MODELLING A WATER CONSERVING TARIFF FOR KAMPALA UGANDA

by

RAMOGODI I. P. MOTOMA

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Supervisor:
Sam Kayaga
BSc Eng (Mak), MSc WWEng, PhD (Loughborough), MSc DevMgmt (Open), CEng, REng,
MCIWEM, MUIPE

Water, Engineering and Development Centre
Department of Civil and Building Engineering

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1 Introduction

1.1 Preamble

The Millennium Development Goals (MDG) set by the United Nations in 2002, have a target of reducing by half the proportion of people without sustainable access to safe drinking water by the year 2015 (UN 2005). Over 1.1 billion people were without access to safe drinking water according to 2004 estimates (WHO and UNICEF n.d.). Already, there are concerns that the target set by the MDG will not be met, especially in low income countries of sub Saharan Africa. Increase in population as well as reduction in available water resources will make reaching this target even more difficult. According to DIFD (2001), global water consumption rose six fold between 1990 and 2000 and the rate is still increasing at an alarming rate. The highest rate of increase is experienced in the urban areas due to population increase and economic growth. In addition, competing uses of water for agriculture, industry and domestic purposes adds to the problem. These activities usually result in water pollution, thus limiting the availability of fresh water (Deverill 2001). Global change is also wreaking havoc on water supplies in that some areas experience shorter periods of high precipitation while other areas of the world experience severe droughts. This results in low ground water recharge and problems in designing for water reservoirs (Kayaga and Smout 2006).

The traditional approach for water utilities or municipalities to shortage of water has been to increase water supply so as to match the increasing demand (Stephenson, 1999). There is evidence of grand engineering schemes the whole world over designed to supply water to urban areas that have acute water shortage. Good examples of such cases are the North South Carrier in Botswana, The great Man Made River in Libya, and the Lesotho Highlands Water Project in Lesotho, all of which are huge and complicated engineering solutions designed to meet rising water demand (Turton, 1999). This approach is, however, proving to be unsustainable since water resources are getting limited, and, as the examples mentioned show, water has to be pumped over long distances at high costs. In addition, the cost of these huge infrastructural undertakings has recently escalated exponentially thus making this approach unsustainable (Stephenson, 1999). For low to middle income countries, this approach spells disaster for the population as resources to construct new water infrastructure is not available, let alone to properly maintain existing infrastructure.

In order for the available fresh water resources to be sustainably supplied to all the people in the world, water will have to be used efficiently following economic principles. The fourth Dublin Principle as set out by the International Conference on Water and the Environment in Dublin, seeks to do just that (GWP n.d.). This principle asserts that

> "***"Water has an economic value in all its competing uses and should be recognized as an economic good"***

This implies that water should be recognized as a scarce resource for which economic principles should be applied. The use of economic principles in water supply will result in efficient distribution and use. However, for this to be successful, consumers will have to recognize water as a good with economic value. Efficient use of water will ensure that resources are used to increase coverage and as a result more people will have access to safe drinking water. The use of pricing in economics attaches an economic value to a good and as a result, water tariffs can and must be used to ensure that water is used efficiently. However, pricing should be carried out with care as water is essential for life and high water prices can have a negative impact on the lives of the poor. A balance should therefore be struck between ensuring that the price is affordable and it encourages people to conserve water.

1.2 Problem Statement

Kampala, the capital city of Uganda is experiencing high population increase due to increased urbanization and economic growth. The increase in population has resulted in the city's water supply system being placed under a lot of pressure. The National Water and Sanitation Corporation (NWSC), the utility responsible for water supply and sanitation services in Kampala, reports that currently water supply coverage in the city stands at 76 percent with the city's poor being mostly unserved (NWSC 2006). Water shortage in the city has also been a problem, but it is expected to go down with the commissioning of the city's third water treatment facility, Gaba III. Inadequate capacity in the distribution network is still a challenge that limits expansion of water services. With the escalating demand for water, a fourth treatment plant Gaba IV is already being planned for construction in 2012, just 5 years after the commissioning of Gaba III (Beller Consult et.al 2004:2-17).

Water level in Lake Victoria, Kampala's only source of water, has been going down recently mainly due to the combined effects of global change and unsustainable use of water from the lake. Increased urbanisation around the lake has resulted in a lot of pollution which has led to deterioration of water quality in the lake. Poorly treated sewage from Kampala is exposed off in Murchison bay, the same area from which raw water for portable treatment is abstracted. This has resulted in an increase in the use of chemicals in water treatment leading to high water treatment costs (NWSC 2006).

All of these challenges require the utility to ensure that its current infrastructure and water resources are used efficiently to meet the city's escalating water demand. A balance between water supply interventions and water demand management would go a long way in reducing the pressure placed on the infrastructure and the water source. This would in turn lead to deferred construction of water infrastructure such as Gaba IV, thus freeing resources for improvement of other infrastructural needs like extension of the distribution network.

1.3 Aims and Objectives

The use of water tariffs as a tool in water demand management has been acknowledged and used by utilities around the world. Experience in areas where tariffs are used as a demand management tool has shown that consumers can be encouraged to reduce water consumption by sending appropriate pricing signals (Magnusson 2005:25). The aim of this project is therefore to develop a tariff that will encourage water conservation in Kampala, Uganda.

The study intends to achieve this aim by developing a model using Microsoft Excel. Input data for the model will be collected by reviewing the literature, carrying out parallel research and by requesting data from NWSC. Outputs from the model will include graphical presentation of the proposed tariff as well as other graphs indicating the amount of water conserved and how water use patterns have been influenced by the change in price. It is envisaged that the model will be of help to NWSC engineers and managers, as well as to other utilities that may want to introduce water conservation tariffs as part of their water demand management programs.

1.4 Limitation of the Study

Due to time constraints, this study was limited to domestic water users connected to NWSC. These customers may be having yard taps or house connections. The decision to concentrate on these consumers was based on the fact that they use about 47% of the total water produced in Kampala and also that they are all metered hence it would be easy to get information on their water use.

The following were some of the limitations encountered during the study.

- Due to financial constraints, it was not possible to undertake a trip to Kampala, and as a result, the author relied solely on reading and on interviewing NWSC staff so as to get a feel of the place. A field trip would have helped the author to understand the situation on the ground better.
- The study relied only on secondary data and as such a margin of error could not be estimated. The use of parallel research in obtaining some of the information could also lead to the model results being inaccurate. However, the model was developed in such a way that verified inputs for Kampala could be used once they are obtained.
- Compilation of billing data by NWSC staff took longer than expected due to other pressing work commitments. This resulted in the data being received late in the study. In addition, the large size of data resulted in a lot of time being spent in formatting the data and hence less time was spent carrying out the actual modelling and writing the final report.

1.5 Structure Of The Report

The report consists of the following five main chapters.

- Chapter two details the literature review.
- Chapter three looks at the data collection methods.
- Chapter four gives a background of Kampala
- Chapter five centres around the tariff design and modelling procedure. Results from the model are also presented and discussed.
- Chapter six contains the overall study conclusions and recommendations

2 Literature Review

2.1 Water Demand Management

Due to the challenges associated with attempting to meet the world's escalating demand for water by increasing water supply, water managers are now looking at synergistically using water demand management and water supply management in their quest to supply water in a sustainable way.

In everyday use, the term water demand refers to the amount of water that consumers are expected to use. A more economic definition refers to water demand as an expression of desire for a particular water service level, measured by the consumer's willingness and ability to pay for it (Deverill, 2001). This is usually referred to as the consumers' willingness to pay for water. This definition ties well with the fourth Dublin Principle which advocates for the treatment of water as an economic good.

Water demand management (WDM) has been described as the development and implementation of strategies aimed at influencing demand patterns so as to achieve efficient and sustainable use of water (Kay et.al 1997 and UKWIR/Environment Agency 1996). The phrase "demand patterns" is important in the description above since WDM can be used not only to reduce demand over a long period, but also to reduce or shift peak demand periods during the course of the day or year. It is generally agreed that WDM interventions should be geared towards ensuring equitable access to water, especially by the poor and the disadvantaged while ensuring sustainable use of water resources (Deverill, 2001).

A number of instruments can be used in Water Demand Management and these have been used to different extents in different countries with varying results. Physical instruments involve imposing water cut-offs and/or pressure control during peak hours and droughts in order to reduce usage. This is a temporary measure and may not reduce water demand but may simply alter the demand pattern as people can only get water during times when it is available. This method also results in heavy energy losses in the system and can be expensive to run (Stephenson, 1999). Sociological instruments involve appealing to the public to alter water consumption patterns. This can be done through the media, or the use of legal enforcements and regulatory tools to ensure adherence to the appeals. Sociological methods are more common during periods of drought after which consumers revert back to their ways of using water. The method can be expensive as the use of the media tends to be costly. Legal enforcement requires the utility to use inspectors which add to operating expenses (Stephenson 1999). The use of economic instruments involves the use of economic principles, such as charging for water service delivery, to influence water use behaviour. This method requires the use of water meters and a careful design of tariffs taking into account issues of equity and cost recovery. A great deal of research, for example in Magnusson (2005:58), has shown that water pricing can be used to control water demand. This report will be concentrating on the use of water tariffs in water demand management.

A review of literature on the use of the various instruments showed that there is no set rule for implementing WDM interventions. Different cities have in the past used a various combinations of the instruments mentioned above to achieve different levels of water conservation. The tourist town of Hermanus in South Africa, with 24000 permanent inhabitants and triple that amount during the summer period (tourist season), introduced a water demand management programme in 1997 (Turton 1999). This programme involved the use of increasing block tariffs, water loss management programmes, appeals to consumers to retrofit water devices as well as appeals to schools to conserve water. According to Turton (1999), the town realised a 16 percent decrease in water demand during the first year of the programme. The city of Windhoek in Namibia also underwent a rigorous WDM programme in 1995 focusing on the key issues of policy, legislation, technical, public education and awareness. The programme saw demand in Windhoek being reduced by about 30% within three years with per capita consumption going down from 201litres to 130litres (Magnusson 2005:55).

The success of WDM programmes in different parts of the world has led many utilities into looking at integrating demand management programmes with supply management interventions. It is clear that this integration will result in the construction of new water supply infrastructure being deferred to later dates thus saving financial resources (Stephenson, 1999). Reduction in demand will also lead to less resources being spent on water treatment and pumping as only the reduced amount will be treated. In other cases, the water saved in WDM interventions can be used to extend services to the poor who had limited or no supply at all. Efficient water usage will translate into reduced wastewater flow resulting in fewer resources being spent on wastewater treatment. All of these achieve overall efficient and sustainable use of existing resources (Stephenson, 1999).

2.2 Economic instruments for Water demand management

The use of economic instruments in water demand management involves the use of markets to influence water use behaviour. This is achieved by using economic principles in the supply of water so as to send signals to consumers to react in a certain way. These instruments reward consumers for acting in the desired way and impose financial penalties on those who behave in an undesirable way (PRI n.d.). The most widely used economic instrument is that of imposing fees on users so as to influence consumers water use patterns. This report will be looking at the use of water tariffs, an example of consumer fee based measures, as a tool in WDM.

The use of user fees for water is in line with the fourth Dublin principle which basically advocates for water to be treated as an economic good in order for it to be used efficiently. The principle asserts that: **"***Water has an economic value in all its competing uses and should be recognized as an economic good*" (GWP, n.d.)

According to van der Zaag (2006), water is a special good that should be treated as a special economic good. The following reasons are presented for regarding water as a special economic good:

- Water is essential for life
- Water has no substitute
- Water is finite

Since water is essential for life and has no substitutes, pricing of water cannot be determined using economic principles alone. This would spell disaster for the poor and disadvantaged who may not be able to pay the price set by economic forces. The last reason refers to water as a finite resource indicating that it is a scarce resource. Being a scarce resource means that it should be used sparingly to ensure its sustainability, but it also means that pricing should be used to ensure that water is used efficiently in all its competing uses.

When setting prices for water, consideration should be given to the Bonn Charter which stipulates that the price of water should be set such that it does not prevent consumers from obtaining water of sufficient quantity and quality to meet fundamental domestic needs. The issue of the right to water has to be taken on board, and that is everyone is entitled to sufficient, safe, acceptable, physically accessible and affordable water (IWA, 2004).

2.3 Water Tariffs

A tariff is a set of rules that determine the amount that a consuner should pay for using a certain service. In water services, the process of designing water tariffs should be governed by economic principles with the intention to conserve water, promote fairness among the consumers and to generate enough revenue to sustain the service (van der Zaag and Savenije 2006).

2.3.1 Does water pricing conform to economic principles?

In market economies, the price of goods is determined by their level of supply and demand. The supply and demand levels of any good follow the Law of Demand and the Law of Supply. The Law of Demand states that, provided all factors remain constant, for any good, the higher the price of the good, the lesser the amount demanded and vice versa (Case and Fair, 1989). As a result the demand curve for any good is down sloping. The demand curve is sometimes known as the willingness to pay curve, since it shows the amount consumers are willing to pay for quantity of a good at a given price (Katko, 1989:68). For instance, in Figure 2.1, consumers would be willing to pay P1 for Q1 of good X.

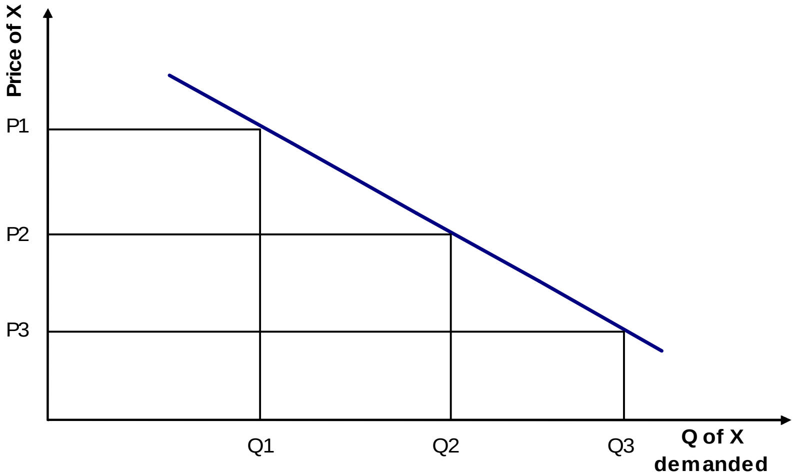

Figure 2.1 Demand curve for good X

Source: Case and Fair,1989

There are a number of explanations as to why the demand curve has a negative slope.

- Income effect – A consumer can buy more goods with the same income provided the price of the good goes down
- Substitution effect – A consumer will always look for goods that can substitute the good in question when the price of the good goes up
- Diminishing marginal utility – The value that the consumers attach to the commodity goes down when the quantity of the commodity goes up (Case and Fair 1989:88).

The Law of Supply, on the other hand states that provided all factors remain constant, the higher the price of a good, the higher the quantity supplied. The supply curve (as depicted in Figure 2.2) shows the quantity that a producer is willing to supply at alternative prices. The two relationships are depicted in figure 2.2 showing the two curves drawn on the same graph. The point where the two curves meet indicate a point of equilibrium showing the amount demanded (Q_e) at the price (P_e) and the amount supplied at that price (Case and Fair, 1989:90).

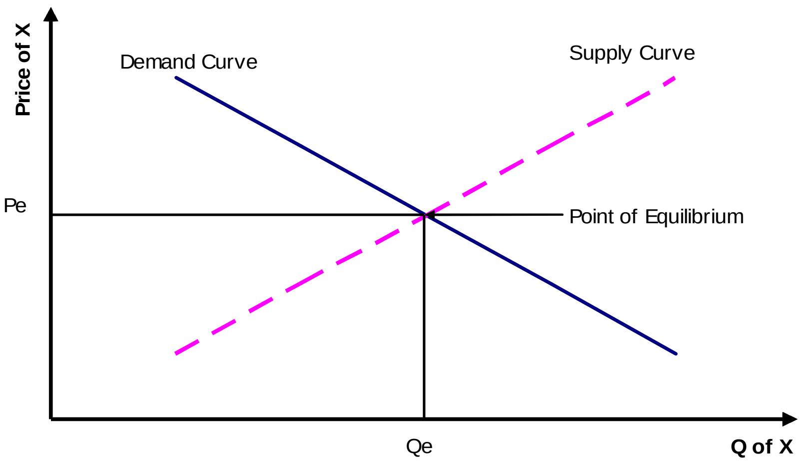

Figure 2.2 Supply and Demand curve for good X
Source: Case and Fair, 1989

The price P_e, which is the monetary value of a good, and the quantity Q_e are determined by market forces. In economics, price is seen as a mechanism for allocating scarce resources among competing users. According to economic principles, the price of a good is set at a point where the marginal satisfaction that consumers derive from the good is equal to the marginal cost of the good. Some level of caution should be exercised when applying this principle to water pricing. The reasons being, if water prices are determined by market forces, then it may end up being unaffordable, and as such, consumers may resort to unsafe water, thus putting their health in risk. On the other hand, low water prices will lead to wastage and inefficient use. As a result, water pricing should be based on the principles of cost recovery, sending the right signals to consumers so as to avoid wastage and ensuring overall affordability (Savenije and van der Zaag, 2002).

2.3.2 Water Tariff Objectives

Water tariffs are usually designed to meet a number of objectives which could be in contrast with each other (Tampere, 1989:87) and these are outlined below,

Cost recovery

The primary objective of tariffs is to ensure that the utility has enough resources to carry out its day to day responsibility of delivering services. Without adequate revenue, the utility runs a risk of failing to maintain its infrastructure and to continue its supply of water (WASH, 1991). It is therefore important for the utility to make a decision as to which costs it is going to recover from consumers. Figure 2.3 shows a diagrammatical representation of the costs undertaken by a typical utility in supplying water. The full water supply cost includes operation, maintenance and capital costs. Full economic cost includes opportunity costs and economic externalities in addition to the full water supply cost. Additionally, the full cost includes all of the costs mentioned plus environmental externalities (Savenije and van. der Zaag, 2002). The decision on level of costs to recover depends on issues such as affordability.

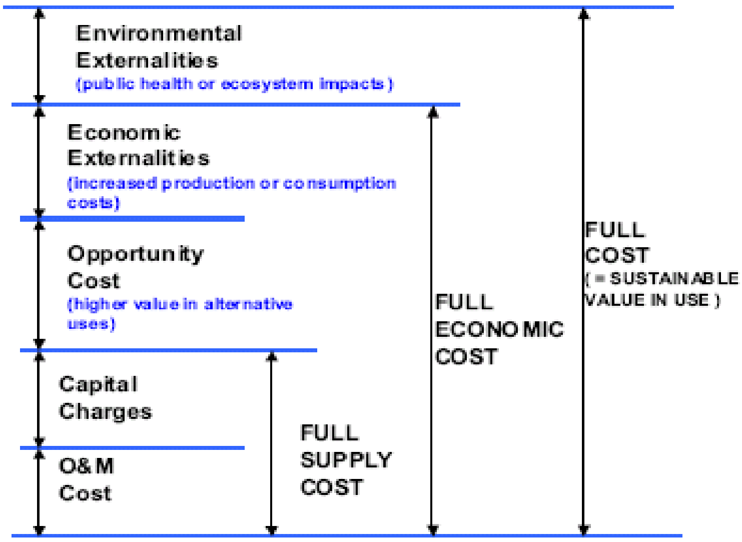

Figure 2.3 Water supply costs

Source: Savenije and van der Zang, 2002

Income Distribution

This is sometimes referred to as cross subsidisation among different users. For example, shown industrial users may be charged more than domestic users, while in some cases high income domestic consumers may be charged more than low income users who may even be give a certain amount of water for free (WELL, n.d.).

Water Conservation

By carefully designing water tariffs, utilities can send appropriate signals to consumers on the cost of water. These pricing signals can trigger consumers to adjust the way they use water thus ensuring available capacity is used efficiently and investments are carried out only when absolutely necessary (Stephenson 1999).

As already mentioned, tariff objectives could be in contrast with one another. For instance, ensuring that water is used efficiently by increasing tariffs could result in consumers using less water which could in turn result in the total revenue realized by the utility going down thus affecting the financial viability of the organization. Tariff design therefore requires many tradeoffs in order to ensure that all aspects are taken into consideration (WASH,1991).

2.3.3 Types of Water tariffs

Generally, water tariffs can be divided into two categories: non-volumetric tariffs and volumetric tariffs. Traditionally, non-volumetric tariffs were common, but they are however being replaced by volumetric tariffs. Following is a description of the different tariffs in use around the world.

Flat rates – This is a non-volumetric tariff and as such consumers are charged a fixed amount, regardless of how much water they use. This tariff does not encourage efficient use of water since consumers do not have an incentive to reduce water use (Chestnut et.al. 1997:2-8). Some countries, for instance the United Kingdom and Canada, as well as some low income countries, are still using this tariff mostly because of the prohibitive costs of metering that is associated with volumetric tariffs. The tariff is also easy to understand as there are no calculations on the part of the consumer.

Decreasing block rates – In this rate, the applicable unit price of water reduces with increasing usage. This rate was devised to encourage industrial growth, however it does not encourage efficient use of water (Katko 1989:99).

Seasonal Rates – These are designed to depict periods of high water demand and low water demand. The rate for water is higher during periods of high water demand and lower during periods of lower water demand(Chestnutt et.al, 1997:2-8). These types of tariffs are commonly used in the United States of America and some other places where there is a seasonal variation in water demand. Figure 2.4 shows a diagrammatical representation of decreasing block and seasonal tariffs.

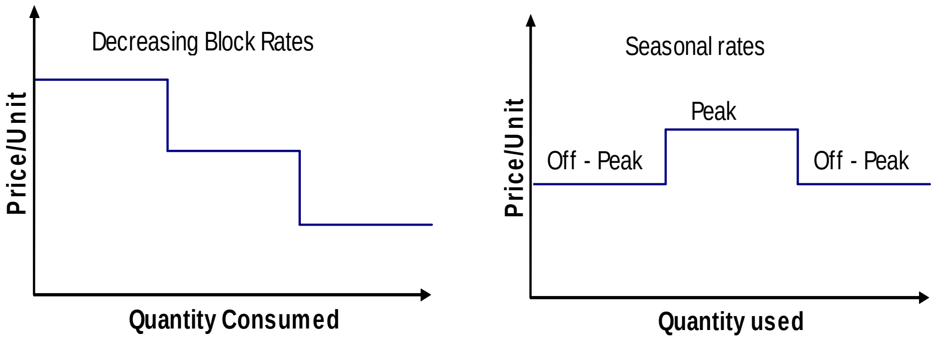

Figure 2.4 Decreasing block rates and Seasonal rates

Sourse: Chestnut et.al. 1997

The increasing block and the uniform rate tariffs are commonly used by utilities that are looking at sending pricing signals to consumers.

Uniform rates – In this rate, consumers are charged at the same rate per unit volume. This tariff is usually preferred by many utilities since it is easy to administer and easy for customers to understand. Rates can vary between classes but not within classes, for example, domestic consumers are charged at the same rate while commercial users are charged at a different rate. Figure 2.5 shows the bill associated with a flat rate tariff. As can be seen, the more water a consumer uses the more they have to pay.

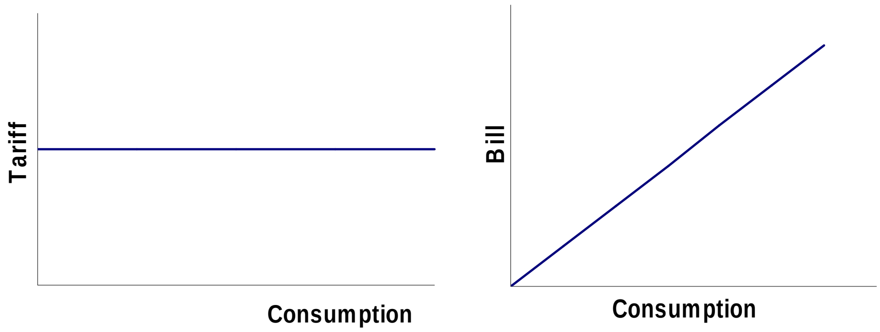

Figure 2.5 Bill associated with a flate rate tariff

Source: Chessnutt et.al 1997

The rate can be set such that enough costs are recovered from the users. The tariff requires that households should be metered in order for this tariff to be enforced.

Increasing Block Rates - This rate structure is hailed as the best conservation oriented rate (Chesnutt et.al 1997:6-9). The unit rate for water increases with increased water usage and this encourages efficient water usage as high water users get charged more. Figure 2.6 shows the bill associated with a rising block tariff.

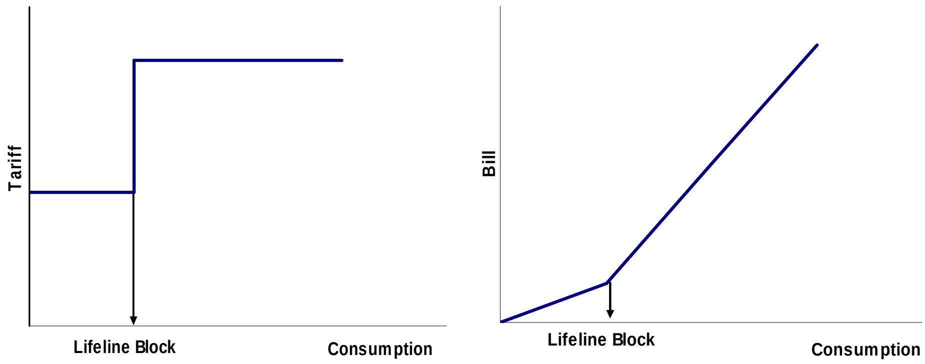

Figure 2.6 Water bill from an Increasing block tariff

Source: Well n.d.

It is also possible for water tariffs to consist of two parts: a volumetric part and a fixed part. The fixed part of the tariff is concerned with recovering the fixed costs of production and administration.

Water utilities are nowadays looking at rates that will encourage water conservation hence the move towards using increasing block tariffs and flat rates. However, the degree to which they achieve conservation highly depends on the rates associated with the tariff structure.

2.4 Water Conserving Tariff Design

In order for water utilities to design water conserving tariffs, they should be able to predict consumer behaviour when faced with different water rates. The price elasticity of demand (Ed) provides the connection between consumer behaviour and price fluctuations. Since this project is looking at water conserving tariffs for domestic consumers, discussions will be limited to domestic water users.

2.4.1 Price Elasticity of Demand

As already pointed out, it is expected that for any price increase of a good the quantity demanded will go down and vice versa. The price elasticity of demand is the ratio of the percentage change in quantity demanded to the percentage change in price (Case and Fair 1989:117).

$$\text{Price Elasticity of Demand} = \frac{\%\ \text{change in quantity demanded}}{\%\ \text{change in price}}$$

Since the relationship between the price and the quantity demanded is always negative, Ed is also negative. However, for ease of use, economists have decided to use the absolute value of Ed, thus making it a positive value. As shown in Figure 2.7, for a linear demand curve, elasticity is unitary (1) at a point that is equidistant from the two axes (Katko 1989). This means that for a percentage price change, the quantity demanded changes by the same percentage. When the price goes up, the price elasticity of demand increases and is more than one. This range is said to be the elastic range, which means that any percentage change in price results in an even higher percentage change in quantity demanded. When prices are reduced to lower than the unitary elasticity point, the range is said to be inelastic. This means that any percentage change in price results in a smaller percentage change in quantity demanded.

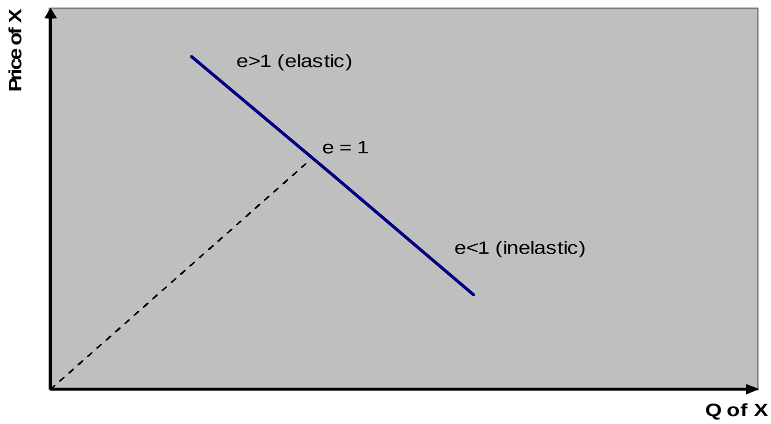

Figure 2.7 Linear demand curve and associated price elasticity of demand
Source: Katko 1991

Elasticity has a bearing on the change in total revenue realized by a supplier when there is a change in prices. For elastic goods, an increase in price without a change in quantity produced results in a decline in total revenue. On the other hand, for inelastic goods, an increase in price without an increase in output results in an increase in total revenue.

Water is known to be inelastic mainly because it is essential for life. The other reason is that water does not have any substitute and as a result consumers will pay any price to get water, provided there are no alternative sources. The following factors affect the price elasticity of water.

Proportion of water bill to total household budget

The lower the price of water the less elastic it becomes. This is because the water bill makes a small proportion of the total household budget, thus resulting in over usage. On the other hand, the higher the price of water, the more elastic it gets since it then makes a higher proportion of household budgets and any increase in prices will result in households seeking to reduce their usage (Case and Fair 1989:119).

Time frame

In the short term, price elasticity of demand for water is usually high (even though it is still inelastic) because consumers do not have any other choice but to reduce their usage. However, in the long run, consumers adjust by, for example, retrofitting water efficient equipment in their houses and this results in a lower elasticity of demand (Kayaga 2007).

Income level

It is well known that low income consumers use less water as compared to high income users (ADB 1999:46). The amount of water used by low income users is usually very close to the minimum required by humans to live and as such any increase in water prices will result in little or no reduction in water use. On the other hand, high income consumers use more water and as a result an increase in prices will result in them lowering their use so as to reduce their bills (Savenije and van der Zaag, 2002).

Seasons

The price elasticity of demand is affected by seasons. During the summer, people need more water due to high temperatures, hence water is found to be less elastic. In contrast, the demand for water is more elastic during the winter since people do not need require a lot of water.

Water use

Outdoor and indoor uses of water have different values of price elasticity of demand with indoor uses having a lower value. This is because indoor uses are mostly for human needs whilst outdoor uses are for recreational purposes and are the first to be targeted for cuts during price increases (Savenije and van der Zaag, 2002). Figure 2.8 shows that for increasing vital uses such as drinking and cooking water is less elastic while for other uses such as washing vehicles water is more elastic. The implication is that if water is used for vital purposes, no matter how much prices are increased, there will be no reduction in water use as water is essential for life.

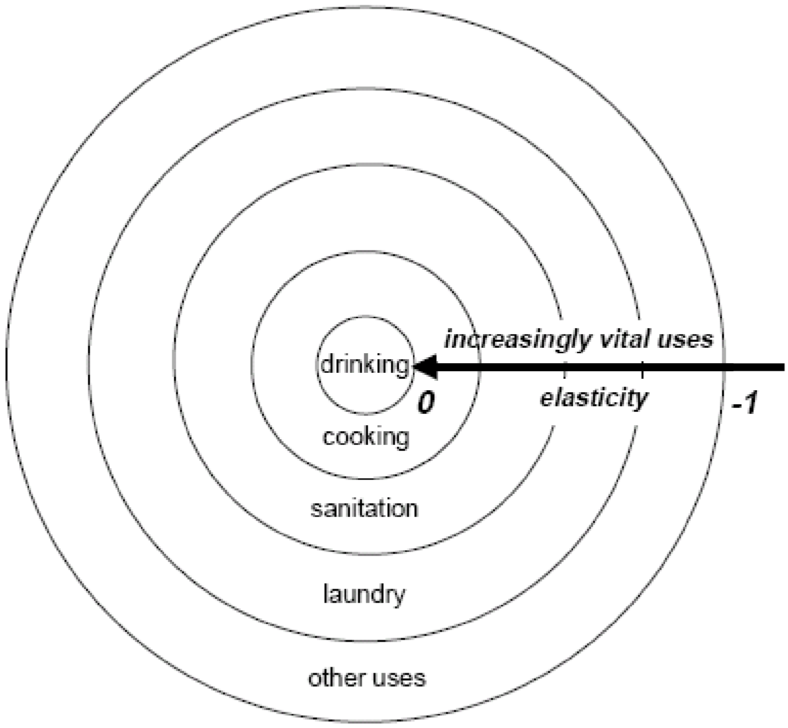

Figure 2.8 Elasticity of demand and water use

Source: Savanije and van der Zaag

Availability of alternative water sources

Availability of alternative water sources tend to make water more elastic. This is due to the fact that if people think the water prices are too high they usually revert to alternative sources which are usually unsafe (ADB 1999:53)

Many studies have been performed on the price elasticity of demand in different parts of the world. A search of the Literature showed that most of these studies have been carried out in high income countries while a few have been conducted in low income countries. In Africa, research on price elasticity of demand has been carried out in Windhoek, Namibia and some cities in South Africa. Table 2.1 shows some values of Ed as reported in the literature.

Table 2.1 Ed estimates of water services in different places

Source: Kayaga 2007

Study	Location	Description	Ed
Howe & Lineweaver (1967)	USA	Indoor demand Outdoor use-wet area	0.23 1.6
Pope (1975)	US 4 cities	Domestic	0.182 – 0.5
Grima (1972)	Toronto	Domestic winter use	0.75 – 1.07
OECD (1987)	OECD	Domestic	0.005 – 0.3
UK Joint Study	UK	Outdoor use Indoor use	1 0.2
Thomas & Syme (1979)	Perth, Australia	Outdoor use Indoor use	0.31 0.04
Veck and Bill	Alberton, S/Africa	Outdoor use Indoor use	0.38 0.13

2.4.2 Residential Water Use Patterns

In order to convey the right pricing message to consumers, water tariff designers should have an understanding of water use patterns in their area (Chesnutt et.al 1997:8-4). Different studies have shown that, in the case of domestic water use, household income has a major influence in water use. Figure 2.9 illustrates the results of a study performed in Windhoek, Namibia and it shows water use patterns according to income levels. It is clear that high income users use more water than low income users. Some of the reasons advanced for this are that high income levels result in lavish lifestyles which involve the use of devices such as washing machines and swimming pools and they usually have large plots with larger gardens (van Rensburg 2006).

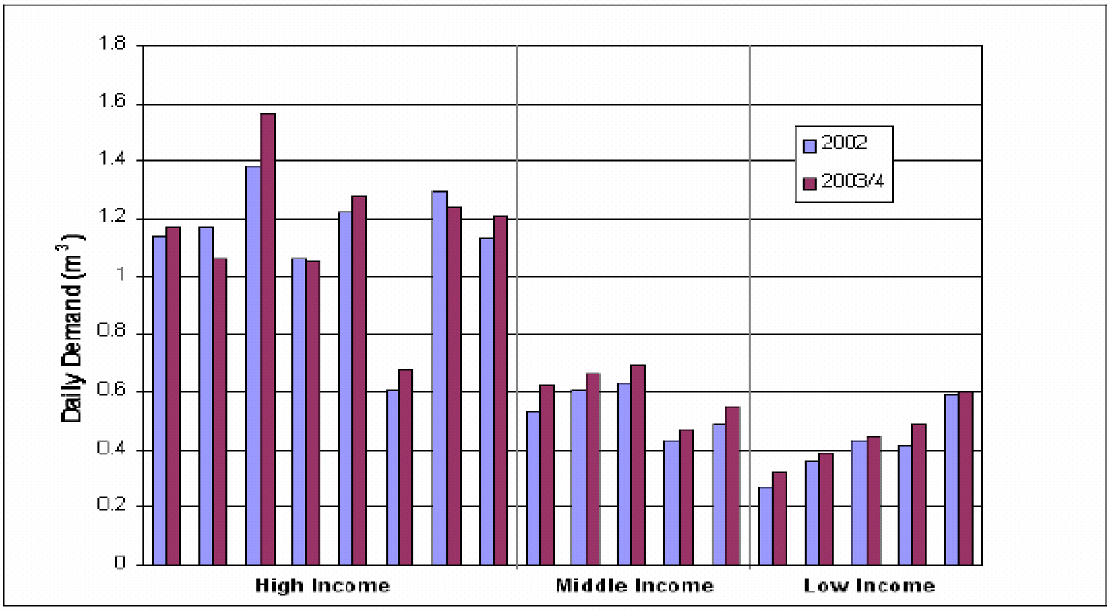

Figure 2.9 Water consumption according to income in some of Windhoek surbubs
Source: van Rensburg, 2006

Apart from differing water consumption patterns according to income levels, research has also shown that the price elasticity of demand for water differs by income category. The reasons for this have already been advanced in section 2.4.1. Research in Cape Town (Jansen og and Shulz 2006), South Africa, showed that for high income consumers, the price elasticity of demand for water is high as 0.99, indicating that 10% increase in prices would result in a reduction in water use of 9.9%. On the other hand, the price elasticity of demand for low income households is low at 0.24 indicating a lower reduction in water use for the same increase of 10%. Table 2.2 shows the price elasticity of demand for water according to income category for the city of Cape Town.

Table 2.2 Price elasticity of demand for different income categories
Source: Jansen og and Schulz 2006

Income category	**Price Elasticity of Demand**
Low Income	0.23
Middle Income	0.32
High Income	0.99

These findings have far-reaching implications in the quest for water conserving tariffs. As mentioned already, economic instruments should be used to impose penalties on those who behave in an undesirable way. The disparity in water use by different income groups calls for the use of economic instruments in order to reduce water use in high water consuming sectors of the community. The use of tariffs in this case is more encouraged by the fact that research has shown that those who consume large volumes of water tend to reduce their water usage by a large amount when higher rates are introduced (due to their high elasticity of demand). This then suggests that it would be appropriate to send different price signals to the different income categories, so that each category can adjust its use accordingly.

2.4.3 Other Tariff design parameters

The design of water conserving tariff also has to look at other issues which may be in contrast to primary purpose of reducing water use. According to Kayaga (2007), the principle of CAFES, which stands for Conserving, Adequate, Fair, Enforceable and Simple should be applied when designing tariffs. These principles are explained below.

Adequate -The tariff should provide adequate funds for the running of the organisation
Enforceable – The utility should be able to enforce the tariff
Fair – The tariff should ensure that consumers are charged fairly with allowance for cross subsidization from the rich to the poor.
Simple - consumers should be able to understand the tariff

Although the degree to which these issues are addressed will differ from place to place, each of them should be considered.

Among the tariffs discussed in section 2.3.3, the uniform rate tariff and the increasing block tariffs were said to be popular water conserving tariffs. The uniform rate tariff however does not have an allowance for cross subsidization from the high income to the low income customers. This then means that for a unit of volume of water, both the rich and the poor face the same rate and as such the tariff does not differentiate between low and high consumers (Well n.d). It then becomes difficult to adjust prices for the high users only since any adjustment in the rate also affects the low consumers. This rate can be problematic in low income countries where the difference in income levels between the poor and the rich is very high and usually, if this tariff is used, the low income consumers end up paying more in terms of the proportion to their income while the rich end up paying less.

The increasing block tariff on the other hand provides for cross subsidization of water between low income and high income users (Well, n.d.). This is because water rates are set at different levels for different levels of consumption. In most cases, the increasing block tariff encompasses the concept of a lifeline tariff thus ensuring that everyone has access to a set minimum amount of water for basic needs. The lifeline tariff is usually based on affordability for the poor and in some countries, like South Africa, water in this block is free. Subsequent blocks are usually charged based on cost recovery.

The task of setting switching points between blocks is not an easy one. Setting the lifeline block at a high volume will result in wastage, whereas setting it at a low volume will result in some low income households with large families paying too much for water. In fact, a study conducted by WHO in 1989 indicated that in places where increasing block tariffs were being used, poor people sharing water connections ended up paying more. The reason being that, the combined consumption of the households sharing the connection placed them on higher blocks, hence a higher rate (Boland and Whittington 1997), which defeats the purpose of the lifeline block. The setting of subsequent tariffs is also problematic in the sense that there is usually no information as to how much water each income level should be using if they are using water efficiently. The use of marginal costing is encouraged when dealing with higher blocks, with the rate of each block being set at the marginal cost of production of that level of consumption. However, in low to middle income countries, the use of marginal costing is limited mainly by the low household income (even for those considered to be high income).

Comparing the two tariffs, the increasing block tariff can be more effective in sending clear signals to high consumers while the lower consumers (who are mostly the poor) can benefit from the lifeline block. Care should be taken to ensure that the lifeline block provides enough water for the low income families.

The issue of fairness when it comes to setting of tariffs is best tackled by using the World Bank's guidelines on water tariffs. The World Bank recommends that consumers, especially the poor, should not spend more than between 3% to 5% of their income on water and sanitation services. This recommendation should be taken on board when designing tariffs.

2.4.4 Conserving Water Tariff Modelling

The use of computers in tariff modelling is fast becoming popular. A review of the literature showed models from the high income countries only. These models provided some guidance on modelling, however, it was found that in all the cases reviewed, the models used revenue requirements as a criteria for setting tariffs (Chessnutt et.al 1997:8-15). This resulted in some case with the model performing iterative calculations in order to ensure that the revenue requirement was met (Barkatullah 1999:160). The models reviewed did not look at issues of affordability especially to the poor. This approach of using cost recovery as a criterion would not be suitable in low income countries where issues of affordability are very important. It is therefore important to incorporate affordability while ensuring that revenues are not negatively affected by the price changes.

2.5 Chapter conclusion

This chapter has reviewed available literature on the issues surrounding the use of economic instruments for water demand management with an emphasis on conservation tariff structures. While tariffs can be used to influence water use, it is important to note that it is not the actual tariff structure that helps to reduce water use, but the level of the rates associated with the tariff that encourages water conservation.

Studies have shown that the price elasticity of demand provides the link between water consumption and prices. The price elasticity of demand for households is affected by income, with low income households having a lower price elasticity of demand. In addition, for residential water use, household income has a big influence on water use with high income households consuming much more than low income households. These two findings have been exploited by water tariff designers when designing conservation tariffs. Two conservation tariffs, uniform rate tariffs and increasing block tariffs, have also been discussed showing the advantage and disadvantage of each type of tariff. When designing tariffs, it is important to ensure that the tariff is fair among all consumers, and that the revenue collected will be adequate for the utility to carry out its activities. The tariff should also be easy for the consumers to understand and should be enforceable by the utility.

Even though modelling for water conserving tariffs has been carried out in high income countries, it is important to devise models for low income countries which will take into account issues of affordability. Utility managers, in low income countries, may be tempted to use models from high income countries without taking into consideration the differences in the economic conditions. It is against this background that the study will develop a water conserving tariff model for Kampala.

3 Data Collection Methods

The main purpose of this study is to model a conserving tariff for the city of Kampala, Uganda. According to Blaxter et.al (2006), case studies are usually used to illustrate problems or show that good practice that has been successful in one area can be used in another area. It is in this light that this study makes use of the case study research methods. In this case, a single case design is being used, which according to Yin (1994) is usually used to confirm or challenge a theory. In this study, the author seeks to show that water tariffs can be used to conserve water in Kampala.

Case studies can be conducted using either primary or secondary data. In this case study, only secondary data was used due to time limitations and budgetary constraints. Secondary data refers to data that was collected for other purposes and not for the research being undertaken. It is important to note that secondary data should be used with caution as it's format may not be compatible with the research it is being used in (Kumar, 2005). The validity as well as the reliability and quality of the data should also be of high standards. With these issues in mind it was ensured that the data collected was from reliable sources.

3.1 Data Collected from Literature

The study made use of parallel research which, according to Katko (1989:79), looks at communities similar to the project area in terms of economic, social and cultural dimensions. This method has been tested with success in areas such as Burkina Faso and Indonesia. When using this method, it is important to always remember that no two communities are exactly the same. With this in mind, values of price elasticity of demand were searched for the literature. The city of Cape Town was ultimately chosen as a parallel city from which these values were obtained.

Other data collected from the literature review were income levels which were obtained from published material. Census related data as well as socio-economic data were obtained through an interrogation of the Uganda Bureau of Statistics (UBOS) database.

3.2 Interviews

Interviews are considered to be one of the most important sources of information for case studies (Tellis, 1997). Different types of interviews are possible, with the unstructured interview being chosen in this case study. An initial unstructured interview was conducted with the General Manager of Kampala Water. The interview provided information in general background of Kampala water, the city of Kampala as well as the utilities customer base. The interview also provided information on the water tariff in Uganda.

3.3 NWSC data

Before embarking on data collection from an organisation, it is important to seek informed consent from that organisation (Kumar, 2005). This basically involves ensuring that the organisation knows about the research in terms of its goals, how it will affect them and the kind of data that will be required. Issues of ethics should also be addressed when dealing with organizational data. Since water tariff studies rely heavily on billing data , it was necessary to request for such from NWSC. In the beginning, contact was made with NWSC, the purpose of which was to establish an interest in carrying out the study. A project proposal detailing the purpose and objectives was sent to NWSC together with details of the information that will be required for the project. On giving consent to the project, the organisation embarked on collecting the requested data. In order to ensure that the data was treated as ethically as possible, the author requested that the names of the account holders should be omitted from the billing data.

Sending of billing data from Kampala to Loughborough was attempted with the use of e-mail. However the data was too large and therefore could not be sent as an e-mail attachment. After considering several methods, including the use of courier services, it was decided to use the innovative method of File Transfer Protocols on the Internet, which proved to be effective. Further clarification and supporting notes on the billing data was sent by e-mails. Appendix 1 provides email communication between the author and NWSC staff.

3.4 Data Analysis

The NWSC billing data was in Microsoft Office Access format. Looking at the format and size of data, it was apparent that computers would have to be used to analyse the data. This was mainly due to the fact that computers are tools that can quickly handle complicated statistical and mathematical calculations on huge amount of data and then display results in graphical form. However, it is important to choose the right software for the analysis that has to be carried out. In this case Microsoft Excel was chosen as the modelling software. This was due to the fact that Excel can handle a large number of mathematical operations and can present results in good quality graphs. The choice was also motivated by the author's knowledge of the software. Statistical Package for Social Sciences (SPSS) was used to generate a random sample from the billing data.

Excel was also used in formatting the data into a form that can be used in the model. Due to the large number of accounts, the process of cleaning, formatting and sampling the data took a substantial amount of time. Development of the model was based on experience gained by other modellers found in the literature review, however, the methods followed were different as the situation in Kampala is different from those found in the literature. A model has three parts to it, an input part, a decision making part and finally an output part. It is important to note that the output of a model is only as good as the input. If the data being fed into the model is bad, the output will be bad as well. Models should be used as a guide with the full knowledge that the results in the real world could be different. Models therefore need to be refined as more information becomes available. Results from models have to be confirmed with actual world results. Typically, a model will use clearly described assumptions to aid in decision making. A utility manager should therefore understand the assumptions made so that he can understand the results he gets from the model.

4 Background to Kampala

4.1 Introduction

Uganda is situated in the Eastern part of Africa and shares borders with The Democratic Republic of Congo, Sudan, Rwanda, Kenya and Tanzania. The population of Uganda is currently estimated at 27.4 million with about 31% living below the national poverty line. According to the 2002 population census, it is estimated that the country is experiencing a 3.2% population increase. During the last decade, the economy has been growing at a rate of about 7% until 4 years back when the rate dropped to about 6%. This economic growth has been fuelled by expansion in the agricultural, construction and communication sectors (DFID, 2006). The country is so well endowed with water resources with about 13% of its surface area covered by lakes. As shown in Figure 4.1, the country is also host to the world's second largest lake, Lake Victoria.

Figure 4.1 Map of Uganda showing surface water resources.

Source: WWAP 2006

The Lake is very important to the economy of Uganda since it is the source of the county's hydropower (WWAP 2006). Despite having a lot of water resources, Uganda is still battling with ensuring that its people have access to adequate, safe water supply. A 2005 estimate reported that 59% of rural and 65% of urban inhabitants have access to safe water. Increasing urbanisation, industrial activities, population growth and lack of environmental pollution control measures has resulted in depletion of the once abundant water resources. This has led the government to initiate reforms in the water sector which included the re-enactment of the National Water and Sanitation Corporation, a water utility that was formed in 1972 through a government act (WWAP, 2006).

4.2 Kampala, The Capital City

Kampala is located on the banks of Lake Victoria and its history dates back to the 18th century when the British set up their headquarters in the area. The city has since grown into the capital of modern day Uganda. Kampala is the industrial hub of Uganda with an estimated 65% of the national economic activities taking place in the city (Beller consult et.al 2004:10). Like most of the cities in low income countries, urbanisation has resulted in a huge increase in population. The 2002 population census places the population of the city at 1.35 million with a household occupancy rate of 5 people. The huge population increase is due to a large migration of people from rural areas searching for better livelihoods. Figure 4.2 illustrates Kampala's population increase since 1969.

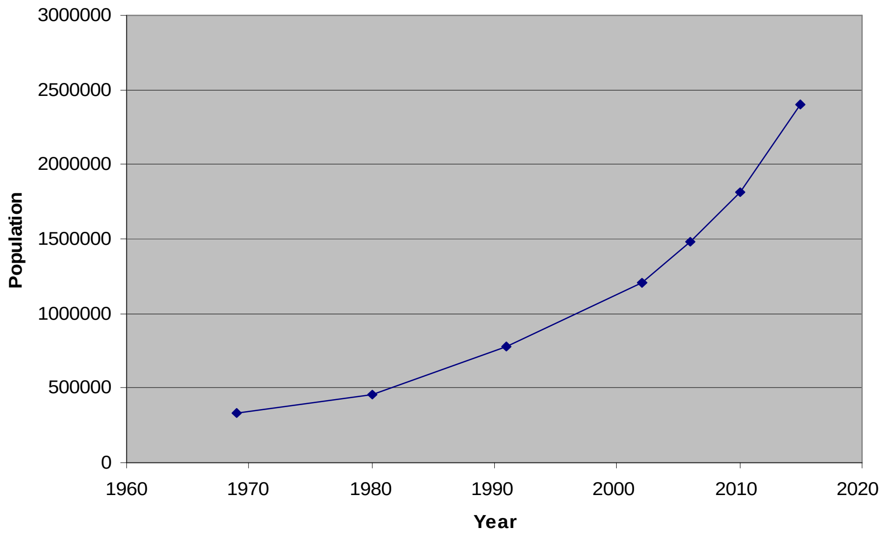

Figure 4.2 Uganda historical and projected population
Source: Nyakaana et.al n.d

According to Beller consultants (2004) , an estimated 30% of the population belong to the low income category while 45% resides in unplanned settlements with a small amount of services. Settlement around the city has been influenced by land tenure and by the flat topped hills and the valleys found in the city. Residential areas in the city can be classified as:

- Low density – these are the areas where high income earners reside
- Medium density – These are for the middle income category
- High density – There are the well planned multi storey buildings for middle income families. The other high density areas are for low income earners and are mostly unplanned lower value plots located in the lower valleys of the city.
- Informal settlements – These are for the poor and are unplanned, have low level of infrastructure and covers about 25% of the total area of Kampala. About 40% of the population lives in these areas. These areas are mostly in the lower parts of the valleys and are flood prone (Beller Consult et.al 2004).

The rapid growth in Kampala has placed the natural resources in the area under a lot of pressure. Issues of concern are water availability, sanitation and pollution as well as waste management.

4.3 The Water Situation

The major source of water for Kampala is Lake Victoria, with water services being provided by the National Water and Sanitation Corporation. Water for two other major town in Uganda, Entebbe and Jinja, is also abstracted from the lake. Despite the fact that Lake Victoria is the second largest fresh water lake in the world, water supply to Kampala is under threat. Water levels in the lake have been dropping at an alarming rate recently mostly due to climate change and overusage (Mubiru 2006). Figure 4.3 shows level trends since the 1900s, and since droughts mostly attributed to global change are regarded as the course for the current drop in level, it is expected that the situation will get worse. Form the graph, the current levels represent the lowest in 40 years.

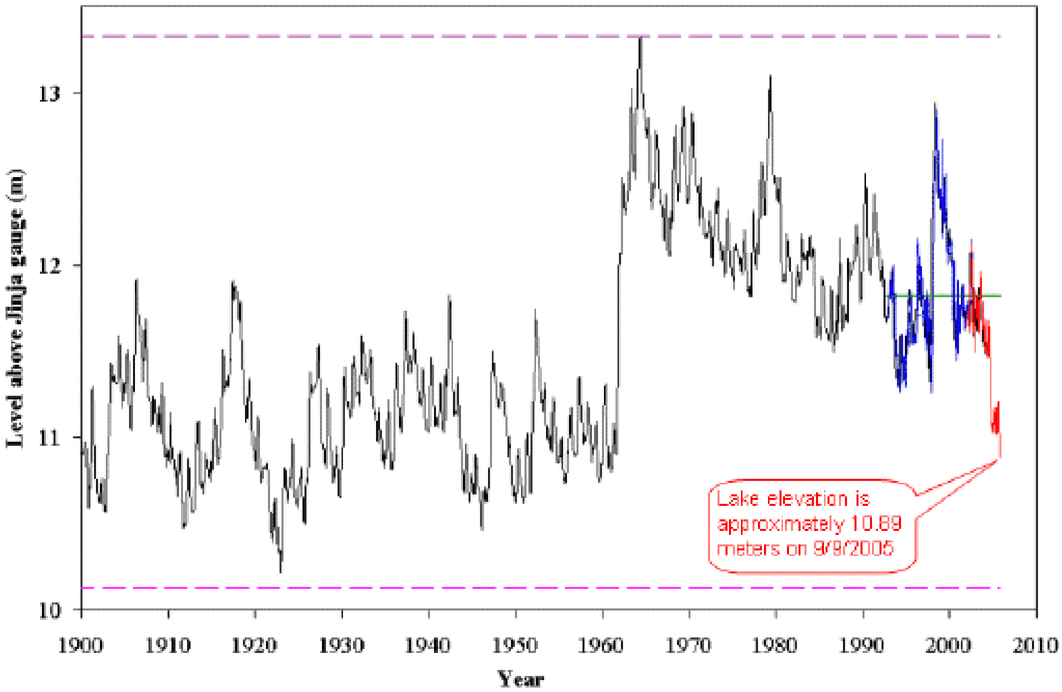

Figure 4.3 Lake Victoria water levels

Source: USDA 2005

The other threat on the Supply of water from the Lake is the pollution level that is rising at an alarming rate. This pollution rate is attributed to population growth and enhanced economic activities around the lake. For instance, the lake has been a receptor to poorly treated sewage from the urban centres surrounding the lake resulting in eutrophication (AWE 2005). The NWSC, being responsible for water supply in Kampala has felt the effects of pollution in that costs of treating water are going up. Being a shared water course, it is difficult to control the effects of urbanisation on Lake Victoria.

Kampala also has a number of ground water sources manifested mostly as springs. Water quality tests carried out by the City council have indicated that the water contains faecal coliform. Despite this, some low income people still prefer to use the springs since they say the water is cheaper than that provided by NWSC (Beller Consult. Et.al 2006:30).

4.4 The National Water and Sanitation Corporation

Material on NWSC was obtained from the NWSC corporate plan report for 2006 to 2007 (NWSC 2006). The National Water and Sanitation Corporation, a utility parastatal wholly owned by the government, was formed in 1972 under decree No. 34. The mandate of the corporation is to provide portable water services to the towns of Uganda as assigned by the government. Initially, the utility served three towns, but it has since grown to cover seventeen urban centres. The utility has gone through a lot of changes over the years with the earlier years being characterised by mismanagement and lack of funds leading to poor service delivery. Through the governments water sector reforms of 1997, the utility was re-enacted through a parliament act and has since strived for improved performance. NWSC had its first corporate plan in during the period of 1997 – 2000 which emphasised the importance of strategic planning and team building. The following planning period (2000 – 2003) concentrated on turning around the operation of the utility. The third plan adopted the concept of devolution of authority to its operational areas. The utility is currently on its 4th plan with the mission statement

"To provide efficient and cost effective water and sewerage services, applying innovative managerial solutions to the satisfaction of our customers"

The current corporate plan has goals that are categorised under the issues of operational efficiency, financial sustainability, water and sewerage coverage, capital work projects and finally reform and restoration.

4.4.1 NWSC water supply system

The construction of water supply facilities for Kampala commenced in 1928 with the construction of Gaba I treatment plant on the shores of Mutchison Bay in Lake Victoria. Gaba II treatment plant was commissioned in 1992 and like Gaba I draws its water from Mutchison bay. Gaba III treatment plant was commissioned in 2007 thus bringing to three the number of treatment works supplying Kampala. It is envisaged that with the estimated growth of demand, a fourth treatment plant will be constructed in 2012. Table 4.1 shows Kapala's existing and proposed water treatment facilities, with the total capacity at the moment standing at 193.4Ml/d (Beller Consult et.al 2006).

Table 4.1 Current and proposed Kampala water treatment plants

Source: Beller Consult et.al

	2002	**2003/4**	**2007**	**2012**
Gaba I	34.2	50	50	50
Gaba II	63.4	63.4	63.4	80
Gaba III			80	80
Gaba IV				80
Total	97.6	113.4	193.4	290

The city's distribution system is divided into two: the high level system served by the reservoir at Muyenga and the low level system served by Gunhill reservoir. There are fourteen reservoirs in the city with a total storage of 57 000 m^3. The distribution system consists of some 762 km of pipelines. Due to financial constraints, the distribution network has been poorly maintained resulting in high levels of water losses (NWSC 2006).

NWSC's customer base is divided into the following categories;

Domestic – these are for household use of water

Commercial – these are those that use water for the purpose of economic gain

Government institutions – schools and parastatals

Standpipes – these are for the city's underprivileged mainly in the slums

The different consumers are charged at different rates.

4.4.2 Water Tariffs

The NWSC water tariff has gone through a lot of changes in the past with the most significant changes being those in 2004. Table 4.2 shows the utilities tariffs starting from 2004/2005 to 2007/2008. Every year a tariff indexation formula, which is basically an inflation adjustment, is applied to the tariff so as to ensure that the value derived from the tariff is not eroded by inflation (NWSC 2006).

Table 4.2 NWSC tariffs between 2004 and 2007

Source: NWSC 2006

Consumer Category	Old Tariff FY2004/05 (Ushs/m3)	Adjustment FY2005/06 Ushs/m3	Adjustment FY2006/07 Ushs/m3	Adjustment FY2007/08 Ushs/m3
Public Standpipe	521	568	688	784
Domestic	806	879	1,064	1,213
Institutions / Government	993	1,082	1,310	1,493
Commercial <500m3/m	1,379	1,462	1,716	1,931
Commercial 500 – 1500m3/m	1,421	1,462	1,716	1,931
Commercial >1500m3/m	1,324	1,324	1,496	1,601
Average Commercial	1,373	1,432	1,643	1,410
Average Tariff	964	1,037	1,332	1,332

With the current tariff, the utility manages to recover operation, maintenance and depreciation costs. If any other costs are recovered through tariffs, then there would have to be a steep increase in tariffs (WWAP 2006). All the capital projects are therefore carried out with financial aid from international donors or the Government of Uganda.

4.4.3 Water Supply Challenges facing NWSC

NWSC is faced with a number of challenges in its quest to supply Kampala with portable water and these are detailed in the 2006 to 2009 corporate plan (NWSC 2006)

1. Shortage of water

The city has been ravaged by shortage of water lately, the main reason being that a lot of their consumers are now connecting to the supply system. This has mainly been attributed to inadequate shortage in treatment capacity at Gaba I and Gaba II, and lack of capacity in the distribution system. However, with the commissioning of Gaba III early this year the problem of treatment capacity has been removed. Currently the organisation is working on improving the distribution network.

2. Low service coverage especially for the city's poor

The utility has been working hard to improve the water supply to the slums in Kampala. This has seen the introduction of a number of standpipes in the low income areas with the intention of improving supply.

3. Receding lake levels

Lake Victoria levels have been going down as shown in Figure 4.3. This results in some of the intake pipes of the treatment plant being exposed and running a risk of not being able to draw water in the future.

4. Poor quality of raw water

In addition to low levels, the lake is also heavily polluted by human activities from around the lake. Poorly treated sewerage is pumped to the same area that the utility draws its raw water for drinking. This has resulted in high pollution and therefore the cost of treating water has highly escalated

Water demand management could be used to reduce the problems faced by the utility. For instance reduction in water use could ensure that the utilities water facilities are used efficiently. The water resource, Lake Victoria could also benefit from efficient use of water, which could lead to less sewerage being exposed off into the lake. The purpose of this study is to look at the use of water tariffs as a demand management tool and to model a water conserving tariff for Kampala.

5 Results and Analysis

Chapter 2 showed that prices can be used to influence water consumption patterns. For utilities, this means appropriate pricing for water can be used to encourage water conservation. This chapter presents the data collected in the project and the development of a model that simulates the effects of price changes on household water demand. Section 5.1 presents the data collected from the literature review and from NWSC. Section 5.2 then discusses the development of the model including the assumptions used in the model. Section 5.3 discusses the results from the model and finally section 5.4 gives the concluding remarks including the implications of the tariff developed.

5.1 Model Input Data

5.1.1 Price Elasticity of Demand

A search of the literature showed that studies on price elasticity of demand for water are not common, especially in low to middle income countries. As mentioned in Chapter 2, price elasticity of demand is the pillar of pricing decisions and as such obtaining appropriate values was of utmost importance.

A study of the literature showed that two cities in Africa, Cape Town in South Africa and Windhoek in Namibia have had such studies in the past. However, the Windhoek studies showed the average price elasticity of demand, thus reporting one value and not values according to income categories (van der Merwe n.d.). As mentioned in Chapter 2, Windhoek carried out a rigorous water demand management exercise in 1995, which included price reforms. The price reforms have affected the price elasticity of demand and as such the values reported by van der Merwe (n.d) are not appropriate as they reflect a situation whereby consumer's use of water is bound by water demand management interventions. However, Windhoek, like Kampala has three distinct classes of low, middle and high income with low income consumers in the slums having a lower level of service consisting of standpipes and prepaid water points.

In the case of Cape Town, a study was commissioned in 1998 to evaluate factors affecting water use patterns among different income classes (Janson and Schulz 2006). The study came up with the price elasticity of demand for low, middle and high income categories. The city of Cape Town has not had a rigorous water demand management programme, but is currently using increasing block tariffs. The city has also had to impose water restrictions during the dry periods in order to temporarily reduce demand.

Taking into account that no two places can never be the same, it was decided that the figures from Cape town will be used for this case study. The values of price elasticity of demand for the city of Cape Town are shown in section 2.4.1. The household income for the different income groups is higher than those of similar groups in Kampala. This is because South Africa is classified as a middle income country while Uganda is classified as a low income country (World Bank, 2007). It is however, expected that consumers in these groups will have similar reactions to changes in water prices. As expected, water is found to be less elastic for the low income groups while it is more elastic for the high income groups. Basically, a price increase will results in more water being conserved by the high income groups than by the low income groups. This suggests that for any price reforms, a higher price levied at the high income class will result in more gains in terms of water conservation.

5.1.2 Household income

In order to set appropriate pricing levels, household income levels should be determined. These are important in order to ensure that the tariff being devised is fair, especially to the poor. Table 5.1 presents income levels determined during a study in 2004 in Kampala (Kayaga and Franceys 2007). The income levels determined during the study are deemed to represent the NWSC residential customer base because the study looked at consumers connected to NWSC. The strength of the data from the report lies in the fact that household spending was used as a proxy for income levels. This is a good way of approximating household income in Kampala where most of the people are not formally employed. The only limitation is that the study looked at a very small sample which could result in a large margin of error.

Table 5.1 Kampala NWSC customer income ranges
Source: Kayaga and Franceys 2007

Income Category	Income Range (2004)	Income Range (2008)
Low	Less than 43000UGShill	Less than 503000UGShill
Middle	430001 – 1,200,000 UGShill	503001 – 1403000UGShill
High	More than 1,200,000 UGShill	More than 1403000 UGshill

The household income levels were adjusted by an annual rate of 6% which is equal to the rate of Uganda's economic growth and the income rates used for the modelling period are shown in Table 5.2 (DFID, 2006).

5.1.3 Billing Data

In water pricing studies, billing data is critical piece of information. This data was collected and sent by NWSC staff through File Transfer Protocols via the Internet in a Microsoft Access Database file. The billing data spanned a period of four years even though, billing data for a period of one year was used due to data processing and time limitations. Table 5.2 Billing data format shows the format of the data as received from NWSC

Table 5.2 Billing data format

Custref	Propref	Period	Net_Billing	Category	Volume
100000	13/33/152	200511	5,274.00	1	6.00
100001	13/34/231	200511	5,274.00	1	6.00
100002	14/34/272	200511	5,274.00	1	6.00
100003	15/38/76	200511	5,274.00	1	6.00
100004	19/31/145	200511	8,790.00	1	10.00
100005	9/35/40	200511	6,153.00	1	7.00

Cust-Ref : This is a unique billing code generated by the CUSTIM billing software. The number has no bearing on the accounts and changes from month to month

Prop-Ref : This is a unique geo-identity based on the Kampala block system. The first four digits are the block number as depicted in the block map while the last digits represent the account number in that block. The number of digits in the last section depends on the number of accounts in the block with accounts being allocated on a first come first serve basis. For example a Prop-Ref number of 21/25/110 represents customer number 110 in block 2125. It is important to note that any leading zeros are omitted when creating a Prop-Ref. For example, block 0908, customer 5 will have 9/8/5 as its Prop-Ref number.

Period: This is the period of month for which the person was billed and it is in the format yyyymm (year and month), for example, a billing period for August 2006 is represented as 200608.

Net Billing: This is the monetary value of the volume of water consumed in Uganda shillings. This is basically the product of the tariff rate and the volume consumed for that billing period.

Volume: This is the volume of water consumed during the billing period. The volume is in m^3 except for Category 4 and 6 which is in multiples of $1000m^3$.

Category: This represents different consumer categories and they are represented in figures one to six.

Category 1 represents domestic connection category which is basically home connections.

Category 2 represents commercial and industrial connections. These are for organizations which use water for financial gains.

Category 3 represents Institutional and Governmental connections. These are for all government parastatals and institutions as well as Non Governmental organizations.

Category 4 and 6 represents public stand pipes which are used by the underprivileged who can not afford water connections. These are run by kiosk operators who sell water to consumers and settle the bill with NWSC.

When receiving raw data, the first step is to ensure that it is in the format that can be used for the purpose it is intended for. The billing data from NWSC was received in Microsoft

Access database files. Since the tariff was to be modeled using Microsoft Excel, the data had to be transferred to Excel. Each file contained a year's billing data which consisted of about 800,000 rows of data, and therefore, due to a limit on the amount of data that can be saved directly from Assess to Excel (only 65000 rows at a time), the data had to be imported into Statistical Package for Social Sciences (SPSS) and then exported into Excel.

In order to select panel sample data for the year beginning June 2006 to May 2007 from the data provided, the following steps were followed

- the data was sorted according to month and all the data for months not falling in the required range were removed.
- The data was sorted according to category and data for category 2 to 6 were removed thus remaining with data for category 1 only.
- The remaining data for category 1 was then separated into twelve worksheets, one for each month.
- Unacceptable data was deleted, examples being, accounts with negative or zero volume and bill amounts, wrong Prop-Ref and category numbers. Cust-Ref number column was removed as it had no relevance to the study.

Due to the large number of accounts, it was decided that a 5% panel data sample would be adequate for this study. A random sample of 5 % from the June 2006 accounts was taken using SPSS. The sample was then exported to excel where the same accounts were now selected from the worksheets of the following months (July 2006 to May 2007). It was found that some of the accounts that were sampled from the month of June 2007 were not in the subsequent months, hence these accounts were removed. The reason these accounts were not in all the months could have been due to disconnections or they could have been removed when formatting the data. The final sample consisted of accounts that were billed for all the twelve months being considered (June 2006 – May 2007).

5.1.4 Water Consumption Estimates

In this study, it was decided to use water consumption estimates for each income category as guidelines for separating water usage among the different income groups. It is fully acknowledged that these estimates do not take into consideration water conservation but are based on current water usage. They are however they are used only as guidelines for each income category and not as standard for water conservation. The latest per capita consumption estimates are depicted in Beller consult et.al (2004) and are shown in Table 5.3. Average monthly consumption values are then calculated assuming a household occupancy rate of 5 people (UBOS, 2002).

Table 5.3 Gaba III water consumption estimates

Source: Beller Consult et.al. 2004

Income Category	**Per capita consumption (liters)**	**Monthly consumption per House hold (m3)**
High	144	22
Medium	100	18
Low	22	3

Monthly water consumption ranges were then calculated using the averages between the different income groups, assuming a household occupancy rate of 5 people. Table 5.6 shows the consumption blocks used in this study.

Table 5.4 Consumption ranges per income categories for Kampala

Source: Calculated by Author using information from Beller Consult et.al. 2004

Income Category	Water Consumption
High (Block 3)	Above 20
Medium (Block 2)	11 – 20
Low (Block 1)	Less than 11

5.2 Development of the Model

This model is based on the results of past studies showing that high income households consume more water than low income households (van Rensburg 2006). These results are also corroborated by the water consumption estimates for Kampala as shown in figure 5.3. The fact that water usage and price elasticity of demand varies with income, guided this study to look at the use of increasing block tariffs as a tool in water demand management. Increasing block tariffs, as explained in Chapter 2, provides a platform through which consumers with different water use patterns can be targeted differently while ensuring that fairness is achieved.

One approach that is commonly followed is to use the utilities revenue requirements as a basis for water pricing. This results in the model performing iterative calculations until the revenue requirements are met (Barkatullar, 1999). In this case study, it was specifically decided to price water using overall affordability as a criterion. This approach was motivated by the fact that, unlike in high income countries, issues of fairness are an important factor because of the high number of poor people. The following is a summary of the assumptions used in developing the model

- Water use depends on income category, with consumption increasing from low income user to high income users. This motivated the use of increasing block tariffs
- The water consumption estimates as presented in Beller Consult et.al. (2004) are still valid
- Each household uses its own water connection (there is no sharing of water connections).
- Annual water price increase due to indexation has no effect on the demand for water
- An annual income increase of 6% based on Uganda’s economic growth
- Average household demand does not change over the modelling period.
- Domestic water use patterns remain the same over the modelling period

5.2.1 Tariff Modeling

The model developed in this project follows the process flow chart shown in Figure 5.1. As mentioned in Section 3.4, a model has an input part, a decision making part and an output part. The model will be described in terms of the steps shown in the flow chart.

STEP 1

This step is the input part of the model. The following inputs are required for the model

- Panel data of 2701 billing data for 12 months
- Household occupancy rate
- Household income ranges
- Water consumption estimates (according to income class)
- Number of accounts at beginning and end of modeling year .

A sample of billing data collected as described in section 5.1.3 should be copied into the worksheet entitled "Bill Sample" while all the other inputs should be entered into the worksheet entitled Input.

STEP 2

The values of price elasticity of demand used in this study have been averaged over a year. It was therefore decided to use the average monthly water consumption for each household, hence the next step is to calculate the average monthly consumption. Each of the households is then assigned a water consumption block as determined in Table 5.4.

Following the World Banks recommendation that households should spend three to five percent of their income on water and sanitation services, it was decided in this study that households will not pay more than three percent of income for water. For each income range, three percent of the lower value was taken to be the amount paid by households on that income range. In the case of the first block, it was decided to use the minimum volume required for a person in Uganda which is 30 litres per person per day (WWAP 2006), as the basis for calculating the rate. For subsequent blocks, the lowest consumption volume in each block was used to calculate the rate for that block.

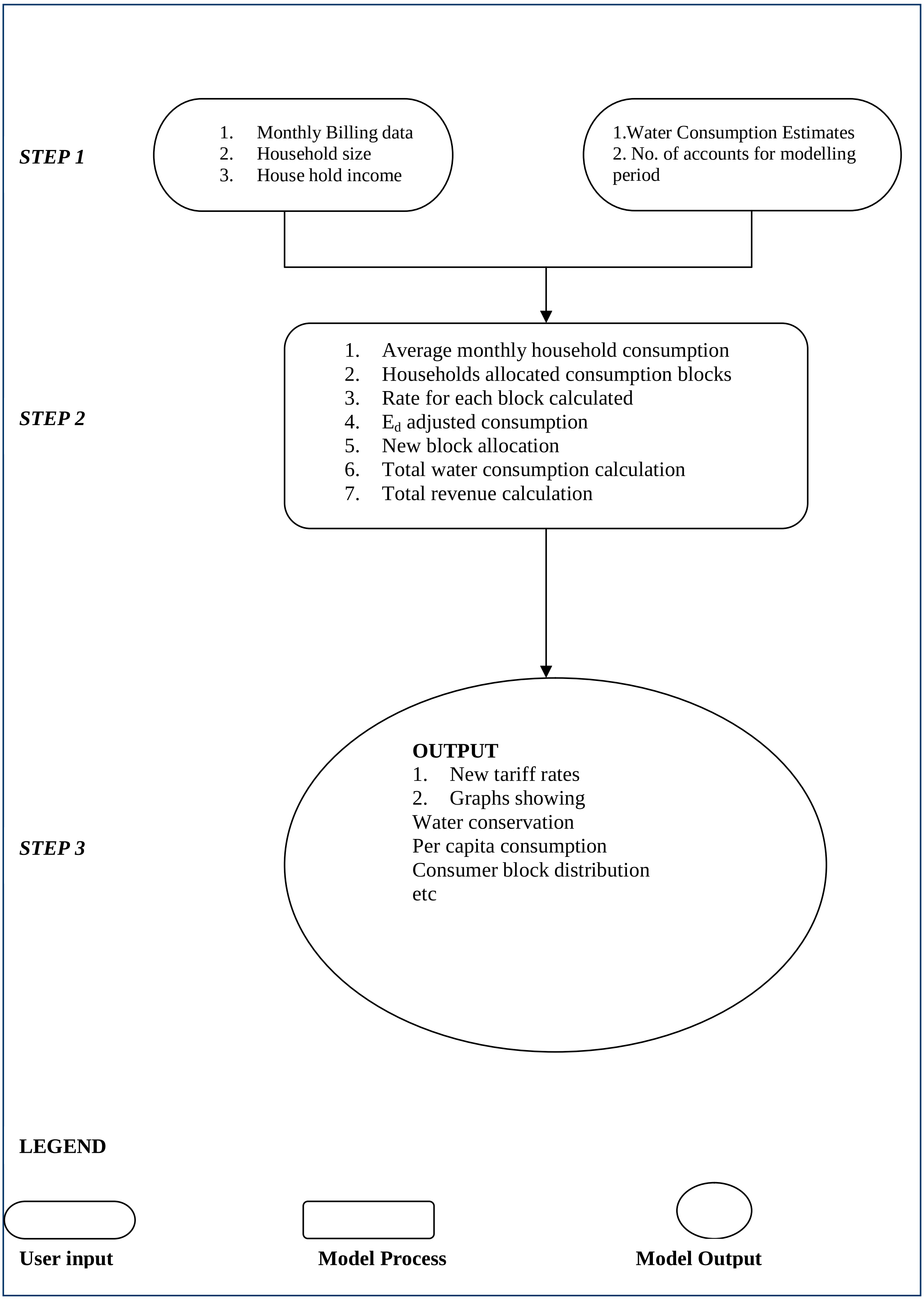

Figure 5.1 Tariff model flow chart

Using the rates determined above, the prevailing rates, as well as the price elasticity of demand, a new elasticity adjusted water consumption value is calculated for each household. This uses a rearranged equation for price elasticity of demand as shown below:

$$Q_2 = \left(1 + \left(\frac{P_2}{P_1} - 1\right) \times E_d\right) \times Q_1$$

Where Q_1 = initial quantity of water consumed

P_1 = initial price

P_2 = Price at current tariff

Q_2 = current Ed adjusted consumption

(Chestnutt et.al., 1997)

Since the new water consumption values are expected to be different from the current values, the consumers are then allocated new consumer categories based on their new consumption but still using Table 5.4 as a guideline. It is expected that some consumers will shift from higher blocks to lower blocks as they respond to increased prices.

The model then calculates the total water conserved by the proposed tariff, as well as the revenue increase that will be expected.

STEP 3

The final step of the model is to show in diagrammatical terms the comparison between the proposed tariff and the prevailing tariff. The first graph shows a diagrammatical representation of the tariff determined by the model with the current tariff shown on the same graph. Since the primary objective of the study is to model a water conservation tariff, the next graph shows total water usage for the prevailing tariff and for the proposed tariff. Other graphs are then used to show how consumers changed their water use in response to price change.

5.3 Discussion on Model Output

This section discusses the output of the tariff model. Figure 5.2 shows the input screen as it appears in the model for the results discussed in this section.

1	**Average House hold size**				5

	House hold income ranges (Uganda Shillings)				
		Min	**Max**	**Average**	
2	**Low**	181000	503000	342000	17
3	**Middle**	503001	1403000	953000.5	61
4	**High**	1403000			22

	Design Parameters	**Min**	**Max**
5	**Low income**	0	11
	Middle income	11.1	22
6	**High income**	22	

	Price elasticity of Demand	
10	Low income	0.23
11	Middle income	0.32
12	High income	0.99

14	**Expected No. of Connections for period being modelled for**	
	June	67759
	May	73942
15	Current Tariff rate	1213

Figure 5.2: Input screen for results discussed

Figure 5.3 shows a diagrammatical representation of the block tariff as determined by the model. Superimposed on the same figure is the current tariff. Block 1 consumers will be charged 1,190 UGShill/m^3, block 2 consumers will be charged 1372 UGShill/m^3 while those in block 3 will be charged UG 1913 UGShill/m^3.

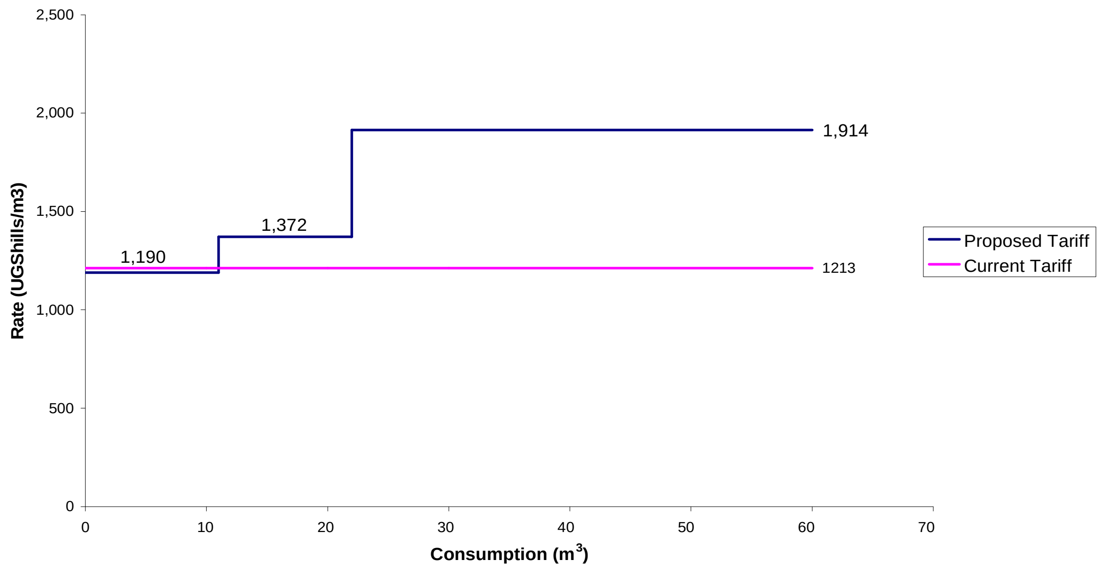

Figure 5.3: Proposed tariff and current tariff

The proposed tariff represents an average increase of 8% in the tariff. As shown in Figure 5.4 consumers in block 1 will experience a 2% decrease in tariffs while those in block 2 and block 3 will experience an increase of 13% and 58% respectively.

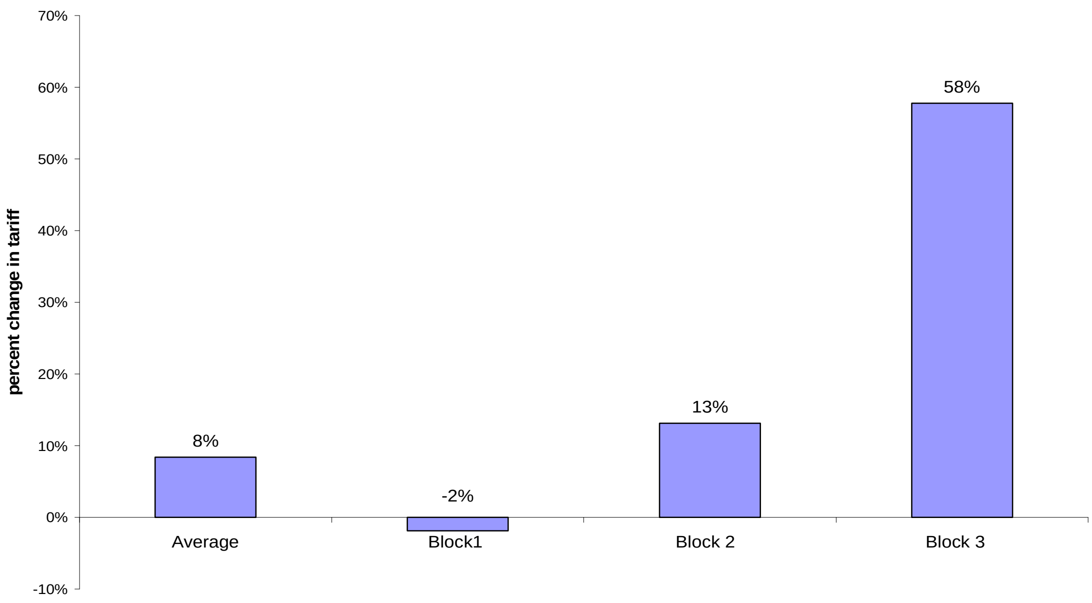

Figure 5.4 Percent change in tariff

Since the objective of this study is to model a tariff that will conserve water, Figure 5.5 shows the amount of water expected to be conserved by the proposed tariff as well as how consumers in the different consumer blocks are expected to change their water use behaviour in response to change in price. Block 1 total consumption is not expected to change while block 2 is expected to have an increase in water use and block 3 a reduction in total water use.

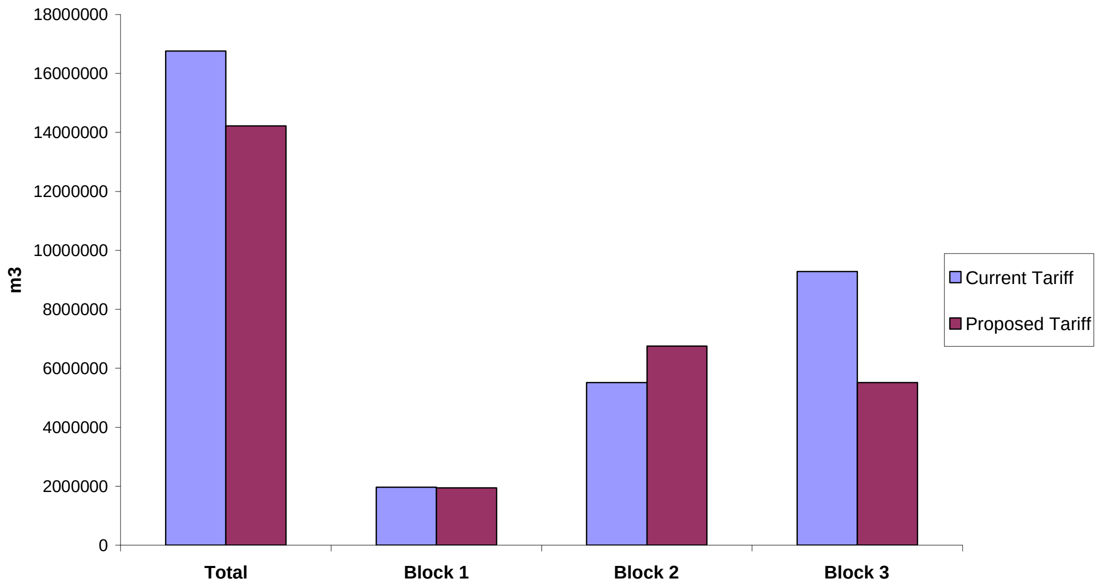

Figure 5.5 Water consumption for current and proposed tariff

The following graphs will be used to explain the dynamics behind this reduction in water use. Firstly, Figure 5.6 shows how per capita water consumption will be affected by the change in price. On average, per capita consumption is expected to reduce from 130 litres to 110 litres per day. As shown in the figure, the per capita consumption for block 1 and 2 is not expected to change a lot while that of block 3 consumers is expect to drop by 53 litres which represents a 21 % reduction.

Figure 5.7 goes on further to show the change in the proportion of users in different categories. The proportion of users in Block 3 is expected to decrease from 29% to 22%

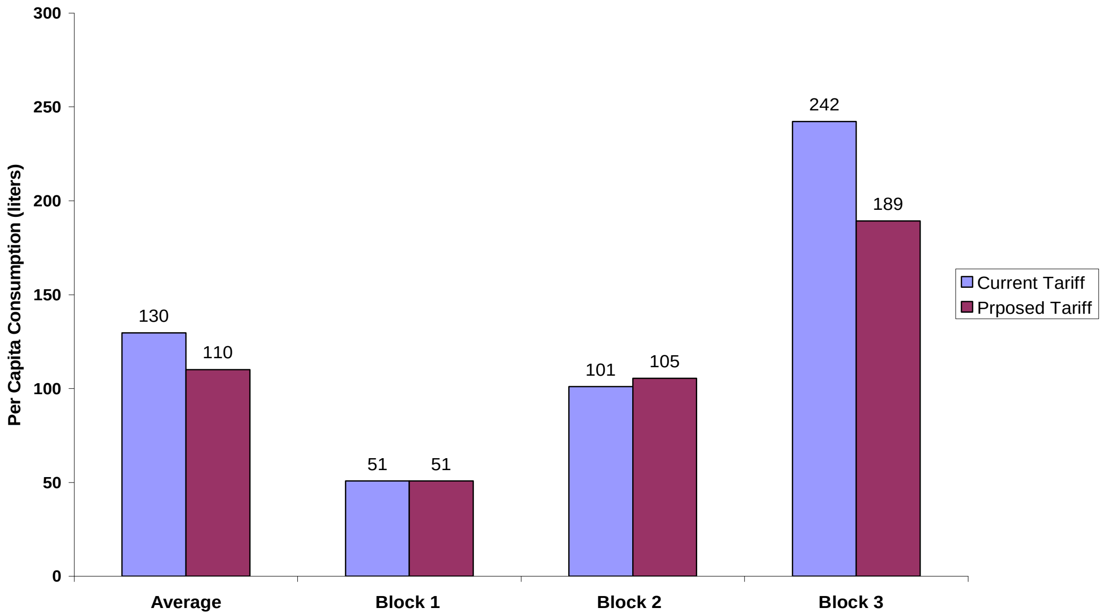

Figure 5.6 Per capita consumption for current tariff and for proposed tariff

while those in Block 2 is expected to increase from 49% to 41% and no change is expected in block 1. From the graph, it is evident that some block 3 consumers are expected to change their usage such that they end up in block 2 resulting in an increase in the number of people in block 2. On the other hand, a closer look at the figures in the model shows that, the number of block 1 users is expected to slightly go down as some consumers in block 1 move to block 2 in response to reduced prices of water in block 1. This change in consumption categories is expected to result in a significant overall water consumption (22%).

The high reduction in number of households in block 3 is in agreement with the principle of economics on price elasticity of demand. Consumers in block 3 have the highest elasticity of demand and hence they are expected to adjust their consumption such that a some of them end in block 2. In comparison, those in block 2 have a less elastic price elasticity of demand, and hence they had a smaller reduction in water usage.

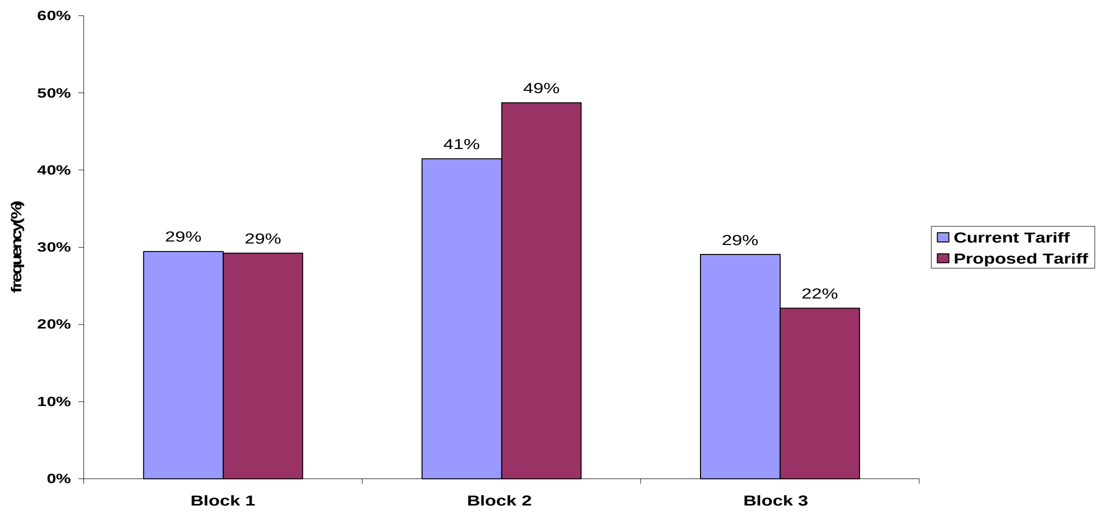

Figure 5.7 Consumption category frequency for current and for proposed tariff

According to Figure 5.8, with the current tariff, block 3 consumers who account for 29% of the total house connections in Kampala consume more than half (55%) of the water consumed by all the house connections. On the extreme side, block 1 consumers, who account for the same number of accounts as the ones in block 3 consume only 12% of the water consumed by the house connection. This state of affairs indicate that block 3 users use far too much water.

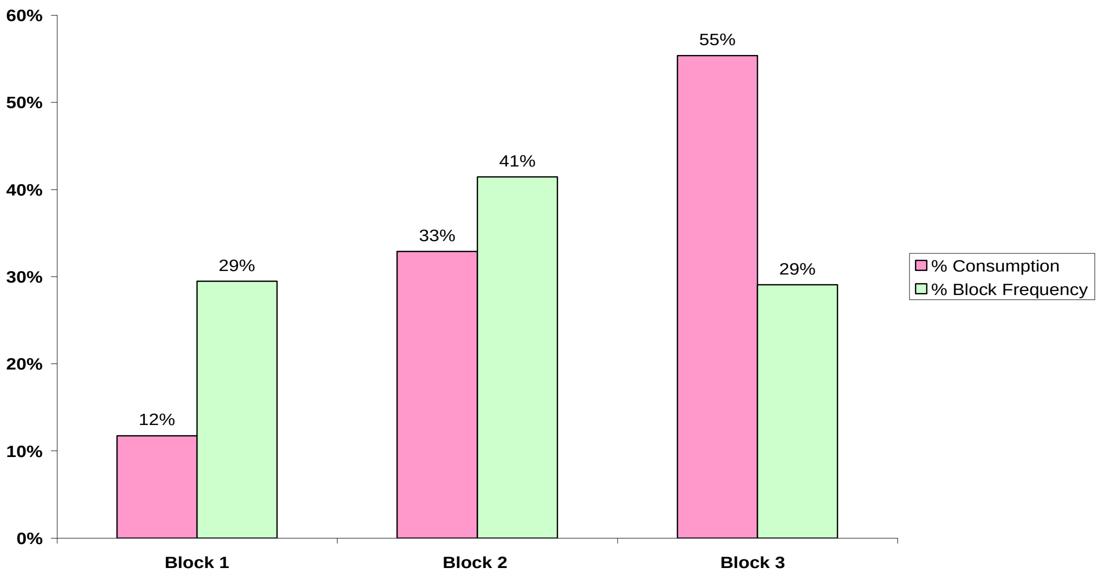

Figure 5.8: Block frequency and Consumption proportion per block for current tariff

Figure 5.9 then shows a similar graph to the one above, but this time with the proposed tariff. In this case, block 3 consumers are expected to make up 22 percent of all the domestic connections and to consume 39 percent of the water for domestic consumers. This is a slight improvement from the current tariff. On the other hand, block 2 consumers are expected to make up 49% of the domestic connections and to consume 48% of the water consumed by all the connected households.

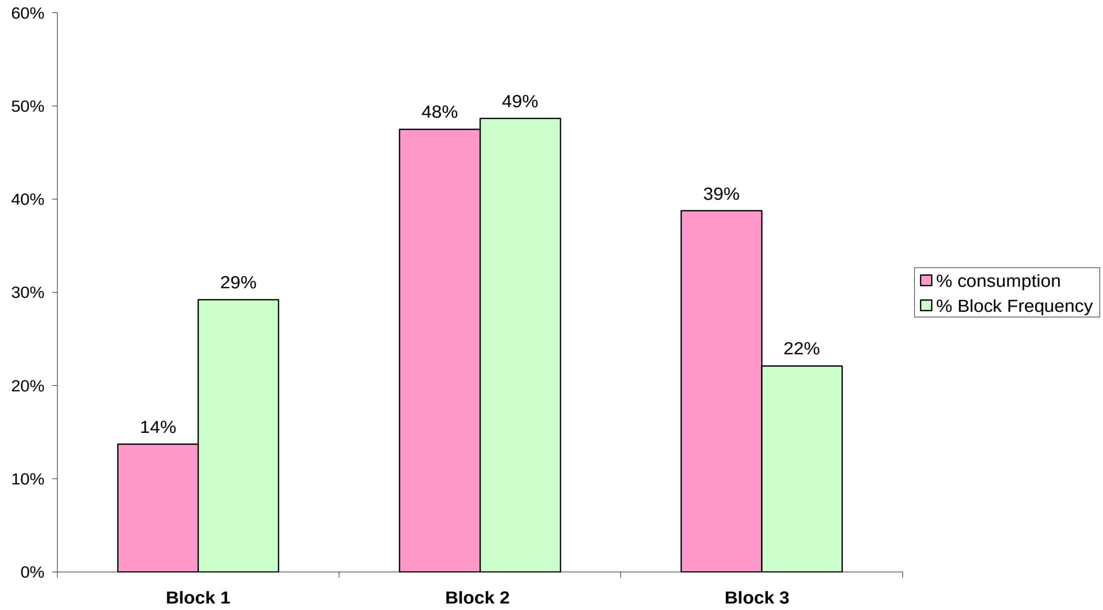

Figure 5.9: Block frequency and consumption proportion per block for current tariff

These changes were brought about by a combination of the change in per capita consumption and the shift in consumption categories by some households.

With the primary objective of the tariff being met, the next item to look at is how the proposed tariff affects revenue. Figure 5.10 shows an increase in revenue will be realized when using the proposed tariff. The revenue expected with the proposed tariff takes into account sales of water that has been conserved. This represents a eight percent increase in revenue.

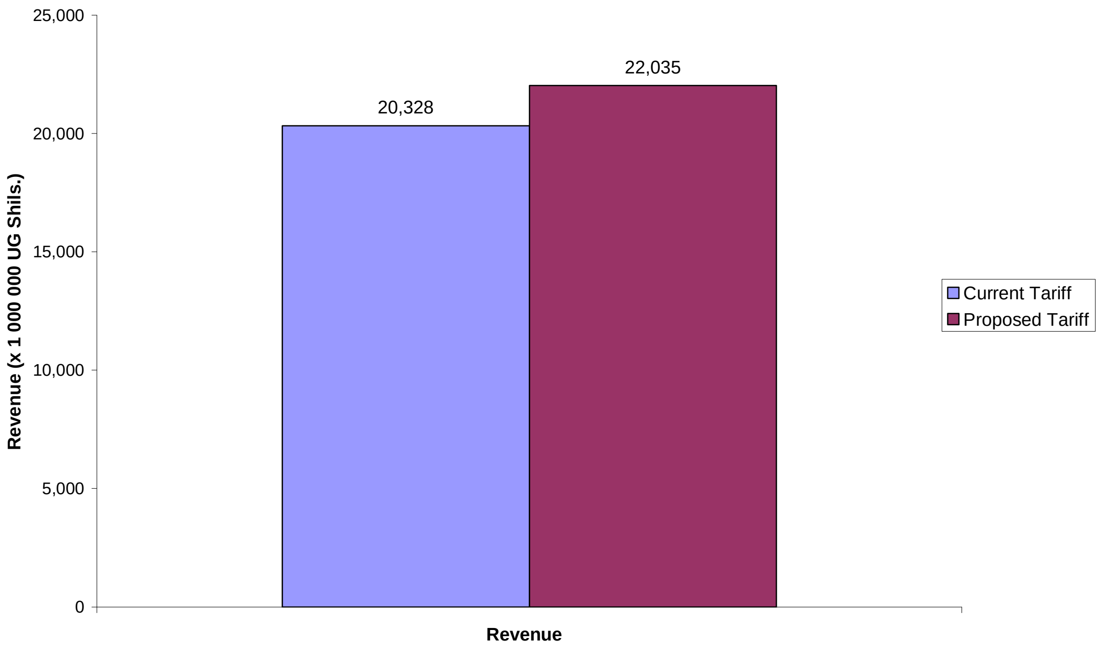

Figure 5.10: Revenue comparison for current and proposed tariff

As mentioned before, the water conserved in this case could be used to expand services, it would therefore be interesting to find out the number of people and subsequently the number of households that can be served by the conserved water. The model does a calculation and returns both the number of people and the number of households that can be served. The number of people that can be served is calculated by dividing the volume of water conserved daily by the average per capita consumption. This is then divided by household occupancy rate to get the number of households that can be served. In this case, the model shows that about 12600 households can be served with the water conserved by the proposed tariff. Supposing the water was diverted to low income people in slums with a per capita consumption of 20liters then some 69000 families could be provided with water. However in this case, the revenue realized would be lower as the tariff for the slum dwellers would be lower to reflect their income status.

5.3.1 Sensitivity Analysis

Due to the fact that the study depended mostly on secondary data and on parallel research to obtain data, it is not feasible to perform an error analysis on the different parameters discussed above. However, a limited sensitivity analysis was performed to show how a change in price elasticity of demand would affect the amount of water conserved and the revenue collected. Since the elasticity for high income is already high at 0.99, it was decided to reduce all the values of Ed in steps of 10% up to 50% and record the percentage of water conserved and the percentage change in revenue. Figure 5.11 shows the change in water conserved when the elasticity goes down. As expected the water conserved is reduced when elasticity is low.

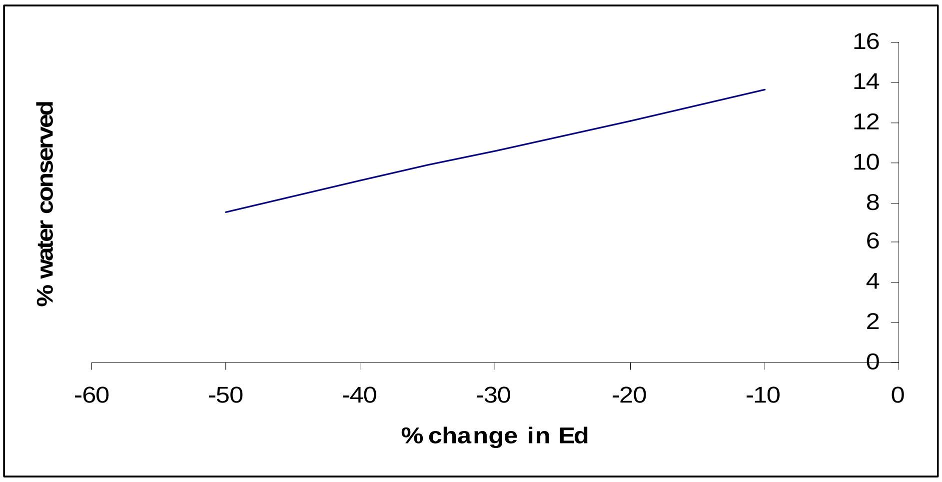

Figure 5.11 % change in water conserved against % change in Ed

On the other hand, the percentage change in revenue goes up when values of Ed are reduced. This is shown in Figure 5.12.

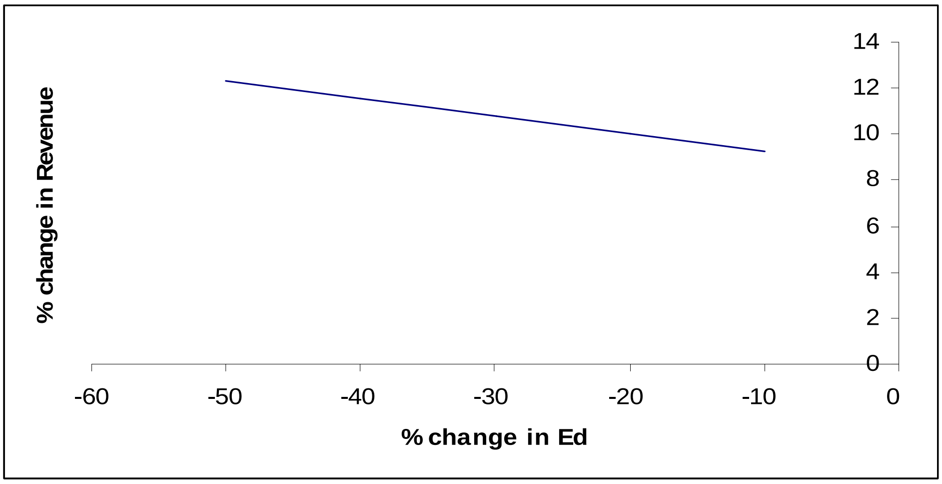

Figure 5.12 % change in revenue against percent change in Ed

Concluding Remarks

The major objective of this study has been achieved in that the tariff designed using this model results in water being conserved. The higher consumers in block 3, have been penalized for their high usage and they responded accordingly by reducing usage. The model has also ensured overall affordability in pricing of water for the people of Kampala. It has even gone to the extent of getting a reduction in rates for the poorer people of the city while increasing prices for those with higher income. The model then showed that the water conserved can be used to serve other households in the area resulting in an increase in revenue of about eight percent. It has been reported that the revenue collected by the utility using the current tariff covers operation, maintenance and depreciation costs. An increase in revenue will therefore improve the utilities cost recovery endeavours. Since all the households under this category are metered, the utility will be able to enforce the tariffs as it will be able to bill consumers. The structure of the proposed tariff is different from the current tariff, it is therefore important that the utility educates consumers on the new tariff structure so that they can be able to adjust consumption accordingly.

It is expected that the tariff will result in a positive improvement in the lives of people in Kampala. With the improvement in coverage due to the conserved water, the lives of people conserved can improve. Research has shown that people spend valuable time looking for water, when they could have used the time for economically rewarding activities (WWAP 2006). In addition for those who had less access to water, improvement in supply has been shown to improve their health status. Studies have shown that lack of water in slums results in health problems for the slum dwellers. Improvement in coverage, especially for the poor will also be in line with the Government of Uganda’s poverty eradication scheme which has since acknowledged water as a precursor to poverty eradication.

In summary, the modelled tariff has potential to benefit the utility in terms of increased revenue and less water shortage in the city. The people of Kampala could also benefit through increased coverage and less water shortages.

6 Conclusion and Recommendations

Increase in population and urban water demand is putting water utilities under a lot of pressure. Utilities, especially those in low-income countries, are not able to cope with high water demand mainly due to lack of adequate infrastructure and low cost recovery. The use of water demand management programmes could help in reducing water demand in these cities and help utilities increase their service coverage. NWSC, like other utilities in low-income countries, is working hard to reduce water shortage and improve water coverage in Kampala hence the need for water demand management measures. The overall objective of this study was to model a conserving water tariff for the city of Kampala.

The methodology used in this research involved data collection through literature review, using secondary data from NWSC and developing a model using Microsoft Excel. It is felt that the methodology used was appropriate for the study, however, the author feels that a field trip could have been helpful in collecting primary data that could have led to better model results. This shortcoming was countered by ensuring that the model developed was flexible enough to accept changes on it.

This chapter discusses and summarises the key findings from the study and then gives key recommendations associated with the recommended tariff.

6.1 Conclusion

The study showed that household income has a significant influence on household water consumption patterns, with high income households using more water and the opposite being true for low income households. The price elasticity of demand has also been shown to differ according to household income. Based on these findings, the study focused on sending unique price messages to different consumers using overall affordability as a criterion. Hence the model developed has three blocks, one each for low, middle and high income households. The proposed tariff, resulted in a 2% decrease in tariffs for the low-income while the middle and high income households had a tariff increase of 13% and 58% respectively. On average the tariff went up by 8 %.

Results from the model show that 15 % could be saved when using the proposed tariff. This would be mostly from the block 3 consumers reacting to the price signal. As shown, the consumers in this block reduce their usage such that their capita consumption drops significantly. Results showed that the low income users would not reduce their usage while middle income and high income users would change usage. The model also showed that the utility will increase its revenue by about eight percent which would increase the utility's cost recovery status.

The study then went on to show that the water conserved could be used to increase coverage by connecting about 12600 households which would result in positive social, economic and health benefits to the people of Kampala.

6.2 Recommendations

It is recommended that the following issues be looked at if the Utility decided to embark on water demand management programme.

1. This study looked at using water tariffs as a tool in water demand management. Research has, however, shown that for the use of water tariffs to be successful they have to be part of a water demand management programme. It is therefore recommended that the utility adopt a water demand management strategy that will encompass issues on policy, pricing, public education campaigns and others as mentioned in chapter 2. Due to the success of the utilities Corporate Strategies, it is highly recommended that the WDM strategy be incorporated into the next strategy.

2. Tariff setting has always been a sensitive and controversial issue. It is therefore recommended that the utility should involve all stakeholders, including customers possibly through the use of focus groups, when dealing with tariff setting.

3. The study relied on secondary data and hence it is important for the utility to carry out studies pertaining to important parameters such as elasticity of demand for Kampala, household income encompassing a wider customer base and an evaluation of water use patterns.
4. It is recommended that a study be conducted on water conserving tariffs for the other categories that were not looked at in this study. This will give a wholesome picture of the effect of tariffs on water demand management.

Finally, it is important to note that models are guiding tools and they should be used in conjunction with other tools that will ensure full participation of all stakeholders. As such this study fully recommends that consumers be taken on board when working towards adjusting tariffs.

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