

CHAPTER 1: SETTING

1.1 Background

Water is considered one of the most essential of all natural resources (Tietenberg, 1992). Current thinking recognises that water resources are an economic good and hence should be defined within a market structure and allocated according to some 'efficient' market price. However due to the nature of water as a social, financial, economic and environmental resource that is subject to spatial and temporal changes it is not easy to determine an appropriate set of prices (Kay et al., 1997; Winpenny, 1994; World Bank, 1993; McDonald and Kay, 1988).

Globally water is classified as a scarce resource in terms of quality where the physical supply is abundant and high levels of pollution and recycling limit access to clean water; and scarce in terms of quantity where climate changes and use patterns are rapidly dwindling established supply sources (Tietenberg, 1992; OECD, 1987; Kahn, 1998). Combined with the inevitable imbalance of water resources in terms of form, quality, location and the temporal characteristic of its nature (OECD, 1987), many countries are expected to reach levels of crisis within the next twenty to thirty years. Engelman and Leroy in Kay et al. (1997), state that 28 countries with an aggregate population of 338 million are currently recognised as water stressed (freshwater supplies of only 1,000 to 1,600 cubic meters per capita per year). Twenty of these have an annual supply of less than 1,000 cubic meters per capita per annum, classifying them as water scarce. Scarcity or shortage referred to here not only describes the limits of some variant condition of the hydrological cycle, but includes the boundaries reflected in economic terms by the gap between the quantity supplied and the quantity demanded of the resource, water (Darr et al, 1976). Barney, in Tietenberg, (1992) estimated that "by the year 2000, world-wide global water supplies would only be three and a half times the demand due to population growth".

1.2 The nature of water

Water is defined by Hassan (1997b) as having the following characteristics:

- It is a public good (by interpretation, not privately owned).
- The renewable supply is governed by the hydrological cycle and the long-run elasticity of water supply is relatively inelastic.

- It is essential to the existence of human life, as well as to the functioning of ecosystems and the perpetuation of biodiversity.
- Water has no substitutes.

Based on the classical theory of public goods and the definition proposed by Samuelson (1954 and 1955) this view implies non-exclusion and non-rivalry in the consumption of water resources, characteristics that are pertinent to developing water economies or situations where supply schemes are operated below their capacity constraints. These views on water as a resource for basic needs are however, challenged by Randall (1981) in his review of the definition of public goods and hence the characteristics of water resources. Accordingly, Randall (1981) recognises four axes of classification for economic goods based on the "possibility that the good may be provided by markets and the possibility that its provision may be pareto-efficient", they are: divisible and exclusive goods, divisible and non-exclusive goods, indivisible and exclusive goods, and indivisible and non-exclusive goods. Based on this work it is evident that water resources and the management thereof can result in rivalry and excludability with allocations falling short of pareto-efficient goals.

The primary source of fresh water comes from precipitation, with stocks held in the form of lakes, rivers, reservoirs and underground aquifers. Precipitation varies considerably within annual timeframes and between years. Constant flow patterns are not normally observed. Floods may follow droughts from one year to the next. Erratic climatic conditions further exacerbate the global unpredictability of precipitation. The spatial characteristics of water means that in some countries scarcity is not necessarily a national problem but may be severe in certain regions, compounded by the demand dependent nature of certain sectors over other sectors. Globally, agriculture is regarded as the largest user of water, followed by industry and households respectively. These observations are often even more skewed for developing countries that have invested a large part of their economies into agriculture (World Bank, 1993).

1.3 Approaches to water resources management

Historical approaches to water resources management have focussed on supply-side management. Demand needs were met through increasing the supply of water, through reservoir construction, infrastructure development, inter-basin transfers and transboundary schemes. These approaches are becoming increasingly expensive due to the costs of infrastructure, operation and maintenance costs, inaccessibility to exploitable

water sources and the spatial distances that need to be covered. No charge was made to account for the opportunity cost or scarcity value of the resource itself. Consequently, water was regarded as almost a 'free good'.

Water demand management approaches provide a means by which user demands may be satisfied without resorting to costly and timely supply-side development. Two approaches to demand-side management are the use of market and non-market incentives to influence user behaviour. The most popular market incentive depends on pricing (water tariffs) followed by water markets, auctioning and pollution charges. Non-market incentives such as: restrictions, education and persuasion, and quotas and norms may also prove beneficial but have generally been evaluated in conjunction with pricing changes, as a result their direct impacts are often difficult to identify (Winpenny, 1994). Demand management aims to elicit desirable changes in the quantities of water demanded by consumers through intervention (both public and private), in an attempt to remove inefficiencies and inelastic supply gaps (Hassan, 1997b). The economist's role in determining the most efficient demand-supply solution will depend not only upon information about consumers incomes, tastes and preferences, the prices of substitutes and compliments, but most importantly on the behavioural response of the consumer to changes in water prices (Darr et al, 1976).

1.4 South Africa

An example of a country that is moving away from supply-side solutions towards demand management in order to cope with water scarcity problems is South Africa. It is situated at the southern most tip of the African continent and is bordered by four countries namely, Namibia, Botswana, Zimbabwe and Mozambique. It is regarded as the economic powerhouse of the South. The country has a total surface area of 1,2 million km^2 and is mapped by a number of perennial rivers, many of which are shared by its bordering countries, for example, the Orange River, shared by Namibia and Lesotho. Rivers are the main source of water in South Africa and approximately 77 percent of the population of 45,5 million have access to safe water (DBSA, 1998). Due to large income discrepancies the ability of large sectors of the population to cover the costs of service provision are limited. In spite of South Africa's extensive services infrastructure and technological efforts, it is becoming less feasible to continue with the development of supply-side approaches to extract exploitable water resources in order to address the water needs within the country, due to the escalating associated costs. Combined with the annual

precipitation of only 500mm per annum and increasing demands, it is expected that current supplies will soon be surpassed by demand. As a result, demand management provides invaluable options for addressing existing inefficiencies and meeting new demands.

In response to the emerging demands on water resources, the Department of Water Affairs in South Africa has undergone a major reform in its water policy evidenced in the compilation of the New Water Act (Act 36, 1998). The new water act addresses issues of equity distribution, efficiency in water use and recognises a reserve allowance to meet primary and environmental water needs. It also discusses the importance of allocating a 'true value' to the nation's water resources. The South African government is determined to redefine water resources as national assets and to establish pricing mechanisms that ensure that efficiency goals are met in conjunction with equity and socio-political goals. One important aspect of this move towards resource pricing is the responsiveness (elasticities) of consumers/ users to these price changes. If users appear to be unresponsive to price changes then government needs to consider other policy measures in order to achieve the desired policy goals.

1.5 Problem statement

In spite of South Africa's extensive infrastructural developments and technological efforts, the development of currently exploitable water resources is no longer feasible due to the high associated costs. In addition, concerns around the ability of existing supplies to meet future water demand are growing. Combined with a semi-arid to arid climate and an annual precipitation of about 500mm per capita, per annum, South Africa is recognised as being a country approaching levels of severe water scarcity. Simultaneously, the Department of Water Affairs and Forestry has undertaken to supply the first block of water for basic needs free of charge. Water demand management, due to the constraints of scarcity and increasing demand is being widely adopted in order to address water management. An inclusive component of this strategy is the economic pricing of water and the new National Water Act for South Africa encompasses this very principle. However, pricing only serves to influence demand patterns where consumers are responsive to price. By understanding the behavioural responses of users to the prices of water, government may be better able to allocate and manage water resources efficiently, furthermore a clearer understanding of the value of water will facilitate allocation of the resource in its 'best alternative use'. This study aims to debate the effectiveness of

demand management for the Tshwane Municipality thereby providing policy recommendations on water pricing management options for the city's water sector.

1.6 Hypothesis

In light of the current emphasis on demand management in South Africa, it is expected that correct pricing may be used as a mechanism for altering demand patterns for water resources within the country. This thesis therefore hypothesises that pricing is an effective tool for water demand management. In order to test this hypothesis the following sub-hypotheses will be tested:

- Residential water demand is price inelastic with the locus of the estimate of elasticity near to that found for arid or semi-arid regions, between 0 and –1.
- Agricultural smallholdings water demand is price elastic with a locus of the estimate of price elasticity between –1 and -∞.
- Industrial water demand is more price elastic with a locus of the estimate of price elasticity closer to –1.

1.7 Objectives and motivation of the study

In response to the policy questions posed by water managers across the country, this study will focus on one specific municipality in order to account for homogeneity in the explanatory variables and aim to achieve the following objectives:

- Collect time-series data on prices and quantities of water used in the Pretoria municipality.
- Derive demand curves for water for the following sub-sectors within the municipality:
- Domestic demand (for middle and low income users)
- Agricultural small- holdings
- Industrial demand
- Estimate the short and long run price elasticities of demand for water in the Pretoria municipality.
- Record and analyse the results.
- Determine a value for water for the municipality based on Gibbons (1986) approach.
- Provide policy recommendations on the results.

1.8 Research methodology

In order to address the policy problem of whether supply pricing mechanisms can be used to encourage a reduction in the quantity of water demand for various user categories, it is necessary to know the level of demand from which elasticities may be determined based on the functional form of the estimated equation.

For the purposes of this study time-series data for different cross-sections of the Tshwane Municipality will be used. This secondary data on prices and quantities is available for the five years (1995 – 2000) disaggregated monthly. Data prior to this time is not available due to the unfortunate incidence of fire destroying previous records. The data is already categorised according to certain user groups based on the reporting structure of the municipality. Further data on influencing characteristics such as rainfall and temperature was obtained from the South African Weather Bureau on a monthly basis.

A model for residential water demand, based on utility theory shown below, will be estimated for the various user categories using ordinary least squares analysis. From the results, elasticities will be obtained in order to inform the role of pricing in water resources.

The generic model will be as follows:

$$quantity\ demanded\ water\ = f\left(\begin{array}{c} average\ price, marginal\ price, number\ of\ users, rainfall, maximum\ temperature, \\ household\ income, population, seasons \end{array}\right)$$

with specifications for three levels of users, namely domestic use, agricultural small-holding use and industrial use as follows:

$$Q_{wd} = f\left(P_{wd}, Other\right) \quad (1\text{-}1)$$

$$Q_{wa} = f\left(P_{wa}, Other\right) \quad (1\text{-}2)$$

$$Q_{wi} = f\left(P_{wi}, Other\right) \quad (1\text{-}3)$$

Where,

Q_w = the quantity of water per capita per annum (cubic meters)

P_{wd} = the price of water (per cubic meter) in Pretoria for domestic use

P_{wa} = the price of water (per cubic meter) for agricultural small holdings

P_{wi} = the price of water (per cubic meter) for industries with Pretoria

from which the derivative of a log function will yield the price elasticity's of demand for water as follows:

$$\frac{\partial Q}{\partial P} < 0, \quad for\ each\ \text{sec}tor \tag{1-4}$$

1.9 Outline of the study

This study will be set out as follows: Chapter 2 provides a background to water availability and use within South Africa, while chapter 3 reviews the literature on various approaches to water demand management. Chapter 4 builds the link between water economics and pricing and reviews the role of demand curves and elasticities. Chapter 5 is a continuation of the literature review with specific focus on the methodology of estimating demand functions and the choice of methodology for this study. Chapter 6 provides a description of the data variables, summarises the estimations and provides an analysis of the results. Finally, chapter 7 gives recommendations for policy based on these results.