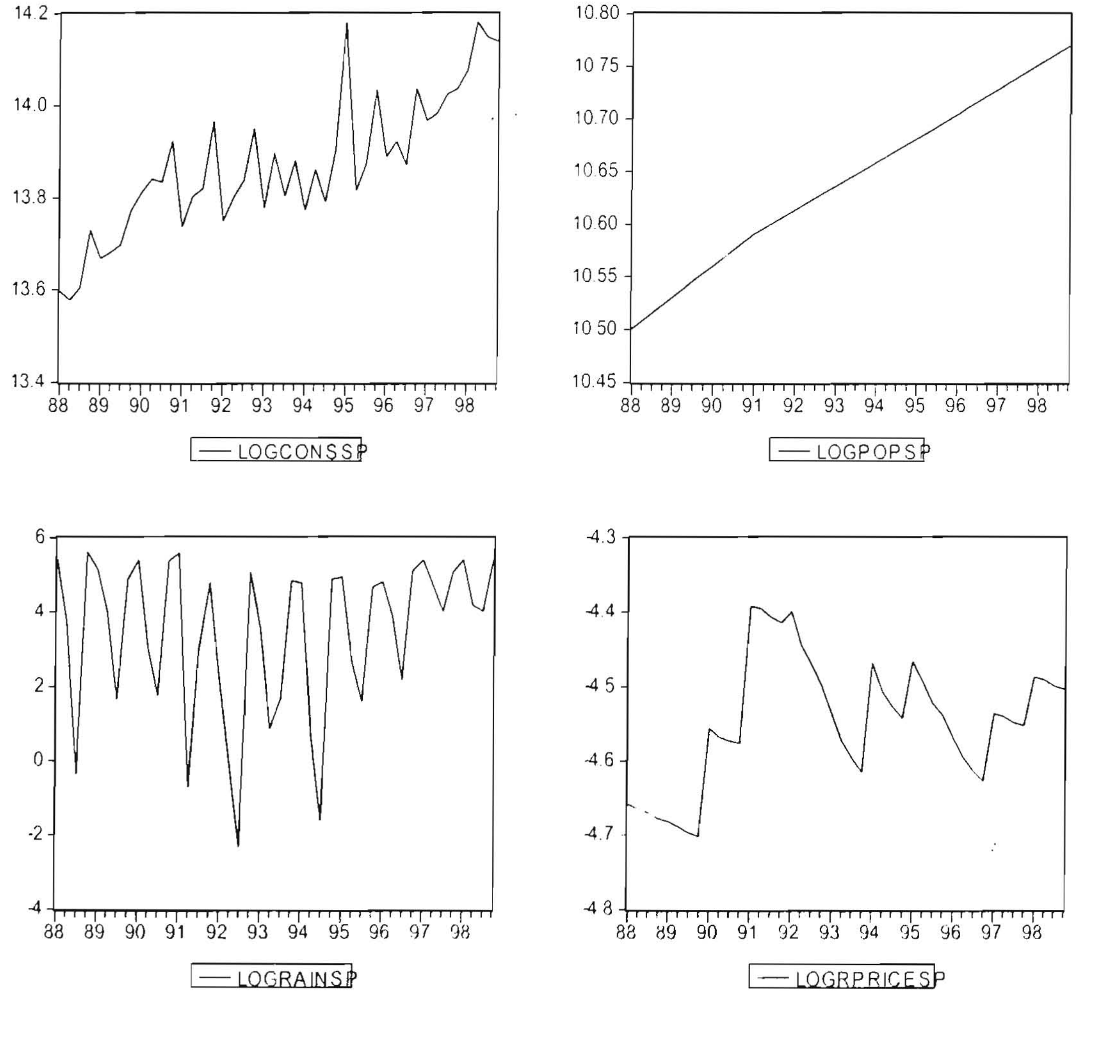


Table 5.10 Regression results for Selebi-Phikwe

Dependent Variable: LOGCONSSP
Method: Least Squares
Date: 03/31/01 Time: 13:03
Sample: 1988:1 1998:4
Included observations: 44

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPOPSP	1.474129	0.168761	8.735033	0.0000
LOGRAINSP	0.015338	0.005803	2.643133	0.0117
LOGRPRICESP	0.226275	0.153666	1.472517	0.1487
C	-0.841404	2.175116	-0.386832	0.7009

R-squared	0.752854	Mean dependent var	13.87052
Adjusted R-squared	0.734318	S.D. dependent var	0.151745
S.E. of regression	0.078216	Akaike info criterion	-2.172172
Sum squared resid	0.244711	Schwarz criterion	-2.009973
Log likelihood	51.78777	F-statistic	40.61580
Durbin-Watson stat	2.170500	Prob(F-statistic)	0.000000

LOGCONSSP = - 0.8414042132 + 1.474129472LOGPOPSP + 0.01533784949LOGRAINSP + 0.2262751296LOGRPRICESP --(11)

These results suggest that the dominant indicators that influence the quantity of water consumed for this area are price of water, population and rainfall. Population and quantity consumed have a direct relationship, which conform to economic theory. An increase in population growth leads to an increase in the amount of water consumed. Price of water and rainfall coefficients have positive signs, which imply that, an increase in price of water and rainfall result in an increase in water consumption and this does not conform to economic theory. This implies that in Selebi-Phikwe, consumers are not that sensitive to price changes and rainfall because they continue on keeping their increasing trends of water usage.

The coefficients of the population and rainfall are significant since the computed t-value of 8.735033 and 3.179489 respectively far exceeds the critical value of 2.021 with 56 degrees of freedom at the 0.05 level of significance. This implies that these variables significantly influence the quantity consumed over time. The p-values and standard errors are encouragingly small, suggesting a high degree of significance. The real price coefficient is insignificant since the computed t-value of 1.472517 is less than the critical value of 2.021 at the 0.05 level of significance. Therefore, the real price variable insignificantly influences the quantity of water consumed over time.

The coefficient of population is 0.147129 and it implies that a 1 % increase in population leads to about 1.47% increase in quantity of water consumed over time. The coefficient for rainfall is 0.015338 and this implies that a 1 % increase in rainfall will lead to about 0.02% increase in water consumption over time. The coefficient of real price of water is 0.226275 implying that a 1 % increase in price of water will result in about 0.23% increase in water consumption over time.

The coefficient of determination, $\bar{R}^2$ of 0.734318 implies that the selected indicators can only explain 73% of the changes in quantity of water consumed overtime, which depict a good model. About 73% of the variations in proportionate change in water consumption in Selebi-Phikwe were due to proportionate changes in population, rainfall and price of water over the study period.

In all urban areas, the normality test for residuals which relies on the skewness and the kurtosis of the residuals depicted that the residuals appear to be normally distributed since the skewness is close to zero and the kurtosis is closer to 3. Given the null hypothesis that the residuals are normally distributed and the Jarque-Bera probabilities being reasonably high and ranging from 0.64 to 0.78, we cannot reject the null hypothesis that the residuals are normally distributed and this implies that there is normality in the error term and the explanatory variables.

The White's Test was used to detect heteroscedasticity in all the models, but it was discovered that the p-values associated with obs*R^2 were ranging from 9.315 to 20.061 implying that the residuals were not significant at 5% level. Therefore we conclude that the residuals are homoscedastic (i.e. there is no heteroscedasticity). The transformation of data using logs reduced chances of heteroscedasticity.

All the models' regression results depict an existence of positive serial correlation in the residuals at 5% level. This may be as a result of:

- Mis-specification error, which results from omission of some explanatory variables or an incorrect functional form.
- Manipulation of data whereby for other variables such as rainfall, quarterly data was derived from monthly data or interpolation of data (e.g. population) whereby actual census were conducted in a ten year interval and the intercensus data calculations were based on assumptions etc.

This is evident by the low estimated Durbin-Watson values, which fall below the zone of indecision (dU=1.480 and dL=1.689) given sixty observations and three explanatory variables at 5% level. Therefore we cannot reject the hypothesis that there is positive serial correlation in residuals.

CHAPTER SIX
Conclusions and Policy Implications

6.1 Conclusions

The relationship between the dependent variable and the independent variables is hypothesised *apriori*, from economic theory. The variables, population is hypothesised to have a positive relationship with the quantity of water consumed. This means that as this variable increase, the quantity of water consumed also increase. The variables, real price of water and rainfall are hypothesised to have a negative relationship with quantity consumed. An increase in these variables result in a decrease in quantity of water consumed.

This study hypothesised that, price of water is insignificant in explaining the trends in water demand (quantity of water consumed) over time. The results revealed that the null hypothesis should be rejected since the price of water significantly explain these trends except for Selebi-Phikwe. The other hypothesis was that arguments (indicators) of the demand function stand in linear relation with the quantity of water consumed. The results revealed that the null hypothesis should be accepted since the variables had a linear relation with the dependent variable. The relationship was both direct and indirect.

The regression results for all the urban areas show that selected variables dominantly influence the quantity of water consumed over the study period. It was found that there exists a statistical significance between water consumption and real price of water in almost urban areas, suggesting that the price elasticity was not zero. These price elasticities have positive signs, indicating that the increase in the price of water was associated with an increase in quantity of water consumed. Population and household size tend to influence the demand of water. As population increases, quantity consumed increases. These population elasticities have positive signs for all towns, indicating that the cross sectional increase in the population was associated with an increase in quantity of water consumed. In all the models, rainfall did not have a significant relationship with quantity consumed except for Selebi-Phikwe. This implies that in other areas, consumption of water is not sensitive to rain and as a result consumers tend to maintain or increase their consumption trend with time whether it rains or not.

The regression analysis results tend to compare very well with the survey results. Domestic consumers tend to increase their water consumption as their income rises but appear insensitive to the price of water. One reason is the causality: as the quantity of water consumed increases so the price of water increases. Increases in population or household size also result in increased water consumption. Though consumers use some water conservation measures, their consumption still increases with time and this may be due to changes in their living standards.

Finally, the changes in tariffs tend to result in a little or no change in the consumption behaviour of consumers. The consumers tend to afford the water charges and these charges need to be increased to reduce the high consumption of water. It is time for the price of water to have an indirect relationship with water, implying that an increase in water prices should lead to a tremendous decrease in consumption.

6.2 Policy Implications

Botswana has mainly adopted a supply side oriented strategy of water transfer schemes and the strategy of demand management (DM) is only utilised to a limited extend as a solution for water scarcity. DM is mainly limited to pricing policy and this should be extended to other policies such as waste reduction, improved cost recovery, development of water efficient methods and appliances etc. This should also be exercised through non-economic measures such as quantitative water restrictions, educational and public campaigns on water conservation, collection of rainwater, re-use of water and introduction of other water conservation technologies. Such policies would not only discourage waste but also increase value added by existing supplies.

Responsible parties should continue to develop more water resources in the country, more especially surface water resources. This will reduce the high rate of groundwater mining and depletion. A lot of resources monitoring should be practised to ensure that water extraction from these sources should not exceed their sustainable yields.

The protection, enhancement and restoration of water quality and the abatement of water pollution should be the main focus, particularly given the importance of providing safe drinking water, which is so critical for improving human health. Pollution of water resources should be minimised to reduce nitrates and phosphates. Encouraging households to construct pitlatrines that are sealed from the bottom and use sewerage systems where possible should reduce pollution of water resources. Affordable and appropriate sanitation and wastewater disposal should be increased to cater for growing urban populations to reduce water pollution and to prevent contamination of potential freshwater supplies. For industrial/institutional waste and mining discharges, the emphasis should be on establishing pollution charges based on the principle of the polluter pays, and effective government institutions and regulations to reduce effluents, especially toxic substances at their source and to reuse of waste water. Guidelines should be established to inform the public on issues relating to industrial and municipal effluent or waste discharges and to help communities to pursue and implement policies that protect public health and environmental sustainability.

An increase in tariffs to reduce excessive water consumption should go hand in hand with the imposition of water regulations to limit unnecessary consumption. Restrictions should be imposed on washing of vehicles, recreational uses, washing of clothes and garden watering. Consumers should reduce the quantity of water used on these activities on voluntary basis and if this is not met, water authorities should monitor the use of water in these areas. Charges should be imposed on those who violate the set standards of water use and no leniency should be done if water conservation is to be met.

Water Utilities Corporation should improve its financial status by improving the billing and collection systems, reducing the high proportion from leaks and wastage and implementing some restrictions on large consumers whom erratically pay their bills. As a result, the Corporation will be self-sustained and be able to repair pipeline leaks, maintain and expand the water supply system. It should also improve its service to consumers because poor service results in a decrease in consumers' willingness to pay existing bills.

REFERENCES

Arup Botswana (1991), Water Use and Affordability, Water Utilities Corporation, Gaborone.

Benedini, M. et al (1992), Water Resources Management: Modern Decision Techniques, AA Balkema Publishers, Netherlands.

Botswana Government (1999), Statistical Bulletin, Volume 24, No. 2, Central Statistical Office, Gaborone.

Botswana Government (1984 – 1998), Statistical Bulletins, Central Statistical Office, Gaborone.

Eberhardt, J. (1983), Economic and Financial Issues, Water 2000: Consultants Report No.3, Australian Government Publishing Service, Canberra.

Eberhardt, J. (1983), Urban and Industrial Water Use, Water 2000: Consultants Report No.3, Australian Government Publishing Service, Canberra.

Gujarati, D. N. (1995), Basic Econometrics, Mc-Grawhill, Singapore.

Kay, M. et al (1997), Water: Economics, Management and Demand, Mc-Grawhill, New York.

Kgathi, D. L. (1998), Water Demand, Population and Sustainability in Botswana: Implications for Policy, Laxenburg, Austria.

Krook, J. (1994), An overview of Water Resources Development in Botswana, Department of Environmental Science, University of Botswana, Gaborone.

Merrett, S. (1997), Introduction to the Economics of Water Resources, UCL Press, London.

Ministry of Finance and Development Planning (1999), Quarterly Review of Recent

Economic Developments in Botswana, Gaborone.

Ministry of Finance and Development Planning (1997), National Development Plan 8, Government Printing, Gaborone.

Ministry of Finance and Development Planning (2001), Economic Report, Government Printing, Gaborone.

Pearce D. et al. (1994), Measuring Sustainable Development, Earthscan Publishers, London.

Snowy Mountains Engineering Corporation(SMEC), WULP, SGAB(1991), Botswana National Water Master Plan Study, Volume 12, Ministry of Minirals, energy and Water Affairs, Gaborone.

Thema, J. M. (1997), Water Pricing experiences (Botswana): An International Perspective, World Bank Technical Paper No.386, Washington DC.

Tietenberg, T. (1992), Environmental and Natural Resources Economics, Harper Collins Publishers, New York.

Water Utilities Corporation (1998), Information Booklet, Gaborone.

Water Utilities Corporation (1999, 2000), Annual Reports, Gaborone.

Water Utilities Corporation (1997/99), Operational Statistics and Performance Indicators, Supplementary Report, Gaborone.

Winpenny, J. (1994), Managing Water as an Economic Resource, Rontledge, ODI.

Winpenny, J. (1997), Water Policy Issues, Water Resources Occasional Paper No.2, ODI.

World Bank (1993), Water Resources Management, World Bank Policy Paper, Washington

APPENDICES

Appendix 1.1 Questionnaire for Domestic Consumers

1. Name of Town----------------------------------
2. Housing Category-------------------------------
3. Owner/Tenant----------------------------------
4. Names and number of household members--

   ----
5. Education status of household members--

   ----
6. Employment status of household members---

   ----
7. Monthly salary or wage---
8. Number of rooms in main house---
9. Number of people staying outside main house e.g. renters or maids--------------------------
   ----
10. How much is paid for water on monthly basis(on average)-----------------------------------
    ----
    ----
11. How much water do households consume on average per month----------------------------
    ----
    ----
12. Do you obtain water elsewhere besides from private connection-----------------------------
    12a) If so from which sources and why? ---

13. Which household appliances do you use that use water--

----

14. Do you have a garden and if yes, how many times do you water it in a day/week----------
----
----

15. Do you have a vehicle and if yes, how many times do you wash it in a week----------------
----

16. Do you have a swimming pool---

17. Where else do you use water besides in the above mentioned activities----------------------
----
----

18. What measures do you use to save or conserve water--

----

19. Did you experience any leaks in the past two years--

19a) If yes, how often and how often do you repair them--
----

20. Are you satisfied with the water charges or do you afford the monthly water bills---------
----

Prepared and administered by myself- February 2001.

Appendix 1.2(a) Gaborone Data Bank

year	consgabs	pricegabs	popgabs	cpi	rainfgabs
1984	889,705	0.91	75,958	80.1	148.5
	886,863	0.91	77,551	80.9	12.4
	739,538	0.91	79,144	81.7	7.1
	841,710	0.91	80,737	82.2	116.6
1985	1,028,143	0.91	82,328	82.7	108.1
	1,183,243	0.91	84,054	83.1	8
	1,179,370	0.91	85,680	83.9	3.5
	1,418,941	0.91	87,306	84.8	104.3
1986	1,547,376	1.33	89,231	85.2	172.8
	1,557,784	1.33	91,102	85.9	26.5
	1,407,949	1.33	92,973	86.2	20.3
	1,372,534	1.33	94,844	86.8	251.7
1987	1,768,328	1.08	96,714	88.7	183.8
	1,713,185	1.08	98,742	89.1	11
	1,490,453	1.08	100,770	89.9	15.3
	1,914,255	1.08	102,798	90.6	176.1
1988	1,864,861	1.72	104,824	91.7	383.3
	1,809,209	1.72	107,022	92.3	64.5
	1,982,734	1.72	109,220	92.8	85
	2,068,916	1.72	111,418	93.5	190.5
1989	2,201,459	1.72	113,614	93.9	310.1
	2,084,012	1.72	115,996	94.6	88.2
	2,110,337	1.72	118,378	95.3	0.1
	2,542,165	1.72	120,760	95.8	284.4
1990	2,280,231	1.87	123,142	96.1	188.1
	2,394,318	1.87	125,724	97.3	75.2
	2,479,148	1.87	128,306	97.8	1.7
	2,805,813	1.87	130,888	98.1	94.4
1991	2,577,732	2.25	133,468	98.6	491.1
	2,624,714	2.25	135,237	98.9	66.3
	2,641,583	2.25	137,006	100.1	5
	2,939,439	2.25	138,775	100.8	145.1
1992	2,643,978	2.48	140,542	105.8	73.9
	2,798,563	2.48	142,545	110.7	20.1
	2,823,469	2.48	144,548	113.5	0.1
	2,897,643	2.48	146,551	116.7	259.6
1993	2,532,417	2.48	148,553	121	120
	2,752,284	2.48	150,596	125.8	17.3
	3,045,987	2.48	152,639	128.7	1.8
	3,357,891	2.48	154,682	131.3	229.1
1994	3,254,968	2.74	156,724	135.1	296.3
	3,731,949	2.74	158,879	140.3	1.1
	3,484,415	2.74	161,034	143.2	0.1
	3,956,510	2.74	163,189	145.5	117.2
1995	3,972,492	3.03	165,343	150.4	252.7
	4,727,280	3.03	167,653	154.8	22.6

	2,573,919	3.03	169,963	159.3	3.9
	3,786,716	3.03	172,273	161.7	304.9
1996	3,375,266	3.07	174,583	164.8	230.9
	3,371,567	3.07	176,809	169.1	72.1
	3,224,321	3.07	179,035	172.4	3.6
	3,594,973	3.07	181,261	174.8	219.9
1997	3,350,123	3.43	183,487	175.3	315.1
	3,258,447	3.43	185,827	176.1	77.7
	3,324,244	3.43	188,167	177.5	84.8
	4,053,361	3.43	190,507	178.2	161
1998	4,094,125	3.83	192,845	179.4	282.3
	4,151,345	3.83	195,245	180.1	6.5
	4,372,924	3.83	197,645	181.6	0.1
	4,671,178	3.83	200,045	182.3	310.8

Appendix 1.2 (b) Francistown Data Bank

year	consft	priceft	popft	cpi	rainft
1984	297,928.00	1.17	38,810	80.1	170.7
	291,480.00	1.17	39,558	80.9	19.2
	306,044.00	1.17	40,306	81.7	33.6
	367,124.00	1.17	41,054	82.2	125
1985	330,589	1.17	41,800	82.7	212.8
	347,066	1.17	42,605	83.1	14.6
	317,127	1.17	43,410	83.9	1
	402,187	1.17	44,215	84.8	92.5
1986	396,005	1.26	45,020	85.2	97
	337,957	1.26	45,887	85.9	93.5
	396,722	1.26	46,754	86.2	15.4
	453,291	1.26	47,621	86.8	244.6
1987	443,860	1.26	48,488	88.7	117
	469,871	1.26	49,422	89.1	0.1
	452,759	1.26	50,356	89.9	8.4
	521,203	1.26	51,290	90.6	395.1
1988	431,378	1.26	52,222	91.7	531.5
	409,838	1.26	53,228	92.3	11
	458,111	1.26	54,234	92.8	0.1
	590,635	1.26	55,240	93.5	114.3
1989	507,323	1.32	56,245	93.9	223.2
	532,408	1.32	57,198	94.6	44.9
	600,519	1.32	58,151	95.3	0.1
	657,859	1.32	59,104	95.8	154.3
1990	665,641	1.46	60,057	96.1	161.6
	705,791	1.46	61,354	97.3	26.3
	795,390	1.46	62,651	97.8	0.2
	852,567	1.46	63,948	98.1	142.5
1991	685,833	1.75	65,244	98.6	289.2
	804,731	1.75	66,092	98.9	0.3

	817,953	1.75	66,940	100.1	0.9
	1,042,728	1.75	67,788	100.8	118.2
1992	805,427	1.95	68,637	105.8	89
	965,284	1.95	69,529	110.7	27.5
	1,022,358	1.95	70,421	113.5	0.1
	1,164,872	1.95	71,313	116.7	283.2
1993	922,548	1.95	72,206	121	141.4
	1,045,687	1.95	73,145	125.8	25.2
	1,124,586	1.95	74,084	128.7	1.3
	1,186,450	1.95	75,023	131.3	154.1
1994	1,015,640	2.24	75,960	135.1	169.1
	1,113,214	2.24	76,948	140.3	1
	916,133	2.24	77,936	143.2	0.1
	1,161,129	2.24	78,924	145.5	68.7
1995	1,062,143	2.48	79,910	150.4	308.7
	1,040,447	2.48	80,951	154.8	42.1
	1,045,610	2.48	81,992	159.3	0.9
	1,195,707	2.48	83,033	161.7	292.4
1996	973,005	2.51	84,075	164.8	325.3
	1,069,119	2.51	85,105	169.1	26.5
	1,014,940	2.51	86,135	172.4	12.8
	1,181,744	2.51	87,165	174.8	178
1997	1,040,046	2.80	88,195	175.3	187.3
	1,115,991	2.80	89,275	176.1	34.3
	1,184,254	2.80	90,355	177.5	15.8
	1,225,723	2.80	91,435	178.2	226.7
1998	1,258,082	3.13	93,598	179.4	252.4
	1,277,949	3.13	94,680	180.1	0.1
	1,259,416	3.13	95,762	181.6	1.1
	1,336,384	3.13	96,844	182.3	298

Appendix 1.2 (c) Lobatse Data Bank

year	conslob	priceLob	poplob	cpi	rainflob
1984	88,930	0.91	20,913	80.1	194.9
	112,557	0.91	21,080	80.9	23.1
	93,158	0.91	21,247	81.7	5
	79,081	0.91	21,414	82.2	153.5
1985	70,239	0.91	21,580	82.7	163.7
	182,928	0.91	21,752	83.1	18.5
	95,322	0.91	21,924	83.9	0.2
	106,650	0.91	22,096	84.8	172.8
1986	123,163	1.33	22,268	85.2	133.1
	144,196	1.33	22,444	85.9	14
	111,299	1.33	22,620	86.2	14.3
	106,166	1.33	22,796	86.8	212.9
1987	345,238	1.08	22,978	88.7	184.9
	383,124	1.08	23,161	89.1	16

	348,702	1.08	23,344	89.9	71.5
	283,051	1.08	23,525	90.6	276
1988	294,937	1.72	23,710	91.7	406.7
	338,166	1.72	23,899	92.3	88.7
	388,884	1.72	24,080	92.8	16.2
	352,144	1.72	24,260	93.5	174.2
1989	366,139	1.72	24,466	93.9	272.8
	395,160	1.72	24,661	94.6	81.8
	426,644	1.72	24,856	95.3	0.1
	362,636	1.72	25,051	95.8	197.1
1990	361,830	1.87	25,247	96.1	227
	397,880	1.87	25,448	97.3	20
	429,256	1.87	25,649	97.8	5.4
	499,704	1.87	25,850	98.1	120.8
1991	406,126	2.25	26,052	98.6	414.9
	488,274	2.25	26,202	98.9	42.8
	416,648	2.25	26,352	100.1	0.2
	423,108	2.25	26,502	100.8	155.5
1992	416,235	2.48	26,651	105.8	63.9
	466,598	2.48	26,804	110.7	6
	512,436	2.48	26,957	113.5	5
	525,687	2.48	27,110	116.7	318.7
1993	465,897	2.48	27,264	121	141.9
	588,423	2.48	27,421	125.8	19.4
	596,241	2.48	27,578	128.7	0.1
	612,548	2.48	27,735	131.3	216.6
1994	454,753	2.74	27,891	135.1	256.5
	461,415	2.74	28,052	140.3	0.2
	511,286	2.74	28,213	143.2	0.1
	494,295	2.74	28,374	145.5	114
1995	455,706	3.03	28,533	150.4	233.2
	656,354	3.03	28,693	154.8	5
	562,605	3.03	28,853	159.3	0.1
	565,743	3.03	29,013	161.7	304
1996	452,823	3.07	29,172	164.8	315.9
	527,270	3.07	29,347	169.1	74
	518,956	3.07	29,522	172.4	12.2
	486,579	3.07	29,697	174.8	258.7
1997	444,807	3.43	29,872	175.3	230.2
	983,952	3.43	30,051	176.1	107.2
	497,278	3.43	30,230	177.5	38.2
	505,326	3.43	30,409	178.2	89
1998	453,159	3.83	30,589	179.4	325.2
	624,090	3.83	30,769	180.1	0.2
	544,076	3.83	30,949	181.6	0.1
	513,491	3.83	31,129	182.3	270.5

Appendix 1.2 (d) Selebi Phikwe Data Bank

year	consumpS	priceSph	populatS	rainfallS	cpi
1984	899,704	0.45	32,242	57.1	80.1
	886,863	0.45	32,487	107.7	80.9
	739,538	0.45	32,732	43.5	81.7
	841,710	0.45	32,977	145	82.2
1985	1,028,143	0.45	33,223	127.9	82.7
	1,183,243	0.45	33,476	25.9	83.1
	1,179,370	0.45	33,729	4.8	83.9
	1,418,941	0.45	33,982	138.2	84.8
1986	1,547,370	0.63	34,235	36	85.2
	1,557,784	0.63	34,495	127.8	85.9
	1,407,949	0.63	34,755	5.6	86.2
	1,372,534	0.63	35,015	87.2	86.8
1987	900,243	0.73	35,277	162.4	88.7
	967,289	0.73	35,545	20	89.1
	926,280	0.73	35,813	1.4	89.9
	1,015,129	0.73	36,081	215.7	90.6
1988	803,699	0.87	36,350	227	91.7
	788,738	0.87	36,627	42.4	92.3
	809,781	0.87	36,904	0.7	92.8
	918,277	0.87	37,181	274	93.5
1989	862,940	0.87	37,457	174.9	93.9
	875,042	0.87	37,742	54.9	94.6
	889,181	0.87	38,027	5.3	95.3
	957,359	0.87	38,312	132.4	95.8
1990	997,292	1.01	38,597	222.2	96.1
	1,026,335	1.01	38,891	21.1	97.3
	1,018,911	1.01	39,185	5.9	97.8
	1,114,790	1.01	39,479	218.4	98.1
1991	924,161	1.22	39,772	267.5	98.6
	987,867	1.22	40,001	0.5	98.9
	1,004,797	1.22	40,230	20	100.1
	1,163,433	1.22	40,459	121.4	100.8
1992	936,448	1.3	40,687	9.2	105.8
	986,522	1.3	40,921	0.9	110.7
	1,023,546	1.3	41,158	0.1	113.5
	1,145,896	1.3	41,395	158	116.7
1993	964,235	1.3	41,623	35.8	121
	1,086,542	1.3	41,862	2.4	125.8
	988,654	1.3	42,101	5.5	128.7
	1,068,942	1.3	42,340	127.2	131.3
1994	958,015	1.55	42,580	118.8	135.1
	1,047,668	1.55	42,825	2	140.3
	975,374	1.55	43,070	0.2	143.2
	1,094,099	1.55	43,315	133.1	145.5
1995	1,441,580	1.73	43,559	140.1	150.4
	999,985	1.73	43,815	14	154.8

	1,061,335	1.73	44,071	5	159.3
	1,247,229	1.73	44,327	106.7	161.7
1996	1,077,554	1.71	44,581	124.1	164.8
	1,113,825	1.71	44,849	49.7	169.1
	1,057,881	1.71	45,117	8.9	172.4
	1,249,209	1.71	45,385	164.6	174.8
1997	1,165,663	1.88	45,651	221.1	175.3
	1,183,307	1.88	45,925	110.9	176.1
	1,234,927	1.88	46,199	55	177.5
	1,247,732	1.88	46,473	160.5	178.2
1998	1,298,303	2.02	46,746	220.6	179.4
	1,442,654	2.02	47,022	64.8	180.1
	1,396,368	2.02	47,298	56	181.6
	1,384,134	2.02	47,574	218.3	182.3

Appendix 1.3 (a) Water Consumption in Gaborone

month	domestic	Bus&Ind	Govt	City Coun	DC&DWA
january	593,994	281,540	201,254	118,645	633,627
february	581,830	277,513	307,741	116,169	462,914
march	506,626	232,460	184,856	147,340	520,262
april	541,082	280,672	211,418	67,365	450,570
may	505,613	226,534	179,164	59,597	411,133
june	626,204	245,094	232,272	82,871	521,216
july	463,012	244,038	171,062	61,536	479,937
august	526,620	225,130	182,269	59,076	422,082
september	798,163	260,387	275,801	75,027	496,412
october	706,559	244,071	346,716	70,513	421,187
november	703,691	277,527	337,699	74,613	570,218
december	708,411	350,624	239,243	65,427	348980

Appendix 1.3 (b) Water Consumption in Francistown

month	domestic	bus&ind	Govt	City Coun	DC&DWA	BCL
january	106,494	142,743	103,668	62,097	59,925	6,034
february	95,915	101,340	122,858	44,518	48,609	9,997
march	94,000	99,863	87,005	50,797	50,852	7,634
april	100,031	91,992	117,346	40,015	120,395	6,264
may	107,177	109,668	130,766	50,983	54,765	8,117
june	125,715	104,078	104,078	56,118	60,990	8,697
july	105,323	104,247	91,141	48,700	60,351	9,065
august	94,329	110,268	79,884	40,849	68,360	9,776
september	146,984	109,881	130,307	59,304	69,598	14,664
october	153,172	121,011	117,025	107,166	59,619	9,802
november	144,561	115,999	112,959	74,609	49,499	8,936
december	157,995	113,065	121,396	59,855	56,085	0

Appendix 1.3 (c) Water Consumption in Lobatse

months	domestic	Bus&Ind	Govt	City Coun
january	32,367	47,351	44,535	20,866
february	37,323	70,003	54,615	25,445
march	27,508	74,413	36,021	26,333
april	34,460	88,484	42,683	17,175
may	32,094	53,194	31,248	15,455
june	31,521	82,424	49,174	17,276
july	35,668	65,117	31,897	14,867
august	33,017	91,799	43,795	18,563
september	39,907	74,439	38,853	23,047
october	40,834	68,375	48,729	21,230
november	38,210	58,611	39,495	20,863
december	71,377	77,373	53,293	25,757

Appendix 1.3 (d) Water Consumption in Selebi-Phikwe

months	domestic	bus&ind	Govt	City Coun	DC&DWA	BCL
january	147,445	203,576	44,667	60,504	2,566	36,979
february	114,717	179,088	37,799	41,393	6,020	28,699
march	88,847	183,202	29,861	29,471	1,587	22,728
april	134,831	186,174	45,385	35,433	2,473	34,126
may	104,094	161,893	32,504	25,031	1,935	35,452
june	132,988	182,253	49,562	36,427	2,760	30,569
july	107,896	177,236	27,232	30,426	1,912	36,011
august	125,676	147,019	28,684	34,658	1,654	40,379
september	153,310	187,359	52,092	33,767	2,208	36,629
october	164,963	224,842	48,212	44,945	3,151	31,453
november	186,479	279,123	91,021	43,888	2,820	0
december	173,924	184,057	87,751	39,753	2,170	0

Appendix 1.3 (e) Water Sales and consumption for urban areas (Year 2000)

months	consGabs	salesGabs	consF/town	salesF/town	consLob	salesLob	consPhikwe	salesPhkiwe
january	1,829,060	13,238,473	480,961	2,538,631	172,119	1,259,277	495,737	1,324,699
february	1,746,167	12,645,059	423,237	2,230,576	187,386	1,389,598	407,716	1,095,740
march	1,591,544	11,477,930	390,151	2,009,409	164,275	1,206,414	355,696	962,572
april	1,551,107	10,980,408	476,043	2,425,817	182,802	1,302,910	438,422	1,172,200
may	1,382,041	9,636,239	481,476	2,470,862	131,991	959,789	360,909	966,207
june	1,707,657	12,129,820	463,747	2,436,571	180,395	1,320,078	434,559	1,176,596
july	1,419,585	10,160,540	418,827	2,192,180	147,549	1,052,419	380,713	1,024,996
august	1,415,177	9,951,260	403,466	2,087,412	187,174	1,359,143	378,070	985,893
september	1,905,790	13,342,381	530,738	2,875,992	176,246	1,304,553	465,365	1,291,063
october	1,789,046	14,967,585	567,795	3,459,645	179,168	1,557,364	517,566	1,577,390
november	1,963,748	16,519,222	506,563	3,114,754	157,179	1,336,132	603,331	1,853,713
december	1,712,685	13,614,846	508,396	3,184,404	227,800	1,965,892	487,655	1,490,385
	20,013,607	**148,663,763**	**5,651,400**	**31,026,253**	**2,094,084**	**16,013,569**	**5,325,739**	**14,921,454**

Appendix 1.3 (f) Sales and consumption by Market Area (Year 2000)

Area	consumption	sales
Gaborone	20,013,607	148,663,763
Francistown	5,651,400	31,026,253
Lobatse	2,094,084	16,013,569
S/phikwe	5,325,739	14,921,454