Aspects of the Economics of Water Management in Urban Settings in South Africa, with a focus on Cape Town

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ABSTRACT

Concerns about the sufficiency of freshwater supplies and the impact of water shortages have placed sustainable water management on the global agenda. This is particularly relevant in South Africa, a country with precipitation rates well below the global average and water resources that have become highly polluted. The scarcity of water for consumption use and of unpolluted water bodies as recreational and environmental good highlights the need for an economic analysis of these issues. This dissertation investigates some economic aspects of water management in the South African context in two distinctive parts. Part One (Chapters 2 to 5) aims to provide an understanding of urban water demand and analyses water pricing as demand management tool. Part Two (Chapters 6 and 7) analyses the values people attach to water resources for recreational and environmental purposes. Quantitative methodological approaches are predominantly used to inform an economic perspective on water demand management.

The extent of water scarcity is discussed in Chapter Two. South Africa is approaching physical water scarcity, but many poor households do not yet have access to water and basic sanitation facilities, i.e. there is also economic water scarcity. Given this background, Chapter Three focuses on water demand management as part of an integrated water management approach. The role of water prices is discussed, in particular the Increasing Block Tariff (IBT) structure which is predominantly used in South Africa.

Chapter Four estimates the price elasticity of demand for water using household water consumption records obtained from the City of Cape Town (CCT). A distinctive feature of this case study is a survey undertaken to collect household information on demographic and water-use characteristics, as water databases are severely lacking in South Africa. The results show water demand to be mostly price inelastic, which concurs with findings from international empirical literature. Furthermore, higher-income households are found to be more sensitive to price changes, thus some reduction in water consumption can be achieved by increasing marginal prices at the upper end of the IBT structure.

Chapter Five analyses the IBT structure as a redistributive tool. Particular attention is given to the Free Basic Water policy of South Africa, which allows each household to receive six kilolitres of water free per month. Empirical modelling indicates that the IBT structure in its current form holds limited benefits for the poor, given the state of service

delivery in South Africa: the lack of access to the water network prevents the poorest households from being the recipients of the cross-subsidisation occurring in an IBT structure.

Part Two studies urban water resources as recreational and environmental goods. The literature review of environmental valuation techniques in Chapter Six places particular emphasis on the Contingent Valuation Method. This method is applied in Chapter Seven, where the value of improving the environmental quality of a freshwater urban lake is analysed in a middle- to low-income urban area. Another survey was undertaken specifically for this purpose of gauging the willingness to pay for improved recreational facilities and water quality of Zeekoevlei. The results show that low-income households do attach value to urban environmental goods, a result which adds to our knowledge of willingness to pay for environmental goods in developing countries.

OPSOMMING

Besorgdheid oor die toereikenheid van varswaterbronne en die impak van watertekorte het volhoubare waterbestuur op die wêreldagenda geplaas. Dit is veral relevant vir Suid-Afrika, 'n land met neerslagkoerse ver onder die wêreld gemiddelde en waterbronne wat hoogs besoedeld geword het. Die skaarsheid van water vir verbruik en van onbesoedelde waterbronne as ontspannings- en omgewingsproduk, beklemtoon die noodsaaklikheid vir 'n ekonomiese analise van hierdie kwessies. Hierdie proefskrif ondersoek sekere ekonomiese aspekte van waterbestuur in die Suid-Afrikaanse konteks, in twee dele. Deel Een (Hoofstukke Twee tot Vyf) beoog om insig te verskaf oor die stedelike vraag na water en analiseer die prys van water as 'n vraagbestuursmaatstaf. Deel Twee (Hoofstukke Ses en Sewe) ontleed die waarde wat mense heg aan waterbronne vir ontspannings- en omgewingsdoeleindes. Kwantitatiewe metodologiese benaderinge word hoofsaaklik gebruik om 'n ekonomiese perspektief op watervraag bestuur toe te lig.

Die omvang van waterskaarsheid in Suid-Afrika word in Hoofstuk Twee bespreek. Hierdie hoofstuk dui aan dat Suid-Afrika besig is om fisiese waterskaarste te bereik, maar die land het ook baie arm huishoudings wat nog nie toegang tot water en basiese sanitasiefasiliteite het nie, dw.s. wat daar is ook ekonomiese waterskaarsheid. Gegewe hierdie agtergrond, fokus Hoofstuk Drie op watervraagbestuur, as deel van 'n geïntegreerde waterbestuursbenadering. Die rol van waterpryse word bespreek, veral die Stygende-Blok-Tarief (SBT) struktuur wat grotendeels in Suid-Afrika gebruik word.

Hoofstuk Vier bepaal die pryselastisiteit van vraag vir water met behulp van huishoudelike waterverbruiksdata, verkry vanaf die Stad Kaapstad. 'n Kenmerkende eienskap van hierdie gevallestudie is die ingesamelde huishoudelike inligting oor demografiese en waterverbruik-eienskappe, aangesien daar ‘n groot tekort aan water-databasisse in Suid-Afrika is. Die uitslae toon dat watervraag meestal prysonelasties is, wat ooreenstem met bevindinge van ander empiriese literatuur. Verder word gevind dat hoë-inkomste huishoudings meer sensitief is vir prysveranderinge. Dus sal 'n afname in waterverbruik bewerkstellig kan word deur marginale pryse aan die hoër kant van die SBT struktuur te verhoog.

Hoofstuk Vyf ondersoek die SBT struktuur as 'n effektiewe herverdelingsmaatstaf. Spesifieke aandag word aan die Gratis Basiese Water-beleid van Suid-Afrika geskenk, wat

voorsiening maak dat elke huishouding ses kiloliter water per maand verniet ontvang. Die bevindinge van empiriese modellering is dat die SBT struktuur, soos dit tans in Suid-Afrika toegepas word, beperkte voordele vir die armes inhou, gegewe die huidige stand van watervoorsiening in Suid-Afrika. As gevolg van die agterstand met betrekking tot toegang tot water, ontvang die heel armes nie die voordele van kruissubsidiëring wat plaasvind onder 'n SBT struktuur nie.

Deel Twee bestudeer stedelike waterbronne as ontspannings- en omgewingsprodukte. Hoofstuk Ses verskaf 'n literatuur oorsig oor omgewingswaardasie tegnieke, met 'n spesieke fokus op die Kontingente Waardasie-metode. Hierdie metode word in Hoofstuk Sewe toegepas, waar die waarde van verbeteringe in die omgewingskwaliteit van 'n varswatermeer in 'n middel- tot lae-komste stedelike gebied ondersoek word. Nog 'n opname is gedoen met die doel om die bereidwilligheid om te betaal vir verbeterde ontspanningsfasiliteite en die waterkwaliteit van Zeekoevlei te meet. Die bevindinge toon dat lae-inkomste huishoudings wel waarde heg aan stedelike omgewingsprodukte.

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LIST OF ABBREVIATIONS

AP	-	Average Price
CCT	-	City of Cape Town
CMA	-	Cape Metropolitan Area
CVM	-	Contingent Valuation Method
FBW	-	Free Basic Water
GDP	-	Gross Domestic Product
GHS	-	General Household Survey
GLS	-	Generalised Least Squares
GNUC	-	Greater Nelspruit Utility Company
IBT	-	Increasing Block Tariff
IBT-cap	-	Increasing Block Tariff per capita water consumed
IRT	-	Increasing Rate Tariff
IRT-cap	-	Increasing Rate Tariff per capita water consumed
IUCN	-	International Union for Conservation of Nature
IWRP	-	Integrated Water Resource Planning
MP	-	Marginal Price
OLS	-	Ordinary Least Squares
PCSE	-	Panel Corrected Standard Errors
RDP	-	Reconstruction and Development Programme
RSP	-	Rate Structure Premium
SADC	-	Southern Africa Development Community
SES	-	Socioeconomic Status
UK	-	United Kingdom
UPR	-	Uniform Price with Rebate
USA	-	United States of America
UNESCO	-	United Nations Educational, Scientific and Cultural Organization
2SLS	-	Two Stage Least Squares
VAT	-	Value Added Tax
VDT	-	Volume Differentiated Tariff
WCWSS	-	Western Cape Water Supply System
WTP	-	Willingness to Pay

INTRODUCTION

CHAPTER ONE
Introduction

> ***"Water … lies at the heart of a nexus of social, economic, and political issues – agriculture, energy, cities, trade, finance, national security, and human livelihoods within rich and poor countries alike. Water is not only the indispensable ingredient for life, seen by many as a right, but also indisputably an economic and social good unlike any other."***
>
> (World Economic Forum, 2011: 3)

1.1 The scope and significance of this dissertation

This dissertation investigates some key economic aspects of water management in the South African context. It contributes towards an understanding of the structure of the demand for water by analysing the influence of price changes on quantity demanded, as well as of the value that people attach to water resources for recreational and environmental purposes. This information is particularly relevant in a country where water resources are becoming increasingly scarce. Given that pricing is administratively determined, water managers have a potential lever to manage water demand (Olmstead 2010) if they have access to and use information on the price elasticity of demand. Furthermore, knowledge on the welfare effects of declining levels of water quality may contribute to more effective management of urban environmental resources for the benefit of society and the environment.

The main contribution of this dissertation lies in the presentation and analysis of the results of two surveys that were especially undertaken for the dissertation; the first to improve our understanding of the demand for water in some urban communities in Cape Town, and the second to determine what value people in low- and middle income suburbs in Cape Town attach to the use of water as a recreational and environmental good. The analyses of these primary data sources are therefore key aspects of this dissertation.

Other chapters deal with more general issues with regard to water as an economic good. They provide an analysis of some secondary South African data related to, *inter alia*, access to water, the equity impact of water tariff structures, as well as the policy of providing free basic water.

1.2 Statement of the problem

Water resources are dwindling and a water crisis is imminent in many regions of the world. This has profound implications for food security, people's health and the functioning of aquatic ecosystems. If appropriate action is not taken, water scarcity problems will worsen and adversely affect humanity (Jury and Vaux, 2007).

The availability of water is influenced by factors such as climate change and pollution, which affect both the quantity and quality of surface water and groundwater. Climate change causes increased global temperatures, which may increase precipitation in certain regions. However, the accompanying increase in potential evapotranspiration could lead to reduced runoff and a decline in renewable water supplies (Jury and Vaux, 2007: 42). Polluted rivers and streams affect agricultural production and negatively affect people's health. Child mortality from exposure to polluted water, for example, has become a big threat with five times more children dying of diarrhoea than of HIV/AIDS worldwide[1] (World Economic Forum, 2011: 132). Pollution of water bodies also adversely affects social welfare, as it reduces the value of water as a recreational and environmental good.

Pressures from the supply- and demand-side have resulted in *physical water scarcity*, and almost all water resources have been allocated. *Economic water scarcity*, in contrast, occurs as a result of the "lack of capital investment or appropriate institutions to support the use of that capital" (Chartres and Varma, 2011: 10 - 12). This causes many poor households to remain without access to water and basic sanitation, even in areas where water is available. The problem of pollution is exacerbated by economic water scarcity, as urbanisation and expanding urban informal settlements contribute to increased urban runoff.

A further problem relates to how water resources have been managed. Institutional inefficiencies have contributed to the lack of access to safe water for consumption and food production, the degradation of water resources and the destruction of wetlands (Cosgrove and Rijsberman, 2000). Attempts to deal with water scarcity have focused primarily on addressing supply shortages, including options such as building or enlarging dams, drilling wells and building water transfer facilities (e.g. pump stations and pipelines)

[1] In the World Health Organisation's African region, diarrhoeal diseases cause more child deaths than AIDS (UNICEF, 2008: 9).

between various water catchment areas. Although new technologies allow for the development of new water sources (e.g. the desalination of sea water), these measures are relatively costly. Desalination in particular has adverse side-effects, since it contributes to the emission of greenhouse gases (Gössling and Hall, 2006). Less attention has been given to institutional mechanisms that influence water management, such as pricing water at full economic cost or taking account of the value of ecosystem functioning.

More recently, water managers have come to realise that water as an economic, social and environmental good requires careful management and as such a more integrated approach. Water resource management encompasses a number of issues and relies on a variety of role players to extract, produce, allocate and distribute water to various sectors and to ensure its preservation as an environmental resource. Therefore, if water resources are to be managed to ensure sustainable use of resources, the behaviour and perceptions of these water users must be incorporated into the decision-making process. Water demand management policies are therefore essential components of an integrated approach towards water resource management.

Water demand management is defined as the use of strategies by water institutions to influence water demand in order to meet diverse objectives (Ali, 2010: 150) and focuses on reducing water consumption to reconcile water supply with demand. Conventional theory argues that household demand for water depends on the price of water, on income and on a range of other factors such as household size and climatic conditions. Water managers can therefore, in principle, achieve a reduction in water consumption by using water pricing as demand management strategy. Water pricing has received much attention in recent years and there are many empirical studies, particularly in developed countries, which estimate the impact of water price changes on the consumption of water.

One of the arguments in favour of using water pricing as demand management tool is that relatively high prices will discourage large-volume users. However, the price elasticity of demand may differ between different categories of households, for example between poor and rich households. Varying consumption patterns between households depend on different lifestyles and habits, which vary with income (Ayadi, Krishnakumar and Matoussi, 2002). If demand for water is price inelastic, substantial increases in price would be required to bring about large reductions in water consumption. Water pricing as demand management tool has therefore not been a popular option, given the belief that its effect as conservation tool is minimal.

The impact of water price changes on poor households is another concern. In most developing countries the tariff structure is used as vehicle to address concerns about the affordability of water. The increasing block tariff (IBT) structure is often implemented, since it is believed that it can fulfil multiple objectives. This tariff structure allows water users to pay different marginal prices for different quantities of water, with increasing marginal prices as consumption increases. Lower-income households are assumed to consume less water and it is considered more equitable to charge higher marginal prices to large-volume users, who usually own more water-using appliances and have large gardens (Whittington, 1992: 75). The IBT structure therefore allows for the cross-subsidisation of water consumption from the rich to the poor.

Assisting the poor by using the tariff structure is, however, controversial. Studies have shown that the use of the IBT structure as subsidy mechanism does not necessarily benefit the poor. A common problem is the assumption that all households have access to safe drinking water through a metered water connection. Inadequate access to water and sanitation, however, is still a huge problem for many households in developing countries (Whittington, 1992). In many instances, these households have to purchase water from a second source at a much higher price (for example, from a neighbouring household with access to piped water). Families also often live in shared accommodation, making the IBT structure less effective as a tool for equity. It is therefore possible that intended benefits will not reach the poor.

Reducing water consumption and improving affordability to the poor through the tariff structure are not the only considerations in an integrated water management approach. Water resources serve urban communities in various other ways. Lakes, rivers and streams are used for recreational purposes and there is an environmental value to conserve water bodies, since they contribute to the effective functioning of ecosystems. On the other hand, polluted rivers, streams and lakes pose health risks to individuals and decrease the potential value of these water bodies as recreational and environmental sites, particularly in urban communities. The value that people attach to water bodies and the impact of pollution on their welfare must therefore also be considered in an integrated management approach.

In South Africa water resource management has also received much attention in recent years, given that the country is approaching a situation of physical water scarcity. South Africa is a dry country with an average annual rainfall of 450 mm per year, about half of the world average (Department of Environmental Affairs, 2006: 145). Rainfall is seasonal and unevenly distributed across the country. In combination with high temperatures and high rates of evaporation, this implies low rates of groundwater recharge (Ashton and Haasbroek, 2002). On the other hand, population growth together with rapid urbanisation and industrialisation has led to an increasing demand for water. A related problem is economic water scarcity, as many poor households in South Africa do not yet have access to safe drinking water or basic sanitation facilities.

Given the current state of water resources in South Africa, sustainable water management is therefore crucial. Water policy and legislation have been developed and enacted which make water demand management an essential part of water management policy. Water pricing is a key element of South Africa's water demand management strategy. Setting the appropriate water pricing structure, though, is a complex task, since it has to comply with multiple objectives and legislation set at national level.

Municipalities in South Africa generally make use of the IBT structure. However, even though water pricing is considered an important tool to reduce consumption, economic principles seldom form an integral part of the tariff-setting process. Hosking (2011: 49) investigated the tariff setting process of fourteen municipalities in South Africa and found that none of them used marginal cost pricing principles as a guide for setting tariffs. Water pricing has therefore not received adequate recognition for its economic role in achieving water conservation. Furthermore, information on how households respond to prices (i.e. the price elasticity of demand) does not form part of the tariff adjustment process, as water managers usually do not possess this information. These types of studies are therefore essential to formulate effective demand management strategies.

A related aspect regarding water pricing is whether an IBT structure can assist the poor by making water more affordable. South African water policy prescribes that the first six kilolitres of water used per month be free of charge to households, i.e. the Free Basic Water (FBW) policy. The question arises whether this water subsidy mechanism will achieve cross-subsidisation from the rich to (the really) poor households. A poorly designed tariff structure may cause most of the subsidy to flow to unintended recipients.

1.3 Research objectives and questions

This dissertation is divided into two distinctive parts (a more detailed outline of the structure is provided in Section 1.4). Part One of the dissertation (Chapters Two to Five) focuses specifically on pricing, both as a demand management tool and on whether it is an appropriate vehicle to provide water subsidies to poor households. Part Two (Chapters Six and Seven) explores the value urban communities attach to water as a recreational and environmental good.

The primary research objective in Part One is to determine to what extent water pricing can be used as demand management tool, i.e. to investigate households' responsiveness to price changes. A secondary research objective is to investigate the distributional implications of the IBT structure as it is applied in South Africa, i.e. to analyse the extent of cross-subsidisation under the IBT structure.

The following research questions will be addressed in Part One:

- What is the price elasticity of demand for water in the domestic sector, particularly for urban households?
- How do these elasticity estimates affect tariff setting, in order to comply with demand management goals?
- Does the IBT structure supplemented by the FBW policy (as it is currently implemented by most urban municipalities) ensure that the benefits of water subsidies reach the poorest households?
- What types of modifications to the IBT structure, alternative pricing structures or other subsidy mechanisms can be considered in order to achieve the stated objectives?

Part Two of the dissertation examines the value of water resources (e.g. lakes and wetlands) for urban households. In many instances these water bodies become polluted as a result of domestic and commercial activities in surrounding areas. Local governments are generally responsible for the rehabilitation and preservation of lakes and wetlands. However, given their other pressing priorities (such as the provision of basic services), less attention is given to environmental conservation. These environmental goods, however, provide important functions and have recreational and environmental value. Thus, the benefit of these water bodies extends beyond society's essential needs for water. The primary objective of this part of the dissertation is therefore to establish the value of water as a recreational and environmental good in urban communities.

The primary research questions in Part Two are as follows:

- What are the values attached to water resources such as lakes, in an urban setting?
- Do lower-income households place a value on urban environmental goods?

1.4 Methodology and structure of dissertation

As indicated earlier, the dissertation is organised into two parts. Chapter One (this chapter) provides an overall introduction to the dissertation topic, stating the research questions, the methodology and structure of the study.

Part One analyses water pricing as demand management tool in an urban setting. The focus is on two specific aspects; how pricing (and more specifically the IBT structure) can be used to reduce water consumption, and whether equity concerns should be addressed in the tariff structure. Part One commences in Chapter Two with an overview of water scarcity in South Africa, in both physical and economic terms. Chapter Two also presents some empirical information on the water scarcity problem, using household survey data from Statistics South Africa – the General Household Surveys and the Community Survey – to analyse access to water and sanitation over a period of eight years (2002 to 2009). Probit models are used to identify the factors associated with improved household access to piped water and sanitation facilities.

A review of the literature relating to water demand management follows in Chapter Three. Different types of water demand management strategies are discussed and a distinction is made between regulatory options (such as water restrictions and water-saving technologies) and economic instruments (such as water pricing). The main focus, however, remains on water pricing (specifically the IBT structure).

The manner in which households respond to price (tariff) changes is analysed in Chapter Four, which estimates the price elasticity of demand for water in urban areas. This case study uses water consumption records of selected households obtained from the City of Cape Town (CCT). Since no micro-dataset exists for this type of study, a distinctive feature of the study is the survey questionnaire that was conducted to obtain information on households' demographic and water-use characteristics. The data collection process was undertaken in five suburbs within the jurisdiction of the CCT. The results can provide useful insights into the price responsiveness of households in an urban setting.

Microeconometric modelling is used to estimate the price elasticity of demand. A literature review informs methodological specifications to estimate the price elasticity of demand for water. In particular, an instrumental variable approach is used to account for endogeneity in the water demand data. Furthermore, the pricing variables included in the regression analysis follow methodological approaches in the existing demand estimation literature.

Chapter Five analyses the distributional impact of IBT structures by exploring who benefits from the water subsidies implicit in the IBT structure, using the same dataset as in the previous chapter. The empirical investigation categorises the households from the CCT dataset into income deciles (using an asset index) and determines average water consumption per income decile. Using access to water statistics for South Africa and an extrapolation to the South African income distribution, water consumption for the South African sample is inferred. The extent of cross-subsidisation is then analysed by considering how much households would have to pay for water under alternative tariff structure scenarios. A literature review complements this analysis and explores modifications to the IBT structure to enhance the targeting of water subsidies to poor households.

As indicated, Part Two of this dissertation emphasises the role of water resources as recreational and environmental goods within an urban setting. Chapter Six provides a literature review of environmental valuation techniques (including methodological specifications and empirical evidence). Particular emphasis is given to the Contingent Valuation Method (CVM), which mainly relies on direct questioning of people about their willingness to pay for an improvement in the quantity or quality of environmental goods or services.

Chapter Seven applies the CVM to determine the value of less polluted water resources and improved recreational facilities for households in communities surrounding a freshwater urban lake, Zeekoevlei, situated in an area of Cape Town known as the Cape Flats. The residents of these suburbs completed questionnaires on their willingness to pay for improved recreational facilities and for an improvement in the water quality of the lake.

Econometric techniques such as interval regression and tobit regression models are used to determine the value of Zeekoevlei.

Chapter Eight presents a summary of the main findings of the dissertation.

1.5 Contribution of this research

This dissertation ventures into a research domain in which the lack of data seriously inhibits empirical analyses and the understanding of important economic phenomena in the South African context. Even though there are extensive South African household data sources, statistical data with regard to water and its management are often lacking. Calfucoy, Cibulka, Davison, Hinds and Park (2009) investigated the provision of free basic water in South Africa and indicated that, even though they were able to access extensive data made available by the South African government on many websites, they were unable to locate (electronically) information on such aspects as water consumption. They mentioned that although such data were collected and updated by municipalities, it was not available to the public. They listed various types of data that would be useful in the empirical analysis of water provision. This includes, inter alia, information on household members, their monthly water consumption, the type of service they receive, and the price elasticity of demand for different categories of households (Calfucoy et al. 2009: 51). The data constraints were also emphasised by Essop and Moses (2009), who attempted an analysis of the fiscal incidence of free basic service provision in South Africa. Given this background, this dissertation makes a new contribution to the empirical literature by analysing primary water data collected in Cape Town, which include some of the information referred to above. To the author's knowledge there are very few South African empirical demand studies.

Two earlier studies (Veck and Bill (2000), and Van Vuuren, Van Zyl, Veck and Bill (2004)) used the Contingent Valuation Method (CVM) to estimate price elasticities based on a hypothetical market setting. Studies that used actual water consumption records include that of Bailey and Buckley (2004). They used household water billing data from the Durban metropolitan municipality and property values to determine the price elasticity of demand for low-, middle- and high-income households. More recently, Szabo (2009) completed a demand study in one of Pretoria's poorer suburbs in which she used household data obtained from the water provider. However, none of these studies had primary data on household demographics, their income or water-use characteristics. This makes the demand study in this dissertation unique, since a distinctive feature of the analysis in Part One is the household survey conducted amongst households in five Cape Town suburbs.

Another significant contribution in Part One is the quantitative analysis of the distributional implications of the IBT structure. Even though there are some studies who have investigated the impact of FBW on the poor, many used qualitative approaches. The research in this study aims to make a contribution in this regard by applying quantitative research techniques in the analysis of the FBW policy.

A final contribution lies in the estimation of the value of urban water bodies to society other than for essential consumption and production activities. The methodology applied is the CVM, which is not new to South Africa, as quite a number of empirical studies have used the same methodology. However, few studies have been performed in the context in which the case study was completed. The environmental good (i.e. the lake) is situated in an urban area which is inhabited mostly by middle- to lower-income households (who are generally expected to place a lower value on the environment). Therefore, the main contribution in Part Two is another household survey, which provides information on the value these people attach to water in their communities.

Taken together, the contribution of this dissertation lies in the application of the methodologies of Economics to the issue of water – for consumption and for recreation – in a mainly urban setting in Cape Town, South Africa. The author hopes that this small contribution is a step towards expanding the pool of knowledge about the Economics of Water in developing countries generally, in South Africa in particular, and especially in the context of poor urban communities.

PART ONE

WATER PRICING AS DEMAND MANAGEMENT STRATEGY IN THE SOUTH AFRICAN CONTEXT

CHAPTER TWO

Water Scarcity in South Africa - an Empirical Analysis

2.1 Introduction

Water is a necessity for human life; it is used for essential consumption activities, such as drinking water and sanitation and for domestic activities such as watering the garden and for swimming pools. In addition, many people use water resources (e.g. lakes and rivers) for recreational activities such as surfing, boating and fishing. At the same time there is a need to use water in the production of goods and services and it is also needed for environmental services. According to Rosegrant, Cai and Cline (2002), water development is essential to the livelihood of people, as well for ensuring growth in the industrial sector and for environmental sustainability.

The stock of freshwater resources depends on a number of factors. First, replenishment of the resource depends on the rate of precipitation and evaporation; this in turn is affected by climate change, which impacts on both the quantity and quality of water (IPCC, 2007). The increased temperatures expected with global warming will affect the hydrological cycle, leading to changes in precipitation and the occurrence of drought in some regions, whilst others experience floods. In addition, pollution affects water quality. This is mainly a result of human activities such as deforestation, which leads to soil erosion and therefore to increased levels of sedimentation. Furthermore, domestic, agricultural and industrial discharges into rivers and streams affect the water quality; as a result water becomes unsafe to consume, and drinking this water can lead to health problems.

The demand for water is primarily determined by human activities. The size of the population affects the demand for domestic consumption and sanitation facilities. People also use water for other uses, such as recreational activities, i.e. swimming, boating, surfing and fishing; these activities are influenced by the quantity and the quality of the available water. Moreover, as the urban population grows, so does the demand for water and sanitation facilities. If this is not accompanied by an expansion of the appropriate water infrastructure facilities, water quality will be affected. In addition, climatic conditions can also alter the demand for water: increased temperatures may cause people to consume more water. Other factors that influence the demand side are changes in the irrigation requirements of the agricultural sector and increased water consumption by manufacturers.

Changes in the factors affecting water supply and demand can lead to water scarcity in many regions. As has been mentioned, climate change and pollution can adversely affect the quantity and the quality of the water supply, resulting in water scarcity. Moreover, the growth in population and increasing urbanisation are some of the demand-side changes that contribute to increasing water scarcity. According to the United Nations (2009), the world population is projected to increase by 4 201 million people from 2009 to 2050.[2] It can therefore be expected that satisfying the basic needs of water consumption and producing goods and services that use water resources will become one of the biggest challenges in the 21st century. A compounding factor relates to economic water scarcity, a situation where the inability to provide adequate water and sanitation infrastructure leads to backlogs in access to water and sanitation services.

The scarcity of water resources in South Africa is an increasing concern as the country is situated in a semi-arid region; its annual precipitation is below the world average and it experiences high evaporation rates (Department of Water Affairs and Forestry, 2004). Furthermore, the rate at which the water quality is declining is a related concern; pollution of rivers and streams and underground water resources is a major problem in South Africa. De Villiers and Thiart (2007: 343) investigated the nutrient status of the 20 largest river catchments in South Africa and found that only one catchment did not exceed the recommended water quality guidelines. Some of the more likely reasons for the level of pollution were found to be runoff from sewerage plants and human settlements. In addition to the physical supply constraints, the demand for water is increasing as the country experiences growth in population and urbanisation.

This chapter provides an overview of the water scarcity problem, with particular emphasis on the water resource situation in South Africa. It commences with some definitions of water scarcity, distinguishing primarily between physical and economic scarcity. This is followed by a brief overview of water scarcity at the global level, and then by a more detailed discussion of South African water scarcity issues. This section has a two-fold purpose: the first part will discuss the increasing scarcity of the resource due to dwindling

[2] This estimate is based on the assumption of a constant fertility variant scenario.

water resources, whereas the second part elaborates on water scarcity in terms of access to and availability of water to households in South Africa.

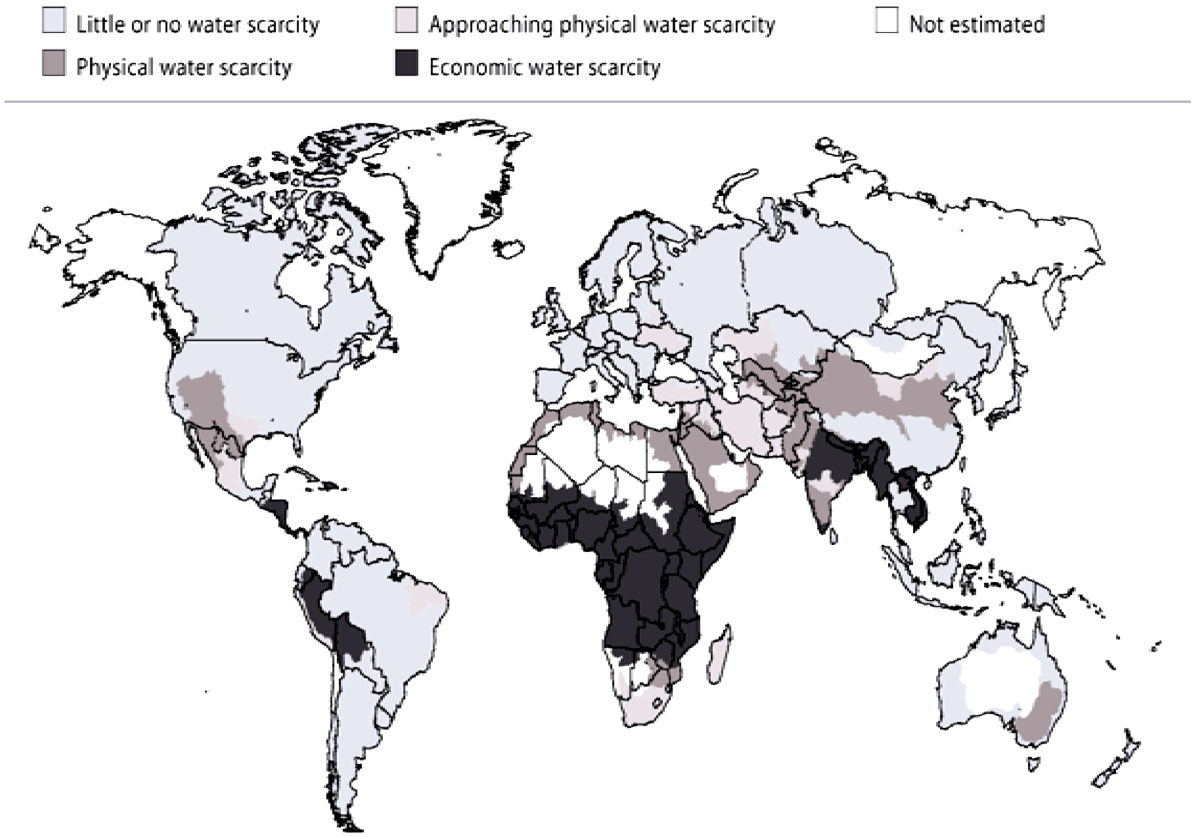
2.2 Water scarcity - Some Definitions and a Global Perspective

Water scarcity can be defined in various ways. Rijsberman (2006: 6) refers to a person as 'water insecure' if that person does not have access to water that is safe and affordable, such that consumption needs can be fulfilled. If this occurs for a sizeable area and for a number of people in the area, the area can be referred to as 'water scarce'. However, Rijsberman (2006: 6) points out that it is not easy to define water scarcity, as a number of factors play a role in determining whether an area can be classified as water scarce. These may include the way the needs of people are defined, whether the requirements of the environment have been accounted for, the percentage of the water resource made available for these needs, and the temporal and spatial scales used in defining scarcity.

A measurement of the scarcity of water is usually based on some relationship between the water resources available and the human population that depends on these resources, i.e. water availability per person per year (Rijsberman, 2006: 7). One measure developed to indicate the level of water stress is the Falkenmark Water Stress Index. According to Gleick (2002), Falkenmark used population and water availability to develop a measure that indicates how many people can be supported by a country's natural water resources. The Falkenmark Water Stress Index sets the water availability per capita per year threshold at 1700 cubic metres, given estimates of sectoral and environmental requirements (Rijsberman, 2006). Countries with a reading of between 1 000 and 1 700 cubic metres per capita per year are considered water stressed. If the water supply falls below 1 000 cubic metres, a region is considered water scarce, and if it falls below 500 cubic metres this indicates absolute water scarcity. Another measure used to express water scarcity is the Water Resources Vulnerability Index, which represents the total annual water withdrawals as a percentage of the water resources available, where the withdrawals refer to the water extracted from the ground, streams and rivers to meet the needs of people (Rijsberman, 2006: 8). Water is considered extremely scarce if annual water withdrawals exceed more than 40% of the annual supply.

An alternative definition of water scarcity draws a distinction between physical and economic water scarcity (Comprehensive Assessment of Water Management in Agriculture, 2007). Physical water scarcity refers to having inadequate resources to meet the demand for water. Sandford (2009: 25) defines it as a state where water use approaches sustainable limits of supply. It is especially the arid regions which experience physical water scarcity. Economic water scarcity, in contrast, is the result of insufficient investment in water infrastructure to cater for the increasing demand for water, or of institutional constraints which make it difficult to ensure the equitable distribution of water, especially where people are too poor to obtain access to water services. According to Van Koppen (2003), this type of water scarcity often prevails in Africa, as some countries do not have the economic resources to develop their water resources. One of the exceptions is South Africa, where the physically available water has already been developed (Van Koppen, 2003: 1048). Figure 2.1 shows a world map indicating varying degrees of water scarcity experienced by different countries.

Figure 2.1: Physical and economic water scarcity

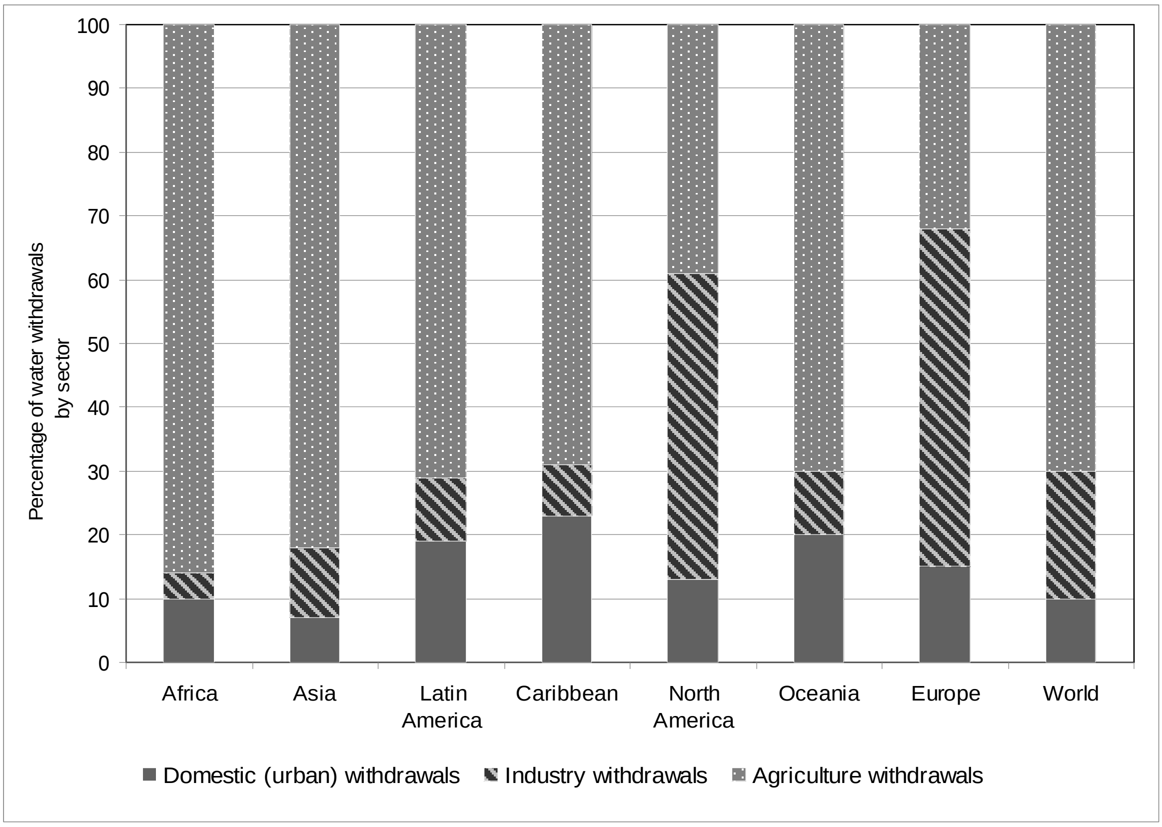


Source: Areas of physical and economic water scarcity (2008)

Although the world surface has an abundant supply of water, this mostly consists of salt water. Only 2.5% of all water resources are fresh water and much of this is difficult to obtain since it is locked up in underground aquifers (Kuylenstierna, Najlis and Björklund, 1998). Even though rainfall may replenish these sources, they are not evenly distributed worldwide. Therefore some regions have an abundance of fresh water resources, whereas others are classified as arid.

Water is primarily used by three sectors in the economy, namely industry, agriculture, and domestic users. According to UNESCO (2009), 70% of the available water in the world is used in the agricultural sector, as illustrated in Figure 2.2. In low- and middle-income countries the agricultural sector uses most water, as their economies are still heavily reliant on agriculture. In Africa, for example, 86% of the available water is used by the agricultural sector. In high-income countries, however, the industrial sector is the main user of water. Figure 2.2 shows that in Europe, 53% of the available water resources are used by the industrial sector. According to Sullivan (2002), a country's level of development is reflected in its use of water. Those countries with a higher GDP per capita tend to use more water, especially in the industrial sector. This implies that increasing demands will be placed on water resources in developing countries as these countries become more industrialised.

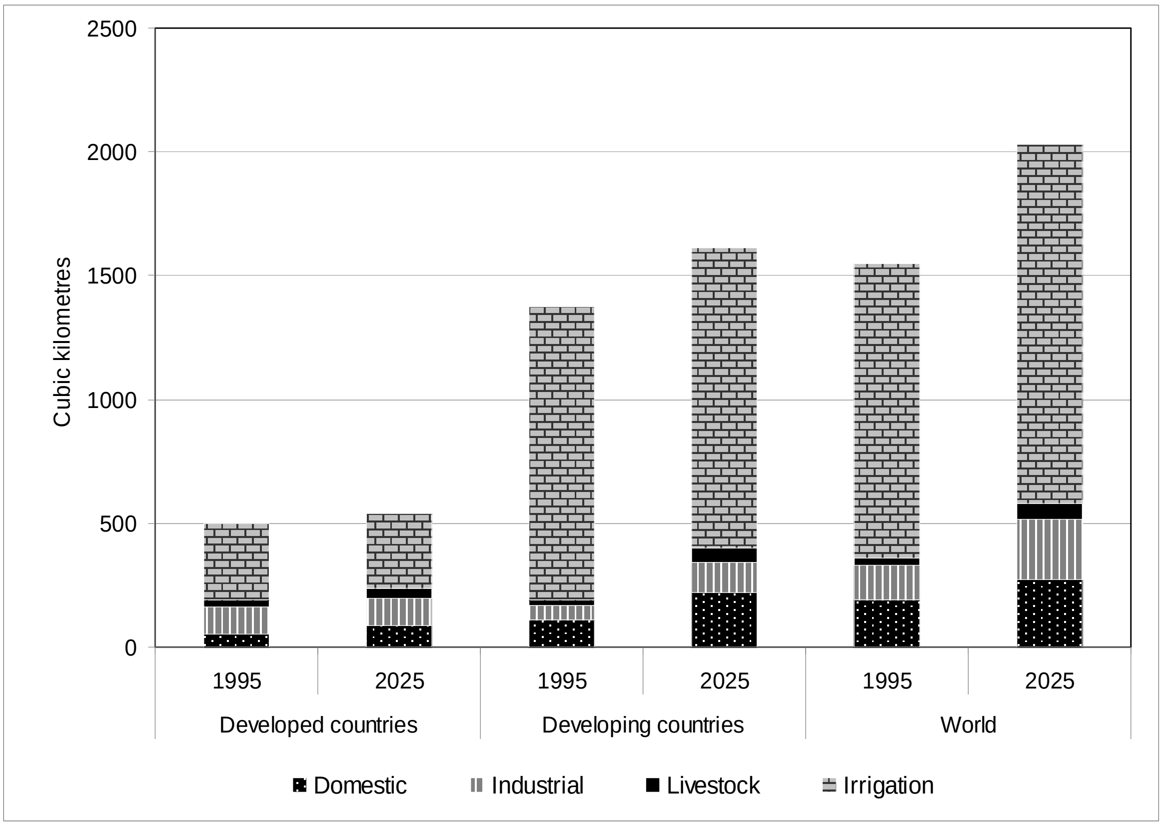
Figure 2.2: Water withdrawals by world region, 2000



Source: UNESCO (2009)

Figure 2.3 shows the projected global use of water by the different sectors in 2025. It shows that the demand for water from the industrial sector is expected to increase at a faster rate in developing countries. At the same time, even though water use by the agricultural sector is expected to grow at a slower rate, it is expected that by 2025 this sector will still make the greatest demand on water resources in the developing world.

Figure 2.3: Projected uses of water: 1995 to 2025[3]



Source: Rosegrant et al. (2002)

Around the world countries have begun to experience increasing scarcity of freshwater relative to growing demand. Rijsberman (2006: 9) states that no matter how water scarcity is analysed, the general conclusion is that almost two-thirds of the world population will be affected by water scarcity. An earlier study by the International Water Management Institute (Seckler, Amarasinghe, Molden, de Silva, and Barker (1998), as cited in Seckler, Barker and Amarasinghe (1999: 29)), estimated that approximately 1.4 billion people reside in regions where severe water scarcity will occur early in the 21st century. In addition, by 2025 absolute water scarcity will become a reality for more than 1 billion people in arid regions. Physical water scarcity is the result of an increasing demand for water due to high population growth, changing lifestyles brought about by economic growth, and climate change. These factors are discussed in more detail below.

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[3] Figure 2.3 indicates that irrigation currently consumes the largest share of water in developed countries, and this trend will continue in the future. This may seem to contrast information in Figure 2.2, where the proportion of water used for agriculture by Europe and North America is the smallest. The information for both illustrations, however, has been sourced from different sources and this discrepancy may be due to the way developed regions have been defined, as well as the classification of water use for agriculture and irrigation.

2.2.1 Population growth and urbanisation

Demographic change has major implications for the demand for water. According to the United Nations (2009), the projected world population is estimated at approximately 11 billion people in 2050 (based on a constant-fertility variant scenario), of whom 87% will reside in less developed regions. The increased growth causes a higher demand for water to fulfil consumptive needs, but it also leads to a greater demand for food. This implies even more pressure on resources to produce goods and services.

At the same time, urbanisation has increased in most parts of the world. In 1970, approximately 67% of the world's population resided in rural areas (UNESCO, 2006). Over the past decades this proportion has declined significantly as people move to cities and towns in search of better living and working opportunities. It is projected that by 2020 only 44% of the world population will be living in rural areas. This trend has implications for water management as more people will require access to basic water and sanitation. The runoff generated from urban settlements will also influence the quality of water resources, especially if adequate water and sanitation facilities lag behind the growth in urbanisation. This is especially the case in many less developed counties. Table 2.1 shows that urbanisation in less developed regions (excluding the least developed regions) is expected to increase to 65.9% in 2050, from 44.6% in 2009.

Table 2.1: Percentage urban population: 2009 and 2050

Region	2009	2050
More developed regions	74.9	86.2
Less developed regions	44.6	65.9
Least developed countries	28.7	54.7
World	50.1	88.7

Source: Own calculations. Data from Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2010)

2.2.2 Climate change

Climate change is another contributing factor to increasing water scarcity. Callan (2010: 287) defines climate change as "a major alteration in a climate measure such as temperature, wind, and precipitation that is prolonged, i.e. lasts decades or longer." One of the contributing factors to climate change is the excessive production of greenhouse gases caused by human activities, such as the burning of fossil fuels (Callan, 2010). The higher temperatures can affect human health and lead to changing weather conditions, such as rising sea levels (due to melting glaciers) and increased storm intensity, both of which will adversely affect coastal towns (Tietenberg and Lewis, 2009).

The impact of climate change on water resources depends on the effect of changing weather patterns on the supply of water, as well as on changes in the demand for water as a result thereof. Water availability is affected when there are impacts on the hydrological cycle, and changing temperatures and variability in precipitation patterns affect the water supply (IPCC, 2007). Increased temperatures result in more water evaporation; however, increased precipitation may offset these losses.

The net effect on water availability also depends on how climate change affects the demand for water. Climate change affects the demand for irrigation water. Warmer and drier weather conditions can make it more profitable for farmers to apply irrigation instead of dryland farming. In regions with available and affordable water, more farmland will be irrigated and increase the water amount applied per acre (Frederick, 1997: 6). However, the impact on global water requirements for irrigation depends on how regions are affected by climate change. According to the IPCC (2001), irrigation-use water models predict lower requirements in regions such as the Middle East and Africa (due to increased precipitation), whereas India will require more water for irrigation. It should be kept in mind, though, that other factors such as pricing and population growth also play a role in determining demand (IPCC, 2001). The impact of climate change on domestic water use depends on what the water is used for (IPCC, 2001). Outdoor water use can be affected if increases in temperature increase the demand for water.

The quality of water can also be affected by increased temperatures, which are a consequence of climate change. Higher water temperatures and variability in precipitation affects water quality, since increased temperatures reduce the dissolved oxygen levels in the water and this affects aquatic life (IPCC, 2007). Moreover, increased rainfall can increase sedimentation and pollution due to higher levels of runoff and flooding. This affects water quality, since excessive amounts of pollutants enter water resources as a result of higher volumes of water. Water resources are further polluted by sources such as farming, urban runoff and industrial activities.

2.2.3 Pollution

Pollution of water resources reduces the supply of clean water. Water quality is worsened by the increasing degradation of the resource through the pollution of rivers and lakes, as well as of groundwater resources. Freshwater resources such as rivers, streams and lakes are environmental receptors for pollution discharge resulting from a variety of human activities. Industrial and agricultural effluents are some of the major causes of water pollution as the water resources do not have the capacity to absorb excessive pollution flows (UN Water, 2007). According to Rosegrant (1997: 5), some of the main contaminants found in water resources are detergents, pesticides, toxic metals, fertilizers, and disease-causing agents responsible for illnesses such as cholera. In addition, surface waters are affected by pollutants through precipitation. Acid rain is the result of atmospheric pollutants affecting surface waters through contaminants in the precipitation (Callan, 2010).

The consequence of water pollution is a decline in the quality of the resource and therefore a decrease in the availability of water. If a water resource is contaminated, there is less water available for competing uses. Water quality problems have adverse consequences for human activities since consumption and production activities are affected. In the case of the former, not only is there less water for drinking purposes, but recreational activities are also adversely affected. People cannot swim, surf or fish in contaminated water as this can lead to health problems.

2.3 Physical water scarcity in South Africa

About two-thirds of South Africa is classified as arid or semi-arid (Kamara and Sally, 2004). The country's average annual rainfall of 498 millimetres (mm) is well below the world average of 890 mm (Meyer, 2007). Moreover, rainfall is erratic and water resources are very unevenly spread across the country. South Africa has an annual fresh water availability of less than 1 700 cubic metres per capita, which according to the Falkenmark Water Stress Indicator implies that the country is water stressed (Otieno and Ochieng, 2007). In 2005 the total renewable water resources for South Africa were estimated at 1 110 cubic metres per capita (UNESCO, 2006). By 2025 the country will experience water scarcity with less than 1 000 cubic metres of water per capita. This projected decline can mainly be attributed to the country's population growth and to increasing water pollution problems. Most of the water needed for urban, industrial and irrigation use comes from surface water. However, surface water is already highly utilised; South Africa already has approximately 320 major dams with a capacity of about 32 400 cubic metres. In addition, although groundwater resources are used, there are certain constraints involved, such as poor water quality (State of the Environment, n.d.).

According to the Department of Water Affairs and Forestry (2004: 19) adequate water resources have been developed to ensure that all current water requirements can be met. In cases where there is no water access, this is primarily ascribed to a lack of infrastructure and the necessary finances to provide and operate these services (the extent of economic water scarcity is discussed in Section 2.4). However, South Africa is fast approaching full utilisation of its water resources, although this will be reached at different times for the respective water catchment management areas[4] (Grant, 2011). A projection was made of current (2000) and future water requirements (2025), taking into account factors such as population growth, the growth of the economy and trends in urbanisation. Furthermore, water requirements to redress inequities and poverty alleviation were also included where available information could be sourced (Department of Water Affairs and Forestry, 2004: 34). A comparison of current water resources and requirements indicated that more than half of the water catchment management areas experienced a deficit, although the country as a whole still had a surplus. Future projections, however, indicated that deficits would become larger and surpluses smaller.

South Africa's water resources are primarily used for irrigation. Table 2.2 illustrates that irrigation (in agriculture and forestry) is the primary user of water resources. This is in contrast to other countries in sub-Saharan Africa, particularly Botswana, where livestock is the predominant user (Lange and Hassan, 2006). The household sector is the second-largest user of water in South Africa. The statistics for 2000 indicate that 15% of water use is by households. A further breakdown of this usage reflects that *urban* households use the greatest proportion (93% of the total water used by this sector, i.e. approximately 14% of total water resources).

[4] South Africa has been divided into 19 catchment-based water management areas (Department of Water Affairs and Forestry, 2004: 15).

Table 2.2: Sectoral use of water in South Africa (2000)

Sector	Percentage water use (%)
Agriculture and forestry	67
Mining	3
Manufacturing	5
Households	15
Other*	9
Total	100**

* The category includes sectors such as electric power generation and services.
** Figures do not add up due to rounding.

Source: Lange and Hassan (2006)

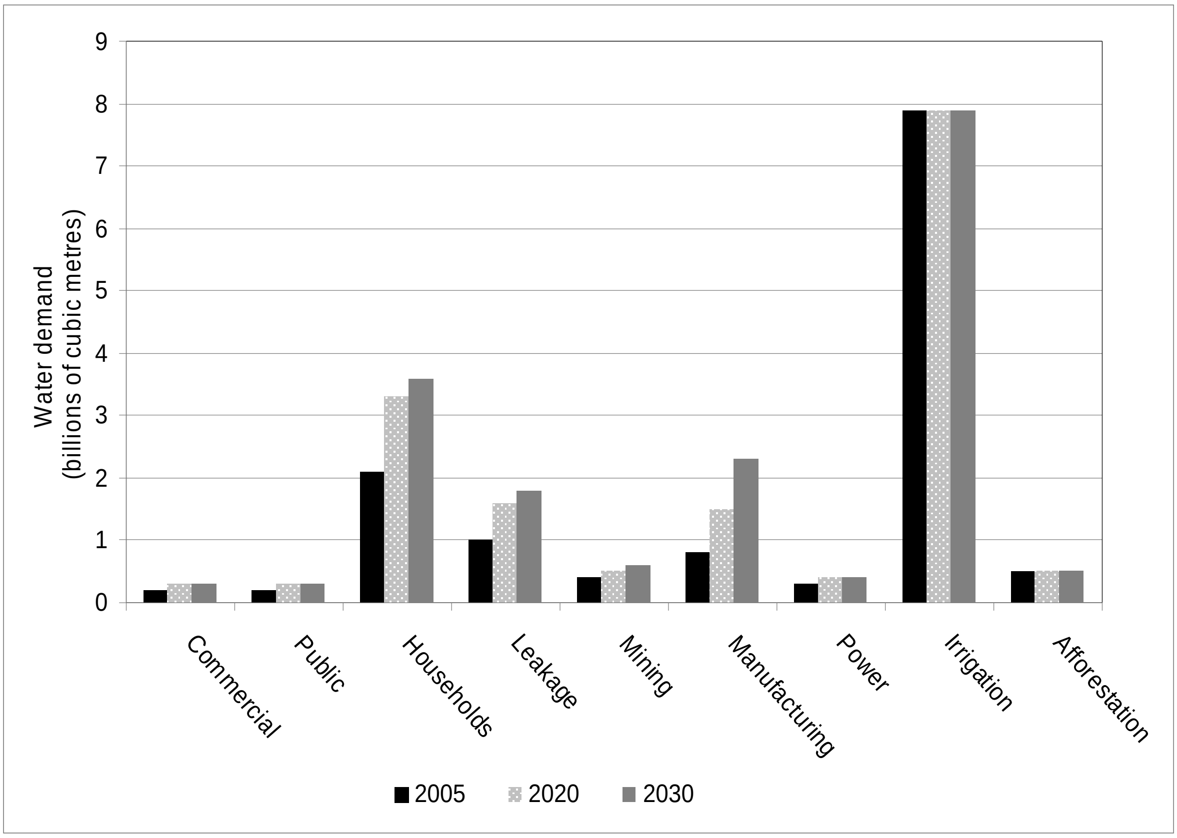
There are several reasons for South Africa's dwindling water resources. The discussion below outlines some of the more prominent contributing factors.

2.3.1 Population growth and urbanisation

There is an increasing demand for water arising from changes in the population and from varying patterns of migration and urbanisation. Assuming a constant fertility scenario (and no fertility decline), South Africa's population growth over the next 40 years is expected to remain relatively constant. The projected growth rates are less than 1% for each five-year period from 2010 to 2050 (United Nations, 2009). However, migration and urbanisation will increase future water requirements.

Urbanisation is already influencing water demand in South Africa and will increase future water requirements. According to the United Nations (2009), South Africa’s projected urban population for 2010 was 61.7% of the total population, as compared to 79.6% projected for 2050. For the five-year period from 2010 to 2015, the urban population will experience an annual growth rate of 1.2%. Kok and Collinson's (2006) estimates of the urban population (analysed by race) showed that in 2001 the White population primarily resided in urban areas. However, they provided figures showing a trend towards increased urbanisation for Blacks, and this is expected to continue (Kok and Collinson, 2006: 22). Based on the expectations of increased water requirements due to migration and urbanisation patterns, Figure 2.4 shows the projected water requirements of the different sectors of the South African economy up to 2030. Even though irrigation is likely to remain the dominant user of water, domestic use shows an upward trend.

Figure 2.4: Water demand by sector: 2005 to 2030



Source: The 2030 Water Resources Group (2009)

2.3.2 Climate change

As mentioned earlier, South Africa is a semi-arid country with sparse and irregular rainfall patterns. In addition, its groundwater resources are limited and often of poor quality (Meyer, 2007: 18). According to the State of the Environment (n.d.), increasing temperatures and higher variability in precipitation will lead to floods in certain areas, and drought in others. Further water stress is likely to occur in areas that are already arid. This is supported in the Southern Africa Environment Outlook, which reports that the long-term prospect for this region is that it will become more arid (SADC, 2008).

A detailed study by New (2002) investigates the future impact of climate change on water resources in the south-western Cape. The premise of the study is that increased temperatures and the expected global warming will affect the hydrological cycle, which has implications for water resources. The study area comprises four catchments within the south-western Cape, representing different precipitation regimes (New, 2002: 369). Using a hydrological model the projections are that precipitation will decrease whereas evaporation will increase, at varying rates. The most likely change is a reduction in streamflow in the next 20 years (New, 2002: 375). In addition, the demand for water will be affected. Given increased temperatures and evaporation, more water will be required for irrigation, and people may demand more water for gardening purposes.

2.3.3 Pollution

The pollution of surface and groundwater adversely affects the amount of water available for use. According to the SADC (2008), the quality of water in Southern Africa is primarily influenced by human activities such as deforestation, irrigation, and industrial and urban pollution. One of the key reasons for increased urban pollution is population growth and increased urbanisation. The latter has placed immense pressure on existing infrastructure and many cities in Southern Africa (such as Lusaka and Johannesburg) are experiencing urban expansion that exceeds the capacity of existing water and sanitation infrastructure systems. This results in urban runoff that is uncontrolled and leads to the pollution of rivers and streams (SADC, 2008).

Another major contributor to water pollution in South Africa stems from mining activities, primarily in the northern regions of the country. According to Oelofse (2008: 2), mining impacts on the environment through the release of chemicals. This degrades water resources, which in turn has health and safety implications for surrounding communities. Recently the acid mine drainage in Johannesburg has received a great deal of attention. Acid mine water is created when old mineshafts fill up and mixes with the sulphide mineral iron pyrite and the acidic water then starts to drain in the environment ("Johannesburg on acidic water time bomb", 2010). If no remedial action is taken, the acid mine drainage not only threatens water ecosystems, it will also affect the water supply and agricultural activities. In addition, it has detrimental implications for the poorer communities of Gauteng, who live close to contaminated areas ("Johannesburg on acidic water time bomb", 2010).

One possible mechanism to increase the supply of water is the desalination of seawater. Desalination entails the removal of salt from water. Seawater is high in salinity and the process of separating the salt from seawater requires large amounts of energy (Kalogirou, 2005). According to the Department of Water Affairs and Forestry (2004), desalination is an option that must be considered in South Africa, especially by coastal communities. However, the costs are relatively high and the environmental implications of this process on the ecosystems of oceans, as well as the release of greenhouse gases from the burning of fossil fuels to generate energy, should be considered.

A comparison of the cost of augmenting water supply with alternative sources such as desalination has shown it to be relatively expensive (Van Rooyen, Basson, Rossouw, Combrinck and Schroder, 2011: 17). An analysis of augmenting options for the Western Cape revealed that desalination of seawater was the most expensive option, costing approximately R12 per cubic metre (expressed in unit cost of water, i.e. the unit reference value[5]) (Van Rooyen et al. 2011). However, even though desalination is currently relatively more expensive than other augmenting options, it is inevitable that the greater Cape Town area will become dependent on desalination for its water supplies by approximately 2030 (Van Rooyen et al. 2011:19).

Another supply augmenting option is reusing of waste water, which is already applied in South Africa and plays a significant role in matching demand and supply of water (Anderson, 2003). The City of Cape Town has for some time provided treated effluent water to large users of non-potable water (Ilemobade, Adewumi and Van Zyl, 2009: 98). Another example is the recycled water flowing into the Hartbeespoortdam, which supplies water to urban centres in the northern parts of South Africa (Anderson, 2003: 5). An analysis of the marginal cost of reusing water, however, showed that it is relatively more expensive than using surface water or groundwater. The estimated marginal cost of reusing water (for the Western Cape) was estimated at double the cost of expanding surface water or groundwater resources (Van Rooyen, 2011: 17).

Although supply augmenting options such as desalination will form an essential component of water resource planning (particularly in the Western Cape), it is not a particular focus of this dissertation. Rather, attention is focused on water demand management (discussed in Chapter Three), which can reduce water requirements and thereby extend the sufficiency of existing water resources (Van Rooyen, 2011: 14).

2.4 Economic water scarcity in South Africa

In addition to physical water scarcity there is also a lack of adequate water infrastructure in South Africa, which results in an unequal distribution of water resources. Many

[5] The unit reference value indicates the marginal cost of water (Van Rooyen et al. 2011: 16).

communities, particularly in rural areas, lack the appropriate water infrastructure and the financial or institutional capability to deliver basic water and sanitation services.

An investigation into the state of municipal infrastructure in South Africa revealed that, even though some municipalities had put in place good practices in terms of infrastructure maintenance, few of them had adequate plans for the provision of renewal infrastructure (CSIR, 2006). Institutional and financial capacity also differed considerably between municipalities. A lack of technical staff, the inability to plan and allocate funds prudently, as well as a reliance on the national government to provide financial support, were some of the underlying reasons for the wide disparities in the delivery of services (CSIR, 2006).

These findings are confirmed and expanded in the report *State of Local Government in South Africa* (COGTA, 2009). The report makes specific references to the challenges facing rural and urban municipalities. Rural municipalities face severe infrastructure backlogs, which require a substantial improvement of financial and institutional capacity (COGTA, 2009: 45). Urban municipalities, in contrast, are faced with increasing population growth particularly an increase in informal settlements, and they must improve their spatial and infrastructure planning (COGTA, 2009: 45).

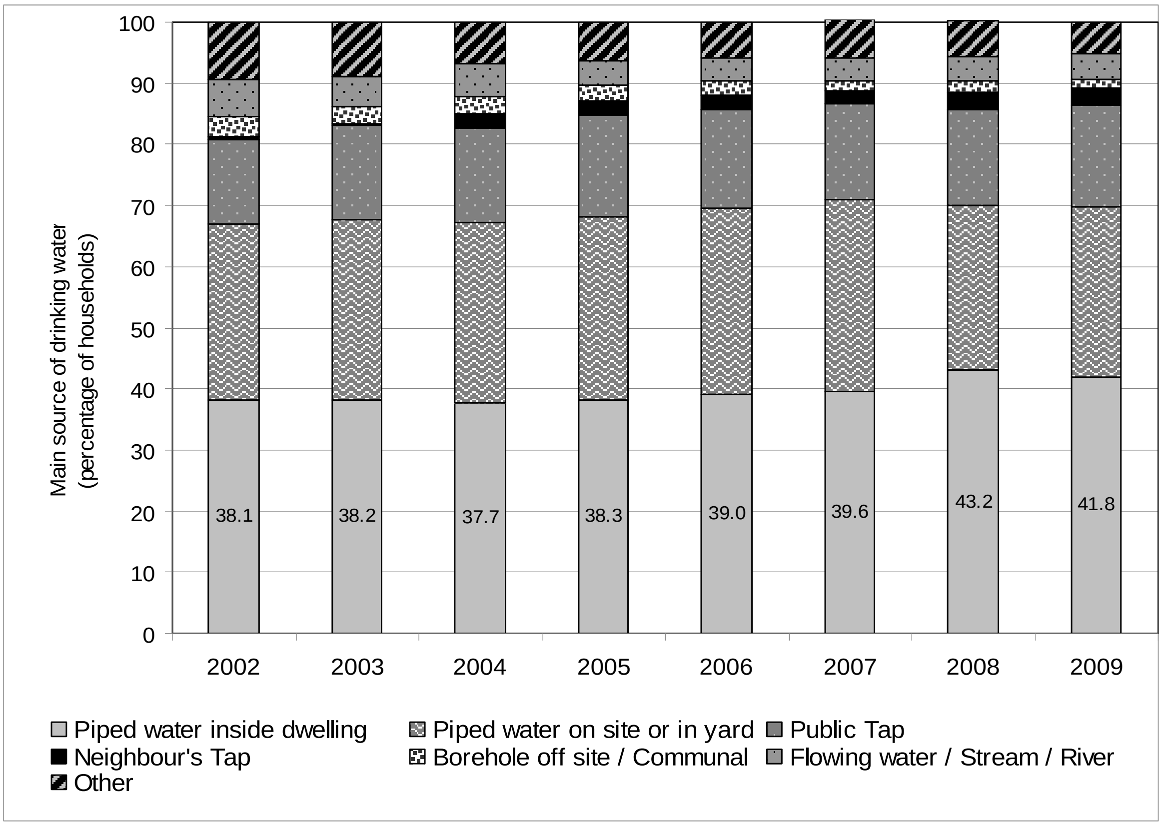
The water scarcity problem in South Africa therefore has two dimensions: there is both physical and economic water scarcity. The subsequent discussion focuses on the extent of economic water scarcity, i.e. the inadequate provision of basic water and sanitation services.

2.4.1 Access to water

This section investigates the water and sanitation infrastructure in South Africa using data from the General Household Survey (GHS) for the period 2002 to 2009. The GHS is a national survey conducted under the auspices of Statistics South Africa. It covers the whole country and approximately 26 000 households are interviewed annually. The statistics discussed below refer to questions relating to water and sanitation access, the payment of water and other water-related aspects. It should be mentioned that the GHS has a limited number of questions on the conditions of water and sanitation. However, from the available data it is possible to establish some trends with regard to water and sanitation provision over the eight year period. The analysis divides households into five quintiles (according to real per capita expenditure[6]). In some instances household data are also analysed by province.[7]

Figure 2.5 indicates the main source of drinking water for households over the period 2002 to 2009.

Figure 2.5: Main source of drinking water for households: 2002 to 2009



Source: Own calculations. Data from GHS 2002-2009 (Statistics South Africa, 2002-2009)

The percentage of households who had access to piped water inside the dwelling increased slightly from 38.1% in 2002 to 41.8% in 2009. However, throughout the period under investigation it remained less than half the number of households in each year. The

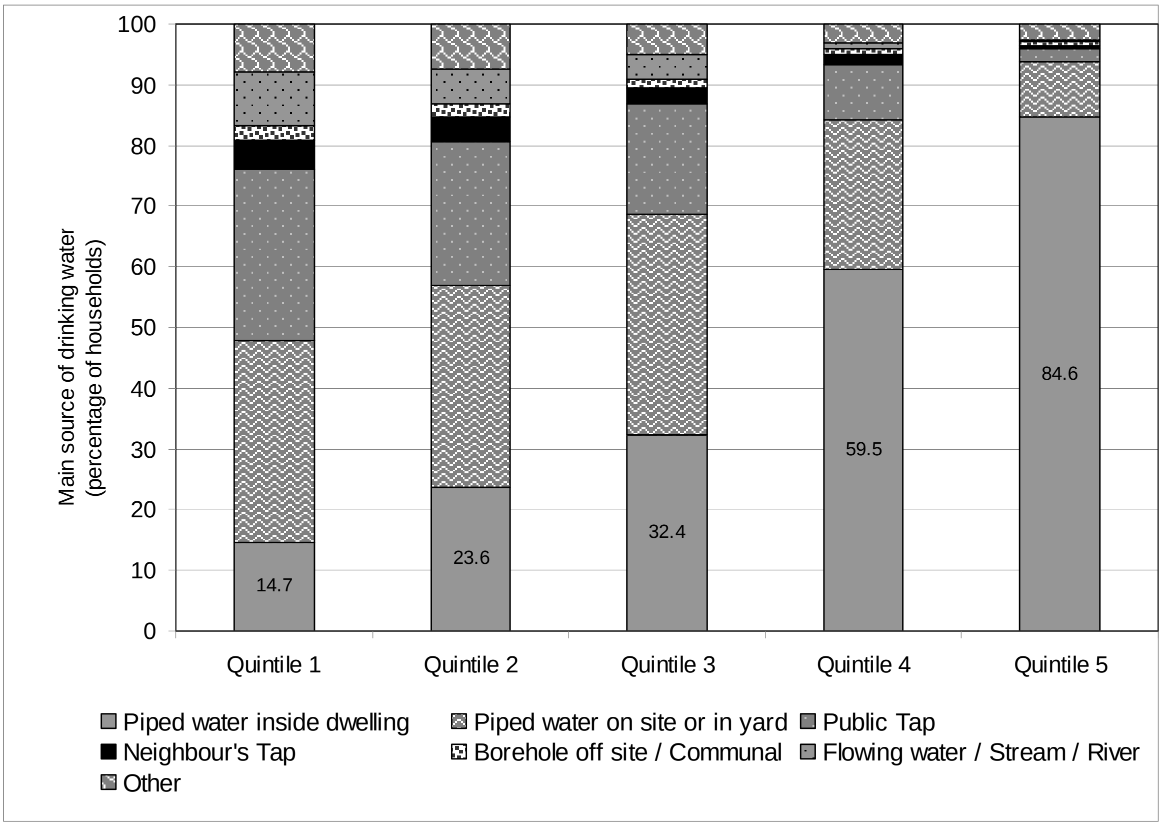
[6] Households were divided into quintiles based on real per capita expenditure (in 2000 prices). Households who did not indicate their expenditure or were unable to provide it were excluded. However, this amounted to a small percentage - only 4.4% of households in 2009. Furthermore, given the interval bands for expenditure in the GHS survey, it is not always possible to obtain exactly 20% of households in each respective quintile. Quintile 5 in 2009 consisted of only 16.3% of households.

[7] It would have been more useful to analyse the data at a micro-level (e.g. at district or municipality level), especially since the analysis focuses on the provision of basic services and these are usually provided by local government. However, the GHS only provides data at the district level for certain years (i.e. 2005 to 2007), limiting the possibilities for a data comparison over time.

use of communal water sources, particularly public taps, showed an increase over this period. In 2002 only 13.8% of households made use of a public tap, whereas this proportion increased to 16.6% of households in 2009.

A similar analysis was repeated for households by quintile for 2009, shown in Figure 2.6 below. The poorest households (quintile 1) had relatively low access to piped water inside their dwellings. Only 14.7% of the poorest households had piped water in their dwellings, as compared to 84.6% of households in the richest quintile. In contrast, the opposite result was found when considering the proportion of households using public taps and relying on streams or rivers as their main source of drinking water. In the case of public taps, 28.2% of the poorest households only had communal water access.

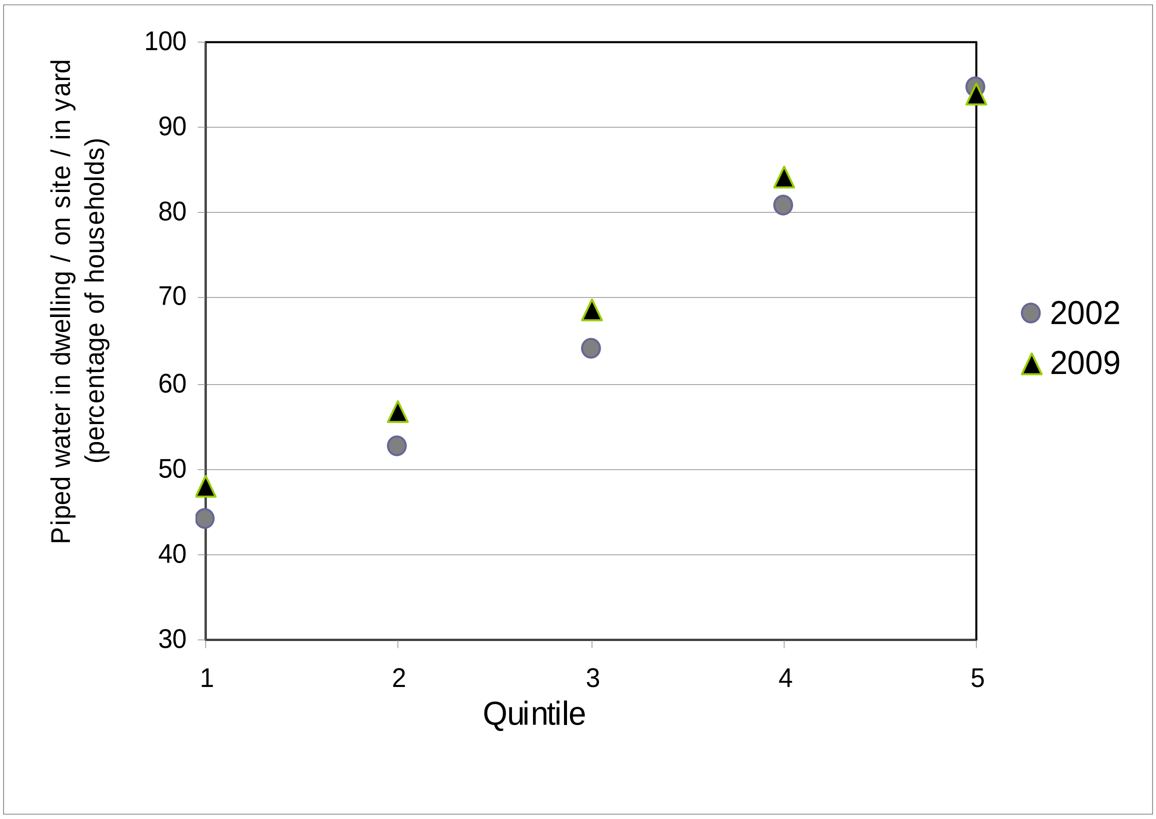
Figure 2.6: Main source of drinking water for households in 2009, by quintile



Source: Own calculations. Data from GHS 2009 (Statistics South Africa, 2009)

Figure 2.7 illustrates the percentage of households with access to piped water in their dwelling, on site, or in their yard, for the years 2002 and 2009 respectively. It is evident that the poorest quintile in each of these years was relatively worse off in terms of access to piped water, as compared to the other quintiles. In both years the percentage of households with access to piped water increases over the quintiles. A comparison between 2002 and 2009 reveals that there was only a very slight improvement for quintile 1, whereas almost all households in quintile 5 had piped water on their property in both years.

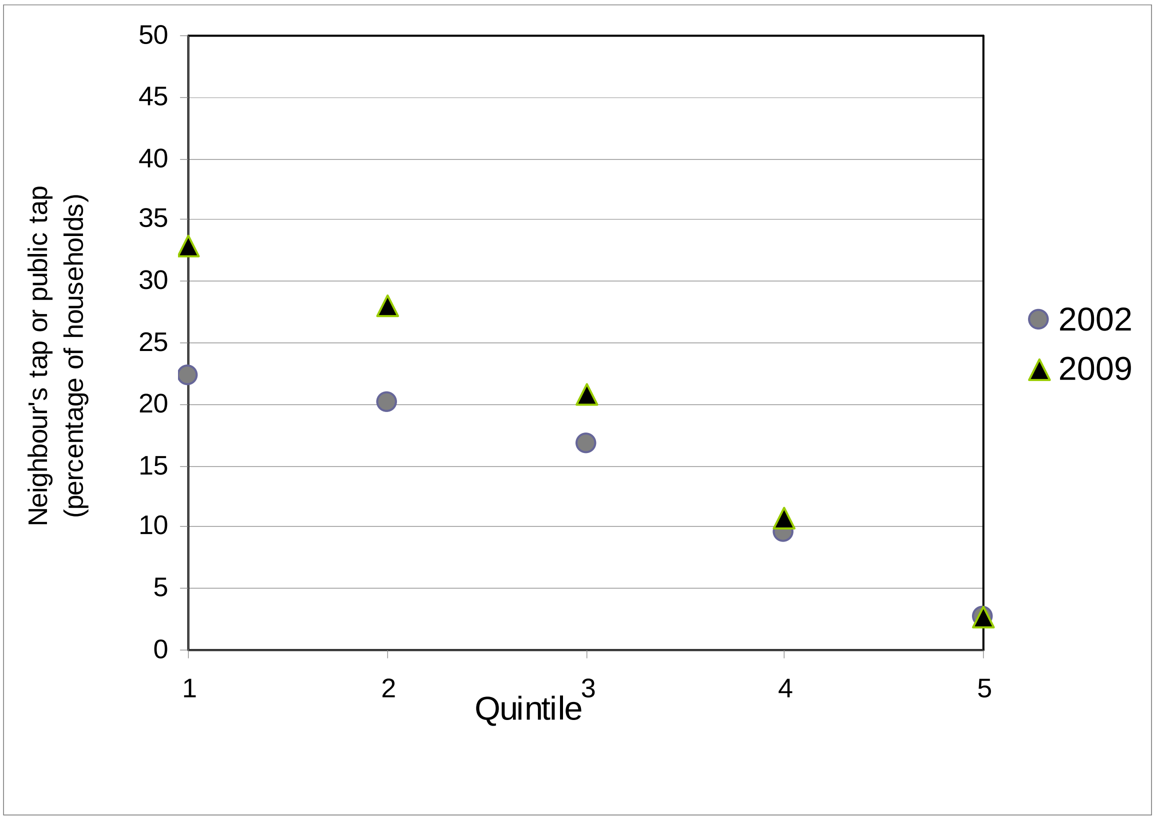
Figure 2.7: Main source of drinking water: piped (tap) water inside dwelling / on site / in yard in 2002 and 2009, by quintile



Source: Own calculations. Data from GHS 2002 and 2009 (Statistics South Africa, 2002 and 2009)

An alarming statistic is the percentage of households that still depend on communal access through a public tap, or from their neighbour's tap. These trends point to economic water scarcity among the poorest households. Figure 2.8 indicates the percentage of households that made use of these sources of water for 2002 and 2009 respectively. A greater proportion of households in the poorest quintile made use of a neighbour's tap or a public tap as their main source of drinking water, as compared to households in other quintiles. This result is evident in both 2002 and 2009. However, there was a significant increase in the proportion of households in the lower quintiles (1 and 2) who made use of these water sources. It is therefore evident that water infrastructure for the poorest households is inadequate.

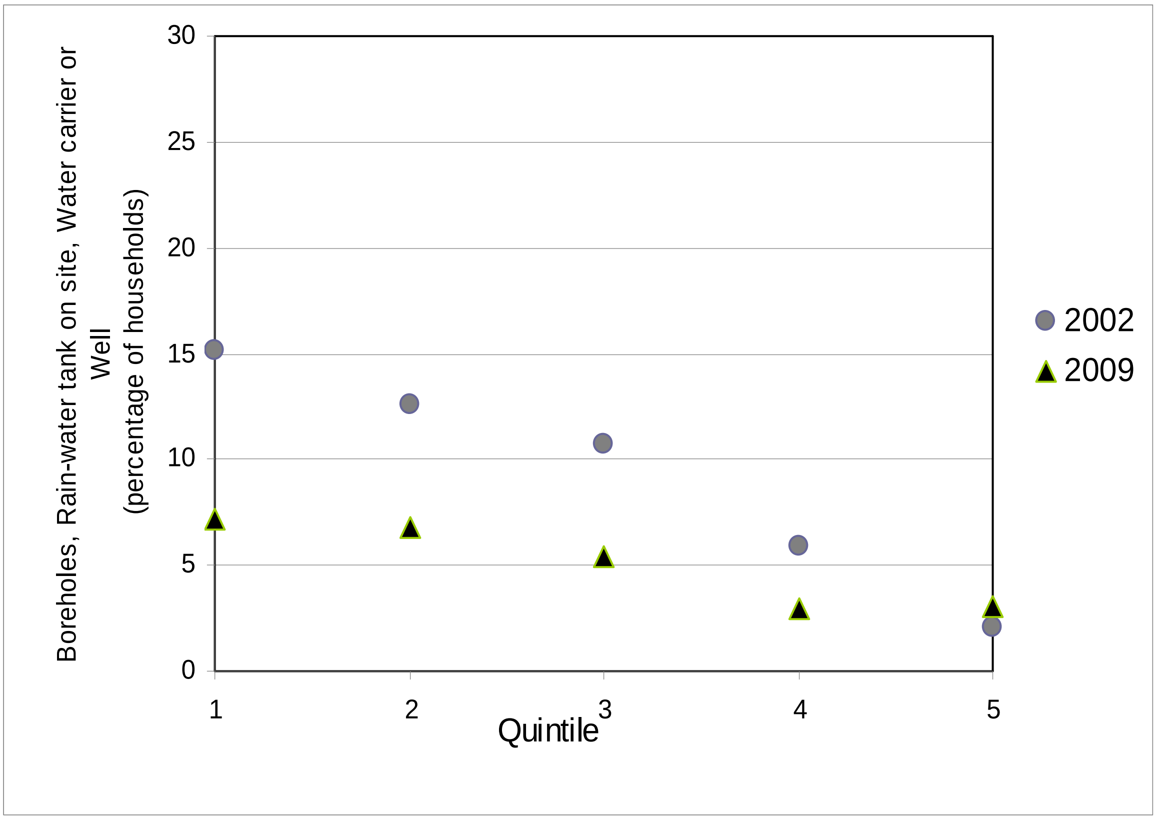
Figure 2.8: Main source of drinking water: neighbour's tap or public tap in 2002 and 2009, by quintile



Source: Own calculations. Data from GHS 2002 and 2009 (Statistics South Africa, 2002 and 2009)

The use of boreholes (on or off site), rainwater tanks, water carriers and wells also decreased from 2002 to 2009. Figure 2.9 illustrates that slightly more than 15% of the poorest households used these water sources in 2002. This percentage decreased to about 7% of these households in 2009. A similar decrease is evident for households in quintiles 2, 3 and 4.

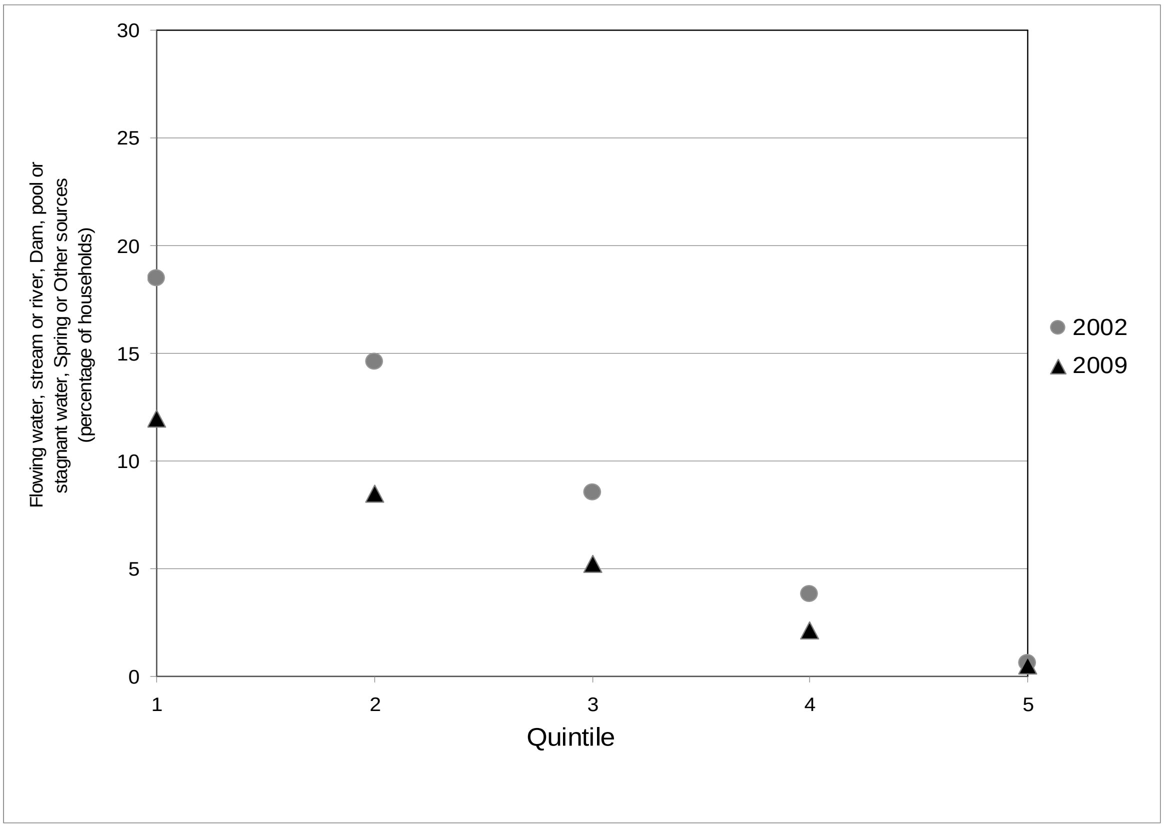
Figure 2.9: Main source of drinking water: boreholes (on or off site), rainwater tank on site, water carrier or well in 2002 and 2009, by quintile



Source: Own calculations. Data from GHS 2002 and 2009 (Statistics South Africa, 2002 and 2009)

A further concern is the proportion of poor households who use water from streams and rivers, and other unsuitable sources such as stagnant water, dams and pools. As discussed earlier, given the extent of river and stream pollution in South Africa, these water resources are generally untreated and are likely to cause health problems. In the period under consideration, outbreaks of water-related diseases such as cholera had already occurred in certain areas. According to Hemson and Dube (2004), the province of KwaZulu-Natal experienced one of the largest outbreaks of cholera in the African continent during the period 2000 to 2001. The primary cause was the lack of adequate sanitation facilities. Thus, even though the South African government has prioritised the provision of basic services to the poor, adequate service delivery has not been realised, resulting in backlogs in the provision of water and sanitation (Hemson and Dube, 2004: 1). Figure 2.10 shows the percentage of households who made use of unsuitable drinking water sources in 2002 and 2009. Almost 20% of households in the poorest quintile used unsuitable water as a drinking source in 2002. This percentage decreased to about 12% of the poorest households in 2009.

Figure 2.10: Main source of drinking water: flowing water, stream or river, dam, pool or stagnant water, spring or other sources in 2002 and 2009, by quintile



Source: Own calculations. Data from GHS 2002 and 2009 (Statistics South Africa, 2002 and 2009)

An analysis of the characteristics of households that influence their main source of drinking water can be performed, using the micro data available in the GHS for the years 2002 to 2009. A probit model is estimated to determine which households are more likely to have access to piped water. The household data include information on the households' demographic profile, their main source of water and other variables too determine the socio-economic status of households (SES). The SES is computed by using five socio-economic variables and applying principal component analysis to extract a first principal component, which is then included as a continuous variable in the regression analysis. The variables included in the principal component analysis include: the type of household dwelling, the type of fuel used for cooking, the type of sanitation facilities and whether the household has a telephone or a cell phone. The variables used in the econometric analysis are shown in Table 2.3, and the results of the probit model are shown in Table 2.4.

Table 2.3: Variables in the econometric analyses

Name	Description	Name	Description
Water	dummy variable: main source of drinking water is piped water inside dwelling / on site / in yard	White	dummy variable: race = White
Sanitation	dummy variable: sanitation facility is a flush or chemical toilet	Primary schooling	dummy variable: years of education is >= 1 and <= 6
Western Cape	dummy variable: province = Western Cape	Secondary schooling	dummy variable: years of education is >= 7 and <= 11
Northern Cape	dummy variable: province = Northern Cape	Matriculation certificate	dummy variable: years of education = 12
Free State	dummy variable: province = Free State	Certificate + diploma	dummy variable: years of education is >= 13 and <= 14
KwaZulu-Natal	dummy variable: province = KwaZulu-Natal	Degree	dummy variable: years of education is >= 15 and <= 20
North West	dummy variable: province = North West	Unspecified	dummy variable: years of education not specified
Gauteng	dummy variable: province = Gauteng	Y2003	dummy variable: year = 2003
Mpumalanga	dummy variable: province = Mpumalanga	Y2004	dummy variable: year = 2004
Limpopo	dummy variable: province = Limpopo	Y2005	dummy variable: year = 2005
Male head of household	dummy variable: head of household is male	Y2006	dummy variable: year = 2006
Employed	dummy variable: head of household is employed	Y2007	dummy variable: year = 2007
SES	index of the socio-economic status of household	Y2008	dummy variable: year = 2008
Household size	size of the household	Y2009	dummy variable: year = 2009
Coloured	dummy variable: race = Coloured	Constant	constant term
Indian	dummy variable: race = Indian		

Note: The reference groups for the dummy variables are as follows: Province dummy - Eastern Cape; Employment status dummy - Unemployed, inactive or unspecified; Race dummy - Black; Educational attainment dummy - No schooling; Year dummy - 2002.

Table 2.4: Probit model: Access to piped (tap) water: 2002 to 2009

Variable	Coefficient	Variable	Coefficient
Western Cape	0.241***	Coloured	0.551***
	(9.47)		*(28.26)*
Northern Cape	-0.223***	Indian	1.193***
	(-8.52)		*(24.62)*
Free State	-0.019	White	1.139***
	(-0.79)		*(38.54)*
KwaZulu-Natal	0.066***	Employed	0.049***
	(2.92)		*(4.21)*
North West	-0.223***	Socio-economic index	0.673***
	(-8.98)		*(129.35)*
Gauteng	0.033	Household size	0.030***
	(1.50)		*(13.51)*
Mpumalanga	0.209***	Y2003	-0.037*
	(8.17)		*(-1.93)*
Limpopo	-0.245***	Y2004	-0.063***
	(-9.83)		*(-3.25)*
Male head of household	-0.057***	Y2005	-0.181***
	(-5.25)		*(-8.91)*
Primary schooling	0.053***	Y2006	-0.153***
	(2.63)		*(-7.32)*
Secondary schooling	0.133***	Y2007	-0.108***
	(7.21)		*(-4.98)*
Matriculation certificate	0.309***	Y2008	0.064***
	(14.33)		*(3.28)*
Certificate+diploma	0.622***	Y2009	0.044**
	(21.19)		*(2.25)*
Degree	0.873***	Constant	-1.084***
	(23.07)		*(-38.08)*
Unspecified	0.231***		
	(4.48)		
Number of observations	208 479		
Pseudo R^2	0.54		

Z-values in parentheses.

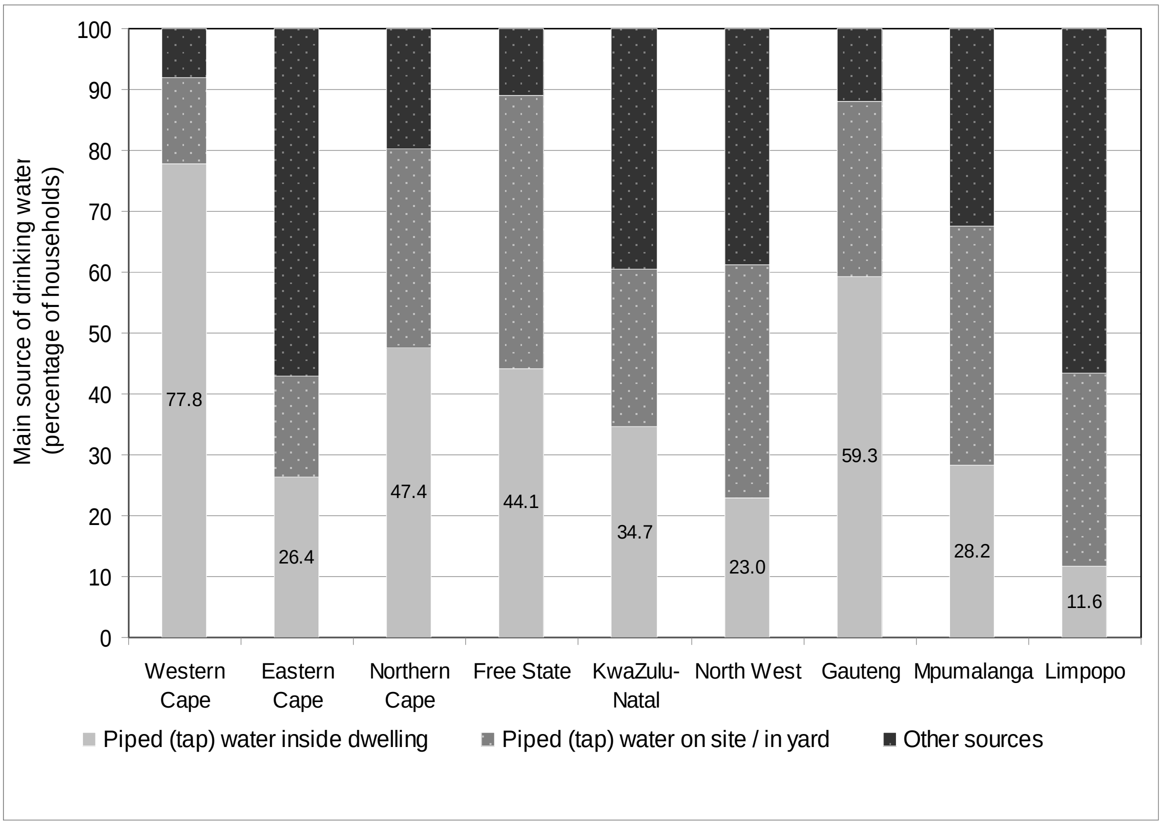
Level of significance: *** - significant at the 1% level, ** - significant at the 5% level, * - significant at the 10% level.

Source: Own calculations. Data from GHS 2002-2009 (Statistics South Africa, 2002-2009)

The results show that where males are heads of households, these households are less likely to have access to piped water. More educated households and larger households are more likely to have access to piped water. Coloured, Indian and White households have a greater probability of piped water, compared to Black households. The socio-economic status of households is positively related to the likelihood of having access to piped water, i.e. a higher index implies a greater chance of having piped water. However, the year dummies indicate that the probability of having piped water has not increased over time, except in the last two years (i.e. 2008 and 2009). The provincial dummies indicate that there is evidence of a substantial backlog in some provinces. The probability of having piped (tap) water inside the dwelling, in the yard or on site is highest in the Western Cape, Gauteng, KwaZulu-Natal and Mpumalanga, compared to the Eastern Cape (the reference province and one of the provinces containing a significant number of poor households). This result is not surprising, since there has been little improvement in service delivery in rural provinces (such as the Eastern Cape, Limpopo and KwaZulu-Natal), as compared to urban provinces such as the Western Cape and Gauteng (Krugell, Otto and Van der Merwe, 2010).

A comparison of the provincial results to the descriptive statistics of the provincial data, reveal that certain provinces lag far behind in the provision of safe drinking water to all households. Figure 2.11 shows the sources of drinking water across the nine provinces of South Africa for 2009. The Eastern Cape and Limpopo are the two provinces with the lowest proportion of households with access to piped water inside the dwelling or on site or in yard (44.2% and 43.3% respectively). Furthermore, these two provinces also have the highest proportion of households that are dependent on a public tap for their main source of drinking water (28.9% and 30.4% respectively). Related to this is the fact that approximately 7% of the households in the Limpopo province use their neighbour's tap, as opposed to less than 1% of households in the Western Cape. The fact that many households still do not have access to safe drinking water attests to the problem of economic water scarcity. In many instances there is insufficient infrastructure to provide access to water and people are too poor to connect to available water networks, as they cannot afford to live in areas where connections are available. According to McGranahan, Mitlin and Satterthwaite (2008: 77), the urban poor usually live in areas where markets do not meet the demand for shelter or services, since markets prefer areas where property rights are well defined and people are willing and able to pay for all household services.

Figure 2.11: Main source of drinking water for households in 2009, by province



Source: Own calculations. Data from GHS 2009 (Statistics South Africa, 2009)

Access to safe water at the district level cannot be analysed beyond 2005 as the recent General Household Surveys do not provide data at this level. However, the Community Survey 2007, released by Statistics South Africa, provides information on access to water at the district level. Table 2.5 provides information on the proportion of households who had access to piped water at the district and metropolitan municipality level.

Table 2.5: Access to piped water in 2007, by municipality

Province	District or Metropolitan Municipality	Piped water inside dwelling or inside yard (% of households)	Piped water outside yard (% of households)
Eastern Cape	O.R. Tambo	12.4	23.2
Eastern Cape	Alfred Nzo	13.9	44.0
Limpopo	Sekhukhune	22.6	42.0
KwaZulu-Natal	Ugu	27.7	40.1
KwaZulu-Natal	Umzinyathi	30.3	27.5
Eastern Cape	Ukhahlamba	31.1	33.2
KwaZulu-Natal	Umkhanyakude	31.5	26.6
Eastern Cape	Chris Hani	39.0	36.6
KwaZulu-Natal	Zululand	39.9	12.5
Northern Cape	Kgalagadi	40.3	51.8
North West	Ngaka Modiri	40.3	41.4
North West	Dr Ruth Segomotsi Mompati	40.6	49.5
KwaZulu-Natal	Sisonke	41.0	13.9
KwaZulu-Natal	iLembe	41.2	28.3
KwaZulu-Natal	Uthukela	42.8	21.3
Eastern Cape	Amatole	43.0	33.3
Limpopo	Vhembe	44.1	47.9
Limpopo	Mopani	46.7	41.5
Limpopo	Capricorn	48.2	34.9
Limpopo	Waterberg	57.3	30.7
KwaZulu-Natal	Uthungulu	59.3	15.8
KwaZulu-Natal	Amajuba	64.3	23.8
Mpumalanga	Ehlanzeni	67.0	24.7
North West	Bojanala	67.0	21.6
Gauteng	Metsweding	74.6	12.2
KwaZulu-Natal	UMgungundlovu	75.8	13.1
Mpumalanga	Nkangala	75.9	15.7
KwaZulu-Natal	***Ethekwini***	***78.4***	***19.1***
Gauteng	West Rand	79.8	17.6
Mpumalanga	Gert Sibande	80.0	11.9
Gauteng	***City of Tshwane***	***80.7***	***16.4***
Free State	Motheo	82.9	16.0
Free State	Thabo Mofutsanyane	83.1	13.3
Free State	Xhariep	84.0	8.6
Northern Cape	Siyanda	85.2	7.7
Northern Cape	Frances Baard	85.8	10.1
Gauteng	***Ekurhuleni***	***86.2***	***12.7***
Eastern Cape	Cacadu	87.3	8.4
Eastern Cape	***Nelson Mandela***	***87.4***	***11.0***
Western Cape	Eden	89.2	8.5
North West	Dr Kenneth Kaunda	89.8	6.4
Western Cape	Cape Winelands	90.4	7.4
Northern Cape	Pixley ka Seme	90.6	4.7

Western Cape	***City of Cape Town***	***91.1***	***8.3***
Free State	Lejweleputswa	91.1	6.3
Western Cape	Overberg	91.5	7.1
Gauteng	***City of Johannesburg***	***91.6***	***6.8***
Free State	Fezile Dabi	92.4	4.7
Northern Cape	Namakwa	92.6	3.1
Gauteng	Sedibeng	92.6	4.9
Western Cape	Central Karoo	94.2	0.6
Western Cape	West Coast	96.4	2.3

Source: Own calculations. Data from Community Survey 2007 (Statistics South Africa, 2007)

The proportion of households with piped water inside their dwelling or inside their yards ranged from a low 12.4% to almost all households (i.e. 96.4%). In most metropolitan municipalities (indicated in italics and bold text in Table 2.5) more than 85% of households had access to piped water inside their dwellings, with the exception of Ethekwini (Durban) and City of Tshwane (Pretoria). Approximately half of the municipalities had less than 70% of households with piped water inside their dwellings. These alarming statistics were more prevalent in KwaZulu-Natal, the Eastern Cape and Limpopo.

Whether households are currently paying for water service provision (primarily provided by local municipalities) can indicate the extent of their contribution to the development and maintenance of water infrastructure and the affordability of the service to households. Table 2.6 shows the proportion of households who paid for municipal water in 2009. The greatest proportion of non-paying households was from the poorest households (i.e. 74.1%). This is because those households who answered 'No' to this question either received the free basic water allowance per month, or received an account, but did not pay.

Table 2.6: Payment for municipal water in 2009, by quintile

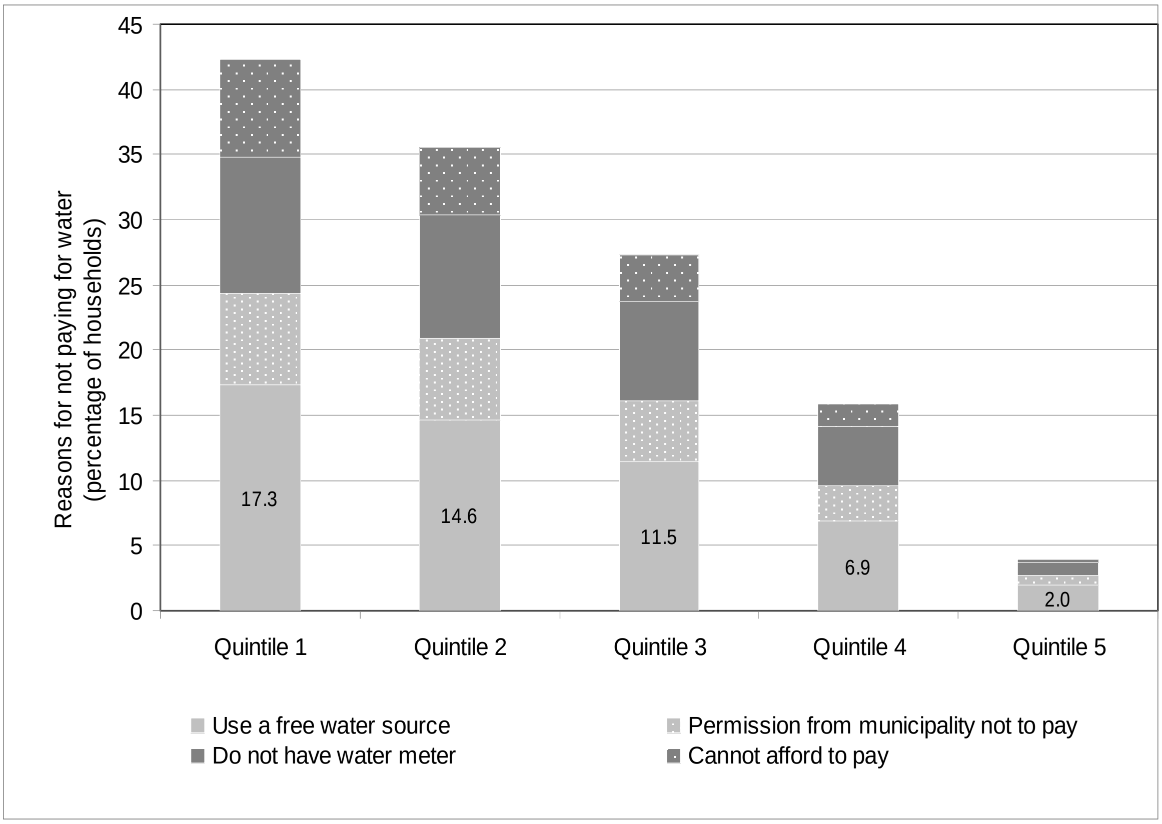
Does the household pay for municipal water? (%)	Quintile 1	2	3	4	5	Total
Yes	18.8	26.8	35.4	56.1	71.4	41.0
No	53.9	49.9	46.5	34.6	22.1	41.9
Not applicable*	27.1	23.2	17.9	9.1	6.4	16.9
Unspecified	0.2	0.2	0.1	0.1	0.1	0.2
Total	100	100	100	100	100	100
No (as a % of those households who receive water from local municipalities)	74.1	65.1	56.8	38.2	25.6	50.6

* This category includes households who did not receive water from local municipalities, or used water from other sources.

Source: Own calculations. Data from GHS 2009 (Statistics South Africa, 2009)

A more detailed breakdown of the reasons for non-payment of water reveals that about 17% of the poorest households used a free water source. Approximately 10% of households did not have a water meter at the time of the survey (but nevertheless received municipal water). Almost 8% of households in quintile 1 indicated that they could not afford to pay for water, as opposed to less than 0.5% of the richest households. It should be noted that the respondents to this particular question in the survey were only those households whose main source of water was supplied by the local municipality. These statistics are illustrated in Figure 2.12.

Figure 2.12: Reasons for not paying for water in 2009, by quintile



Source: Own calculations. Data from GHS 2009 (Statistics South Africa, 2009)

Table 2.7 shows the number of households that experienced interruptions in 2008, as a percentage of all households that had access to piped water (inside the dwelling, in the yard, or on site). Approximately 40% of the poorest households experienced daily, weekly or monthly interruptions in water supply, whereas only 15.1% of households in quintile 5 experienced similar interruptions. Only 41.3% of the poorest households hardly ever experienced interruptions, as opposed to 68.6% of the richest households. The main (specified) causes of water supply interruptions, as indicated in Table 2.7, were burst pipes and general maintenance problems.

Table 2.7: Frequency and causes of interruptions in water supply in 2008, by quintile

Frequency of interruptions in piped water supply (percentage of households)	Quintile					
	1	2	3	4	5	Total
Daily	7.7	6.3	5.6	4.4	2.9	5.0
Weekly	14.5	12.6	10.3	7.6	3.4	8.8
Monthly	17.6	18.2	15.1	12.5	8.8	13.6
6-monthly	11.5	12.0	12.5	11.6	8.7	11.1
Yearly	6.3	5.8	5.5	5.5	6.0	5.8
Almost never	41.3	43.3	49.3	56.6	68.6	54.1
Unspecified	1.1	1.8	1.5	1.9	1.6	1.6
Total	100	100	100	100	100	100

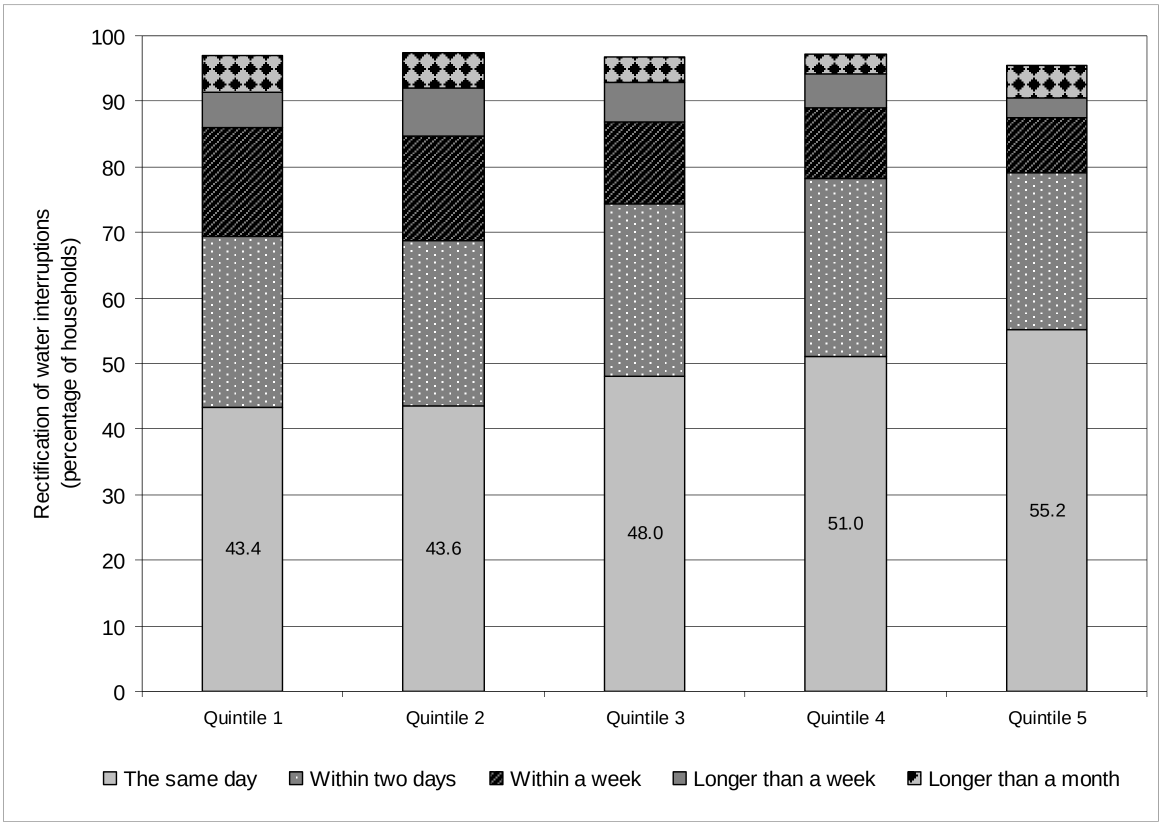
Note: only respondents who had piped water inside their dwelling or those who had access to a communal tap, answered this question.

Causes of piped water supply interruptions (percentage of households)						
Burst pipes	44.6	41.5	43.5	44.5	50.4	44.8
Pump not working	6.0	7.9	5.1	5.9	3.4	5.7
General maintenance	31.5	32.2	31.8	35.5	32.0	32.6
Not enough water in the system (demand too high)	7.1	5.5	6.3	4.2	2.7	5.2
Water only delivered at fixed times	2.4	1.4	2.4	1.1	2.4	1.9
Non-payment for services (cut off)	2.0	1.2	1.4	0.5	0.3	1.1
Vandalism	1.0	2.3	2.5	1.5	1.2	1.7
Other reasons	0.3	0.5	0.4	0.3	0.5	0.4
Don’t know	5.2	7.5	6.7	6.4	7.2	6.6
Total	100	100	100	100	100	100

Source: Own calculations. Data from GHS 2008 (Statistics South Africa, 2008)

The response of local government to water interruptions provides some insight into the state of service delivery. Figure 2.13 shows that most households indicated that interruptions to water supply were rectified on the same day. However, the poorest households had to wait somewhat longer for interruptions to be fixed. For example, 11.0% of households in quintile 1 had to wait longer than a week to have their water interruptions fixed, as opposed to 8.1% of households in quintile 5. This may be indicative of lower standards of service delivery by local governments in areas with a high proportion of poor households.

Figure 2.13: When interruptions to water supply were rectified in 2008, by quintile



Source: Own calculations. Data from GHS 2008 (Statistics South Africa, 2008)

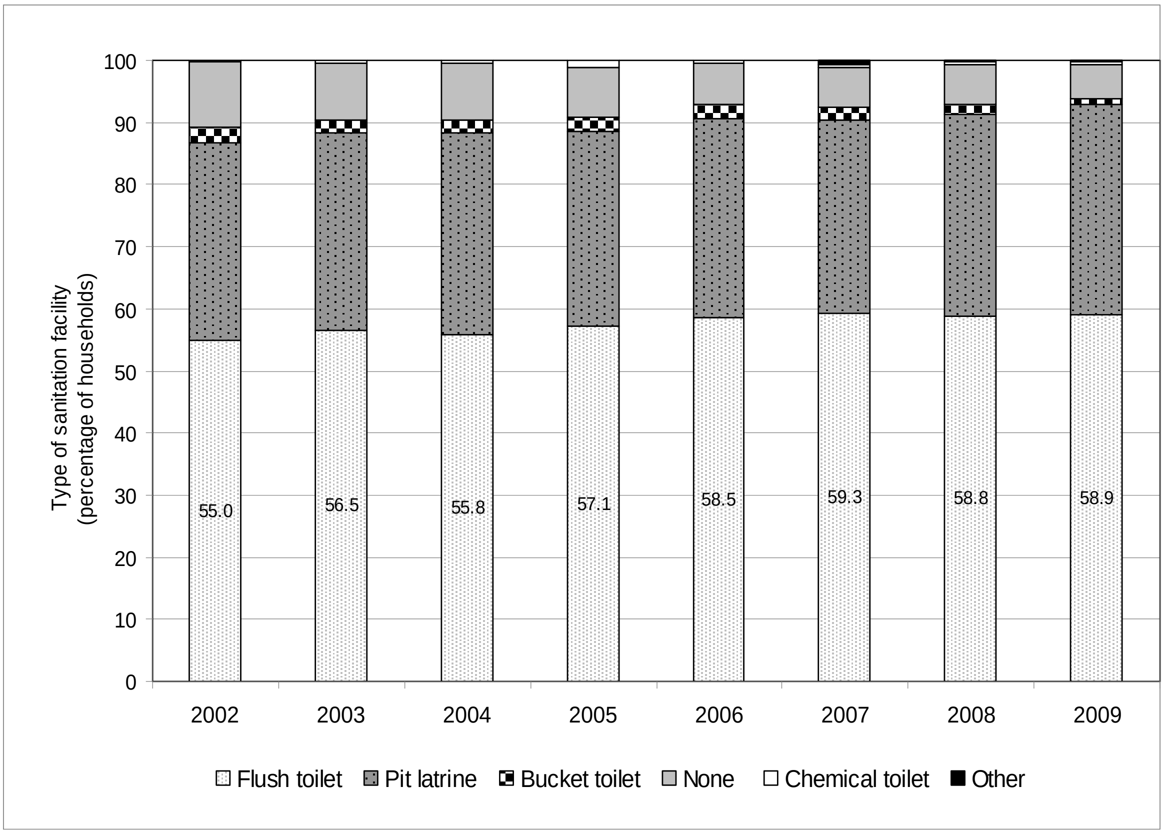
2.4.2 Access to Sanitation

Inadequate basic sanitation facilities have a direct impact on the living standards of communities. People who are exposed to untreated sewerage and effluent water experience health problems, which have further repercussions for society. Children are unable to attend school and adults are unable to participate productively in economic activity. Furthermore, many urban informal settlements are situated close to rivers

(Department of Constitutional Development, 1998) and the runoff from these settlements has an adverse effect on those who live and work downstream.

In South Africa many households still do not have access to basic sanitation facilities such as a flush toilet on the premises. An analysis of sanitation facilities over the period 2002 to 2009 reveals that there was only a slight increase in the proportion of households who with access to a flush toilet. Figure 2.14 indicates that 55% of households had a flush toilet in 2002. In 2009 this proportion increased to just below 60%. A substantial proportion of households still used a pit latrine (approximately 34%); this proportion remained relatively constant over the eight years under review.

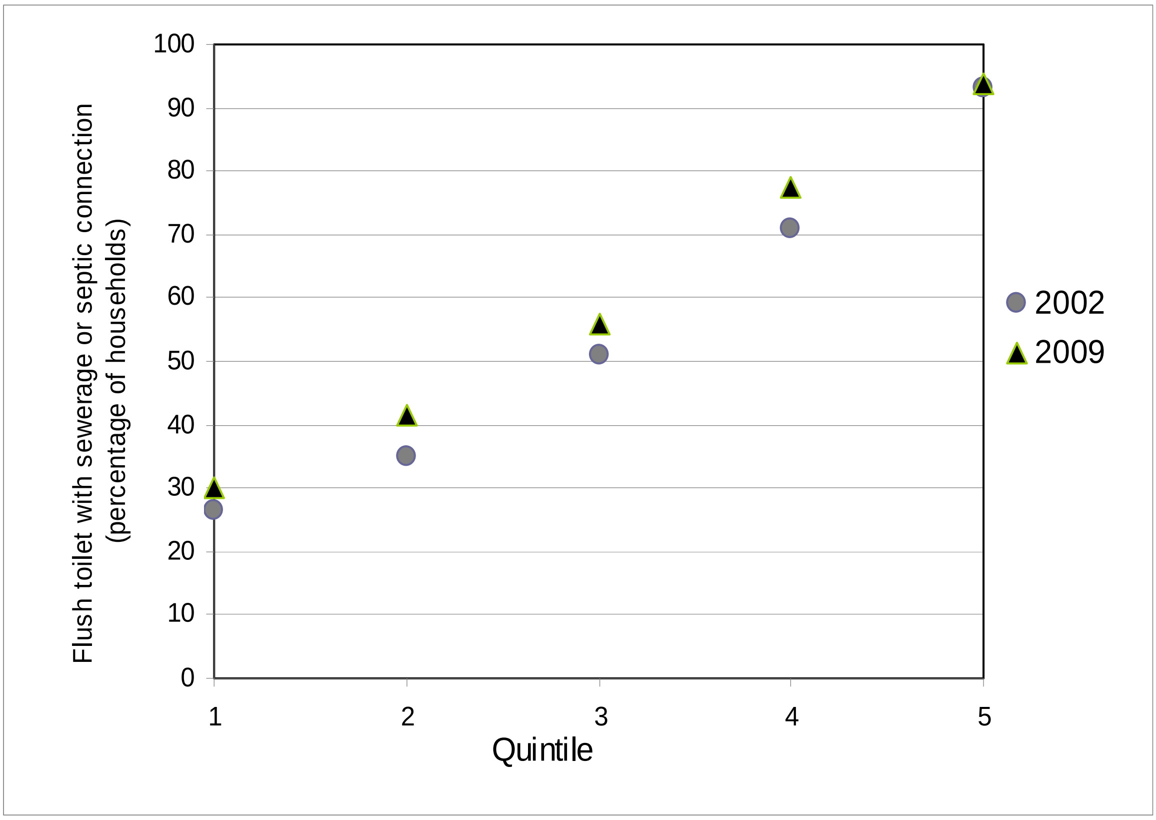
Figure 2.14: Type of sanitation facility: 2002 to 2009



Source: Own calculations. Data from GHS 2002 to 2009 (Statistics South Africa, 2002 to 2009)

Figure 2.15 shows a comparison of the proportion of households with access to flush toilets by quintile for 2002 and 2009. In 2002 approximately 27% of households in the poorest quintile had access to flush toilets, whereas slightly more than 93% of the richest households had access to flush toilets. By 2009, the proportion of the poorest households with a flush toilet had only increased to 30%.

Figure 2.15: Access to flush toilet in 2002 and 2009, by quintile

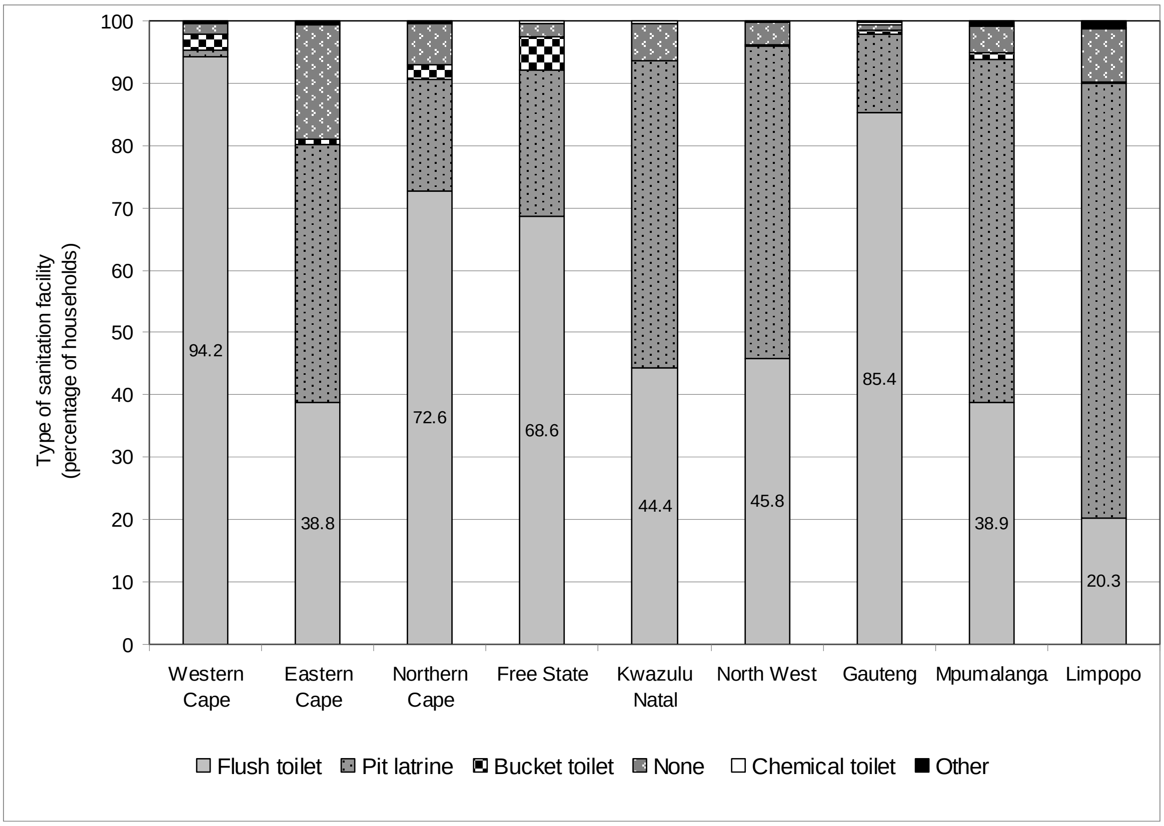


Source: Own calculations. Data from GHS 2002 and 2009 (Statistics South Africa, 2002 and 2009)

A great concern is that 49% of poor households used a pit latrine (either with or without a ventilation pipe) in 2002; a proportion that increased to 56% in 2009. With increased population growth and urbanisation and with no significant improvement in service delivery levels, the provision of sanitation services remains inadequate (Hemson and Owusu-Ampomah, 2004). This is evident given only a slight decline in the proportion of households with a pit latrine (without a ventilation pipe) for households in quintile 1. One positive change has been a slight decrease in the proportion of households using bucket toilets, from 3.4% in 2002 to 1.6% in 2009.

The provincial data for 2009 show that the Eastern Cape, Limpopo, Mpumalanga, KwaZulu-Natal and North West were the provinces lagging behind in the provision of sanitation facilities (see Figure 2.16). In these provinces less than 50% of households had flush toilets. In addition, more than 40% of households in these provinces used a pit latrine with or without ventilation on site. The bucket toilet system was used by a small proportion of households, mostly in the Western Cape, Free State and Northern Cape.

Figure 2.16: Type of sanitation facility in 2009, by province



Source: Own calculations. Data from GHS 2009 (Statistics South Africa, 2009)

At municipality level, the Community Survey 2007 data can once again be used to determine the extent of sanitation facilities available to households. Table 2.8 provides information on the proportion of households who had access to flush toilets at the district and metropolitan municipality level.

Table 2.8: Access to flush toilets in 2007, by municipality

Province	District or Metropolitan Municipality	Flush toilet (connected to sewerage system)	Flush toilet (with septic tank)
Eastern Cape	Alfred Nzo	1.2	1.1
Eastern Cape	O.R.Tambo	5.8	2.0
Limpopo	Sekhukhune	6.5	1.0
KwaZulu-Natal	Umkhanyakude	10.0	4.0
Limpopo	Vhembe	13.0	1.5
Limpopo	Mopani	16.3	2.2
KwaZulu-Natal	Zululand	16.7	2.4
KwaZulu-Natal	Ugu	17.2	4.6
Eastern Cape	Ukhahlamba	17.7	2.5
Limpopo	Capricorn	19.2	1.9
KwaZulu-Natal	iLembe	19.7	3.6
KwaZulu-Natal	Umzinyathi	20.1	2.8
KwaZulu-Natal	Sisonke	23.2	2.8
KwaZulu-Natal	Uthungulu	24.4	3.4
KwaZulu-Natal	Uthukela	24.7	4.8
Eastern Cape	Chris Hani	26.8	2.1
Mpumalanga	Ehlanzeni	27.5	1.7
North West	Ngaka Modiri Molema	28.1	2.3
Northern Cape	Kgalagadi	29.0	4.2
North West	Dr Ruth Segomotsi Mompati	30.9	1.9
North West	Bojanala	34.2	3.3
Eastern Cape	Amatole	35.2	3.9
Free State	Thabo Mofutsanyane	37.0	1.9
Limpopo	Waterberg	42.0	2.5
Mpumalanga	Nkangala	42.3	2.4
KwaZulu-Natal	Umgungundlovu	47.7	6.3
KwaZulu-Natal	Amajuba District	49.7	1.3
Free State	Motheo	51.1	2.0
Gauteng	Metsweding	53.9	6.2
Mpumalanga	Gert Sibande	61.2	2.8
Northern Cape	Siyanda	63.7	7.0
Eastern Cape	Cacadu	64.9	9.4
KwaZulu-Natal	***Ethekwini***	***65.3***	***4.4***
Northern Cape	Pixley ka Seme	66.0	2.5
Northern Cape	Namakwa	67.2	5.8
Free State	Lejweleputswa	67.9	1.1
Free State	Xhariep	68.3	2.1
Gauteng	***City of Tshwane***	***71.3***	***1.8***
North West	Dr Kenneth Kaunda	74.1	1.4
Gauteng	West Rand	75.2	2.9
Northern Cape	Frances Baard	76.8	3.3
Western Cape	Eden	82.5	3.6
Free State	Fezile Dabi	82.9	1.7
Gauteng	***Ekurhuleni***	***83.0***	***2.0***
Western Cape	Cape Winelands	84.3	9.3

Eastern Cape	***Nelson Mandela***	***85.0***	***2.6***
Gauteng	***City of Johannesburg***	***86.7***	***2.7***
Gauteng	Sedibeng	86.9	1.6
Western Cape	West Coast	87.0	6.5
Western Cape	Overberg	87.4	6.2
Western Cape	***City of Cape Town***	***91.2***	***1.6***
Western Cape	Central Karoo	92.0	2.2

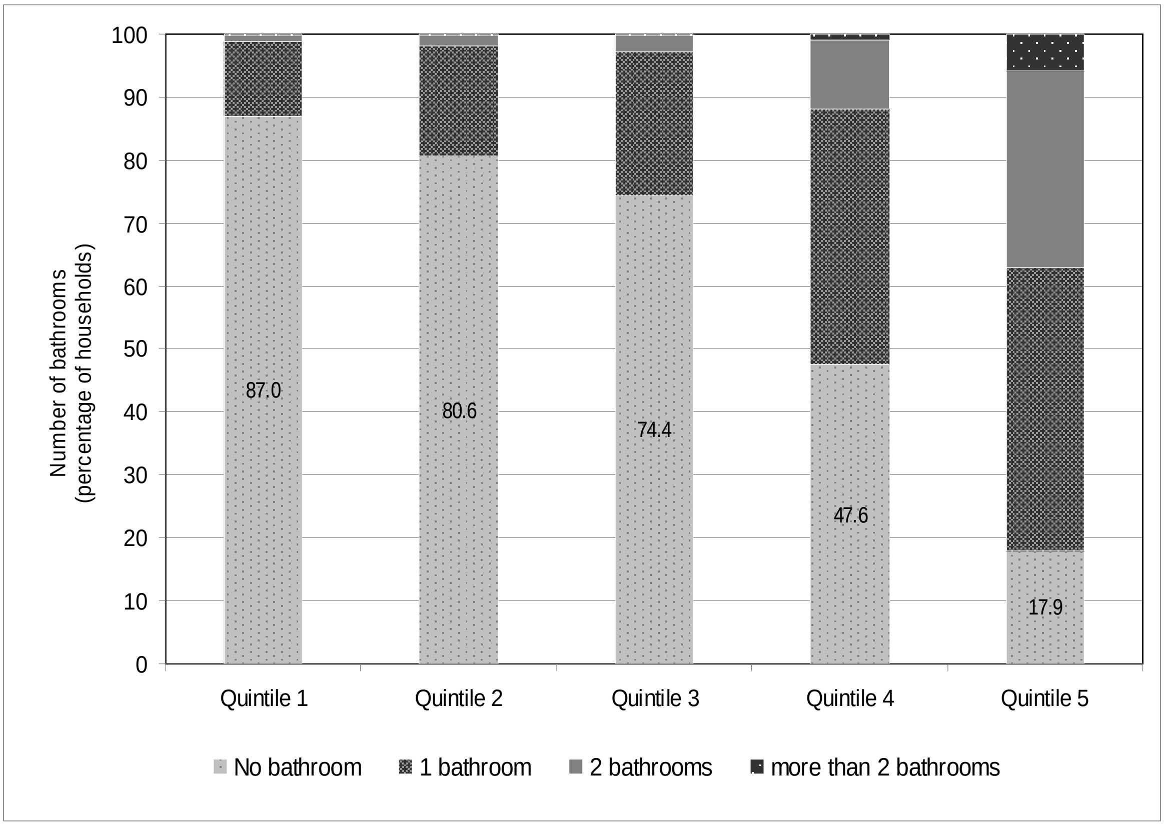
Source: Own calculations. Data from Community Survey 2007 (Statistics South Africa, 2007)

It is evident that the provision of water-borne sanitation (i.e. flush toilets connected to the sewerage system) was inadequate. 27 district municipalities had less than 50% of households with a flush toilet. In quite a few of these municipal districts, households predominantly used pit latrines and the bucket system. An example is the Alfred Nzo district municipality (Eastern Cape), where approximately 51% of households used a pit latrine without ventilation, 19% had access to a pit latrine with ventilation and approximately 15% used buckets.

An analysis of sanitation facilities by income group shows that in 2002 slightly more than 20% of households in quintile 1 had no sanitation facilities at all. This proportion declined to 11% in 2009. A further analysis of the 2009 data reveals that most of the poorest households did not have bathrooms or toilets in their dwellings. Figures 2.17 and 2.18 indicate that more than 85% of the poorest households did not have a bathroom inside their dwelling. In addition, just slightly less than 80% of these households did not have a room consisting only of a toilet[8].

[88] Although quintile 5 seems to have an unusually high proportion of households with no toilet, this is not unexpected since is not common to have separate rooms for bath and toilet facilities.

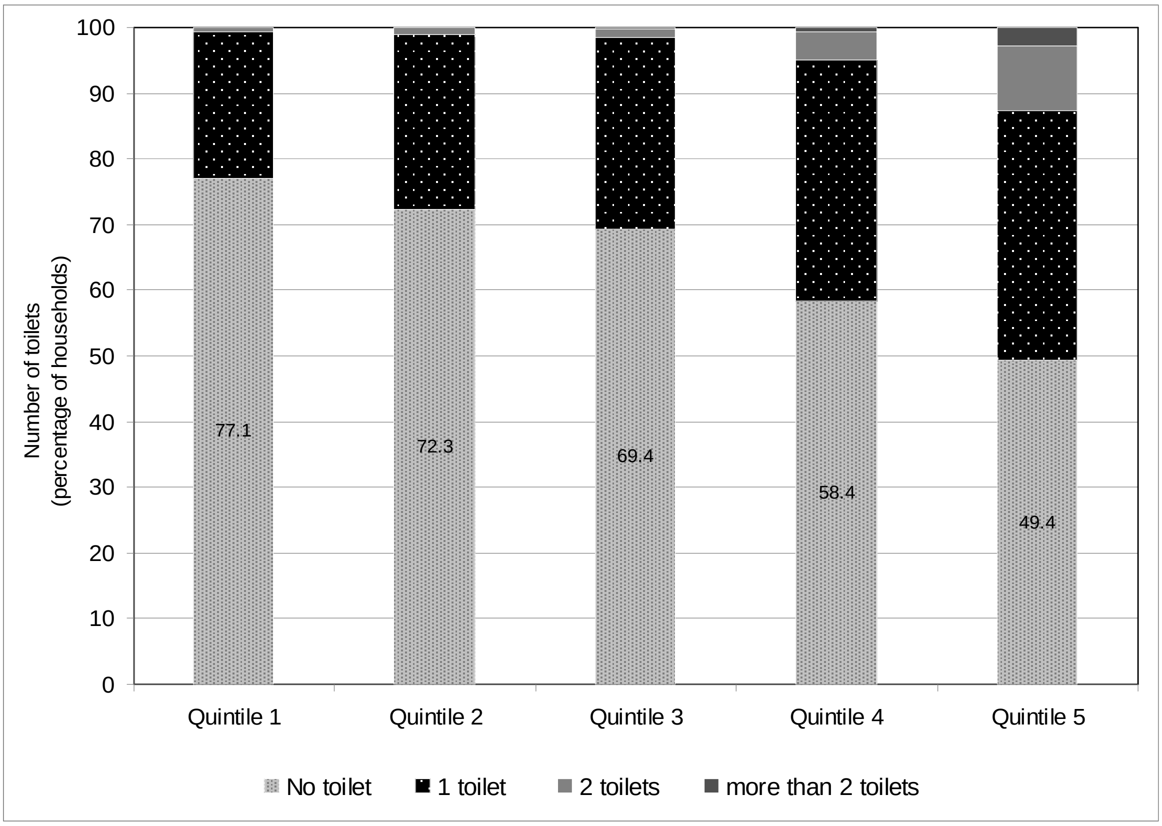
Figure 2.17: Number of bathrooms inside dwelling[9] in 2009, by quintile



Source: Own calculations. Data from GHS 2009 (Statistics South Africa, 2009)

[9] This excludes garages and outbuildings unless they were occupied by a member of the household.

Figure 2.18: Number of toilets inside dwelling[10] in 2009, by quintile



Source: Own calculations. Data from GHS 2009 (Statistics South Africa, 2009)

A probit model is once again used to determine the factors influencing the probability of households' access to sanitation facilities. The dependent variable is a dummy variable, which equals one if the sanitation facility is a flush or chemical toilet. The explanatory variables are the same as those used in the previous analysis (in Section 2.4.1 and Table 2.4), with the exception of the computation of the socio-economic status variable (SES1). The index is again determined by using the socio-economic variables specified earlier, with the exception of the type of sanitation facility, which is now replaced by access to water. The results of the probit model are shown in Figure 2.9.

[10] This excludes garages and outbuildings unless they were occupied by a member of the household. Note that toilet refers to rooms with only a toilet.

Table 2.9: Probit model: Access to a flush or chemical toilet: 2002 to 2009

Variable	Coefficient	Variable	Coefficient
Western Cape	1.395***	Coloured	0.133***
	(38.35)		*(5.42)*
Northern Cape	0.371***	Indian	1.016***
	(14.87)		*(12.10)*
Free State	0.344***	White	0.986***
	(16.71)		*(11.01)*
KwaZulu-Natal	-0.069***	Employed	0.255***
	(-3.80)		*(22.98)*
North West	0.002	Socio-economic index	0.610***
	(0.12)		*(142.71)*
Gauteng	1.282***	Household size	-0.073***
	(59.39)		*(-34.82)*
Mpumalanga	0.005	Y2003	0.085***
	(0.25)		*(4.50)*
Limpopo	-0.648***	Y2004	0.095***
	(-33.60)		*(4.90)*
Male head of household	0.076***	Y2005	0.030
	(7.21)		*(1.46)*
Primary schooling	0.098***	Y2006	0.002
	(6.08)		*(0.12)*
Secondary schooling	0.265***	Y2007	-0.018
	(17.73)		*(-0.87)*
Matriculation certificate	0.376***	Y2008	0.024
	(18.96)		*(1.26)*
Certificate+diploma	0.359***	Y2009	-0.036*
	(13.17)		*(-1.87)*
Degree	0.391***	Constant	-0.155***
	(6.64)		*(-6.33)*
Unspecified	0.135**		
	(2.46)		
Number of observations	208 479		
Pseudo R^2	0.56		

Z-values in parentheses.

Level of significance: *** - significant at the 1% level, ** - significant at the 5% level, * - significant at the 10% level.

Source: Own calculations. Data from GHS 2002-2009 (Statistics South Africa, 2002-2009)

The provincial dummies reveal that households in the Western Cape, Gauteng, Free State and Northern Cape are most likely to have flush (or chemical) toilets, as compared to the reference province (i.e. the Eastern Cape). However, two provinces are even less likely than the Eastern Cape to have these types of sanitation facility, namely Limpopo and KwaZulu-Natal. This confirms the descriptive analysis in Figure 2.16. Furthermore, households with male heads are more likely to have flush toilets, in contrast to larger households.

The education variables indicate that educated households are more likely to have access to flush toilets, as compared to those with no schooling. In addition, all race groups have a greater probability of having flush toilets when compared to Black households, other things being equal. Once again the socio-economic index shows a positive correlation with the likelihood of having access to flush toilets. The year dummies show that over time there has been some marginal improvement in the likelihood of having access to flush toilets. Compared to 2002, most of the year dummies have a positive coefficient, but they are very small (which confirms the findings in Figure 2.14).

A comparison of these results with the probit model in Table 2.4 (i.e. access to piped water inside the dwelling, in the yard, or on site) reveals that the factors that determine the probability of having access to water and sanitation are quite similar. The richer, better educated, urban employed households are more likely to have tap water and flush toilets inside their dwellings. The provincial dummies show significant differences between provinces. In both models, the likelihood of having access to tap water or flush toilets is greater in the richer more urbanised provinces, as compared to the Eastern Cape.

2.5 Concluding remarks

Water resources in South Africa are under pressure, due to both supply- and demand-side factors. On the supply side there is a decline in water availability as a result of the country's erratic rainfall pattern and increasing pressure from climate change and pollution. At the same time there is an increase in the demand for water due to population growth and urbanisation. South Africa is fast approaching physical water scarcity, but it also lacks sufficient water infrastructure and the institutional capacity to ensure universal access to basic water and sanitation services (i.e. there is economic water scarcity).

Given the scarcity problems discussed in this chapter, water managers must ensure that water resources are used in a sustainable way and that there is protection against further pollution and degradation. There is also a need to ensure that all people in South Africa have access to basic water and sanitation services at an affordable cost. To achieve these multiple objectives, the focus can no longer only be on augmenting the supply of water in order to increase water availability. Water scarcity necessitates considering other management options. One option is water demand management, which entails managing water resources by reducing the demand for water.

The next chapter discusses the main ideas behind water demand management, keeping in mind the complex problem of water scarcity. It is not only the physical quantity of water that must be conserved; water managers must also ensure that sufficient revenues are raised to expand services to those who currently are without water and who cannot afford to pay for it. A particular emphasis is on water pricing as demand management tool. The remainder of this part of the dissertation therefore explores water pricing as demand management tool and provides an empirical analysis on the efficacy of pricing to reduce urban water consumption (i.e. estimating the price elasticity of demand). A final empirical section discusses the distributional implications of water pricing structures in South Africa.

CHAPTER THREE
Water Demand Management

3.1 Introduction

Many societies face the problem of water scarcity as they have an inadequate supply of water to fulfil the needs of their growing populations. Expected demographic changes in developing countries such as population growth and urbanisation will ensure a growing demand for water. As discussed previously, it is estimated that the proportion of the urban population of developing countries will rise to over 60% by the year 2050 in less developed regions (see Section 2.2.1), which will affect the quantity of water required. It will also influence waste water management, since the quality of water is also an important aspect of water management.

In the past, water managers expended much effort in building dams to increase the supply of water. According to Renzetti (2002: 131), society's efforts to regulate and allocate water resources were focused on issues relating to water supply. This was based on the assumption that water needs were exogenously determined and therefore not sensitive to government policy. Water managers therefore supplied water without really considering its cost (Winpenny, 1994: 2). This led to the problem that easily accessible water resources were exhausted and the supply of water had often reached its physical limit. Developing new water resources is relatively expensive and there are hydrological limits to the supply of water. The cost of supplying water is increasing, as are the environmental costs associated with the extraction and transfer of water over long distances (Winpenny, 1994:25).

More recently researchers have started to criticise the supply-side approach to water management. Even in the sixties Hirschleifer, De Haven and Milliman (1960), as cited in Renzetti (2002), examined water-related investment decisions and concluded that administrators did not pay enough attention to improving the use of existing water supplies. According to Radif (1999: 147), the limitations of supply-side management became evident and in the eighties an integrated water resource management approach was advocated. This approach suggests that fragmented policies should be integrated into a national economic framework. The core of this approach is the establishment of multi-disciplinary teams at various levels to communicate different perspectives on the supply of water (Radif, 1999: 149). Thomas and Durham (2003: 22) state that an integrated approach entails looking at the development of alternative resources, protecting the resource in an effort to stabilise and improve its quantity and quality, and implementing demand management at the level of each river basin. Moreover, given the growing need for water and the uncertainty of how resources will be affected by factors such as climate change and human activity, it is necessary to adopt an integrated approach to water management, where all factors are considered in the process of decision making (Bouwer, 2000: 218). According to Jonker (2002: 719), integrated water resource management should be concerned with issues such as access, resource protection, using water efficiently, protecting and governing the resources, as well as land use.

An essential part of integrated water resource management is the inclusion of policies to influence the demand side of water. Past experience and research suggest that water demand management policies can assist in reducing water deficits in water-stressed regions (Dziegielewski, 2003: 29). The aim of these policies is to address consumptive demand for water, thereby avoiding the development of new resources (Butler and Memon, 2006). Price and non-price policies are considered as options to change the behaviour of water users. In the case of water tariffs, water managers need information on the water demand structures in order to implement effective policies. Restrictions, rationing and water-saving technologies are further options that may reduce water consumption.

This chapter focuses on water demand management, with an emphasis on pricing as a demand management tool. It commences with a definition of water demand management, which is followed by a discussion of demand-side strategies to reduce water consumption. Water pricing is given specific attention. In particular, the Increasing Block Tariff (IBT) structure is of interest, since it is the tariff structure applied in South Africa. Furthermore, the empirical analyses in Chapters Four and Five focus on specific aspects of this tariff structure. The latter part of this chapter gives a concise overview of water demand management in South Africa, with a discussion of water policy and legislation and the need for water demand management. This is followed by examples of the implementation of water demand management strategies in different parts of South Africa.

3.2 Defining water demand-side management

Water demand management aims to reduce the amount of water required by consumers, as well as to bring about a more efficient water distribution system without leakages. Water demand management is "about the governance and tools that motivate people and their activities to regulate the amount and manner in which they access, use and dispose of water" (Baroudy, 2005: 1). According to Arntzen (2003), water demand management is undertaken for both environmental and economic reasons. The former refers to the increasing water scarcity faced by many countries, and implies managing the demand on the environment (Green, 2003: 239). Economic reasons include ensuring that water is distributed to users in the most cost-effective manner, since water demand management can reduce water losses and costs (Arntzen, 2003: 11). In some countries, physical water scarcity is not a concern and water demand management is mainly applied for economic reasons. In countries such as South Africa, however, both environmental and economic reasons apply (Arntzen, 2003).

Water demand management is typically presented as part of an integrated approach to water resources management and corrects an historic tendency to overemphasise supply-side investment. Dziegielewski (2003: 30) indicates that water demand management should receive explicit consideration within an integrated water resource management framework, since it broadens the options available in a holistic management approach. A thorough knowledge and management of the demand side will assist water professionals to manage the available resources within a complex and dynamic system.

A distinction is made between demand management and demand-side management (Stiles (1996), as cited in Brooks (2006: 523)). Demand management refers to a broad range of methods and processes applicable to the requirements of water consumers, as opposed to the supply needs of water providers. In contrast, demand-side management refers to activities that are adopted specifically by water utilities to balance supply augmentation and demand reduction. In his quest to provide an operational definition of water management in the broader sense, Brooks (2006) emphasises the importance of not viewing water demand management as yet another technology. Rather, it should be seen as policy that operates within a larger framework, i.e. it is a governance concept. For this purpose Brooks (2006: 524) provides an operational definition which focuses on both the quantity and the quality of water, the efficacy of conveying water, given different levels of demand, and the need to ensure resilience in water systems when dealing with shortages.

Other definitions of water demand management in the literature include that of Renzetti (2002: 132), who defines it as "policies that are meant to contribute to the efficient allocation of water through the 'management' of water demands." According to Meyer (2007: 23), demand management refers to strategies applied by water institutions in an attempt to influence the demand for water, taking into account various objectives such as efficiency, social development and equity, and the sustainability of water supply and services. It is therefore important to keep in mind that the design of policies must meet various criteria and cannot only address the efficient use of the resource. This view is supported by Savenije and Van der Zaag (2002: 99), who state that not only should policy achieve an efficient and sustainable use of the resource, it should also encourage equity and environmental integrity.

Water demand management policies differ from supply management options in that the behaviour of consumers must be considered. According to Borisova, Rawls and Adams (2009), demand management is related to the choices made by consumers and requires their active participation through behavioural changes. It is therefore imperative that water managers are aware of the preferences of water consumers, since this is vital for water conservation (Dupont, 2005). Knowledge of water use on the demand side can be used to design alternative water demand management options. One example is the community-based educational programmes suggested by Mathipa and Le Roux (2009). They analysed the water-use patterns of two rural communities in South Africa and designed a framework to develop community-based educational programmes. One aspect of their design entails the establishment of water committees for each community and the official recognition of such bodies by local authorities.

3.3 Demand-side strategies

Water managers can use both structural and non-structural measures on the demand side to reduce the shortage of water. Structural measures include the retrofitting of water appliances, as well as recycling options and reuse, whereas non-structural measures include water tariffs, awareness campaigns and the imposition of water restrictions (Gumbo and Van der Zaag, 2002). According to Rixon, Moglia and Burn (2007: 73), water demand management entails water utilities making use of policies that will affect the demand behaviour of water consumers. Since it attempts to make water use more efficient, "water as an economic good is fully compatible with the concept of demand management" (Savenije and Van der Zaag, 2002: 100). Demand management strategies therefore primarily involve mechanisms that influence the behaviour of water users, using policy options such as water-pricing structures, educational campaigns, financial incentives (rebates for more efficient use of water), quantity restrictions and the encouragement of recycling.

Quantity restrictions mean a restriction on the amount of water users may consume during specified times. Quotas set upper limits to the amount of water that can be used for a certain purpose (Savenije and Van der Zaag, 2002: 100). According to O'Dea and Cooper (2008: 10), economists argue against the use of quantity restrictions due to their economic inefficiency, arising from the fact that water allocations are not based on willingness to pay. They do state, however, that there are some benefits associated with the use of quantity restrictions, which include a high probability of public acceptance. The Independent Pricing and Regulatory Tribunal of New South Wales in Australia, in its household survey of 2003, found that 63% of people were willing to accept restrictions once every year (O'Dea and Cooper, 2008: 10). In addition, quantity restrictions may be more effective than price increases in the short run since water demand tends to be price inelastic.

In a study of the efficiency and equity implications of water demand management in Melbourne, Australia, Edwards (2006: S62) argues that there is a cost associated with alternative types of water demand management. In the case of quantity restrictions, the costs of informing communities and administering and enforcing the restrictions should be considered. This argument is supported by Olmstead and Stavins (2009: 2), who compare price and non-price approaches to conservation. They indicate that conventional prescriptive policies such as water restrictions and other regulatory (command-and-control) policies are less cost-effective than market-based instruments, since the former are less flexible than the latter and incur greater economic losses.[11]

The government or water managers can apply direct intervention to reduce water consumption (Brooks, 1997); this may require the installation of water-saving devices. Water-saving technologies include measures such as double-action cisterns and low-volume showers, which may be viewed as more long-term water conservation measures (Stephenson, 1999: 115). Other instruments include efficient garden irrigation systems and tank displacement devices. There is obviously a cost associated with the use of these

[11] Command-and-control (CAC) policies usually require all households and firms to undertake similar proportional reductions in water consumption (i.e. a uniform conservation burden), since they receive directives from water authorities and there is little room for flexibility. For this reason, CAC policies are less cost effective than market-based policies. See Olmstead and Stavins (2009) for a more detailed discussion.

devices and for this reason rebate systems are often used to lessen the household burden. According to Dolnicar (2010), many states and councils in Australia make use of the rebate system to lower the cost of reducing water consumption through technological devices. For example, they provide a rebate for water-saving washing machines and rainwater tanks (Dolnicar, 2010). In a study modelling household water demand, Renwick and Archibald (1998) evaluated the use of water-saving technology, in particular low-flow toilets and showerheads. Their findings indicated that both these devices were effective in reducing household water demand (Renwick and Archibald, 1998: 355-356). In addition, water-efficient irrigation also reduced the demand for water; the extent of the reduction depended on the area of land area to be irrigated.

In another study of water demand measures, Renwick and Green (2000) evaluated the demand management policies of eight water agencies in California. Their findings showed that the majority of these agencies used a combination of water demand management measures. The most popular non-price policy instruments were public information campaigns (offering a rebate on fitting an ultra-low-flow toilet), water rationing and water restrictions, and the distribution of retrofit kits (which included low-flow showerheads, tank displacement devices and dye tablets to detect water leakages) (Renwick and Green, 2000: 41). Their findings indicated that non-price demand management instruments such as retrofit kits, water rationing and water restrictions, as well as public information campaigns, do affect the aggregate water demand. The estimated coefficients for these measures were all negative and significant (in relation to water demand). Mandatory measures such as water restrictions were, however, more effective in reducing demand than the voluntary measures (such as those promoted in public information campaigns). These results indicate that water managers have a range of policy options available to them, but the way a community reacts to these measures depends on its socio-economic and structural characteristics (Renwick and Green, 2000: 51).

A combination of measures is usually implemented when there are severe restrictions on supply availability. In addition, Olmstead and Stavins (2009) indicate that it may be politically difficult to raise water prices – hence the need to use water pricing and non-pricing measures concurrently. It is therefore imperative to consider the impact of all policies when assessing the efficacy of demand-side management measures. Failure to take account of both price and non-price policies may result in an over-estimation of the responsiveness of water users to changes in the price of water (Renwick and Green, 2000: 38).

The price of water is one of the key determinants of the demand for water and is an important tool for reducing demand (Griffin, 2006: 243). This is based on the economic principle that water is an economic good and should be priced according to its opportunity cost. Griffin (2001: 1335) states that the increased cost of supplying water can be attributed to increasing water scarcity, higher infrastructure costs and stricter environmental and health regulations. As discussed in Chapter Two, many countries face growing physical water scarcity. This, coupled with the escalating cost of water, has led to the realisation that the efficiency of water allocation and use must be improved (Grimble, 1999: 78). If water supply authorities aim to achieve a more efficient use of the resource, consideration must be given to pricing water as close as possible to its cost of production, as well as to the marginal user cost. Gunatilake, Gopalakrishnan and Chandrasena (2001: 281) define marginal user cost as the "net benefit foregone by a future user, due to consumption of a non-renewable resource at present."

Water was recognised as an economic good long before the Dublin Water Principles proclaimed it as such in 1992 (Rogers, de Silva and Bhatia, 2002: 1). An important aspect of this classification is its impact on the management of water. If water is perceived as a private economic good, pricing will play an important role in its distribution to different users. Those who are willing to pay for water will receive it. However, it is precisely this approach that is questionable. Perry, Rock and Seckler (1997) emphasise the distinction between water as a private and as a public good. Those who support classifying water as a public good refer to the needs of the poor that cannot be ignored. This point is also raised by Briscoe (1997), who points out that if water is treated as an economic good, the poor will suffer, since their basic human needs will not be considered. However, he indicates that there are examples where the poor can benefit when water is treated as an economic good. One of the examples he discusses is the Chilean case, where the government made use of means-tested targeting to identify the poor and subsidise their water use. This will be discussed in more detail in Chapter Five.

Since the price of water is controlled administratively, the manipulation of price is "a prime demand management strategy." (Griffin, 2006: 243). According to Gumbo (2004: 1226), even though water pricing is only one of the water demand management strategies, it receives disproportional attention given the integrated water management principle of water as an economic good. Research on the structure of water demand has shown water use to be sensitive to both the structure and level of water prices (Renzetti, 2002: 131). Changing the price of water signals a change in the cost of consumption to consumers and promotes a reduction in water consumption. However, this does not imply that water shortages will be eliminated. The 'water market' functions very differently to the usual competitive market. In the latter case, any shortages in the market can be eliminated by appropriate price adjustments. In the case of water, however, increases in administered water prices affect consumption, but do not necessarily eliminate shortages.

One consideration that favours the use of demand-side management tools, particularly water pricing strategies, is that they are usually less costly to implement than supply augmentation (which may entail building more dams). The premise behind this is that water demand is not fixed and can be adjusted (Cantin, Shrubsole and Aït-Ouyahia, 2005). Renzetti (2005: 22) argues, however, that in practice there has been little emphasis on using the price of water to signal the opportunity cost of consumption. In fact, water pricing rarely achieves efficient levels of consumption (Tyler, 2007). In addition, water pricing does not take account of variations in use in relation to distance from source or the time or season of use. This has led to water being consumed at more than the optimal social level.

3.4 Water Pricing as Management Strategy

One of the key issues water managers must consider in developing appropriate water management strategies is how to structure water prices. The pricing structure is more important than setting the price level, as consumers are more sensitive to the structure of water prices (Cantin et al. 2005). Griffin (2006: 245) defines a rate structure as the way the per-unit water price varies according to usage. Majumdar and Gupta (2007: 578) define a tariff structure as "a system of procedures and rates that determines a consumer's total water bill."

Setting appropriate tariff structures requires two key kinds of information. One must have adequate information about water consumers' behaviour. It is not enough to only have information on the use of water. Water managers need information on "the perceptions, attitudes and beliefs of consumers" (Cantin et al. 2005: 9). This will provide a better understanding of the factors influencing the use of water, as well as of the behaviour of water users. Water tariff structures are often set to achieve cost recovery. However, economic factors such as customers' responsiveness (i.e. the price elasticity of demand) are rarely taken into account. According to the Food and Agriculture Organization (1995: 18), although water pricing is normally regarded as a cost recovery measure, in many instances full cost recovery is not achieved.

The second kind of information involves the goals the pricing structure must achieve. If water pricing is solely used for the purpose of achieving an efficient use of the resource, the most appropriate pricing structure is one that is closest to full economic cost pricing (i.e. marginal cost pricing). Marginal cost pricing implies setting a price equal to the long-run marginal cost of production, where the long-run marginal cost is a measure of marginal cost when the water capacity can be varied incrementally (Sibly, 2006: 23). Although marginal cost pricing would be the most efficient way of pricing water, the challenge is to determine what this long-run marginal cost is. This means determining the infrastructure costs (operating, maintenance and replacement costs) as well as determining the value of opportunity costs and any externalities (Cantin et al. 2005). Hence, cost recovery pricing and marginal cost pricing differ, since the former involves setting a price that is equal to the average cost (so that water utilities break even) (Cantin et al. 2005: 5).

Water managers often have multiple objectives in mind when setting appropriate structures. These objectives have to be considered when water utilities decide on the allocation of water and the appropriate water tariff structure. Whittington (2003: 63) refers to the following objectives which influence the setting of water tariff structures:

- Revenue sufficiency: the tariff should be set in such a way that enough revenue is collected to cover the total cost of water provision.
- Economic efficiency: water tariffs must be set at a level that minimises welfare losses. Thus, the price of water must be equal to the marginal cost of supplying it.
- Equity: tariffs should take into account socio-economic disparities.
- Poverty alleviation: water should be provided free or at a subsidised rate to the poor.

The objectives of fairness, equity and poverty reduction imply setting alternative pricing structures. There are three main types of pricing structure which water utilities can use to influence water use, namely increasing block tariffs (IBT), decreasing block tariffs[12] and uniform rate structures (Hajispyrou, Koundouri and Pashardes (2002: 659).

In the case of uniform pricing, the consumer is charged a single price. Water users are therefore charged a single volumetric rate for all levels of water use (Olmstead, Hanemann and Stavins, 2003). In instances where a flat rate is used, it is generally not equal to the marginal cost of production. However, the constant or flat-rate structure is the simplest pricing structure to adopt. It is easy to understand and it simplifies administration (Majumdar and Gupta, 2007). In addition, it is useful in cases where water metering is not available (Lefebvre, 2005: 22). However, it does not necessarily encourage efficient usage of the resource, since consumers pay the same rate for each unit of water. It is therefore more appropriate in countries with abundant water resources (United Nations, 2005: 17).

The IBT structure provides a specific form for the volumetric part of the tariff as it uses graduated marginal prices as the consumption of water increases. The IBT structure usually starts off with a marginal price that is below the marginal cost. The marginal price increases for subsequent blocks, and later exceeds the marginal cost in the higher consumption blocks. According to Barkatullah (1999: 54), the IBT structure is an extension of the two-part tariff, where the usage component has a number of steps. A two-part tariff has an access fee (or fixed fee) and a usage fee, consisting of a single unit price (see Barkatullah (1999) and Griffin (2006) for a more detailed discussion). In an IBT structure, water officials must therefore set three parameters for each category of water use, namely the number of blocks, the volume of water use and the per-unit price for each block (Boland and Whittington, 2000: 217).

It is possible to achieve some welfare gains through the implementation of IBT structures. According to Olmstead, Hanemann and Stavins (2007), with an IBT tariff structure it is possible to achieve some welfare gains if more water users were to face the efficient price (i.e. the long-run marginal cost) in the upper blocks of consumption. However, there may be some welfare losses when consumers in the lower-priced consumption blocks are subsidised. It is possible for water utilities to overcome their rate-of-return constraints by manipulating the block cut-offs and inframarginal[13] prices (Olmstead et al. 2007: 183).

[12] Decreasing block tariffs are not discussed in detail here as this tariff structure is rarely applied.

[13] The concepts intramarginal and inframarginal are used interchangeably.

Intramarginal rates refer to those rates applicable in water consumption blocks which do not correspond to the current level of consumption (Bachrach and Vaughan, 1994: 8).

The type of pricing structure chosen will be determined by the management objectives of water authorities. However, this is a complex task since there is no strict relation between a particular objective and a pricing structure (Montginoul, 2007: 863). If efficiency is paramount, then volumetric tariff structures (where consumers are charged per unit of water consumed) are preferred. According to Montginoul (2007), a two-part tariff structure is appropriate, given the constant price applied to volumetric consumption. She also mentions the IBT structure as a consideration if the marginal prices in the higher consumption blocks are set close to the marginal cost of production, as this can lead to gains in efficiency. This, however, depends on the sensitivity of consumers to water prices. High water users will fall into the higher consumption blocks and if their demand is more responsive to changes in prices, efficient usage of water can be achieved, especially if these marginal prices are set relatively high. In contrast, Hajispyrou et al. (2002: 660) state that IBT structures do not favour efficiency and argue that there is no conclusive evidence that it has "a 'psychological' effect helping water demand management ".

The IBT structure is the tariff structure most commonly used in developing countries (Whittington, 1992). Mathur and Thakur (2003: 12) consider the key advantage of the IBT structure its contribution to equity, in that it allows poor consumers to pay lower tariffs than other consumers. With an IBT structure, marginal prices are higher for high-income households (based on the assumption that these households usually consume more water, as they have more water-using appliances than poorer households). Tyler (2007) states that there is widespread consensus on the need for some form of social tariff that takes into account the water use of poor households. However, there are some practical issues to be kept in mind when designing an appropriate water pricing structure, particularly in poor urban areas. Volumetric pricing requires all households to have individual water metres, which is not always feasible, since high-density living in poor suburbs often involves families sharing water connections. In addition, Tyler (2007: 9) emphasises that if poverty reduction is a concern, water demand management should then not aim at absolute water reduction, but should also allow for the expansion of services to more consumers. Water pricing can help to achieve this by increasing the revenues obtained from changes to water tariff structures, which can contribute to the expansion of services.

Another common reason for using IBT structures is the promotion of water conservation (Whittington, 1992). With the IBT, the first block is usually charged at below cost. Subsequent blocks have higher marginal prices to discourage water usage and to encourage water savings. However, the effect depends on the price elasticity of the demand for water. In addition, the achievement of objectives such as efficiency, equity and cost recovery depends on how sensitive households are to the type of price used as well as to the overall pricing structure. According to Montginoul (2007: 863), some consumers respond to average prices rather than marginal prices and there are also more complicated responses when alternate block tariff structures are considered. The response of consumers to different pricing variables and structures is discussed in more detail in Chapter Four.

3.5 Water demand management in South Africa

This section discusses water demand management in South Africa and commences with a brief overview of recent changes to the South African water legislation (with an emphasis on water demand management). This is followed by a discussion on the implementation of water demand management, elaborating on selective examples. Particular attention is given to water demand management policies in Cape Town, since this is the area from which household data are used to estimate the price elasticity of demand in Chapter Four.

3.5.1 Water policy and legislation

Water policy in South Africa has undergone substantial changes. In 1998 the South African government enacted the National Water Act (No. 36 of 1998), whose main purpose was to ensure that the nation's water resources were developed, used, protected, controlled, conserved and managed in a sustainable and equitable manner, for the benefit of all people (Republic of South Africa, 1998). Efficiency in the context of water policy refers to using water in the most socially and economically advantageous way, with minimum water wastage; equity means ensuring that everyone has access to water and that water is allocated fairly. The Act makes water public property and places water in the care of the state, although some private tradable rights are allowed (Saleth and Dinar, 2000: 186).

According to the Water Conservation and Demand Management National Water Strategy Framework, water conservation is the minimisation of loss or waste, the preservation, care and protection of water resources, and the efficient and effective use of water (Department of Water Affairs and Forestry, 1999). Water demand management is one way of achieving water conservation goals as set out in the legislation. As discussed earlier, water demand management involves setting policies and strategies that will affect the demand for water, while taking into account the objectives of efficiency, equity, protection of the environment, sustainability of water resources and political acceptability (Department of Water Affairs and Forestry, 1999).

While the National Water Act focuses on the use of the nation's water resources, the Water Services Act (No. 108 of 1997) focuses on water services, in particular potable (drinkable) water and sanitation services supplied by lower level authorities, such as municipalities (Republic of South Africa, 1997). The Act specifies as its objective the provision of basic water and sanitation to all in such a manner that is not harmful to the environment or human beings, while setting appropriate tariffs for water services and providing an institutional framework for the delivery of these services by water authorities (Republic of South Africa, 1997). In particular, the Water Services Act provides guidelines for the norms and tariffs for water services and indicates that tariff setting should take account the concerns of equity, financial sustainability and cost recovery (Republic of South Africa, 1997).

To incorporate equity concerns into water pricing policy, the Free Basic Services Policy was introduced in 2000 and implemented in 2001. It makes provision for free basic water and sanitation services (Department of Water Affairs and Forestry, n.d.). Since it was argued that poor households would not be able to afford cost-recovery water tariffs and would face cut-offs of water supplies, the primary objective of this policy is to achieve a more equitable distribution of basic services, ensuring that households who cannot afford to pay for water still have access to sufficient water to meet their basic needs.[14] Section 27(1) (b) of the South African Constitution also guarantees every citizen the right to access sufficient water for their basic needs (Malzbender, Goldin, Turton and Earle, 2005).

The Free Basic Water policy allows six kilolitres of water per household per month free of charge, irrespective of household demographics. According to Bond and Dugard (2008: 9), this quantity of 25 litres per person per day was influenced by a pilot project in Durban, as

[14] The policy applies to the basic services of water, electricity, sanitation and refuse collection. See Smith (2009) for more information.

well as RDP standards and the average size of households from the 2001 census. Furthermore, each municipality must decide how to set its water tariffs to include the free basic component. Households receive the first six kilolitres of water free of charge, after which consumption is charged at an escalating rate (i.e. the standard tariff is applied). Municipalities therefore implement an IBT structure in order to achieve both cross-subsidisation between high-volume users and low-volume users, and the conservation of water (i.e. high-volume users of water will pay high marginal prices, which will reduce their consumption). Thus, the government wanted to show that it was not deviating from the cost-recovery principle by implementing free basic water, since households consuming more than the basic amount would be expected to pay for water at the standard rates (Smith, 2009: 15).

In 2003 a means-tested indigent policy was introduced by the South African government through the then Department of Local and Provincial Government, in terms of which the delivery of free basic water would be aimed primarily at poor households (Smith, 2009). This implied a shift away from delivery to all households in favour of targeted households. The primary objective of the indigent policy was to develop a plan to comply with the constitutional rights of poor people to basic socio-economic services, without sacrificing the "overall integrity and sustainability of the financial or natural resource base" (Department of Provincial and Local Government, 2005: 5). Van Ryneveld, Parnell and Muller (2003: 6) define an indigent policy as one that delineates how poor households must be handled in relation to generating income for the municipality. It is also a social safety net to ensure that poor people have access to a basic service to enable them to participate in society's activities in a productive and healthy manner. According to Smith (2009: 64), there were no explicit guidelines in place for the implementation of indigent policies and municipalities therefore had to use their own initiative to interpret 'indigency' and implement appropriate policies.

According to the Department of Provincial and Local Government (2005), an essential services package to indigent households should consist of a basic supply of water, refuse removal, sanitation, access to energy and housing assistance. However, municipalities have varying capacities to deliver this package to the poor. This is particularly the case for rural municipalities (Type B4)[15] which are very small, consisting of only one or two towns. These municipalities also have the highest proportion of residents without access to a basic water supply, whereas municipalities classified as Type B2 (i.e. local municipalities with large towns) have the lowest proportion of people without access to an adequate water supply. (Department of Provincial and Local Government, 2005: 13).

Even though there are a number of municipalities with an indigent policy in place, the registration of indigent households appears to be low. Provincial statistics from the 2009 GHS reveal that the proportion of registered indigent households was relatively low, particularly in Limpopo and KwaZulu-Natal (i.e. less than 10% of households in these areas were registered as indigent households). It should be kept in mind that a high proportion of households did not have access to basic services (see Chapter Two), which may have contributed to the low proportion of registered households.

Table 3.1 provides information on the proportion of households that received their main source of drinking water from local municipalities and includes statistics for households that received their water inside the dwelling, in the yard, or from a public (communal) tap. It clearly shows that a significant proportion of the poorest households did not have access to piped water and were therefore not able to reap the benefits of an indigent policy.

Table 3.1: Main source of drinking water supplied by a municipality inside the dwelling, in the yard or from a public tap in 2009, by quintile

Main source of drinking water supplied by a municipality (% of households)	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	South Africa
Yes	72.7	76.8	82.1	90.8	93.6	83.0
No	26.7	22.8	17.6	8.9	6.2	16.6
Don't know	0.4	0.4	0.3	0.2	0.2	0.3
Unspecified	0.2	0.1	0.0	0.1	0.1	0.1
Total	100	100	100	100	100	100

Source: Own calculations. Data from GHS 2009 (Statistics South Africa, 2009)

[15] The municipal categories referred to here were applied in the Municipal Finance Review in 2001, which was completed for the Department of Local and Provincial Government (see Department of Provincial and Local Government (2005: 12)). Type B referred to local municipalities; B1- secondary cities; B2 - municipalities with one large town as core; B3 - municipalities with a substantial proportion of urban residents, but no large town as core; and B4 - mainly rural municipalities with a few small towns.

Arntz, Bekker and Botes (2003) investigated the factors influencing the effective implementation of municipal indigent policies. Their case studies were based on four municipalities: two metropoles, (Ethekwini Unicity (Durban) and Nelson Mandela Metropole (Port Elizabeth)), a secondary town (Manguang Local Municipality, Bloemfontein), and a small town (Witzenberg Local Municipality, Ceres). According to Arntz et al. (2003), their selection was based on whether or not the municipalities had an indigent policy, and if so, whether it had been implemented for some time. The indigent policy approach adopted by the municipalities ranged from a universal approach (i.e. providing all households with the free basic water) to a targeted approach, where residents needed to apply and register as an indigent household to qualify for targeted subsidies.

One of the issues highlighted in their research was the formulation of policy design. Effective indigent policy design was affected by various factors, such as the criteria that determine eligibility, the purpose of unconditional transfers received from national government, and insufficient socio-economic research to identify the causes of the problem (Arntz et al. 2003: 109). The implementation of indigent policies was influenced by communication problems and by inadequate monitoring of the process.

Effective targeting of subsidies is also discussed by Muller (2008), who distinguishes between subsidies paid through transfers from national government (which must finance free basic water) and the cross-subsidies received from the tariff policy (where high-volume users pay higher tariffs than low-volume users, who pay below cost). The tariff policy has the additional objective of promoting conservation and sustainable water use. According to Muller (2008: 80), when the efficacy of targeted subsidies is investigated, the source of the subsidy must be established before judgment is made on whether errors of inclusion or exclusion have occurred. This issue is further explored in Chapter Five, where cross-subsidisation as a result of the tariff policy is investigated.

3.5.2 Implementing water demand management strategies

Water demand management policies have become increasingly popular in both the developed and developing world. According to Still, Erskine, Walker and Hazelton (2007), there are many examples of water demand management programmes around the world. For example, both the cities of Seattle (USA) and Windhoek (Namibia) were able to reduce water consumption through successful campaigns. In Southern Africa, various initiatives have driven water management processes. According to Gumbo (2004: 1226), these initiatives included the IDRC[16] Dryland Water Management Programme Initiative for Africa and the Middle East. This project was implemented to investigate which institutions and researchers were involved in water demand management initiatives and to explore the relevant literature, with the purpose of instituting water demand management networks (Forster, 1997: 27). A related project was the World Conservation Union (IUCN) Water Demand Management Project, with similar aims (Gumbo, 2004).

In a comparison of water demand management initiatives in eight Southern African cities, Gumbo (2004) found that, at the time, Johannesburg and Hermanus were the only cities in South Africa to have implemented a water policy with the related legislation. Two of the six cities in other Southern African countries (Windhoek and Bulawayo) had also adopted water demand strategies. All eight cities used a block tariff system. However, using the percentage level of unaccounted water as a rough measure of the efficacy of water demand management, Gumbo (2004) found that only Bulawayo, Windhoek and Hermanus had unaccounted water losses of 20% or less. In the other cities, more than half of the water they supplied was unaccounted for. Johannesburg had a higher percentage of unaccounted water (i.e. 30%), since it has many informal settlements in which water is often obtained through illegal connections (Gumbo, 2004).

The implementation of water demand management policies, however, has not received adequate attention in African countries. Mwendera et al. (2003: 767) state that all the countries in their study of the Southern African Developing Community (SADC) region had indicated that they had not been able to meet the need for water demand management in all sectors. One of the key reasons for this was that inadequate financial and human resources were assigned to the implementation of water demand management. The failure to properly implement water demand management policies led to a demand for augmentation (Mwendera et al. 2003: 769), which could only be overcome by emphasising the benefits of water demand management.

An example of an integrated approach to water demand management is Hermanus in the Western Cape. Hermanus is predominantly a seaside holiday town (Turton, 1999). One of the main attractions of the town is whale-watching opportunities and it is a popular tourist destination, especially during the summer months. This gives rise to uneven water

[16] International Development Research Centre (Canada).

consumption patterns, with unusually high peaks during these summer months. During the nineties, Hermanus experienced a property boom, which led to more water being used than the estimated water allocation for the period. A hydrological analysis revealed that they would not be able to augment water resources from the supply side, which meant finding alternative management strategies (Turton, 1999: 7). They turned their attention to water demand management and implemented a twelve-point plan, referred to as the Greater Hermanus Water Conservation Programme.[17] This plan involved a number of management tools, ranging from economic incentive instruments to command-and-control policies. Among the more pertinent instruments was the use of a multi-tiered tariff structure (or IBT structure). It included a subsidised rate at the lower end of the scale to accommodate those consumers who were not able to pay for water. Another aspect of the programme was the installation of water-efficient devices in homes and buildings. They also made use of educational campaigns and a water loss management programme, which entailed locating unmetered or illegal connections, inaccurate meters, as well as leaks in the reticulation system (Turton, 1999: 9). The implementation of the Hermanus water conservation programme led to marked reductions in water use. In November 1996 a 36% reduction in water consumption was recorded, compared to 1995/6, which was the base year (Turton, 1999: 13). In addition, Turton (1999: 12) argued that the design of the programme was geared towards achieving sustainable water use, as it aimed to change people's attitudes to water consumption over time and, if the programme continued, it would comply with the water demand management goals of efficiency, equity and sustainability.

Water demand strategies have mainly been implemented in the urban domestic sector. In a paper on the potential of water conservation and water demand management in Southern Africa, Rothert and Macy (2000) indicate that, with the exception of Hermanus, the implementation of water conservation and water demand management practices in South Africa has been limited to the big cities of Johannesburg, Durban and Cape Town. As far as the Southern African region was concerned, they found that some countries (notably South Africa, Namibia and Botswana) had water conservation and water demand management policies and/or legislation, but few had started to apply specific measures in the different sectors. Thus, even though these findings indicate a less than optimal position in terms of water demand management implementation, there is reason for optimism

[17] For a detailed discussion of the Greater Hermanus Water Conservation Programme, see Turton (1999).

regarding the prospects for water conservation and demand management. They further postulated that in the Gauteng region of South Africa, more than 50% of the water supply was lost as a result of inefficiency, leakages and illegal connections. Assuming a reduction in the region's urban water demand of 20%, this could lead to a saving of some 1 600 million cubic metres of water annually, sufficient to provide water to 29 million unserviced urban households (Rothert and Macy, 2000: 7). Water conservation and water demand management are therefore important strategies in the management of scarce water resources.

Effective water demand management in the SADC region is, however, constrained by a number of factors. A lack of financial and human resources prevents water service providers from implementing water demand management effectively and ensuring that infrastructure is properly maintained (Mwendera et al. 2003: 769). This is accompanied by a failure to understand the advantages of water demand management, by poor service delivery and by the vested interests of interest groups such as engineers and financiers (who concentrate on supply augmentation). All these factors culminate in a skewed preference for supply augmentation. If there is a lack of understanding of water demand management and why it is needed, there is probably also a lack of available skills to ensure proper planning and implementation (Mwendera et al. 2003).

A review of the status and use of water-efficient devices in South Africa was completed by Still et al. (2007). This survey was conducted in commercial and institutional settings with suppliers of water-fitting devices, architects, and households to determine the efficiency and extent of use of water-saving devices. Their findings indicate an increase in the use of these devices. An example is the City of Cape Town, which opted to install Hippo Bags in public buildings (Still et al. 2007). A Hippo Bag is a water-saving device that consists of a heavy-duty plastic bag which is placed in the toilet cistern and reduces the amount of water used for each flush of the toilet (Wilson, 2007). The domestic sector was less efficient in that only 29% of the households surveyed indicated that they were using a water-efficient device in their house. Two reasons for this were a lack of knowledge about these types of devices, and affordability. However, consumers indicated that they would consider acquiring such a device if the price of water were to increase, if water restrictions were enforced and if incentives such as rebates for installing such devices were offered (Still et al. 2007).

McKenzie and Wegelin (2009), in their study of the implementation of water demand management measures in Gauteng, identified additional problems. They indicated that if politicians did not support these measures, it would be extremely difficult to implement water demand management. One example mentioned was the restriction on watering gardens at times when the increased demand for water adversely affected the supply of water. The lack of political will to implement appropriate restrictions when required meant that water demand management measures would be ineffective. Furthermore, a lack of consumer support could also hamper the effective implementation of these measures. According to McKenzie and Wegelin (2009: 173), per capita water consumption is substantially higher in some areas of South Africa than in some other countries where water resources are more abundant. An example is Sebokeng (Johannesburg), where water demand was estimated to average 200 litres per capita per day. They do, however, point out that some progress is being made in educating water consumers on water use and in changing their perceptions and water-use habits.

3.5.3 Water demand management in the City of Cape Town

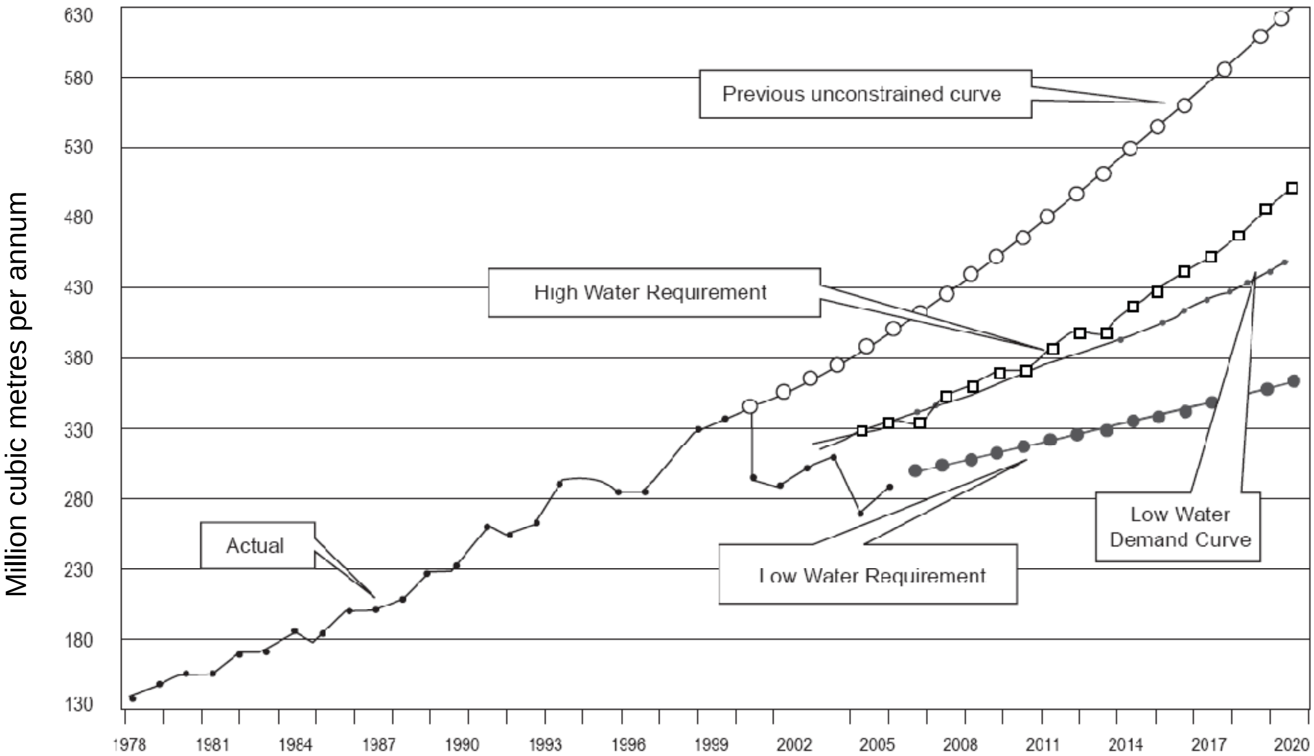
As mentioned previously, Cape Town is an appropriate investigative area, since this region has experienced increasing water scarcity. More importantly, information from households in this area will later be used to estimate the price elasticity of demand for water in Chapter Four, and to analyse the distributional impact of IBT structures in Chapter Five. It is therefore appropriate to discuss the water demand strategies applied by the City of Cape Town (CCT). Cape Town is one of the urban centres where water demand management has been adopted and implemented as part of an integrated approach to water resource management. This section first provides a brief overview of Cape Town's water supply and demand, before focusing on its demand management strategies.

Most of the annual rainfall in Cape Town occurs during the winter season (June to August). Rainfall is highly variable and usually infrequent; it occurs at discrete intervals and drains quite rapidly (Joubert, Stewart and Eberhard, 2003: 17). The summers are very dry and long. The Cape Metropolitan Area (CMA) has few permanent rivers of a substantial size and there is little possibility of increasing the water supply by building more dams (Joubert et al. 2003). Cape Town receives its water from the Berg River catchment area, although this area does not have sufficient water to fulfil demand. It is therefore necessary to transfer water from other catchments such as the Palmiet River (via the Steenbras dam), as well as the Theewaterskloof Dam on the Sonderend River. The water is channelled using the Western Cape Water Supply system (WCWSS), a system of dams and bulk infrastructure owned by Department of Water Affairs and Forestry and the City of Cape Town (Department of Water Affairs and Forestry, 2009: 1). More recently a new dam, the Berg River project, was developed to increase the water supply options of the Western Cape. This project was intended to provide additional water for domestic and commercial use in the Cape Town area (Kasrils, 2003). However, the South African government is adamant that this development should not be seen as a departure from attempts to manage water on the demand side.

The demand for water has also been increasing in Cape Town. In 2000 the Integrated Water Resource Planning study by Ninham Shand and Arcus Gibb projected a future unconstrained growth rate of 3% in the demand for water (City of Cape Town, 2001: vii; Frame and Killick, 2004). According to Ogutu (2007: 68), a Department of Water Affairs and Forestry study estimated the long-run growth in water demand for the CCT at between 1.6% and 2.8% per annum, depending on the population and economic growth rates of the region.

Figure 3.1 shows the bulk water supplied by the CCT and a projection of future water demand based on different scenarios, i.e. a high and a low water requirement (City of Cape Town, 2007: 65). The former refers to a scenario of high population growth and high economic growth, whereas the latter assumes low population growth and low economic growth. The high water requirement curve assumes no water conservation or water demand management interventions, whereas the low water demand curve includes this assumption.

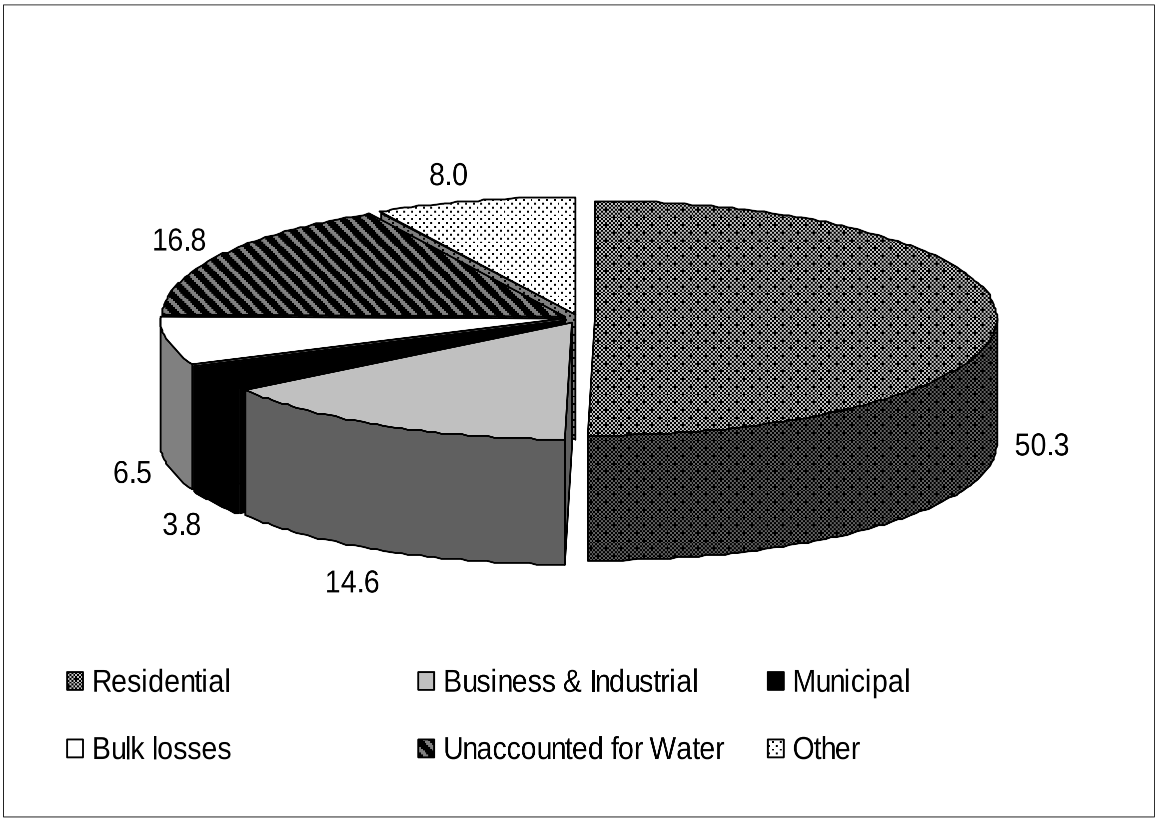
Figure 3.1: Water demand projection for the City of Cape Town



Source: City of Cape Town (2007)

Figure 3.2 shows the sectoral water demand in the CCT, based on consumption data for 2004. It is evident that the residential sector accounts for more than 50% of the demand for water. This is followed by demand from businesses (10.5%), while 16.8% of usage is unaccounted for. The latter includes water lost as a result of leakages and non-payment by consumers.

Figure 3.2: Sectoral Water Demand in the CCT, 2003/04 (percentage of total)



Source: Adapted from City of Cape Town (2007)

One of the more important developments in water resource management in the CCT has been a shift away from supply-oriented strategies, to adopting an integrated water management approach. In 1995 the CCT (then known as Cape Town City Council) initiated water demand strategies (Frame and Killick, 2004). The results of an Integrated Water Resource Planning (IWRP) study at the end of 1999 indicated that water demand strategies in Cape Town ranked favourably in terms of affordability, implementation timeframes and social acceptability, as compared to various supply augmentation options (Frame and Killick, 2004). More importantly, the study indicated that significant water savings could be achieved by implementing these water demand management initiatives. The CCT adopted and implemented a water demand management policy in 2001 (City of Cape Town, 2007).

The IWRP study described a number of policy options which could achieve significant reductions in water demand. Among these were measures such as water pressure management, optimal tariff setting, user education and targeted leakage repairs in low-income areas (Frame and Killick, 2004: 100). The Khayelitsha Pressure Management

Project was one of the initiatives emanating from the IWRP study. The project was implemented in Khayelitsha, one of the biggest townships in the Western Cape, situated about 20 km from the centre of Cape Town. According to McKenzie, Mostert and De Jager (2004: 1096), at the time of their study Khayelitsha had about 43 000 serviced sites with both water on the site and water-borne sewerage. Another 27 000 housing units were serviced by communal standpipes. Over time the township had grown, which led to an increase in water consumption and, more alarmingly, greater water leakage from the system. In their study, McKenzie et al. (2004) estimated the leakage at about 70% to 80% of the water supplied to the area. The main reason for the leakage was the high system pressure experienced in the area. Since the installed taps and toilets were not designed to absorb this kind of pressure, the result was internal leakages on properties (McKenzie et al. 2004). In 2001 it was therefore decided to implement a pressure management system that would reduce the excessive pressure. This led to water savings in the region of 9 million cubic metres per year, which represented about 40% of the original 22 million cubic metres per year supplied to the area before the project was implemented in 2001.

Further water demand management measures implemented were water restrictions and water-efficient fittings (Joubert et al. 2003). Water restrictions have often been used by the CCT, especially during periods of severe drought. For example, in 2000 the Minister of Water Affairs and Forestry announced that due to the poor rainfall experienced during the winter season, water restrictions would be implemented in the CCT at the end of that year. The restrictions were limited, aiming at a 10% reduction in water consumption (Kasrils, 2000). According to the City of Cape Town (2004), savings amounted to 15.5%, which was attributed to the large number of consumers who changed their consumption habits. A study by Jacobs, Geustyn, Fair, Daniels and Du Plessis (2007) analysed the efficacy of water restrictions in Cape Town during specific periods (i.e. during 2004 and 2005). They conducted a comprehensive demand analysis and reported that significant savings were made, mainly in the residential sector.

The CCT has also been using water tariff structures as a demand management tool. The IBT structure has been in place for quite some time. The pricing structure is progressive in nature, with the aim of ensuring a pro-poor approach to assist those households who cannot afford to pay for water, and to reduce water consumption by high users. According to the City of Cape Town (2007), the stepped tariff structure was designed to discourage high levels of water consumption and simultaneously ensure that all water consumers were able to adjust their consumption levels to pay for water use. However, in its long-term water conservation and water demand management strategy, the CCT indicated that water tariffs are too low (compared to other metropolitan municipalities) and tariffs should be brought in line with marginal cost principles. At the same time, though, the objectives of equity and revenue should be considered (City of Cape Town, 2007).

3.6 Concluding remarks

Water demand management is defined as the adoption of measures that will affect the demand for water. The definition of Brooks (2006) encapsulates the view that demand management should not be viewed as yet another policy measure to reduce water demand. It is a governance concept that emphasises the quantity and quality of water and effectively allocates water to ensure resilience in water systems.

Water utilities can apply both non-price and pricing policy measures to influence the demand for water. Non-price policies include regulatory instruments such as quantity restrictions and water-saving technologies. Existing empirical literature indicates that both non-price and pricing policy measures reduce the demand for water, with varying rates of success. Quantity restrictions may be more effective in reducing water consumption in the short run, especially if the demand for water is price inelastic. However, the cost of implementing non-price measures is generally higher than that of implementing pricing policies. This includes the cost of informing consumers and, in the case of water-saving technologies, installation costs.

Using pricing as a demand management strategy requires an appropriate tariff structure. The IBT structure is commonly used in developing countries, particularly since it is proclaimed to achieve multiple objectives (among them water conservation and addressing equity concerns). Proponents of the IBT structure argue that since the marginal price increases with consumption, high water users will be motivated to reduce their consumption. A more equitable distribution of costs can also be achieved by charging low water users (usually assumed to be poor households) a price below the marginal cost. Since high water users pay tariffs in excess of the marginal cost, cross-subsidisation can occur between the rich and the poor.

One of the factors influencing the realisation of these goals is consumers' reaction to water tariff changes. The empirical literature reflects that water demand is relatively price inelastic (although there are varying estimates for different water consumers, which imply varying responses to the conservation of water). However, it is important to emphasise that there is a response. Pricing as a water demand management tool should therefore not be disregarded. Water managers must take this into account when they decide on appropriate policy measures to achieve sustainable water use. The next chapter investigates the factors influencing water demand for households using a household survey conducted in Cape Town. Given the increasing water scarcity in this region, the focus is on establishing the sensitivity of households to water price changes, and therefore the possibility of using water pricing as demand management tool.

CHAPTER FOUR

Water Pricing as Demand Management Tool - investigating water price sensitivity of households residing in Cape Town

4.1 Introduction

The challenges facing South African water managers were discussed in Chapter Two. In the first instance the country is fast approaching physical water scarcity. In addition, the backlog of basic water and sanitation services implies that economic water scarcity is also present. Many poor households use unsafe water sources for drinking purposes and the lack of proper sanitation has adverse effects on consumption and production activities. To ensure that South Africa's remaining water resources are used in a sustainable manner, effective management policies are required (Seckler et al. 1999).

The initial response to the increased demand for water was to consider expanding the supply of water resources. However, as discussed in Chapter Three, this option has become less viable, since most of the readily available water resources have been fully utilised and it will be costly to develop new sources. According to Stephenson (1999: 115), the increased cost can be ascribed to the distances it will be required to pump water, as well as the storage required.

South Africa initially used supply augmentation as a management tool and many dams have been built over time. There are also water treaties with neighbouring countries to increase the supply of water.[18] The reality that supply augmentation will not provide adequate water for future needs has been accepted by the South African government. This is evident in water legislation where demand-side water management policies feature quite extensively. This signals a shift in water management options on the part of water authorities. Water pricing (tariffs) are seen as an essential component of water demand management in South Africa and water legislation specifically refers to setting norms and standards related to water tariff structures, in order to promote more efficient use of water resources. Water pricing is therefore perceived as an important tool to achieve water

[18] The Lesotho Highlands Water Project is one example, where the South African government has reached an agreement with the government of Lesotho for the provision of water to Gauteng Province. The project consists of different phases, which include increased provision of water infrastructure such as tunnels and dams. These include the Katse and Mohale dams, which have already been completed (Holman, 2010).

conservation. The Water Services Act (No. 108 of 1997) specifically refers to the powers of the Minister of Water Affairs and Forestry to prescribe norms and standards for setting water tariffs, for the promotion of water conservation (Republic of South Africa, 1997).

However, if water managers wish to implement effective demand-side management policies, they must have information on the behaviour of water consumers and use this in developing water policy. As discussed in Chapter Three, setting appropriate tariffs requires knowledge of the objectives that must be met by the tariff structure, as well as of how consumers react to changes in the price of water. Information on the usage, beliefs and attitudes of water consumers will inform and assist policy making. Zetland (2011) indicates that information on price elasticities is important, since it enables water managers to estimate the impact of price changes on the use of water for different purposes (i.e. for indoor and outdoor use). Therefore, estimating the price elasticity of water demand is an important empirical task.

The primary objective of this chapter is to empirically estimate the price elasticity of demand for urban residential households. This is the type of study that can provide water managers with crucial information on consumers' reaction to price changes. This can assist in developing tariff structures to achieve the objectives of reducing water consumption and ensuring an equitable distribution of water costs.

This chapter commences with a literature overview of the impact of water prices on the consumption of water. There is a specific focus on the methodological specifications to estimate the price elasticity, as well as on the findings of a diverse range of demand studies. The main focus of the chapter is a case study which analyses the factors influencing consumer water demand, with the primary aim of estimating the price elasticity of demand for residential water in a Cape Town setting. The price elasticity of demand is estimated using data relating to households residing within the jurisdiction of the City of Cape Town (CCT), a metropolitan municipality in the Western Cape Province.

4.2 Estimating the impact of water prices - a literature overview

To measure the impact of water pricing as demand management tool, it is necessary to estimate the price elasticity of demand for water. This is a crucial empirical exercise, especially since water pricing as a demand-side strategy requires some sensitivity on the part of water consumers to price changes. Over the years various studies have estimated the relationship between the price and the quantity of water demanded and have shown that there is a negative relationship. This section provides a review of some empirical water demand studies, with a particular emphasis on their methodological specifications and findings.

4.2.1 Methodological specifications in estimating price elasticity of demand

Numerous studies have attempted to find the most appropriate ways of estimating the effect of water prices and other variables on the consumption of water. Researchers have paid particular attention to pricing, using various specifications in an attempt to accurately capture the impact of both the price level and price (tariff) structure on water demand. This section commences with a brief outline of the factors influencing water demand, before focusing exclusively on the estimation of the price elasticity of demand.

4.2.1.1 Factors influencing Water Demand

Water demand is based on the behaviour and needs of consumers. Water is part of the bundle of goods consumed that adds to human well-being. The mainstream approach of demand studies provides an understanding of the factors influencing water demand. Since water constitutes only a small part of total consumption, many studies use a partial approach.

Weather patterns influence the consumption of water, since more water is consumed in hot weather and less during rainy periods. Howe and Linaweaver (1967) specified a sprinkling demand model to account for the summer precipitation and maximum day evapotranspiration (see Section 4.2.2 for their price elasticity of demand estimates). Weather variables were also used by Renwick and Green (2000) in their study, with specific climatic equations included as part of the water demand model.

Individual differences between households also influence water demand. Household size is important (Nieswiadomy and Molina, 1989), as well as the age structure of the household. Other variables, like the house size and access to appliances (showers, bathrooms, washing machines, etc.) are relevant (Barkatullah (2002), Renzetti (2002)). Public information campaigns, water-saving technology and other factors may also influence household water consumption. In modelling water consumption, a distinction is made between indoor and outdoor use. This specification can accommodate the distinction between basic use and the additional use of water (for pools, lawns, washing cars, etc.).

Income is a primary determinant of consumption. Renwick and Green (2000) used median household income for each of the water agencies included in their study, based on aggregated water data. Barkatullah (2002) used income and property values as indicators of the budget available for households. Höglund (1999) included the average real gross household income in her study, while Gunatilake et al. (2001) used household income data obtained from a survey. Renzetti (2002) reported on a 1998 study by Hanemann, which listed price and income elasticities and indicated that income elasticity was mostly positive, but low.

Economic theory usually suggests that consumers react to the marginal price of a product. This is not obviously the case in a situation with different fixed fees and an IBT structure. For instance, Arbués, Garcia-Valiñas and Martínez-Espiñeira (2003) argue that most consumers may not be sufficiently informed about the rate structure to react to marginal prices, but they state that this can only be determined by empirical investigation. If the marginal price differs from the average price, then an implicit lump sum transfer is linked to the purchase of water. Many studies include the Taylor-Nordin difference variable, namely the Rate Structure Premium (RSP) to account for this transfer. According to Barkatullah (2002), the RSP is the second 'price' variable, introduced by Taylor (1975) and further developed by Nordin (1976).[19] A more detailed discussion of model specifications is provided below.

4.2.1.2 Water pricing

One of the most relevant considerations in estimating the price elasticity of water demand is which pricing variable to use. In the case of block pricing, particularly IBT structures, the non-linear structure of pricing can influence the choice of pricing variable. Arbués et al. (2003) refer to the difficulties of analysing the effect of intramarginal rates in the case of block pricing. According to Bachrach and Vaughan (1994), if marginal prices change for the block in which the consumer is currently consuming, this will cause both a substitution and an income effect. However, if intramarginal rates change, this causes only an income

[19] There is a relationship between 'average price' (AP), 'marginal price' (MP) and the RSP, where Q stands for the quantity consumed: $AP = MP + RSP/Q$ (see Barkatullah, 2002).

effect in the current consumption block, since the rate schedule will merely shift parallel inwards or outwards (Bachrach and Vaughan, 1994: 8). Researchers who wish to estimate the demand for water are therefore faced with the complex problem of deciding which pricing variable to include. They have attempted to solve this problem by using a two-part specification for the pricing variable, an approach first suggested by Taylor (1975) and Nordin (1976). The first part is the marginal price of water and the second part is a 'difference variable', which is the difference between what the consumer is paying and what the consumer would have paid if all water units were priced at the highest marginal price (Grafton et al. (2004: 163); Barkatullah (2002)).

Price specification using the marginal price and the difference variable is based on the assumption that consumers have complete knowledge of the pricing schedule. However, Chicoine and Ramamurthy (1986) point out that if there is a lack of knowledge regarding the rate structure, consumers will often respond to the average price rather than the marginal price. They tested this hypothesis using household data from Illinois, USA. Their model included average and marginal prices and was based on a decreasing block rate structure. The demand function specified the quantity of water demanded as a function of a decomposed average price, i.e. the marginal price and a second price variable which is equivalent to the average price minus the marginal price (Chicoine and Ramamurthy, 1986: 27). They tested various possible outcomes to determine which pricing specification would be most appropriate given their data. If the coefficient of the second price variable was not significantly different from zero and equal to the marginal price coefficient, using only average price would be most appropriate. However, they found that the coefficient of the second price variable was significantly different from zero and also different from the marginal price coefficient, which pointed to the use of a decomposed price model (including marginal prices and a second price variable). Chicoine and Ramamurthy (1986: 31) do indicate, however, that choosing the appropriate demand model is case specific and depends on the behaviour of consumers.

The use of block rates can also cause identification problems as the price determines the quantity of water demanded, but the quantity of water consumed determines the price to be paid; i.e. there is the problem of simultaneity bias (Grafton et al. 2004: 163). This is especially the case for non-linear price schedules where the price cannot be considered to be exogenous. In this case Ordinary Least Squares (OLS) estimation will not produce unbiased and consistent parameters, since there is some correlation between the error term and the explanatory variables (Arbués et al. 2003: 92). This means that OLS regression estimation will lead to an overestimation of the price elasticity of demand in the case of an increasing block structure (Bachrach and Vaughan, 1994). One of the techniques used to address this problem is the use of instrumental variables.

Nieswiadomy and Molina (1989) addressed the endogeneity problem, using the specification of the marginal price and a difference variable, to incorporate the non-linearity of the block-rate structure in their estimation of the price elasticity of demand. They applied the instrumental variable technique, which included regressing observed water demand against actual marginal prices faced by consumers for different consumption blocks. From this they derived predicted quantities, which were then used (with the actual rate schedule) to determine predicted marginal prices, as well as to calculate the rate structure premium (or difference variable).[20] These two price variables were then included as independent regressors in the demand function. This methodology was applied to both increasing and decreasing tariffs. Their empirical analysis therefore addressed both the pricing specification, as well as the problem of simultaneity. The instrumental variable technique illustrated a negative relationship between the marginal price and the quantity of water demanded, which contrasted the result obtained when they applied OLS without instrumental variables. In addition, they did not find empirical support for the hypothesis that the difference variable captures the income effects associated with the intramarginal rates. This is consistent with the difficulties of similar studies in verifying the Nordin theoretical model (Nieswiadomy and Molina, 1989: 286).

Barkatullah (2002) used a panel data set at the household level to estimate a mixed-effects residential demand model for Sydney, Australia. This study addressed the problem of simultaneity by using instrumental variables. The marginal prices of water, as well as income, climate and household-specific variables were used to explain water consumption. The study also included a 'difference' variable, in order to reflect the difference between the marginal and the average price for water. Barkatullah (2002) estimated a marginal price elasticity coefficient of -0.21, indicating inelastic water demand. Her estimates reflected a high sensitivity to her estimation methods.

[20] The technique explained here is discussed more fully later in this chapter, where the same methodology is applied to estimate the price elasticity of demand in a South African context.

Renwick and Green (2000) investigated the impact of demand-side management policies such as pricing, restrictions, education campaigns and water-efficient technologies and also applied the Nordin difference variable. They used cross-sectional data for eight water agencies in the USA and applied a Two-Stage Least Squares (2SLS) estimation technique to account for the endogeneity problem caused by block pricing. Furthermore, their residential water demand model was a multi-equation model which consisted of price equations, climate equations and a water demand equation. The price equations for the marginal price and the difference variable were included to capture endogeneity between price and the quantity demanded, while the climate equations explained variations in temperature and precipitation due to seasonality (Renwick and Green, 2000: 42). The predicted values from these two equations were included in the water demand equation. The difference variable was transformed to provide a more intuitive explanation, by multiplying the values by -1. This made the difference variable (the actual bill minus the bill if all units of consumption were charged at the marginal price in the block of current consumption) non-negative. According to Renwick and Green (2000: 43), this allows for a more intuitive understanding of the coefficient of the difference variable, since a positive sign indicates that a higher income subsidy is associated with a higher quantity of water consumed. This transformation is also applied in the empirical case study later in this chapter.

As mentioned earlier, some water demand studies have made use of the average price as the price specification in their models. One such study is an aggregate demand model estimated by Gaudin (2006), who used the average price specification because of incomplete information regarding the full pricing structures of the water utilities. His primary question was whether information (such as billing information, history of water use, or conservation messages from the water utility) had any significant influence on the price elasticity of demand. Differences in the way water bills were issued to residents by water utilities were used to establish whether price elasticities were endogenous to the information provided to consumers. Since endogeneity can arise from non-linear price structures, Gaudin (2006: 389) performed endogeneity tests by comparing the coefficient estimates from OLS and Two-Stage Least Squares (2SLS) models. The two-stage procedure involved estimating instrumented price (using total water charges for the monthly bills and other exogenous variables). No evidence was found of a systematic bias in the OLS coefficients and Gaudin (2006) reported his OLS regression results. His findings were that pricing information had a significant influence on price elasticity of demand, since this increased by at least 30%. However, including additional information in the water bill did not have any significant effect.

Another issue that must be considered when estimating residential demand under IBT structures is that the consumer faces a piecewise linear budget line and can consume at different points, such as on the interior of a particular segment (corresponding to a particular block), or at the kink point (the quantity of water at which the marginal price increases) (Olmstead, Hanemann and Stavins, 2005: 9). The instrumental variable models discussed thus far are unable to incorporate consumption at different points along the kinked budget line and do not take account of changes in the price structure (Olmstead et al. 2005: 9). For this purpose, Olmstead et al. (2005) proposed a discrete-continuous choice model, which accounts for the consumer equilibrium locating at interior or at kink points of the piecewise linear budget line. They applied the latter model using household data from sixteen water utilities across North America and found a price elasticity of demand estimate of -0.64. Using uniform marginal prices and applying a random effects model resulted in a price elasticity of demand estimate of -0.33. This is an important finding, since it suggests that the price elasticity of demand is affected by the type of tariff structure adopted.

Olmstead et al. (2007) used the discrete-continuous choice model to estimate the price elasticity of demand for a broadly representative sample of USA households. In addition, they also compared the price elasticity of demand under different pricing structures, by comparing estimates under an IBT structure to the price elasticities under a uniform pricing structure where a single marginal price was adopted. They therefore addressed the question of whether the water quantity used by the consumer was a function of the price structure, or whether they were just capturing the effect of heterogeneity in the pricing structures of water authorities across the USA (Olmstead et al. 2007: 182). Their findings showed a higher price elasticity of demand in the case of the IBT structure (-0.59) compared to the uniform price structure (-0.33), although the latter result was statistically insignificant. A study by Kenny, Goemans, Klein, Lowrey and Reidy (2008) supports this result. They investigated the factors influencing residential demand in Aurora, Colorado and found that households facing an IBT structure consumed less water than those facing a uniform tariff structure. They suggested this could possibly be ascribed to awareness amongst households under the IBT structure that high consumption levels would lead to high costs (Kenny et al. 2008: 202).

Two possible explanations for the differences in price elasticity estimates (given different pricing structures) were considered by Olmstead et al. (2007). The first consideration was that the variation in elasticity could be attributed to the different pricing structures. However, for this to be true, they had to eliminate a second possibility, namely that the endogeneity of pricing structures at the water utility level might have influenced the outcome. This would mean that utilities may have been more aware of household characteristics when setting the pricing structures. For example, a community that is more aware of the need for water conservation may be more likely to accept an IBT structure (Olmstead et al. 2007). However, to remove the effect of an endogenous pricing structure would mean using a two-stage approach where appropriate instruments are found to explain the choice of pricing structure by the utility. Given their specific dataset, they were not able to perform such tests and therefore could not conclusively explain why the price elasticity of demand estimates were higher under IBT structures (Olmstead et al. 2007).

Szabo (2009) also used a structural approach to estimate the price elasticity of the demand for water in Pretoria. She referred to the reduced form regression analysis as an inappropriate estimation technique if the pricing structure is very complex. This technique uses water consumption as the dependent variable and then either the average price or the marginal price of water, and some other regressors to estimate water demand. According to Szabo (2009: 14), there is no guarantee that using these price variables will be an adequate proxy for the price schedule. She therefore opted for a structural model where estimation takes account of the fact that consumers may base their water consumption choices on the entire pricing schedule. Consumers will choose the block they want to consume in, based on all the marginal prices in the pricing schedule and, within a particular block, they will choose the quantity to consume based on the marginal price applicable to that specific block (Szabo, 2009: 15).[21]

The type of functional form used in demand studies has also received consideration in the literature. Arbués et al. (2003: 90) distinguish between the linear, log-linear and log-log functional forms. The linear specification is normally easier to estimate. However, the log-log model specification provides direct estimations of price elasticity and is therefore quite popular amongst water researchers. It should be kept in mind, though, that this

[21] The results of this study are discussed in more detail later, since a summary of all South African-based demand studies is provided later in this chapter.

specification provides a constant elasticity estimate irrespective of whether prices are low or high. An example of the log-linear specification is the Stone-Geary form, in which allowance is made for a minimum amount that is needed, even if prices are extremely high (Arbués et al. 2003: 92). This is the main advantage of using this specification, as it allows the incorporation of some minimum amount of water into the model (Worthington and Hoffman, 2008). In terms of the statistical modelling, this model also allows for the estimated price elasticity of demand to change along the demand curve, However, Gaudin (2006) indicates that his research had shown such a specification is not the most appropriate for water demand, and Espey, Espey and Shaw (1997) have also indicated that the price elasticity of demand estimates at the mean are not significantly influenced by the choice of functional form. Another possibility is to perform a Box-Cox transformation to find the best flexible functional form, where the Box-Cox involves subjecting the dependent variable to a non-linear power transformation (Mittelhammer, Judge and Miller, 2000: 210). Dalhuisen, Florax, De Groot and Nijkamp (2003) and Espey et al. (1997) have both provided meta-analyses of the implications of different functional forms for estimating price elasticities of demand. Dalhuisen et al. (2003) report estimates of an extended sample of studies in which they specify the linear and Box-Cox models.[22]

In a study investigating the residential demand for water in Kandy, one of the fast-growing cities in Sri Lanka, Gunatilake et al. (2001) applied a log-log model specification. They estimated the demand for domestic water based on a sample of 40 randomly selected households, using price variations over a six-year period. They used the marginal price and the difference variable as their pricing variables and included income and household size as the other explanatory variables. After doing a specification test, they decided to use the log-log model. In the case of the difference variable, they transformed this to positive values (see the earlier discussion on this transformation, in Section 4.2.1.2). The positive difference variable was then specified in log form and included in the model. They also ran a Durbin-Watson test and found positive autocorrelation, which they corrected by using the Prais-Winston transformation.[23]

[22] See Dalhuisen et al. (2003) and Espey et al. (1997) for more details. See Höglund (1999) for an application.

[23] See Greene (2000) for more on the methodology of the Prais-Winston transformation.

4.2.2 Price elasticity of demand estimates

One of the first studies on residential water demand was an estimation of the price elasticity of demand for indoor and outdoor use in the USA by Howe and Linaweaver (1967). They found domestic demand (defined as water used inside the dwelling) to be relatively price inelastic (-0.23), as opposed to sprinkling demand (outdoor use), which was relatively more elastic (in the range of -0.7 to -1.6). An explanation for this finding was that there are greater alternatives for watering outside, such as less frequent use of sprinkling systems (especially in areas of frequent rainfall) or reducing the size of the irrigable area by increasing the gravel or paved sections (Howe and Linaweaver, 1967: 19). Nieswiadomy and Molina (1989: 287) compared residential water demand estimates under decreasing and increasing block rates and found significant elasticity estimates ranging from -0.36 to -0.86. The price elasticity of demand estimate in the study conducted by Renwick and Green (2000: 49) supported the findings of earlier studies as the estimated coefficient of the marginal price was negative and statistically significant, at a value of -0.16. In addition, their difference variable had the anticipated positive sign, but was statistically insignificant, which they explained could be due to their use of aggregated water and billing data for the eight water agencies.

A meta-analysis of the empirical findings on the price elasticity of demand was completed by Dalhuisen et al. (2003). The analysis considered 64 studies over the period 1964 to 2001. One of the findings was that the average price elasticity of demand in the case of IBT structures was relatively higher, as compared to flat rate and decreasing block structures (Dalhuisen et al. 2003: 13), although estimates were still price inelastic. More recent studies of water demand and specifically the impact of water pricing also found the demand for water to be price inelastic. Nauges and Whittington (2008), in an overview of water demand studies, reported that most studies in industrialised countries found water demand to be relatively price inelastic and income inelastic. Olmstead et al. (2007: 182), in a study of water demand under alternative price structures in the USA, found a price elasticity of demand of approximately -0.33.

Although most empirical studies have found the demand for residential water to be price inelastic (less than 1 in absolute value), findings differ on how this changes across income groups. The price elasticity of demand for residential water can have implications for the effectiveness of water pricing reforms. According to Israel (2007: 62), if the price elasticity of demand is higher (in absolute value) for lower income groups this will make price increases less regressive if the same across-the-board price increase is applied to all income groups. Empirical evidence provided by Agthe and Billings (1987), Renwick and Archibald (1998), as well as Rietveld, Rouwendal and Zwart (2000) indicates that lower-income households are more responsive to water price changes than higher-income households (although in most cases, the price elasticity estimates for both groups are still less than one, in absolute terms). Mansur and Olmstead (2006) analysed the price elasticities for different uses of water, both indoor and outdoor. They found that increasing water prices was more likely to cause low-income households to reduce consumption than high-income households. This was because their estimations showed that the price elasticity of demand for outdoor use was greater for poor households (with small lot sizes) than it was for wealthy households (with large lots).

Hentschel and Lanjouw (2000), in contrast, argue that since water is essential for drinking and washing, high-income households would have a higher price elasticity of demand since they are more likely to own luxury goods that use water, such as swimming pools and gardens. This is supported by Ayadi et al. (2002) who state that the consumption of water at individual or household level depends on habits and lifestyles which vary according to the income level. They argue that the demand for water to satisfy basic needs (such as drinking, cooking and cleaning) will be very price inelastic, as compared to the demand for refilling swimming pools and watering the garden (which is expected to be relatively more price elastic). Water required for these purposes may be considered a luxury (Ayadi et al. 2002: 10). Table 4.1 provides a summary of some demand studies in developed countries.

Table 4.1: Water demand studies in developed countries

Author(s)	Data	Sample	Pricing structure	Dependent variable(s)	Independent (price) variables	Estimation techniques	Price elasticity
Agthe and Billings (1987)	Panel	Arizona, USA 1974-1980	IBT structure Flat rates	Monthly household water consumption	Marginal price Difference variable	OLS	Short-run: -0.18 to -0.36 Long-run:-0.27 to -0.5
Nieswiadomy and Molina (1989)	Panel	Texas, USA 1976-1985	IBT structure Decreasing block tariff	Monthly household consumption	Marginal block price	OLS, IV and 2SLS	-0.36 to -0.55
Barkatullah (1996)	Panel	Sydney, Australia 1990-1994	IBT structure Flat rates	Quarterly household water consumption	Nordin difference variable Marginal price	OLS, 2SLS, ML	-0.21
Renwick and Green (1998)	Panel	California, USA 1986-1990	IBT structure	Total water consumption	Marginal price Nordin difference variable	2SLS, OLS	Overall: -0.33 Low income: -0.53 Middle income: -0.21 High income: -0.11
Rietveld, Rouwendal and Zwart (2000)	Cross-sectional	Salatiga, Indonesia 1994	IBT structure	Monthly water consumption	Marginal price Virtual income	OLS	-1.28 to -1.16
Martínez-Espiñeira (2003)	Panel	Spain 1995-1999	IBT structure	Proportion of consumers in each block; Average monthly per account water use	Marginal price Difference variable	IV, Logit, OLS, GLS	-0.37 to -0.67
Gaudin (2006)	Cross-sectional	USA 1995	IBT structure	Per capita residential consumption	Average price of water	OLS, 2SLS	-0.37

Note: OLS – Ordinary Least Squares, 2SLS – Two-stage Least Squares, IV – Instrumental Variables, ML – Maximum Likelihood, GLS –Generalised Least Squares

Source: Adapted from Worthington and Hoffman (2008)

The estimates regarding the price elasticity of demand in developing countries are similar to those for developed or industrialised countries. Almost all the studies found the demand for residential water to be price inelastic. In a study of residential water demand in the presence of non-linear progressive tariffs, Ayadi et al. (2002) estimated the price elasticity of demand using data classified by consumption bracket for different regions of Tunisia. They grouped their consumption brackets into two blocks, i.e. the lower and upper consumption blocks. Their empirical model involved two stages. In the first stage they combined all data from the different regions of Tunisia and the two consumption blocks and estimated the demand model for each block using a fixed-effects model. Their results were a price elasticity estimate of -0.10 for the lower consumption block and -0.45 for the upper consumption block (Ayadi et al. 2002: 15). In the second stage they once again combined the data but each consumption block's regression allowed for variation in the price responses across regions, i.e. using a variable coefficient model. They found that price elasticities for the upper consumption block were significantly higher (in absolute value) than those estimated for the lower consumption block (Ayadi et al. 2002: 21).

Gunatilake et al. (2001), in their water demand study for Sri Lanka, found that the price of water was negatively related to the consumption of water, i.e. a 1% increase in the marginal price would decrease the consumption of water by 0.33% (Gunatilake et al. 2001: 286). Moreover, they estimated an income elasticity of water demand of around 0.08 and also found household size to be a significant explanatory variable with regard to household water consumption, with an estimated coefficient of 0.38. According to Gunatilake et al. (2001: 286), a possible explanation for their low income elasticity of demand finding was that their study area did not include very high-income groups.

There are fewer water demand studies in developing countries. This can be attributed to the difficulties of performing studies in regions where not all consumers have metered connections, where the quality of existing data is questionable, and where water consumers rely on alternative water sources. According to Nauges and Whittington (2009), there are three types of water consumers in developing countries: Firstly, there are households who are part of the formal water and sanitation system; as incomes grow, there will be an increase in demand for water and sanitation services and more households will join this formal system. The second group of households are those who reside in the informal urban sector and do not have access to the formal system and do not earn sufficient income to gain access. In some instances they receive water from communal standpipes and public subsidies are required to provide them with the necessary basic services. The last group involves households in rural areas which, according to Nauges and Whittington (2009: 266), are least likely to receive in-house connections. Therefore, water policy makers in developing countries face quite different challenges, compared to their counterparts in developed countries. Nauges and Whittington (2009: 265) point to the importance of understanding how water prices and tariff structures affect consumption, and to the need for this to inform public pricing policies. This implies that the estimation of water demand in developing countries requires modified estimation techniques to overcome difficulties such as a lack of good quality data.

Researchers can employ different strategies to address data problems in developing countries. One way of dealing with a lack of data is to design a household survey that can be combined with consumption and pricing data from public utilities.[24] Another approach is to use a hypothetical market situation in which water users are questioned about their water use behaviour in response to hypothetical changes (Nauges and Whittington, 2009).[25] Other possibilities are to look at secondary markets to provide information on how consumers will react to improvements in water services (e.g. housing), or the use of experimental techniques (such as randomised control trials), which test the response of households to alternative water supply interventions (Nauges and Whittington, 2009).

4.3 Estimating the price elasticity of demand in South Africa: some empirical evidence

There are relatively few South African studies of the demand for residential water. Two studies using a similar methodology to estimate the price elasticity of demand for different households were completed by Veck and Bill (2000) and Van Vuuren et al. (2004). Both studies were commissioned by the Water Research Commission of South Africa.[26] The primary methodology was the Contingent Valuation Method (CVM), which uses surveys to determine the economic value of (mostly non-market) goods. In brief, the approach entails creating a hypothetical market setting by using surveys in which respondents are asked

[24] This is precisely the technique employed later in this chapter, where the case study of the estimation of water demand combines two processes of data collection. One is the secondary data obtained from the local water authorities. The second stage of data collection involved completing a survey questionnaire. See Section 4.4.

[25] See Whittington, Briscoe, Mu and Barron (1990). Some South African applications are discussed in this chapter.

[26] The Water Research Commission of South Africa was established in terms of the Water Research Act (Act No 34 of 1971), following a period of serious water shortage. Its primary aim is to create and disseminate knowledge. See its website for further details (http://www.wrc.org.za).

how much they would be willing to pay for a good or service.[27] According to Veck and Bill (2000), they opted to use this method as the usual econometric analysis would have required data which were not available to researchers.

The earlier of the two studies by Veck and Bill (2000) estimated the price elasticity of demand for water amongst different income groups in two suburbs of Johannesburg, Alberton and Thokoza[28]. Their sample size included 161 interviewees. The methodological approach was two-fold; an initial survey was conducted to establish the water usage profile of different income groups in the two suburbs. The second survey then used the contingent valuation approach to estimate the price elasticities. The CVM makes use of a hypothetical analysis and asks people directly to state their willingness to pay for a commodity, instead of observing behaviour in a market (Alberini and Cooper, 2000). Their results for total water usage in both suburbs reflected a price elasticity estimate of -0.17 (Veck and Bill, 2000: 7-6). In addition, they also estimated elasticities for different income groups, as well as for indoor and outdoor water usage. Table 4.2 reflects the results of their findings. The demand for indoor use is price inelastic for all income groups. For outdoor use, however, the upper income group is more responsive to price changes. Finally, the price elasticities for total use reflect that the upper income group is slightly more price responsive than the other income groups.

Table 4.2: Price elasticity of demand by income group (contingent valuation approach)

Income Group	Price elasticity of demand - indoor use	Price elasticity of demand - outdoor use	Price elasticity of demand - total use
Upper income group	-0.14	-0.47	-0.19
Middle income group	-0.12	-0.46	-0.17
Lower income group	-0.14	-0.19	-0.14

Source: Veck and Bill (2000: 5-9)

The results of Van Vuuren et al. (2004) are similar to the findings of Veck and Bill (2000). They used the same methodological approach and applied it to three metropoles, namely Tshwane (Pretoria), Cape Town and Ethekwini (Durban). The price elasticity of demand estimates for different income groups reflected a significant difference between the low

[27] See Veck and Bill (2000) for more details on the general literature on the Contingent Valuation Method. Part Two of this dissertation will also provide a comprehensive overview of the CVM.

[28] Thokoza is actually a township on the outskirts of Johannesburg.

and high income groups, in particular with regard to outdoor use. According to Van Vuuren et al. (2004: 5-20) this result can be expected since 'luxury' water usage (such as for washing the car, or filling up the swimming pool) has a more elastic demand schedule.

King (2002) estimated the price elasticity of demand for various users of water for the city of Tshwane in South Africa. This study used water consumption data for the period 1995 to 2000, disaggregated by area within the Tshwane municipality, to estimate the price elasticity of demand for small agricultural holdings, household water users at different levels of income, and industrial water users (King, 2002: iii). The data were further disaggregated into different levels of use (i.e. low, middle and high use). A distinction was also made between two specific suburbs (i.e. Atteridgeville and Mamelodi) and the rest of Tshwane, to estimate the effect of different income levels on demand.[29] Residential water demand was found to be price inelastic (although the author indicated the difficulty of obtaining appropriate data for these estimations).[30] In particular, it was suggested that possible improvements to the data could include (amongst other things) the use of larger samples and the use of panel data. There was also an indication of a slightly more price elastic demand for water in the suburbs of Atteridgeville and Mamelodi (which are assumed to have lower income consumers), compared to other household consumption categories such as duplexes/simplexes or domestic businesses (King, 2002: 133).

Another study estimating the impact of water tariff structures on the water consumption and welfare of households was undertaken by Bailey and Buckley (2004: 759). They investigated optimal tariff structures to attain the multiple objectives of equity and revenue sufficiency. Their case study was based on domestic households in the jurisdiction of the Durban Metropolitan Municipality. They obtained household water billing data, in addition to the municipal property valuation roll. A log-linear regression model gave the price elasticity of demand estimates across different income groups. Their results indicated that lower income households' water demand was more price elastic (-0.55) than that of high income households (-0.10).

The recent paper by Szabo (2009) was completed a few years after the case study presented in this dissertation. In an analysis of South Africa’s free basic water policy,

[29] Residents in Atteridgeville and Mamelodi are lower income consumers (King, 2002: 133).

[30] In some regressions, the estimated sign of the average price variable was positive.

Szabo estimates the residential demand for water and evaluates the impact of free water on the welfare of households. She suggests possible amendments to the current IBT structure given the constraints of revenue neutrality and the absence of any increase in the consumption of water. The empirical analysis used residential water billing data which were obtained from the water provider (Odi Water), which is contracted by the Tshwane municipality to provide water to townships in Tshwane (Szabo, 2009: 7). The data were at household level, and also distinguished between households who were registered as indigent and households that received a restricted service due to an unpaid balance in their accounts.[31] Table 4.3 shows the price elasticity of demand estimates from the regression analysis.

Table 4.3: Price elasticity of demand by income group (maximum likelihood estimation)

Type of household	Average price elasticity of demand
All households	-0.175
Indigent	-0.106
Non-indigent	-0.184
Restricted	-0.135

Source: Szabo (2009)

These estimates of the price elasticity of demand are quite low, supporting the findings of previous studies that the demand for residential water is price inelastic. The results indicate that the demand for water by indigent households (which included poorer households) was less price sensitive. Szabo (2009: 28) explains that this could be due to indigent households not fully comprehending the pricing structure, or to their not monitoring their usage effectively and so not readily changing their consumption of water.

In summary, even though the effect of the price of water is relatively small (i.e. the price elasticities are generally smaller than 1 in absolute value), there is still an impact and therefore the use of price as a tool to influence the consumption of water should not be disregarded. Arbués, et al. (2003: 84) argue that although the demand for water is price inelastic, and although water is typically a small proportion of the consumer's monthly bill, water pricing should be an essential part of water demand management as long as the price elasticities are not zero. It is also important to realise that it is relatively more costly to

[31] According to Szabo (2009), a restriction would apply if the households had an unpaid balance on their account for more than 40 days. In this case, the water flow was limited using restriction devices.

implement command-and-control (regulatory) methods, even if implementing water pricing is not completely efficient (Olmstead, et al. 2005: 2). In addition, if the demand for water is not perfectly inelastic and the willingness to pay for scarce water differs considerably among consumers, Mansur and Olmstead (2006: 1) suggest that there is reason to believe that using prices to influence consumption is more likely to benefit consumers than the use of non-market approaches.

4.4 Case study - Estimating the price elasticity of demand of households residing in Cape Town[32]

Water metering occurs in many suburbs in urban areas and pricing policy can be used to manage water distribution amongst these users. Contrary to perceptions, some households in informal settlements pay for their water and low-income groups also have metered connections. This allows the pricing of water to be part of a management system in an attempt to distribute water in an efficient and equitable way. However, pricing policy can only address these objectives effectively if information about the price responsiveness of households is known. Changes in water tariffs affect the revenue of municipalities, influence water consumption and have welfare implications for water users. It is therefore imperative that information about the price elasticity of demand be used to determine the most appropriate tariff structure to achieve specified objectives. This case study aims to add to current knowledge about households' responsiveness to tariff changes in South Africa.

As discussed previously, Veck and Bill (2000) applied the CVM to estimate the price elasticity of demand in South Africa. Van Vuuren et al. (2004) extended their analysis by including more urban metropolitan areas. They also estimated responses to price shifts by using the CVM, which uses hypothetical price changes. However, since there is recorded data of consumers paying for metered water, it is more appropriate to study households' response to real changes in price. This makes the estimates more reliable, since the analysis is then based on observed water consumption and not on hypothetical scenarios.

There are few studies in developing countries which use household data to estimate the price elasticity of demand (particularly where many households are poor). The majority of

[32] The fieldwork for this case study research was conducted during 2003 - 2004, and an earlier version of the paper was published in 2006 in the *South African Journal of Economics*, Volume 74 (3). It was co-authored with the late Prof. Carl-Erik Schulz from Norway.

existing micro-econometric studies have a strong bias towards studying the water demand of relatively richer households in developed countries. South African studies that are comparable to the case study presented in this section include King (2002), Bailey and Buckley (2004) and Szabo (2009).

4.4.1 Data collection and methodology

Water demand studies are complicated by the fact that data, especially at a micro-level, is not readily available. This is generally also the case in South Africa. Even though municipalities have water consumption records which they use in their billing process, very few datasets include household-level information on water use and consumers' perceptions of water pricing. To estimate micro-level water demand researchers need to compile such a dataset. This necessitates field work to collect information on household demographics and behavioural characteristics regarding water use, as well as attitudes to water consumption and tariffs. The dataset used in the study presented below was compiled using information collected through a survey questionnaire (see Addendum A for the questionnaire); this information was then matched with water consumption data obtained from the CCT.

The process of obtaining data from the CCT involved several visits and communication with their water services department, to obtain permission for the data to be made available. The CCT was willing to release the data, provided that a signed permission slip was obtained from each household visited by the fieldworkers during the survey. This was necessary because the CCT stated they could not release water consumption records without the express permission of water consumers. The data collection process therefore entailed two phases. The fieldworkers first produced a letter from the researchers, explaining the purpose of the research and the reason why the household's permission was required. The household was assured that all information collected would be treated confidentially and their details would only be revealed to the principal researchers. Anonymity was guaranteed, since statistical analysis of the data would not disclose any personal details. If the household agreed to participate, the permission slip was completed.

The second phase of the interview was the completion of the survey questionnaire. Fieldworkers had to submit their slips and accompanying completed questionnaire for the purpose of capturing the data. The permission slips, accompanied by the relevant household information, were submitted to the CCT, after which households' monthly water consumption records were released. The water consumption data covered monthly readings for the period from July 1998 to June 2003, with up to 60 readings per household. However, for some households the time series was shorter as their meters were only installed later during the specified period. Some households had to be excluded due to mismatching or incomplete records with the CCT. This left a total of 275 households in the final sample.

The fieldworkers were all students or staff of the University of the Western Cape. The selection of fieldworkers was an important part of the data collection process. The reason for this was that some residents were quite sceptical about an 'outsider' asking them questions about their water use, and then signing a permission slip for submission to the CCT. Some households regarded the fieldworkers as representatives of the CCT and refused to complete the permission slip or the questionnaire. This problem was addressed by selecting fieldworkers who were either from the suburbs in question, or who knew the area quite well. This meant that households were approached by someone who was familiar with the culture and attitudes of residents in each suburb. For the suburb of Gugulethu, the fieldworkers selected resided in Gugulethu. Five fieldworkers were selected and trained to conduct the interviews.

In Pinelands, the wealthiest suburb included in the case study, fieldworkers experienced some problems of access due to safety concerns. For this reason, a prior appointment was usually needed. The researchers therefore elected to contact households telephonically prior to the visit, in order to set up appointments. A verification process was conducted afterwards, in which some households were contacted to confirm that the interview had taken place.

Data were collected to provide information on the influence of various factors on residential water demand. Since the aim was not to estimate the water consumption of a specific area (like the Cape Town Metropolitan Area, (CMA)), sampling was done in such a way as to ensure that a fairly diverse group of households was included. The informal settlements and the very poor comprise one part of the market. However, they usually obtain their water from communal standpipes or other unmetered sources, so that measuring their consumption could only be done by on-the-spot observation and measurement inside each household.[33] The study therefore does not include those households without metered water. To take into account possible differences in water consumption between different cultural and income groups, observations were selected from two historically 'Black' suburbs, two historically 'Coloured' suburbs, and one historically 'White' suburb (all falling within the CMA). All the suburbs therefore fell within the jurisdiction of the same municipality (the CCT).

Households were selected at random in each suburb.[34] The sample is therefore not representative of the aggregate water consumption of Cape Town. However, this is not a problem as long as the estimation is of the consumption patterns of households and not of the area as such. Since each household had to give its signed permission for providing monthly readings of its water consumption from the CCT, this increased the reliability of the data, since fieldworkers had to visit all the households included in the study. This procedure could have resulted in less reliable income data. However, using categorical income variables may have been less intimidating and assisted in obtaining a more realistic response.

Table 4.4 and Figures 4.1 and 4.2 provide some demographic and socio-economic information on the selected suburbs. The information was obtained from the CCT’s ward profiles and is based on the 2001 census data. The demographic profile indicates that, at the time, the five suburbs were not racially integrated. Gugulethu and Langa were predominantly 'Black', Mitchells Plain and Kensington were predominantly 'Coloured' and Pinelands was mostly 'White'. The age profiles indicate that the 'Black' and 'Coloured' suburbs had a younger population. The only suburb with more than 15% of its population above 65 years of age was Pinelands.

[33] These households do not pay for water; therefore their consumption cannot be influenced by price changes. Poor households inside the zero-price segment of the metered water supply cannot fully represent the consumption of these households since the former group has potable water inside their houses. Their consumption is not comparable to households who must draw water from a standpipe. However, households without potable water represent only a small part of the urban consumption of water.

[34] In certain suburbs, some areas were not easily accessible. The data collection process also had to ensure the safety of the fieldworkers.

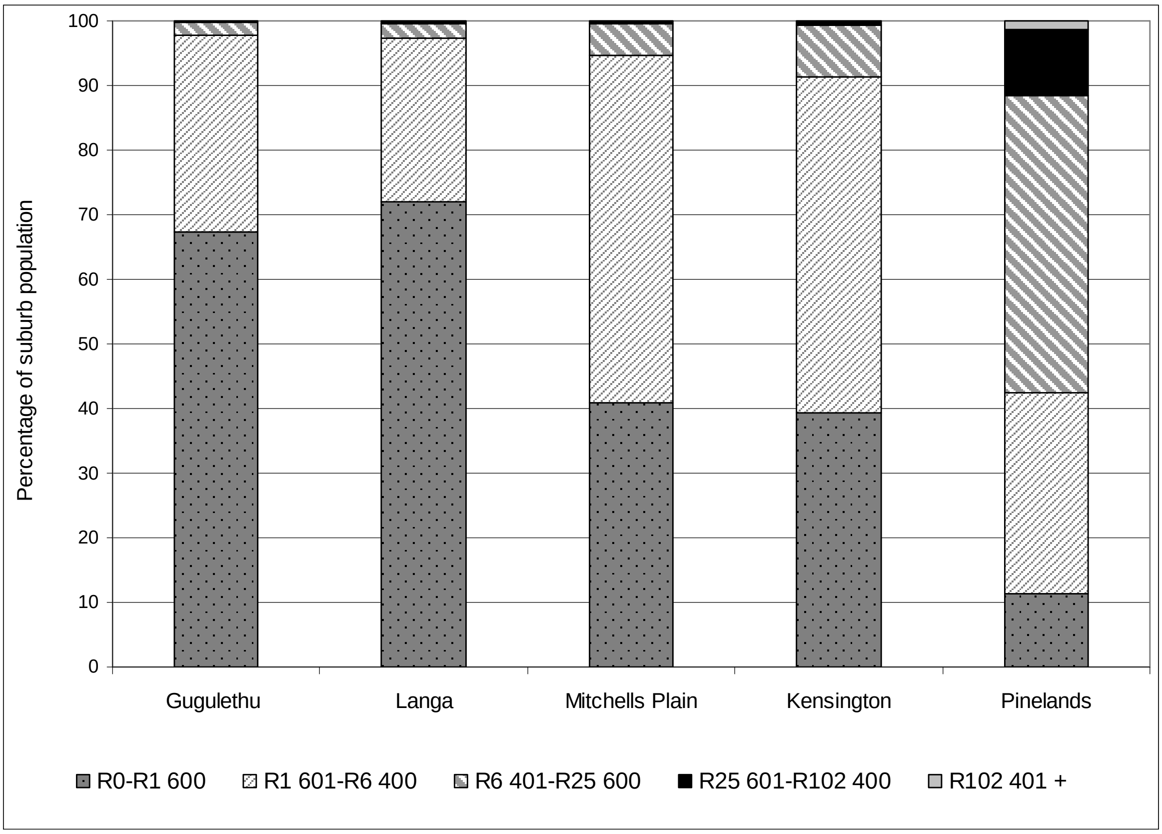
Table 4.4: Demographic profile of suburbs, 2001 census data

Suburb	Racial profile (%)				Gender (%)	Age profile (in years)			
	Black	Coloured	Indian / Asian	White	Female	0-17	18-34	35-64	65+
Gugulethu	98.8	1.2	0.02	0.01	52.5	31.2	37.6	26.8	4.4
Langa	99.6	0.4	0.0	0.02	50.7	29.8	43.1	24.5	2.7
Mitchells Plain	9.4	89.6	0.6	0.3	51.9	37.3	30.3	30.0	2.5
Kensington	2.3	96.2	1.1	0.4	53.4	31.1	27.7	32.4	8.8
Pinelands	6.2	7.8	2.5	83.5	55.1	22.0	20.7	37.8	19.5

Source: City of Cape Town (n.d.)

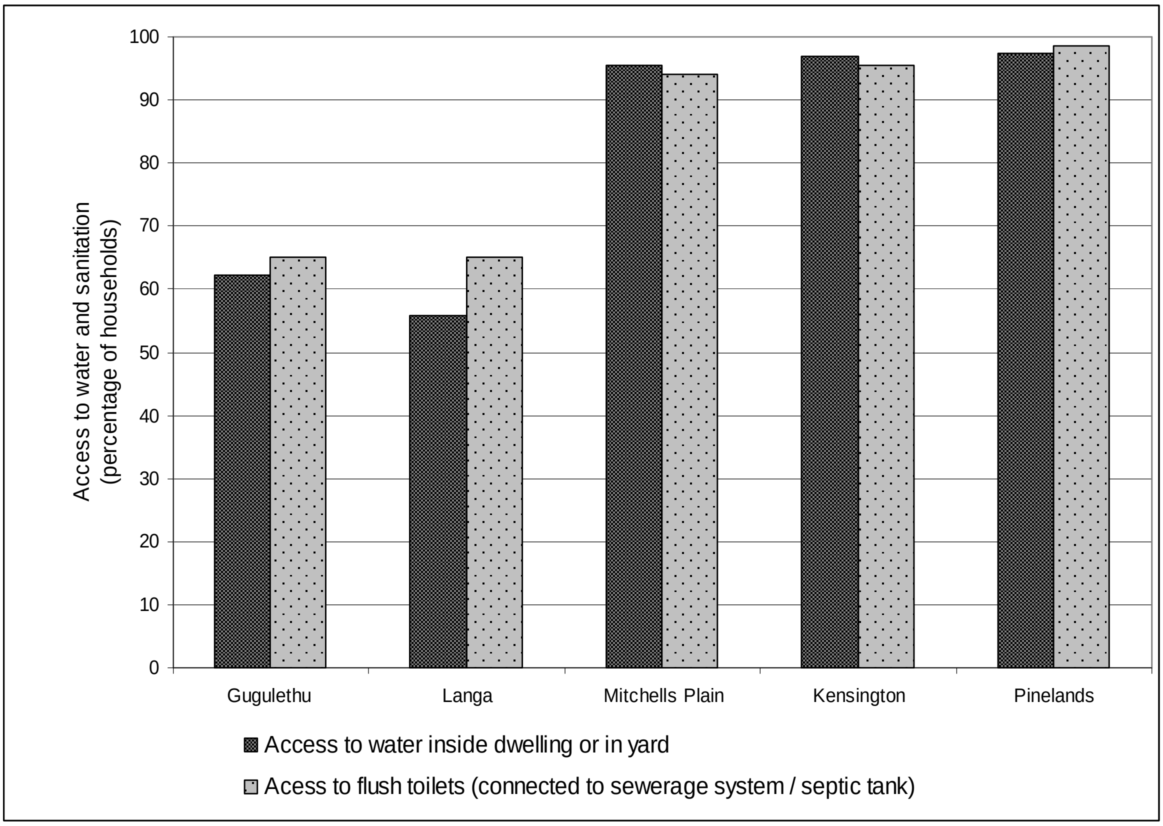
As Figure 4.1 shows, residents of Pinelands were the most affluent in the sample. Only 42.4% of its (working) population earned below R6 401 per month, as compared to more than 90% of the population in the other suburbs. The 2001 census data also revealed that more than 95% of households in Mitchells Plain, Kensington, and Pinelands had access to water and sanitation facilities. The suburbs of Gugulethu and Langa had a much lower proportion of households with access to water inside the dwelling or in their yard. Figure 4.2 indicates that only 55.9% of households in Langa had water on site. The data reveal a similar situation with regard to sanitation services. Only 65.2% of households in Gugulethu had access to a flush toilet (either connected to the sewerage system, or a septic tank).

Figure 4.1: Monthly income of income earners, 2001 census data



Source: City of Cape Town (n.d.)

Figure 4.2: Access to water and sanitation services, 2001 census data



Source: City of Cape Town (n.d.)

4.4.2 Descriptive statistics on sample data

The cross-section data were collected from July to August 2003. To create a panel data set, the survey data were combined with the water consumption data from the CCT[35], as well as the average monthly rainfall and average monthly maximum temperatures for the CMA.[36] Table 4.5 provides an overview of the size and age distribution of households in the sample. The data reveal that the average household size was larger in the suburbs of Gugulethu, Langa and Mitchells Plain. However, the age profile differs from that given in the 2001 census data, referred to earlier in Table 4.4.

[35] The data set includes time-series data: water consumption, water tariffs, climate and household age, as well as cross-sectional data: household size, income, plot size and other demographic variables and appliances, etc. relating to the household. The descriptive statistics support the assumption that income and household size did not change significantly during the period under investigation.

[36] The weather variables were obtained from the South African Weather Services.

Table 4.5: Distribution of household size and age of household members, by suburb

Suburb	Total number of households	Average number of household members					
		Total	Babies (0-3 yrs)	Children (4-11 yrs)	Teenagers (12-18 yrs)	Adults (19-60 yrs)	Elderly (61+ yrs)
Gugulethu	64	6.6	0.3	0.9	0.9	3.5	1.0
Langa	49	5.2	0.3	0.6	0.9	2.8	0.5
Mitchells Plain	73	5.4	0.3	0.85	0.9	3.1	0.4
Kensington	53	4.9	0.1	0.3	0.6	3.2	0.8
Pinelands	36	3.4	0.03	0.2	0.4	2.2	0.6
Total	275	5.1	0.2	0.6	0.7	3.0	0.7

Source: Own calculations

Almost all (99%) households lived in a house[37] and 97% owned their dwelling. Only 1% of the sample could access water from a borehole for their consumption. 39% of households only had a bath, 37% had both a shower and bath, while 22% of households had neither. Less than 10% of households owned a dishwasher, but around 70% of households owned a washing machine and 45% of households had a car. More than 60% of households had a geyser, but just 9.5% had a swimming pool. 49% of households had a garden at the time of the survey. The statistics on access to a car and household appliances indicate that the very poor and destitute groups were less represented in the sample.

As far as water-related attitudes were concerned, 78% of households indicated that they were aware of water restrictions, while 94% indicated they checked indoor taps for leakages to save water. Of households in the survey, 45% preferred paving their yard as a way of reducing outdoor water use. Only 29% indicated that they knew the water tariff structure. More than two-thirds of households stated that they did not change their consumption patterns when the tariffs changed, with many households indicating that it was difficult to reduce water consumption. Approximately 77% of households found it reasonable to pay for water, but more than 60% said it was not reasonable to cut off water for non-payment of water bills.

[37] Households living in flats usually share one water meter for each block.

It was in general difficult to obtain reliable income data. Respondents tended to be wary of providing information about their incomes. Some 25% of households indicated an income change over the last two years (that is, from 2001 to 2003), 18% indicated a decrease in income, whilst 7% of households stated that their income had increased. Seven percent of households indicated an increase in household size during the specified period, while 6.6% of households indicated a decrease in size. Given these insignificant changes in income and household sizes, it was assumed that these factors remained constant over the study period.

Table 4.6 shows the number of households in each income category for each of the five suburbs. It is evident that most households in Gugulethu (98%), Langa (94%), and Mitchells Plain (78%) were in the two lowest income categories. This was a substantially higher proportion than for Kensington (38%) and Pinelands (3%). At the other extreme, only Pinelands (44%) and Kensington (6%) had households in the highest income category.

Table 4.6: The number of households by income category (Rands per month)

Suburb	Less than R1 000	R1 001 to R5 000	R5 001 to R10 000	R10 001 to R20 000	Greater than R20 000	Total number of households
Gugulethu	39	24	1	0	0	64
Langa	20	26	3	0	0	49
Mitchells Plain	18	39	12	4	0	73
Kensington	4	17	22	7	3	53
Pinelands	0	1	11	8	16	36
Total	81	107	49	19	19	275

Source: Own calculations

The CCT also provided information on their IBT structure for the period 1998 to 2003. This is shown in Table 4.7.

Table 4.7: Domestic water consumption tariffs: City of Cape Town

Tariff Change Date	01 Jul 1998		01 Jul 1999		01 Jul 2000		01 Nov 2000	
Step	Kilolitres	Price[38]	Kilolitres	Price	Kilolitres	Price	Kilolitres	Price
Step 1	0-30	R1.05	0-5	R0.50	0-6	R1.09	0-6	R1.09
Step 2	31-150	R2.22	6-15	R1.60	7-15	R1.86	7-15	R1.95
Step 3	150+	R3.65	16-30	R2.70	16-30	R2.91	16-30	R3.06
Step 4			31-50	R3.80	31-50	R4.40	31-60	R4.62
Step 5			50+	R5.00	50+	R6.00	60+	R6.30
Tariff Change Date	01 May 2001		01 Jul 2001		01 Jul 2002		01 Jul 2003	
Step	Kilolitres	Price	Kilolitres	Price	Kilolitres	Price	Kilolitres	Price
Step 1	0-6	R0.00	0-6	R0.00	0-6	R0.00	0-6	R0.00
Step 2	7-15	R1.95	7-20	R2.60	7-20	R2.73	7-12	R2.00
Step 3	16-30	R3.06	21-40	R4.10	21-40	R4.30	13-20	R4.00
Step 4	31-60	R4.62	41-60	R5.20	41-60	R5.40	21-40	R5.10
Step 5	60+	R6.30	61+	R7.00	61+	R7.35	41-60	R6.20
Step 6							61+	R8.00

Source: P. Rhode (personal communication, October, 26, 2004)

4.4.3 Methodology

The econometrics approach uses a panel data analysis. Essential demographic and water-use information for the 275 households was combined with water consumption records for 60 months, as well as with information on the tariff structures. Climatic information was also added. This dataset constituted an unbalanced panel.

The starting point for the basic panel data model is given below (Greene, 2003: 285):

$$Y_{it} = X_{it}'\beta + Z_i'\alpha + \varepsilon_{it}$$

Where:

i = 1…..275, t = 1…..60

Y_{it} = household water consumption

X_{it} = vector of regressors

[38] These prices are exclusive of Value Added Tax of 14%.

Z_i = a constant term plus a set of individual or group-specific characteristics, such as sex, race, and origin (observable) or family-specific characteristics, such as skills (that are not observable)

The method of estimation is based on the specifics of the data. In the case of a pooled regression, Z_i contains only a constant term. This does not fit the data analysis in this study. Most of the differences in consumption were between different households; water consumption for each household was not as volatile during the period under investigation.

An analysis of the variation of water consumption for individual households over this time period is shown in Table 4.8. This shows the proportion of households that deviated from their mean consumption by more than 5, 10 and 20 kilolitres per month, indicated by suburb. It is evident that most households in Pinelands experienced a deviation of more than 5 kilolitres from their mean consumption over this period. As the benchmark is increased, the proportion of households experiencing a deviation decreases, in some cases to zero households (when a deviation greater than 20 kilolitres per month is considered).

A similar exercise was conducted for all households within a particular suburb, shown in Table 4.9. These results show that the variation from the mean, for almost all suburbs, is greater than 10 kilolitres.

Table 4.8: Number and proportion of households that deviate from mean monthly water consumption by more than 5, 10 or 20 kilolitres

Suburb	Standard deviation from household mean > 5 kilolitres per month	Standard deviation from household mean > 10 kilolitres per month	Standard deviation from household mean > 20 kilolitres per month
Pinelands	33 (92%)	17 (47%)	5 (14%)
Kensington	16 (30%)	4 (8%)	0 (0%)
Mitchells Plain	20 (27%)	6 (8%)	0 (0%)
Langa	26 (53%)	15 (31%)	4 (8%)
Gugulethu	35 (55%)	13 (20%)	7 (11%)

Source: Own calculations

Table 4.9: Mean and standard deviation (in kilolitres of monthly water consumption), by suburb

Suburb	Mean monthly water consumption (rounded to zero decimals)#	Standard deviation from mean (in monthly kilolitres of water)
Pinelands	33	16.2
Kensington	24	14.6
Mitchells Plain	18	9.0
Langa	22	17.8
Gugulethu	20	13.0

Note: the mean is calculated taking all observations into account, i.e. it includes all households in each suburb and over the entire time period (1998-2003). However, 69 observations (with a monthly consumption greater than 100 kilolitres) were excluded.

Source: Own calculations

It is evident that there is less deviation from mean consumption for each household than the average deviation for all households per suburb, which means the fixed effects model may be less applicable. In this approach all household differences are included in the constant term and the differences *within each household* are analysed over the time period. In the fixed effects model it is assumed that $Zi'\alpha = \alpha_i$, thus a household-specific *constant* term is added into the regression model. This is given by the following equation (Greene, 2003: 285):

$$Y_{it} = X_{it}'\beta + \alpha_i + \varepsilon_{it}$$

In the fixed effects model all the time invariant variables drop out of the regression. This excludes important information which may explain the quantity/price variation. The alternative option is the random effects model, which incorporates this information by modelling the differences between households as a random variable. The random effects model assumes that a household-specific random term $Z_i'\alpha = \alpha + u_i$, is included. Therefore the assumption is that the unobserved individual heterogeneity is random, but not correlated to the explanatory variables. This model is specified as follows (Greene, 2003: 285):

$$Y_{it} = X_{it}'\beta + \alpha + u_i + \varepsilon_{it},$$

The term u_i denotes a group specific random element that, for each group, is identical in each period. However, a Hausman test revealed that the random effects model would not be suitable, since there was heteroscedasticity in the data. Serial correlation was also found to be a problem.

Two appropriate models under these circumstances are the Generalised Least Squares (GLS) and the Panel Corrected Standard Error (PCSE). Both allow for corrections of heteroscedasticity. For this case study, the PCSE model was chosen (the STATA version of this model, XTPCSE, was used) as the benchmark for the demand study). The analysis included a correction for serial correlation and heteroscedasticity, both within panels and across panels in the same period, using a pairwise comparison.[39]

4.4.3.1 The IBT structure

As discussed in Chapter Three, the IBT structure implies that high levels of water consumption will coincide with high marginal prices. Due to the increasing steps, the random element will be skewed, since higher prices interact with higher random elements. Hence, using OLS will yield biased estimates. This problem is well known in the literature and various techniques have been used to address the problem.

One possible solution is to use a Two-Stage Least Squares (2SLS) model. This case study adopts the standard approach of Taylor (1975) and Nordin (1976), Terza (1986), Billings (1982), Nieswiadomy and Molina (1989) and Barkatullah (2002) (see Section 4.2.1.1 for

[39] The PCSE model produces coefficients estimated using a Prais Winston regression, which estimates panel corrected standard errors and it is assumed errors are heteroskedastic and contemporaneously correlated across panels (Volden and Bergman, 2001).

more details on their methodological specifications). In the first step the relationship between *observed* water consumption and a set of marginal prices for some *predetermined* quantities is estimated, each reflecting a step in the IBT structure. A set of other exogenous variables[40] is selected for this estimation. The estimated parameters[41] are then used to predict water consumption, Con^*_{it} for each observation.

$$Con^*_{it} = f(MP_{it}, Z_{it})$$

Where: Con^*_{it} = predicted water consumption
MP_{it} = vector of prices corresponding to the predetermined quantities
Z_{it} = other exogenous variables selected

Con^*_{it} is now used to calculate the instrumental variables. The instrument for the marginal price (MPIV) is the price in the actual IBT structure that corresponds to the predicted consumption, Con^*_{it}. As mentioned before, the IBT structure implies an implicit subsidy to the consumer (a rate structure premium (RSP)). The instrument for this premium (RSPIV) is calculated in a similar fashion, as the RSP corresponding to Con^*_{it} for each observation using the actual tariff structure (see Barkatullah, 2002). The relevant equations are as follows:

$$RSP = (\text{average price} - \text{marginal price}) * \text{quantity}$$
$$MPIV = g(Con^*_{it}), \text{ where } g(.) \text{ reflects the IBT structure}$$
$$RSPIV = h(Con^*_{it}), \text{ where } h(.) \text{ reflects the RSP structure}$$

These instruments were used in the second step to estimate water consumption. A log-linear demand model was adopted, which implies that the coefficients of the explanatory variables provided expressions of the elasticities. However, the RSP was included in real values, to avoid unstable estimators.[42] A model reflecting the results when using the log of

[40] The variables used in the first step of the analysis included: marginal prices for the predetermined quantities, temperature, rainfall, plot size, age, household size, and the income dummy variables.

[41] The first step regression yields an adjusted R^2 = 0.20.

[42] Initial model specifications (such as the GLS model) reflected some unstable results when the log of RSP was included. The sign of its coefficient was opposite and the instrumented MP variable became insignificant. Since the RSP is of not the focal point of this research, the real instrument instead of its log value was used.

RSP is presented for comparative purposes (see Model 2 in Table 4.11). Interaction variables were used to allow for different demand curves for each income group. The variables used in the econometric analyses are listed in Table 4.10. Real values were indexed according to the 2003 Consumer Price Index. The water demand function is as follows: water consumption is regressed against the instrumented price variable, income variables, the RSP variable, weather variables, household size, plot size, age, the interaction variables and dummy variables for having a bath, garden and washing machine.

The water demand model was estimated based on the following equation (see Table 4.10 for the full description of the variables):

$$lcon = \beta_0 + \beta_1\, lrmpiv + \beta_2\, y1 + \beta_3\, y2 + \beta_4\, y3 + \beta_5\, y4 + \beta_6\, rrspiv + \beta_7\, ltemp + \beta_8\, lhh + \beta_9\, lplot + \beta_{10}\, lrain + \beta_{11}\, d1999 + \beta_{12}\, d2000 + \beta_{13}\, d2001 + \beta_{14}\, d2002 + \beta_{15}\, d2003 + \beta_{16}\, lage + \beta_{17}\, int1 + \beta_{18}\, int2 + \beta_{19}\, int3 + \beta_{20}\, int4 + \beta_{21}\, bath + \beta_{22}\, garden + \beta_{23}\, wmachine$$

Table 4.10: List of variables in regression

Name	Description	Name	Description
lcon	Natural log of water consumption	y1	Dummy: monthly income between R1 001 to R5 000
lrmpiv	Natural log of real instrumented marginal price	y2	Dummy: monthly income between R5 001 to R10 000
rrspiv	Instrumented real rate structure premium (RSP)	y3	Dummy: monthly income between R10 001 to R20 000
lplot	Natural log of plot size	y4	Dummy: monthly income greater than R20 000
inti	Interaction variable (yi*lrmpiv), to allow for different slopes for each income group, i=1 to 4	bath	Dummy: household has bath/shower
ltemp	Natural log of average maximum monthly temperature	garden	Dummy: household has a garden
lrain	Natural log of average maximum monthly rainfall[43]	wmachine	Dummy: household has a washing machine
lhh	Natural log of household size	d1999	Dummy: year 1999
lage	Natural log of average age of household members	d2000	Dummy: year 2000 (water restrictions imposed)
d2001	Dummy: year 2001 (water restrictions imposed)	d2002	Dummy: year 2002
d2003	Dummy: year 2003		

[43] To secure the inclusion of observations for months with no rainfall, these observations were assigned a value of 1 mm rainfall.

4.4.3.2 Panel data analysis

The results for the benchmark model (PCSE Model 1) are given in Tables 4.11 and 4.12. An AR(1) adjustment was applied, with an estimated rho of 0.885. A second model is also shown in Tables 4.11 and 4.12, i.e. PCSE Model 2, which uses the log of RSP[44]. The estimated price elasticity of demand coefficient for the poorest group is -0.374, while the lower income segments show some variation (although close to zero). However, the richest group of consumers has a relatively higher price elasticity of demand estimate of -1.019. This is approximately equal to one in absolute terms (and is therefore unitary price elastic). This supports the assumptions of Moilanen and Schulz (2002) and it also supports the empirical findings of the contingent valuation study of Veck and Bill (2000) that higher income groups have a higher price elasticity of demand for water. The overall goodness of fit for the model is 0.33.

[44] Since the instrumented RSP contains zeroes, an adjustment had to be made before the natural log could be calculated. In the event of a zero value, R1 was added.

Table 4.11: Estimation results for the PCSE regression models

	PCSE Model 1		PCSE Model 2	
Variable	Coefficient	Z-value	Coefficient	Z-value
lrmpiv	-0.374***	(-4.26)	-0.310***	(-2.98)
rrspiv	0.007***	(5.18)	------	------
lrrspiv	------	------	0.118***	(3.45)
int1	0.024	(0.71)	-0.040	(-1.16)
int2	-0.069	(-1.61)	-0.168***	(-3.43)
int3	-0.124**	(-2.50)	-0.219***	(-4.10)
int4	-0.645***	(-4.42)	-0.403***	(-3.18)
ltemp	0.277**	(2.55)	0.348***	(3.01)
lrain	0.0001	(0.01)	0.004	(0.44)
lhh	0.534***	(7.92)	0.554***	(8.40)
lage	0.129**	(2.03)	0.131**	(2.09)
lplot	0.213***	(3.51)	0.233***	(3.77)
y1	-0.133**	(-2.40)	-0.058	(-1.05)
y2	0.057	(0.80)	0.186**	(2.37)
y3	0.115	(1.27)	0.236**	(2.52)
y4	1.144***	(5.19)	0.849***	(4.15)
d1999	0.030	(0.41)	0.022	(0.28)
d2000	0.072	(0.80)	0.052	(0.54)
d2001	0.079	(0.76)	0.046	(0.41)
d2002	0.107	(0.93)	0.068	(0.55)
d2003	0.092	(0.72)	0.055	(0.40)
bath	0.260***	(4.15)	0.278***	(4.32)
garden	0.067	(1.57)	0.073*	(1.76)
wmachine	0.193***	(6.88)	0.194***	(7.13)
constant	-0.615	(-1.25)	-1.211**	(-2.39)
Number of observations	13 621		13 621	
Number of groups	275		275	
Rho (AR1)	0.885		0.884	
R^2	0.33		0.32	

Level of significance: *** - significant at the 1% level, ** - significant at the 5% level, * - significant at the 10% level.

Source: Own calculations

Using these results, it is possible to calculate the price elasticity of demand for each of the income categories. Table 4.12 shows these results.

Table 4.12: Estimated Price Elasticities for Different Income Groups

Income Group (monthly income in Rands)	PCSE Model 1 Price Elasticities	PCSE Model 2 Price Elasticities
R0 to R1 000	-0.374	-0.310
R1 001 to R5 000	-0.350	-0.350
R5 001 to R10 000	-0.443	-0.478
R10 001 to R20 000	-0.498	-0.529
Greater than R20 000	-1.019	-0.713

Source: Own calculations

All price elasticities of demand are negative and half of the interaction variables are significant, which demonstrates a marked difference between the upper income segment and all other households. The results show that a 10% price increase for the highest income group will reduce the water consumption of each household by approximately 10%, while for the poorest group the same price increase will only reduce their (already small) water use by 3.74%. This means that only the highest income group reacts significantly to price changes (although consumers from the suburb of Pinelands are not necessarily the ultra-wealthy). Although it may seem counter-intuitive that higher-income groups are relatively more price sensitive, this behaviour is well documented in the water demand literature. Boland and Whittington (n.d.: 17) state that "the usual assumption [is] that larger water users (e.g. upper-income households) have a higher price elasticity of demand". Furthermore, Liu, Savenije and Xu (2003: 212) also expect "that demand in the high blocks will be more elastic than demand in the low blocks".

A theoretical justification for this result can be derived from the Stone Geary approach to consumer demand. This approach postulates that the demand for basic needs will be price inelastic, with additional consumption being more price sensitive. As mentioned earlier, the study by Veck and Bill (2000), conducted in Alberton and Thokoza, also found higher price sensitivity for the upper income groups (especially for outdoor use of water), as compared to the lower income groups. According to Hentschel and Lanjouw (2000: 21), "we can envision a higher price elasticity for high incomes (as water is used as inputs for luxury goods such as swimming pools and gardening), we can assume that the elasticity for the poor or near poor . . . are small". Thus, one of the justifications for this result is the distinction between the price elasticity of demand for indoor and outdoor water usage. Consumers are generally more price sensitive to outdoor rather than indoor water demand. In a study of households in the USA and Canada, Mansur and Olmstead (2006) found that the richer households with big properties had a higher price elasticity of demand for outdoor use than for indoor use. However, there are also studies documenting the opposite result.[45]

The coefficients of the dummy variables for bath, garden and washing machine all have the 'correct' sign and most of them are statistically significant. As far as climate is concerned, water consumption increases with increases in temperature and rainfall. The latter coefficient, however, has little or no effect and is statistically insignificant. Household size, the average age of the household and plot size all contribute positively to water consumption. The dummies for the years with water restrictions (i.e. 2000 and 2001) have positive coefficients. However, they are not significantly different from zero, compared to the reference year (1998).[46] This may be explained by the fact that the CCT usually increases water tariffs annually (especially the higher steps in the IBT structure) at the same time of year. If the results from the model are correct, it is possible to argue that the decreases in consumption are due to increases in water tariffs, and not necessarily to the quantity restrictions. More affluent consumers will therefore decrease consumption to keep their water bill constant. Over the time period of the study, the coefficients of the year dummies (1999-2003) reflect an increase in water consumption, but they are statistically insignificant. The restriction periods therefore do not significantly influence residential consumption. This is contrary to the observed long-run effect of the restrictions on total water demand trends for the CMA. It therefore seems to be price increases that matter, and not only formal water restrictions. Finally, the results show that the high income groups, an increase in income seems to increase demand substantially, while for the lower segments increases in income do not have a major influence.

4.4.3.3 Instrumented versus actual real prices

The benchmark model was compared to a PSCE model using the actual prices of water (i.e. a model without using the instrumental variables). Previously it was argued that the use of the actual prices and the RSP would yield biased estimators, given an IBT structure (since the error term must be correlated with the quantity consumed). Table 4.13 shows the results of this comparison.

[45] See Olmstead et al. (2007).

[46] Results from regressions which only included dummy variables for the years 2000 and 2001 (when water restrictions were imposed) had no impact on the regression results.

Table 4.13: Estimated Price Elasticities for Different Income Groups – Comparing PCSE: instrumented versus actual real prices

Income Group (monthly income in Rands)	Reference: PCSE (instrumented prices)	Reference: PCSE (actual prices)
R0 to R1 000	-0.374	0.131
R1 001 to R5 000	-0.350	0.101
R5 001 to R10 000	-0.443	0.082
R10 001 to R20 000	-0.498	0.074
Greater than R20 000	-1.019	0.012
Rho (AR1)	0.885	0.728
R^2	0.33	0.61

Source: Own calculations

The results reflect that using actual prices yielded positive price elasticities. This finding is similar to those of Nieswiadomy and Molina (1989) and Barkatullah (2002). This supports the use of instrumental variables in the main model.

4.4.3.4 Robustness of the results

Different model specifications have been used to check the robustness of the results. Other panel data specifications are available, such as the 'fixed effects' and the 'random effects' models. In the fixed effects approach, invariant variables dropped out of the regression, as did several other variables, due to the unbalanced panel together with the use of an (AR1) disturbance. However, the key elasticity estimates remained similar to the results of the PCSE model (for the different income groups). The assumptions of the random model were also tested. A Hausman specification test was performed, testing for orthogonality of the random effects and the regressors (Greene, 2003: 301). In this analysis, the random effect model was tested without correcting for serial correlation. The test gave a chi2 (13) = 35.18, which meant rejecting the hypothesis of equal standard errors, with a probability of Prob>chi2 = 0.0008.

An alternative method for the second step, the Generalised Least Squares (GLS), was also tested. This model included an adjustment for heteroscedasticity, but no correction for serial correlation. The estimated parameters for the price elasticities were lower but did not change much (when comparing the lowest and highest income groups). The model could not include a correction for serial correlation, as the time series (60 periods) was too short, in comparison with the number of households (275), and the panel was unbalanced. Thus, three specifications seem to be important for the results, i.e. the choice of the panel structure, the correction for serial correlation, and the use of instrumental variables.

4.4.4 Some policy implications

Chapter Two elaborated on the water scarcity problems of South Africa, while Chapter Three emphasised the role of water demand management as a crucial component of an integrated water management approach. Water pricing as a demand management tool must therefore receive serious consideration as part of the policy toolbox for changing consumers' water consumption patterns. Even though it is evident from the literature and the case study presented in this chapter that water demand is generally price inelastic, it is not entirely unresponsive to price changes. Therefore, increasing water tariffs will reduce water consumption.

Water managers can, however, only use pricing as an effective tool if they know how consumers respond to price changes. This information will assist them to design water tariff structures which take into account multiple objectives. Most empirical studies have found demand to be price inelastic, at least in the short run. However, the case study found that lower income households were less responsive to price changes, as compared to higher income groups (which were more price sensitive). Even though this result may seem contrary to expected consumption behaviour, it is consistent with some of the literature discussed previously. Policy makers should therefore take into account the varying consumption patterns of different income groups.

This case study found that the price elasticity of demand of the high-income segment (-0.967) differed significantly from that of the remaining households (for the lowest income group: -0.324). A 10% price increase applied to the marginal consumption of the high income group triggers a 10% reduction in their water consumption. These estimates indicate that a uniform policy applied to all households will be unlikely to achieve the desired results. Furthermore, an overall policy of managing water and restricting consumption that relies on pricing will be effective, especially with regard to the upper segment of the market in this sample. Since high-income consumers are also the largest consumers of water, an adjustment of the higher steps of an IBT may work quite well. Increasing the marginal prices of the lower steps will generally affect the poorer households in the lower blocks and will act as a tax on these consumers. Given their price elasticity of demand estimate, they will not reduce their consumption by much, since they only consume the water required to meet essential needs. Cheap water clearly does not lead to an enormous waste of this scarce resource. Even if one observes the consumption of those households in the segment that receives free water (less than 6 kilolitres per month), only 29% of the meter readings indicate use of the maximum free allocation. Hence, increasing the tariff is not an appropriate option and alternative measures should be considered to influence their water consumption. These may include quantitative restrictions, the use of low-pressure systems, other physical restrictions and educational campaigns.

There are very few water demand studies featuring lower income groups, particularly in developing countries. This study should assist water management in dealing with multiple objectives. The results add to our knowledge of water demand patterns. However, the consumption patterns in Cape Town may not reflect patterns in the rest of the developing world. This study did not include very poor and destitute groups that only have access to unmetered water. The focus was also on urban households, and rural areas probably face different management problems. There is clearly scope for other interesting and relevant water demand research. However, for those consumers without metered water, demand management using volumetric pricing is irrelevant.

Price increases may also have implications for equity, especially in circumstances where many people cannot afford to pay for their basic consumption of water (this issue is specifically addressed in Chapter Five). The estimates in this study can help water managers to set appropriate tariff structures, particularly if they want to adjust an IBT structure to achieve multiple objectives. The importance of considering these goals has been emphasised by Moilanen and Schulz (2002), who showed that an IBT structure should vary, depending on the welfare goals of the municipality, as well as on the demand structure of rich and poor households.

Varying the price elasticity of demand estimates for different income groups is important when using the IBT structure for equity purposes. Based on the findings of the case study, richer households spend approximately the same amount on water regardless of price (i.e. their price elasticity of demand estimate was -1.019). Increasing the marginal price for this group would have little effect on their water bills, which means that it is possible to adjust total water consumption without really influencing the revenue of the municipality. If municipalities want to raise additional funds from this group to increase redistribution to poor households, they would have to consider using fixed fees as an alternative source of revenue. The distributional implications of the IBT structure are analysed further in Chapter Five.

4.5 Concluding remarks

An important aspect of assessing the efficacy of water pricing as a demand management tool is determining how responsive consumers are to changes in their water tariffs. There is a vast literature of water demand studies estimating the price elasticity of water demand. Most studies have found demand to be relatively price inelastic, although there is some variation in the price elasticity estimates, particularly for different income groups and for different tariff structures. The methodologies vary from basic OLS models to instrumental variable and structural models. One of the main estimation issues is which pricing variable to use. This is particularly problematic since block tariff structures do not have one marginal price. Block tariff structures also cause endogeneity problems, since price is determined by the quantity consumed and the quantity consumed determines the price. Researchers have addressed this by using instrumental variable models, i.e. 2SLS and structural models. Existing empirical literature in South Africa is sparse, with few micro-level studies estimating the price responsiveness of different households. The most recent study by Szabo (2009) was completed after the case study presented in this chapter. The findings of that study indicate that demand is quite price inelastic, although wealthier (non-indigent) households are relatively more price sensitive than poorer (indigent) households. The case study presented in this chapter estimated the price elasticity of demand for households residing in the Cape Town area. Its findings also confirm that the demand for residential water is price inelastic, although less so for higher income households. The price elasticity estimates are somewhat higher than in previous studies or that of Szabo (2009).

The main finding of this chapter is that consumers do react to water tariff changes. However, it must be kept in mind that water tariffs, especially IBT structures, are set to achieve multiple objectives. Water utilities need to ensure revenue sustainability, a more efficient use of water resources and a more equitable distribution of resources and costs. Knowledge of the price elasticity of demand can help inform a tariff structure that attempts to achieve these objectives. Chapter Five explores attempts to achieve one particular objective, i.e. to ensure a more equitable distribution of resources, through the tariff structure.

CHAPTER FIVE

The Increasing Block Tariff structure as subsidy mechanism - a South African case study

5.1 Introduction

The Increasing Block Tariff (IBT) structure is an example of quantity targeting, which Komives, Halpern, Foster, Wodon and Abdullah (2007: 661) define as "the allocation of subsidies based on the quantity of water or electricity a customer uses." In an effort to incorporate equity concerns, the IBT structure is designed to charge prices at below cost for the first consumption blocks; this is sometimes referred to as the lifeline tariff. The fact that consumers who use a lot of water pay more implies that a more equitable provision of services is achieved as there is variation in the prices paid by different consumers. The tariff structure therefore allows for cross-subsidisation from richer to poorer consumers, if richer consumers indeed consume more.

One of the reasons for adopting an IBT structure is to achieve a more equitable outcome. This can be explained by the concepts of horizontal and vertical equity. In tax literature, horizontal equity means equal tax payments from people in equal positions, whereas vertical equity implies that those who can afford to pay more, should do so. Within the context of water distribution, horizontal equity suggests that those with equivalent water requirements should be treated in the same way, whereas vertical equity takes into account the value of the last litre of water used (Gibbison, 2009). If it can be shown that the poor have less access to water, or that they are likely to be at greater risk of developing health problems as a result of a lack of safe water, water distribution policy should be adjusted in favour of the poor (Gibbison, 2009: 3).

South African municipalities use the IBT structure as a subsidy mechanism. After the first democratic elections in 1994, tariff and subsidy policies emphasised cost recovery, but also had to take account of the need to expand services to many people without access to safe water (Muller, 2008). However, it soon became evident that the poor could not afford to pay for water services, hence the implementation of the Free Basic Water Policy (FBW). As discussed in Chapter Three, South African water legislation requires municipalities to provide the first six kilolitres of water free of charge to households. Each water provider has the discretion to decide how to design and implement the IBT structure to finance the provision of free water (i.e. they can determine the size and numbers of each block, as well as the marginal prices). The FBW implementation strategy clearly indicates that tariffs should be set according to guidelines that are prescribed in the Municipal Systems Act, and in water services and tariff regulations. These advocate providing a 'lifeline' to the poor, while ensuring financial sustainability (Department of Water Affairs and Forestry, 2002).

The provision of water subsidies through the IBT structure can be financed using cross-subsidisation between users. This will, however, only be effective if municipalities are able to implement a well-functioning metering and billing system and if most users have access to the water system. In addition, to recover costs municipalities require sufficient numbers of high-volume water users in order to generate sufficient income so that a price below cost can be charged to low-volume water users. However, the efficacy of using the IBT structure as a subsidy mechanism has been called into question. In particular, the design of the IBT structure has been criticised for not cross-subsidising to the really poor households. As previously discussed (in Chapter Two), many poor households in developing countries do not have access to metered water systems. These households tend to purchase water from vendors or other households, paying much more for water than connected users. Furthermore, some poor households consume more than the subsidised quantity of water, which places them in higher consumption blocks of the IBT structure and therefore increases their cost of water.

A related problem is that some municipalities do not have a strong enough base of high-volume water users to allow for cross-subsidisation between water users. This means that some municipalities cannot finance water at below cost to the poor. In these cases, municipalities can resort to external funding (such as transfers from the national government). This is precisely how water subsidies are financed in South Africa. In addition to possible cross-subsidisation, municipalities receive an unconditional transfer, i.e. an equitable share of tax income from the national government. This equitable share to municipalities is an entitlement prescribed by the Constitution with the aim of ensuring a minimum level of service provision (De Visser, 2005: 208). The transfer is allocated according to a formula which comprises five components, namely institutional support, basic services, revenue-raising capacity, development and a correction and stabilisation component (Calfucoy et al. 2009: 12).

To verify whether the design and implementation of the IBT structure achieves the set goals, it is crucial that empirical studies are conducted. Komives et al. (2007: 659) emphasise that policy makers are interested in improving the efficacy of transfer mechanisms aimed at reducing poverty. There is thus a need for further empirical investigation of subsidies for residential water and electricity via utility tariff structures. This chapter aims to contribute to the empirical literature on water subsidies by investigating the extent to which IBT structures, as they are currently applied in South African metropolitan cities, achieve equity objectives. The chapter commences with a discussion on the factors that inhibit the IBT structure from achieving equity goals. This is followed by a discussion of water subsidies in South Africa. The main empirical analysis in this chapter investigates the equity implications of the use of the IBT structure in the South African urban domestic sector. Household water consumption data are used to verify whether cross-subsidisation between the rich and the poor does take place when an IBT structure is used. The analysis distinguishes between an IBT structure with and without a free basic water component, in an attempt to investigate the effect of the provision of free basic water on the poor. The final section of this chapter discusses possible alternatives and improvements to the current tariff structure, which aim to improve the water subsidy mechanism to the poor. This section relies heavily on existing empirical evidence, and particularly on studies in developing countries. The chapter concludes with policy recommendations in the South African context.

5.2 Factors influencing the attainment of equity objectives using IBT structures

The IBT structure in developing countries does not necessarily achieve cross-subsidisation from the rich to the poor. According to Brooks and Smith (2001: 14), it is difficult to target cross-subsidies accurately and this often leads to a situation where the net transfers to poor households are insignificant. This section elaborates on the various factors that could lead to poor households receiving less than the intended benefits.

5.2.1 No Access to Water

The most common type of subsidy via the tariff system is a lifeline tariff, which implies a subsidy for low consumption (Komives et al. 2007: 660). One of the main arguments against using the IBT structure as a subsidy mechanism, however, is that many low-income households in developing countries are not connected to the formal metered piped-water system, or have shared connections. This is especially true in the case of rural areas. In Africa, for example, statistics for the year 2000 indicated that only 27% of households in Cotonou (Benin) had access to piped water, as compared to 85% in Dakar (Le Blanc, 2007). In Cape Verde poor households had less access to the public network than the rest of the population (Komives, Foster, Halpern, Wodon and Abdullah, 2005). In such cases, this subsidy is regressive since the non-poor receive most of the benefit.

Water subsidies through the IBT tariff structure are often used to charge lower tariffs to poor households. However, this could be poorly targeted if the benefit accrues mostly to households in higher income brackets, because poor households are less likely to have access to the network, or to connect to the network[47] and generally consume a smaller quantity of water than non-poor households (Le Blanc, 2007). Consumption differences between water users need to be quite substantial and the tariff structure must be designed with a very small first consumption block, if higher income households are to cross-subsidise the poor (Komives et al. 2007).

Walker, Ordoñez, Serrano and Halpern (2000: 1) examined cross-subsidies in Central American countries and found that, since there was little variation in consumption between income groups, the more affluent households captured a significant proportion of the implicit subsidy. They also found that in cities with high coverage (i.e. households with water connections), poor households did receive a subsidy.

According to Whittington (1992: 76), the IBT structure fails to achieve its intended equity objectives for two reasons. Firstly, poor households in developing countries tend to live in high-density housing, with the result that individual metering is not applied. Households often share a single-meter water connection, which leads to high water consumption figures that increase as more families share water connections. Another reason is the difficulty in accessing water connections experienced by poor households. Many poor households do not have access to a private connection and purchase water from secondary sources such as neighbours with a water connection, or private vendors, or they use water sources that may not be entirely safe to consume, such as water from rivers or streams. These households have to purchase water at extremely high prices from water vendors or households that are connected to the network. The latter households

[47] There is often a cost to connect to the network. This, however, is not the case for poor households in South Africa as a result of the roll-out of services by the government.

charge higher prices since they have to pay higher prices, on average, for the increased consumption (Whittington, 1992) and possibly also want to earn some profit.

Access and uptake are key determinants of the benefit of water subsidies in the IBT structure (Angel-Urdinola and Wodon, 2007b). Improved access to water infrastructure can greatly improve the efficacy of IBT structures in achieving equity objectives. Angel-Urdinola and Wodon (2007b) investigated the targeting performance of water consumption subsidies in Nicaragua and their study revealed that increasing access to piped water improved the targeting performance, even though the tariff structure remained unchanged over the period of the investigation. Their research was an extension of previous work by the same authors (see Angel-Urdinola and Wodon, 2007a) in which they measured the distributional incidence of utility subsidies. Their indicator provides an estimate of the share of subsidy benefits to the poor, as a proportion of the poor. The indicator can be decomposed into five important factors that influence its value: (1) access to utility networks; (2) use of the service in cases where there is access; (3) a subsidy-targeting element (using the value of one if the household receives a subsidy); (4) the rate of subsidisation; and finally, (5) the quantity of water consumed (Angel-Urdinola and Wodon, 2007a). Angel-Urdinola and Wodon (2007b) further argued that increased access was the best way of achieving an improved targeting performance, particularly when compared to the effect of changes in the rate structure. The regressivity of the IBT structures is therefore largely caused by the exclusion of the poor from water networks (Olivier, 2006: 6).

5.2.2 Household size

The size of the household connected to a single metered connection can lead to a water bill that has a regressive impact as a result of the IBT structure. Larger households tend to consume greater quantities of water. This finding has been confirmed in the water demand literature, with many studies pointing to a positive correlation between the size of the household and water consumption. In the Cape Town case study in Chapter Four, household size was also positively correlated with water consumption. Whittington (1992: 76) referred to the IBT structure as having the opposite effect to that which was intended, where low-income households are penalised as they tend to have bigger families (or share accommodation with extended families) and share one individually metered connection, which places them in a higher-priced block. In a simple regression analysis, Whittington (1992: 80) confirmed this positive relationship. He investigated the relationship between the average price paid for water and the number of households in a building, using household data from Kumasi, Ghana. His findings showed that there was a positive correlation between the number of households in a building and the average price of water. Moreover, he also found that it was generally the poorer households that lived in the more densely-populated apartment blocks; since the average price paid for water increased as the number of families in the building increased, it was the poor households who paid the highest prices.

Using the Cape Town data (from the case study in Chapter Four), an investigation into the correlation between household size and water consumption was performed. The monthly meter readings over the period 1998 to 2003 were used to determine mean water consumption by household size, shown in Table 5.1.

Table 5.1: Mean household consumption and per capita consumption, by household size

Household size	Mean monthly consumption# (kilolitres per month)	Mean monthly consumption per capita (kilolitres per month)	Mean consumption per capita per day (litres per day)
1	12.4	12.4	413.1
2	18.2	9.1	303.1
3	20.1	6.7	223.3
4	22.7	5.7	189.4
5	22.9	4.6	153.0
6	23.4	3.9	129.9
7	19.7	2.8	93.8
8	28.8	3.6	119.9

#Monthly consumption observations greater than 100 kilolitres have been excluded, as well as household sizes greater than 8 members.

Source: Own calculations

The mean household water consumption increases as household size increases. Households with three members use approximately 70% of the water consumed by households with eight members. Mean monthly consumption per capita also mostly shows a declining trend as household size increases, which is similar to the findings of Smith (2010: 600). It is evident, however, that the mean consumption per capita per day for this (limited) sample is much higher than the prescribed minimum quantity (i.e. twenty litres per capita per day). According to Calfucoy et al. (2009: 3), this is the least amount of water considered by the World Health Organization necessary to meet an individual's *most basic water needs*.[48]

Further evidence that household size is relevant in estimating the potential benefits of cross-subsidisation is provided by Pashardes and Hajispyrou (2002). They argue that the efficacy of IBT structures in achieving intended equity objectives can be criticised as water consumption is not only influenced by a household's income. Factors such as household size, composition, type of dwelling and the use of specific water-using appliances can all have an impact on the quantity of water consumed. The primary focus of their research was to investigate the notion that IBT structures are inequitable as a result of their failure to take household size and age structure into account. To this end, they argued for household allowances which will take account of the burden placed on households as a result of their size and age structure. Their methodology included estimating the size of these allowances by using the concept of relative equivalence scale. This is a money metric measure that indicates the relative compensation needed by demographically different families to experience unchanged utility levels, given different pricing regimes (Pashardes and Hajispyrou, 2002: 2). Their results showed that larger families would spend more on water as they would have to pay higher prices with an IBT structure, and their water budget share would be higher. Therefore, at subsistence income, larger households were at a greater disadvantage than smaller households, and needed to spend more on water to maintain the same level of utility (Pashardes and Hajispyrou, 2002: 15).

5.2.3 Production in the informal sector

The provision of safe and sufficient water for domestic use is usually associated with consumptive use only. According to Moriarty and Butterworth (2003: 11), even though safe and secure water for drinking and eating purposes is needed to ensure the survival and health of poor people, consideration should also be given to the many other benefits that can be achieved. Not only does safe water contribute to a healthier environment for the family, it can also save time, enhance food security and, importantly, generate income. The benefit of income generation is especially important in communities where poverty levels are high and formal employment is limited. An adequate supply of clean, safe water

[48] Twenty litres, however, would not be sufficient to meet other requirements such as laundry or bathing (Calfucoy et al. 2009: 3).

for domestic use would assist with home-based production activities such as growing crops, feeding animals and other service activities.

In South Africa many people resort to self-employment activities to earn an income. The 2006 Labour Force Survey indicates that 22% of the employed engaged in informal sector activities (Essop and Yu, 2008: 4). The top ten occupation categories of informal employment included food vendors, hairdressers, and tavern and shebeen operators (Essop and Yu, 2008: 17). Some of these activities, such as hairdressing, require water as an essential component to provide these services. According to Abraham, Van Rooijen, Olufenke and Raschid-Sally (2007), water (especially potable water) is an important input for small businesses offering catering services. Furthermore, livestock businesses require water for animals. Car-wash services and crop production also require water, although the quality may be less important. The value of these informal sector activities has been recognised by the South African government. In the draft White Paper on water services, economic activities deriving from household production are given explicit attention:

> "Municipalities do not, and should not, only provide water services necessary for basic health and hygiene. It is important that municipalities undertake health education, facilitate the provision of higher levels of services for domestic users and provide services which support the economic development and well-being of communities." (Department of Water Affairs and Forestry, 2002: 7).

Understanding how water for productive purposes influences the livelihood of poor households is crucial in developing poverty-reduction strategies. According to Speelman, D'Haese, Ochieng and Vandermeulen (2006), the benefits of water for productive purposes should be considered not only in water management policies, but should also feature in poverty reduction strategies. Speelman et al. (2006) explored the productive water activities in a community situated in the eastern province of Kenya and found that water was used for crop and livestock production and was also sold. They also investigated the effect of these activities on the income of local households and found that crop production had a significant impact on household income, while livestock production had a significant effect on their nutrition.

5.2.4 Affordability to the household and revenue implications for water agencies

One of the key aspects of designing a pro-poor pricing strategy for water is the affordability of tariff changes to low-income households. Many people perceive water to be a basic right and therefore argue that its cost should be kept low or that it should be provided free of charge, especially to poor households who cannot afford to pay for basic services. However, the design of the pricing structure must also take into account the financial sustainability of the water service provider. According to the OECD (2009: 18), two key issues must be addressed if these goals are to be achieved at the same time. Firstly, what portion of the cost must be covered by revenues? Secondly, how must the cost be allocated between different income groups, family types or geographical units? The limits to affordability are most appropriately determined at local level, where knowledge of the spending patterns of poor households and their willingness to pay for improved services is available. This can be incorporated into the design of rate structures, which can provide more accurate assessments of affordability constraints and willingness to pay.

Payments for water, electricity and other utility services make up a substantial proportion of a poor household's budget (Fankhauser and Tepic, 2007). Affordability refers to the ability of households to pay for a minimum level of the service. An affordability ratio can be expressed as the share of income spent on utility services (Fankhauser and Tepic, 2007: 1039). An example of the affordability of water services to the poor is provided by Foster and Yepes (2006: 14), who estimated the percentage of the population that would have difficulty paying for water and electricity services when these services are charged at cost recovery prices. By setting some boundaries for water consumption at subsistence levels[49], they estimated the monthly cost for households to meet their basic needs in urban areas. To determine affordability, these cost figures were then compared to the average household income (or household expenditure). The benchmark against which these estimates were compared was a threshold of 5% of income, which is assumed to be reasonable for expenditure on water in Latin America (Foster and Yepes, 2006: 16). This analysis was undertaken for countries in Latin America, Africa, East Asia and India. Their findings indicated that in Latin America, only the poorest 20% of households had affordability problems. However, the region's poorer countries, such as Bolivia and Honduras, would face a significant affordability problem when cost recovery tariffs were

[49] A lower limit was set at 7.5 kilolitres per month and an upper limit at 15 kilolitres per month, for a family of five members.

applied. In addition, India and countries in Africa would face even more severe problems, with 70% of households unable to afford these tariffs (Foster and Yepes, 2006: 22).

The affordability of utility payments can affect the expansion of network services to households not yet connected, which has distributional implications (as discussed above). Local governments, particularly in rural districts, may not be able to finance the expansion of services, especially when they have an IBT structure in place that recovers too little of the cost of provision. This happens because they have insufficient rich households to recover the cost of providing/expanding services to poor households.

Related to the issue of affordability is the non-payment for services. Affordability ratios may seem acceptable if there is a high occurrence of non-payment for services (Fankhauser and Tepic, 2007), as it implies low levels of spending on utility services and results in lower affordability ratios. These ratios will therefore not be a true reflection of the extent of water poverty (Fankhauser and Tepic, 2007: 1041). Non-payment of water services can occur for a number of reasons: it can result from a poor quality of service as well as from an absence of metering. It therefore will reduce the water utility's ability to raise adequate revenues to provide, maintain and expand its services.

5.2.5 *The design of the IBT structure*

The design of the consumption blocks of an IBT structure, particularly the first block, is another frequent criticism of IBT structures. In many countries, particularly in the developing world, there is political pressure to have a reasonably large first consumption block (Boland and Whittington, 2000). This, according to Boland and Whittington (2000), is common practice around the world and can be ascribed to the pressures on politicians to implement a large first block. Since the subsidy generally applies to all metered connections, a large number of non-poor households also benefit from the initial block. According to Brocklehurst, Pandurangi and Ramanathan (2002), as cited in McKenzie and Ray (2004), the size of the first block in India generally exceeds the amount of water that would be required to meet basic needs. According to Foster, Pattanayak and Prokopy (2003), state and federal governments in India spent around 0.5% of GDP on water subsidies. However, most of this did not reach the poor.

5.3 Water subsidies in South Africa

The use of water has been subsidised in South Africa for a long time, especially in the agricultural and municipal sectors. However, as previously mentioned, post-1994 water policy legislation emphasised an increased awareness of the need for water pricing to reflect cost recovery. According to Lange and Hassan (2006), water users in South Africa have generally been more highly subsidised than those in two other water-stressed African countries, Botswana and Namibia. Table 5.2 reveals the extent of water subsidies of different water providers in South Africa in 2000.

Table 5.2: Water subsidies in South Africa (2000)

Service provider	Extent of subsidy
Department of Water Affairs and Forestry	Aggregate subsidy estimated at roughly 35% of supply cost
Irrigation Boards	Agricultural subsidies estimated at roughly 87% of supply cost
Water Boards	No subsidy
Municipalities	Aggregate subsidy reduced to roughly 5% of supply cost

Source: Adapted from Lange and Hassan (2006: 183)

Municipalities usually provide water subsidies through the tariff system. The provision of subsidies to poor households who cannot afford basic water services can be traced back to the Reconstruction and Development Programme (RDP)[50], in which the affordability of water and the right to access water featured prominently (Mosdell and Leatt, 2005). The IBT structure was already seen as a possible means to cross-subsidise between water users in an effort to make water more affordable to the poor.

The City of Cape Town has been using block tariffs for many years; this even predates the implementation of free basic water. Table 4.7 in Chapter Four illustrates that the CCT used a three-step IBT structure as early as 1998 and replaced it later with an IBT structure with more steps. Since the affordability of water was considered a problem for poor households

[50] The RDP was a socio-economic policy framework which was adopted by the South African government immediately after the elections in 1994.

(which precluded access to safe water) the FBW policy was introduced. This policy was adopted by the CCT in May 2001 (see Table 5.4 below).

As discussed previously, the FBW prescribes a free first block of six kilolitres of water per month for a family of eight members. According to Smith (2010), initially the Department of Water Affairs and Forestry indicated that this was based on 'recommendations' from the World Health Organization, but later on indicated it was based on internationally accepted norms and guidelines. However, it has been argued that the initial free basic water policies applied in Durban (implemented before national policy had been finalised) had a significant influence on national policy legislation. The EThekwini Municipal Council (Durban) replaced a bailiff-operated system[51] in informal settlements with free basic water of six kilolitres per month, as it was more costly to operate the former system (Smith, 2010: 597).

Whether this amount of water is sufficient to cover basic needs has been questioned. According to McDonald (2002), as cited in Earle, Goldin and Kgomotso (2005), 6 000 litres per month is usually insufficient to sustain low-income households, since they often have more members and dilapidated infrastructure could also increase their water usage. Muller (2008) also points to objections raised by civil society groups in South Africa with regard to the basic amount of water. Recently these groups supported court action against the City of Johannesburg in which the complainants objected to the implementation of the policy of a maximum of 6 kilolitres of free water to households per month. The main argument was that this amount was insufficient to meet basic needs; the steep (unaffordable) tariffs in subsequent blocks were also regarded as unaffordable for poor households.

5.3.1 Financing water subsidies

The IBT structure is one of the financing mechanisms proposed by the Department of Water Affairs and Forestry to increase access to water. In particular, the free basic water policy was implemented on the assumption that cross-subsidisation would assist in financing free basic water to poor households. A survey conducted by the Department of Water Affairs and Forestry in 2006 revealed that 183 of the 236 municipalities surveyed were using IBT structures (Smith, 2009). The Eastern Cape and KwaZulu-Natal had the lowest number of municipalities with IBT structures (Smith, 2009: 8). In addition,

[51] This system involved having a bailiff operate a standpipe or prepaid ground tank, where the latter was filled with 200 litres once a day (Bailey and Buckley, 2004).

municipalities applied diverse targeting mechanisms. According to Mosdell and Leatt (2005), there were three methods of implementation: (1) municipalities could use the IBT structure and provide a basic amount of free water to all households; (2) they could implement targeted subsidies where poor households were identified by means-testing (this is similar to the discussion on indigent policies in Chapter Three); or (3) they could apply service-level targeting, which implies that consumers who receive differential service levels (such as restricted flow) would be charged differential tariffs.

Many municipalities, however, cannot rely solely on cross-subsidisation to finance the provision of free basic water. Firstly, they do not have adequate numbers of middle- to high-income households to sustain cross-subsidisation. For cross-subsidisation to be effective, the Department of Water Affairs and Forestry suggests that at least 40% of households must consume more than 20 kilolitres of water per month (Palmer Development Group (2001), as cited in Calfucoy et al. (2009)). However, this is only viable if municipalities also set prices and consumption blocks to cover their average cost of production (Calfucoy et al. 2009: 8). Therefore, options such as targeted subsidies or even service-level targeting may be more appropriate in the case of poorer municipal areas (Mosdell and Leatt, 2005), as these options involve a lower cost of free water to (targeted) consumers. This does also imply an additional administrative burden to identify indigent households, something which has not yet been successfully achieved in all areas (see the earlier discussion on indigent policies in Chapter Three). For this reason, transfers from national government to municipalities have become an important financing mechanism for the provision of free basic water.

The intergovernmental transfer, i.e. the local government equitable share (LES) received by municipalities, is one of their main sources of finance. As previously mentioned, the LES is a guaranteed share of the revenue collected at national level, as provided for in the South African Constitution (Brown, 2005). The LES is distributed according to a formula which includes a component (referred to as the S-grant), the sole purpose of which is to ensure that poor households receive basic services. However, the LES is not conditional, and municipalities may or may not use the full grant to finance basic services (Mosdell and Leatt, 2005). Other national grants relating to basic services include a municipal infrastructure grant. This grant is conditional and is geared towards expanding and improving basic infrastructure (Brown, 2005). Table 5.3 shows the apportionment of LES and other municipal conditional grants for the 2010/ 2011 fiscal year.

Table 5.3: Local government equitable share and municipal conditional grants (2007/08 to 2010/11)

Grant	2007/08 (R million)	2008/09 (R million)	2009/10 (R million)	2010/11 (R million)
Equitable share and related	20 676	25 560	23 845	30 559
Municipal infrastructure grant	6 967	6 968	8 788	9 515
Water services operating subsidy grant	642	985	871	670
Expanded public works programme incentive grant for municipalities	---	---	202	623
Municipal drought relief grant	90	9	54	320

Source: Republic of South Africa (2011). National Treasury. Budget Review 2011.

The provision of these grants recognises the fact that most municipalities will not be able to deliver basic services on a sustainable basis if they have to rely entirely on their own funds and on cross-subsidisation using the tariff system. According to Loots (2003), the inter-governmental fiscal system in South Africa implicitly recognises this by making provision for an equitable share allocation, which also suggests that the application of national standards for basic services is inevitable. An analysis of municipalities in the Western Cape in 2002 revealed that the majority of municipalities (83%) provided free basic water (i.e. six kilolitres of water) to all households, and that most of them relied on both the equitable share and cross-subsidisation to finance the cost of these services (Loots, 2003). In particular, only eight municipalities contributed some of their own revenue towards the cost of indigent services, which implies that there was a heavy reliance on the equitable share as a source of funding for services to indigent households. This was, however, not sufficient to cover the full cost; cross-subsidisation was necessary and financed about 56% of the 2002 cost of free basic services (Loots, 2003: 12).

5.3.2 Efficacy of subsidy mechanism – some empirical findings

The FBW has received particular attention as it was developed for the benefit of the poor. This section outlines some findings of selective case studies that investigated the affordability of water services to the poor and the impact of water subsidies in South Africa. This provides an appropriate context for the empirical case study presented later in this chapter.

Brown (2005) investigated the impact of FBW on affordability in Mbombela, the provincial capital of Mpumalanga. Water service providers included both the municipality, as well as a private company, the Greater Nelspruit Utility Company (GNUC), which supplied water to almost 50% of the total area. The town had a combination of well-serviced areas with good water infrastructure, and informal settlements where water provision was inadequate and little infrastructure had been developed (Brown, 2005). This study highlighted that the introduction of FBW led to an increase in prices (to address cost recovery) for both water providers. They also relied on external funding, i.e. the national grant in the form of the equitable share. However, the increased prices for subsequent blocks (after the first block of free water) meant that poor households were still unable to afford water services if their consumption was greater than 6 kilolitres. This problem of insufficient cost recovery was worsened by the increase in non-payment for services (in part due to the unaffordability of services).

Another qualitative study investigating whether FBW was able to provide sustained and adequate access to water was undertaken by Peters and Oldfield (2005). They examined the impact of cost recovery and the FBW policy for low-income households in Grabouw, a small municipality in the Western Cape. Their main argument was that poor households were worse off due to the cost-recovery policies the municipality adopted (e.g. the use of water-restricting devices such as drips, which limit water supply to the FBW quantity). Although FBW provided a certain amount of water at no cost, their interviews indicated that households did not perceive the basic amount to be sufficient for their needs (Peters and Oldfield, 2005: 329). Non-payment for services also created financial problems for the municipality, which affected their ability to deliver services on a sustainable basis.

5.4 A South African case study[52]

This section is an empirical analysis of the equity implications of the IBT structure as it is currently implemented in many of the metropolitan cities of South Africa. The specific question addressed is whether the IBT structure, and in particular the FBW policy of the South African government, meets intended equity objectives.

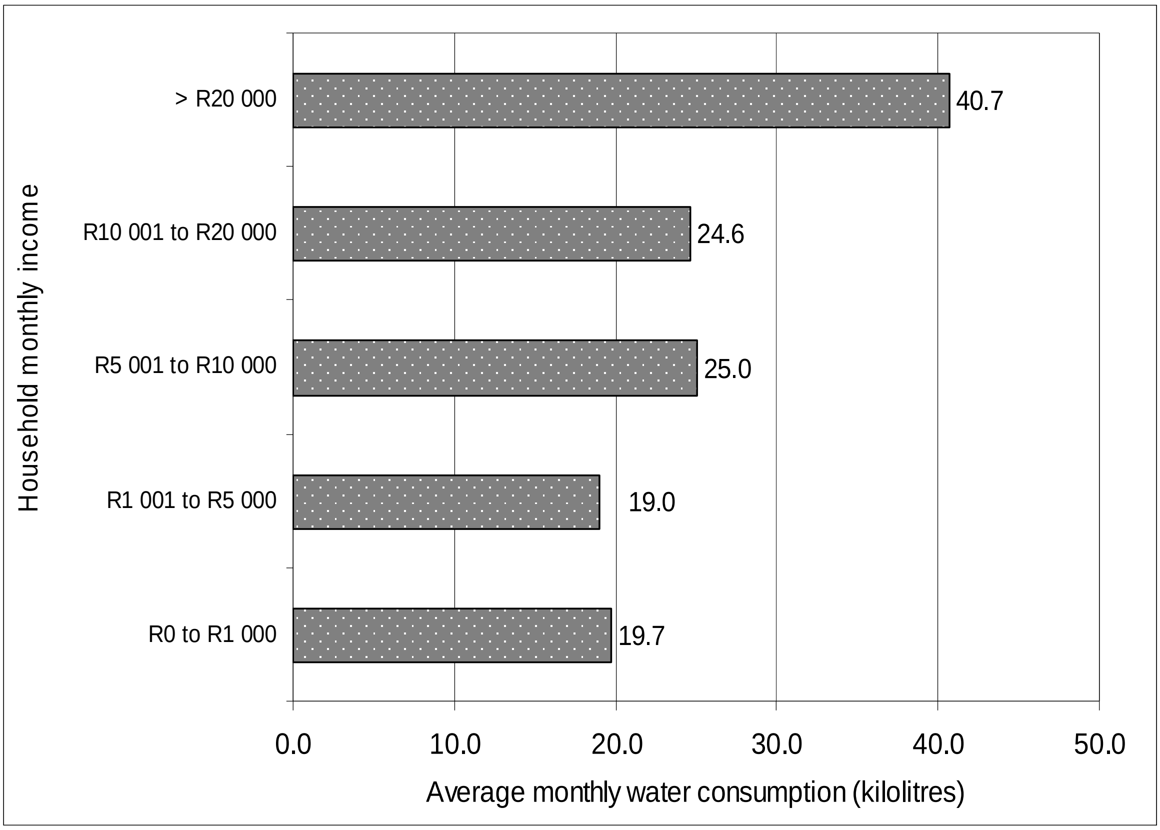
5.4.1 Data

One of the biggest constraints in analysing microeconomic questions at the household level is the unavailability of data. None of the household surveys conducted in South Africa have credible data on household water consumption. For the purpose of this case study the Cape Town data collected previously (see Chapter Four) was used. As discussed earlier, the dataset consists of information on water use and water-related consumption activities of households from particular suburbs in Cape Town. The data used in this case study only use information on 273 of the 275 households (due to some missing observations). The data pertain to their monthly water consumption for the period July 2002 to June 2003 and includes information on household demographics such as household size, household income and the ownership of cars and water-use appliances (this information was part of the survey discussed in Chapter Four).

Figure 5.1 illustrates the mean monthly water consumption (for 2002/03) by income category. It clearly shows a positive relationship between water consumption and income, which is to be expected given the positive income elasticity of demand estimates reported in the water economics literature (see for example Rietveld et al. 2000). The IBT tariff structures applied in the subsequent analysis are those of the CCT and are shown in Table 5.4.

[52] The empirical estimations in this case study were initially completed in collaboration with Mr. Cobus Burger, a researcher in the Department of Economics, Stellenbosch University.

Figure 5.1: Average monthly water consumption per household, by income category for Cape Town sample



Source: Own calculations

Table 5.4: City of Cape Town IBT structures (nominal prices)[53]

Consumption blocks (kilolitres per month)	November 2000	May 2001
0 – 6	R1.09	R0.00
7 – 15	R1.95	R1.95
16 – 30	R3.06	R3.06
31 – 60	R4.62	R4.62
60+	R6.30	R6.30

Source: P. Rhode (personal communication, October, 26, 2004)

[53] These prices exclude VAT of 14%. Given the short time period between November 2000 and May 2001, no adjustment was made for inflation.

5.4.2 Methodology

The intention of this study was to investigate what happens to households' welfare (measured in terms of changes in their water expenses), given different water pricing options. The following steps were applied:

- A comparison was made between what households across the income distribution paid for water, given the CCT's water tariff structure (the IBT structure for November 2000, prior to the introduction of the FBW policy and shown in Table 5.4), and what they would have paid if all households had paid the same fixed unit price per kilolitre of water and their consumption remained unchanged.[54]
- A comparison was made between what households paid under the IBT structure after the introduction of the FBW policy (see the IBT structure for May 2001 in Table 5.4), and what they would have paid if all households had paid the same fixed unit price per kilolitre of water and their consumption remained unchanged.

The differences in cost (across the household income distribution) will give an indication of whether rich households paid proportionally more than poor households, in the case of the IBT structure (before and after the introduction of the FBW policy). The analysis commences with an overview of the households in the Cape Town sample and is followed by an explanation of how these households compare to households across the South African income distribution, based on scores determined by a wealth index. The water consumption of the Cape Town households is then used to infer average monthly water consumption for South African households across the income distribution. These water consumption figures are used to calculate the estimated water expenses for the different IBT structures, as compared to what households would have paid with a fixed unit price per kilolitre of water.

5.4.2.1 Households in the Cape Town sample

Given the information on the assets and income of the households from the Cape Town dataset, an asset index was created to determine the position of each household in the income distribution (at this point for the sample). By using the asset index, each household in the sample was placed within a certain income decile. Average monthly water consumption over a year (2002/03) was determined. Applying the 2000/01 tariff structures

[54] Although local governments determine their own pricing structures, it was decided to use the IBT structure of the CCT as information on the tariff structure before and after the implementation of the FBW policy was available for this municipality. It was therefore used as a representative tariff structure in all calculations.

of the CCT allows for the calculation of a fictitious water bill (considering only costs for volumetric consumption). For convenience, an assumption is made that the price elasticity of demand for water is zero, i.e. that consumption remains constant irrespective of price changes. As discussed earlier, this is not an extreme assumption given the empirical evidence that water is very price inelastic, although for high-income groups the absolute value of the price elasticity of demand estimate is greater (see Chapter Four for a discussion of these empirical findings).

Water expenses given different pricing regimes were then compared, i.e. how much households would have paid under the two IBT structures, as compared with what they would have had to pay if households were all charged a fixed unit price. An average price for water was determined by first calculating the water bill per month for each household in the sample, summing this over all the months for each household, and then summing over all households. The total water expense was then divided by the total monthly consumption of all households. The difference between the actual water expense (given the tariff structure) and what the household would have paid with a fixed unit price gives an indication of the extent of redistribution that took place as a result of the IBT structure, or the IBT structure plus the implementation of the free basic water policy.

5.4.2.2 Comparison of the Cape Town sample to the South African society

The data represent only those households that are located in the Cape Town metropolitan area and have access to water. The subsample is therefore not representative of the South African society. This is evident when comparing water access and relative incomes between Cape Town and South Africa. The water access for the surveyed sample in Cape Town was 100% (only people who had access to water were interviewed in the original survey), while access for the South African population as a whole is roughly 70% (see Chapter Two for statistics on water access). Similarly, if the normalised asset index value is compared to the South African sample, it can be seen that the mean asset value for the subsample of individuals who reside within the Cape Town metropolitan area far exceeds that of the larger national sample. The Cape Town sample had a mean of 0.93 and a standard deviation of 0.53, while the South African mean was 0 and standard deviation equal to 1.

To overcome this problem, the expected water consumption of the Cape Town subsample was mapped onto the larger South African sample. This was achieved by assigning the

Cape Town households to income deciles using the scores from an asset index. Table 5.5 shows where the larger South African sample would lie, if accommodated within the bounds of the smaller Cape Town income deciles. Since Cape Town is one of South Africa's more affluent cities, it can be expected that a large portion of the national sample would fall within the lower income deciles of the Cape Town sample.

Table 5.5: South African sample fitted to Cape Town sample income deciles

Cape Town income decile	1	2	3	4	5	6	7	8	9	10
Proportion of South African sample	50%	9%	7%	6%	6%	5%	5%	5%	4%	4%

Source: Own calculations. Data from Community Survey 2007 (Statistics South Africa, 2007)

As indicated, using water access[55] statistics and an extrapolation of the Cape Town sample to the South African income distribution, water consumption for the South African income distribution can be inferred (shown in Table 5.6). For each income decile, consumption of households with water access was estimated as a weighted average of the water consumption of the different income deciles those households would have fallen into if they had been part of the original Cape Town survey (which was conducted across households who have access to water).

5.4.3 Results

5.4.3.1 Comparison of IBT structure to fixed prices (uniform pricing structure)

Table 5.6 indicates the monthly water consumption of a representative household within each income decile of South Africa. The volumetric water bill and unit price are indicated for two scenarios: (1) what the actual volumetric water expenses were, given the IBT structure for 2000, and (2) what this would have been, given the assumption of a fixed price structure generating the same revenue (i.e. where all households paid the same average price for water). The difference indicates the benefit or loss of paying for water consumption under the 2000 IBT structure.

[55] The assumption was made that the municipal water consumption for those households that did not have piped water would be zero.

Table 5.6: Comparison of 2000 IBT structure to fixed prices, across income distribution

Income decile	Access	Monthly consumption per household (kilolitres)	IBT 2000		Fixed price structure		Difference (Net benefit (+) or cost (-))	
			Total cost (Rands per month)	Unit price (Rands per month)	Total cost (Rands per month)	Unit price (Rands per month)	Total benefit (Rands per month)	Unit price (Rands per month)
1	3%	0.4	0.65	1.5	0.79	1.8	0.14	0.3
2	20%	3	5	1.5	6	1.8	1	0.3
3	41%	6	9	1.5	11	1.8	2	0.3
4	61%	9	14	1.5	17	1.8	3	0.3
5	82%	13	19	1.5	23	1.8	4	0.3
6	94%	17	28	1.7	30	1.8	2	0.1
7	98%	18	31	1.7	32	1.8	1	0.1
8	99%	19	33	1.8	34	1.8	1	0
9	99%	20	35	1.7	36	1.8	1	0.1
10	99%	30	67	2.2	54	1.8	-12	-0.4
Average	67%	15	26	1.8	26	1.8	0	0.0

Note: Some figurers are rounded to zero decimal places.

Source: Own calculations

Under the 2000 IBT structure, households in the first income decile had a water bill that was approximately 18% smaller than what they would have paid with a fixed (average) price structure. As expected, households in the highest income decile would have saved the most if a fixed pricing structure were applied. With the IBT structure, they had a water bill of approximately 22% more than what they would have paid with the fixed price structure. Since these households paid a premium for water under the IBT structure, this allowed for some benefit to be distributed to households in the lower income deciles. What is noticeable, however, is that most of this benefit was received by the households in income deciles 4 and 5. The rich households (income decile 10) paid more under the IBT structure, which was distributed to the other households across the income distribution. The most prominent result is that, although the IBT structure does give some benefit to the very poor, given the fact that few of the really poor households in South Africa have access to piped water, most of the benefit was received by the middle-income groups. Redistribution policies (by using the IBT structure) are therefore less effective than would have been expected.

5.4.3.2 Comparison of the IBT structure with free basic water to fixed prices (uniform pricing structure)

To ascertain whether the FBW policy has had any significant impact on the poor in South Africa, the effect of the IBT structure (with FBW, i.e. a zero price for the first six kilolitres of water per month), is compared to a fixed pricing structure. Again it is assumed that water consumption is perfectly inelastic.

Table 5.7 provides a similar analysis to that of Table 5.6, with the exception that the fixed price structure is now compared to the 2001 IBT structure (which incorporates free basic water). The results are similar to the previous findings, and show that the benefit goes to the middle-income households. However, in this case the result is more pronounced, i.e. the gains to the middle-income households are bigger and the cost to the richest income decile is higher. These results are also reflected in Figure 5.2, where the lines represent the cost incurred by households across the income distribution (given different IBT structures), as well as the subsequent redistribution effect of each of the tariff structures relative to a fixed unit pricing system.

Table 5.7: Comparison of 2001 IBT structure to fixed prices, across income distribution

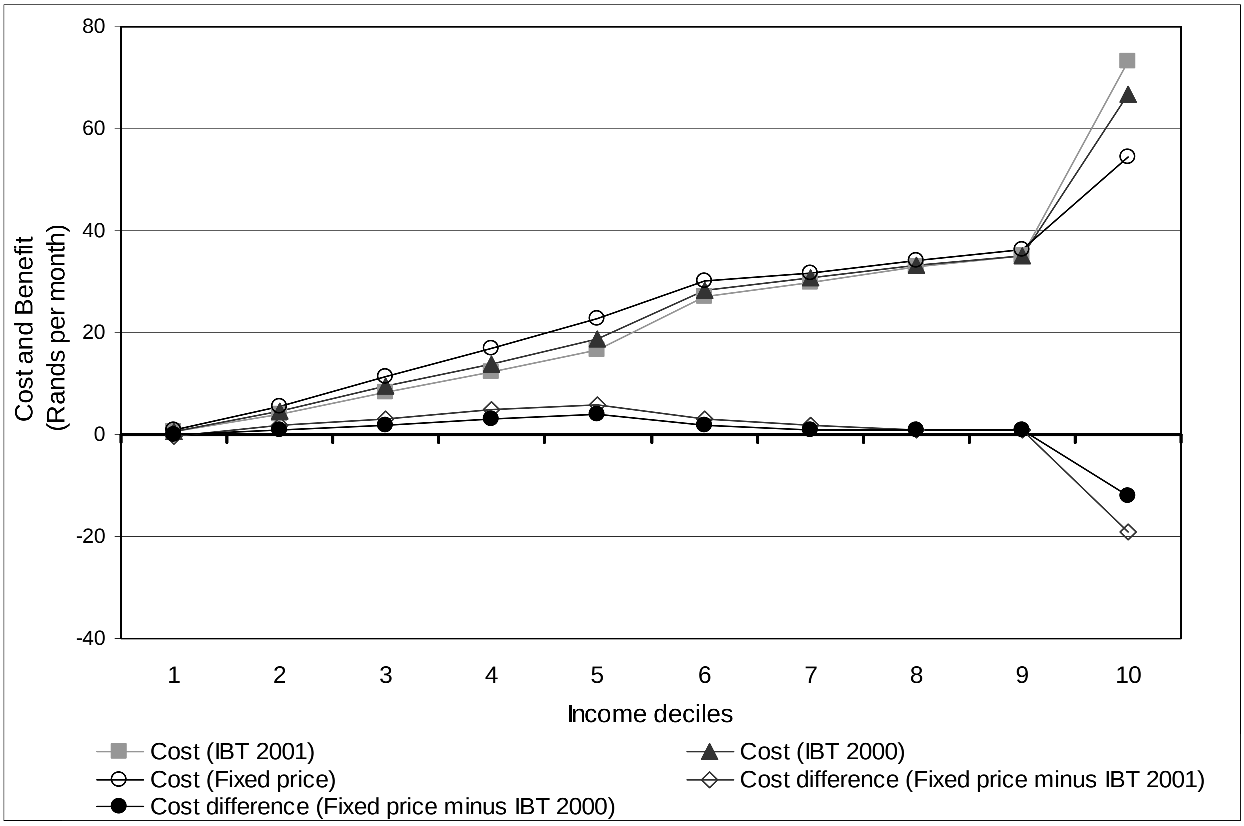
Income decile	Access	Monthly consumption per household (kilolitres)	IBT 2001		Fixed price structure		Difference (Net benefit (+) or cost (-))	
			Total cost (Rands per month)	Unit price (Rands per month)	Total cost (Rands per month)	Unit price (Rands per month)	Total benefit (Rands per month)	Unit price (Rands per month)
1	3%	0.4	0.57	1.3	0.79	1.8	0.22	0.5
2	20%	3	4	1.3	6	1.8	2	0.5
3	41%	6	8	1.3	11	1.8	3	0.5
4	61%	9	12	1.3	17	1.8	5	0.5
5	82%	13	17	1.3	23	1.8	6	0.5
6	94%	17	27	1.6	30	1.8	3	0.2
7	98%	18	30	1.7	32	1.8	2	0.1
8	99%	19	33	1.7	34	1.8	1	0.1
9	99%	20	35	1.7	36	1.8	1	0.1
10	99%	30	73	2.4	54	1.8	-19	-0.6
Average	67%	15	26	1.8	26	1.8	0	0.0

Note: Some figures are rounded to zero decimal places.

Source: Own calculations

Figure 5.2 clearly reflects the benefits of the IBT structure, with free basic water providing a relatively bigger gain to households in income deciles 4 and 5, as compared to the IBT structure without free basic water.

Figure 5.2: Cost and benefit across income deciles

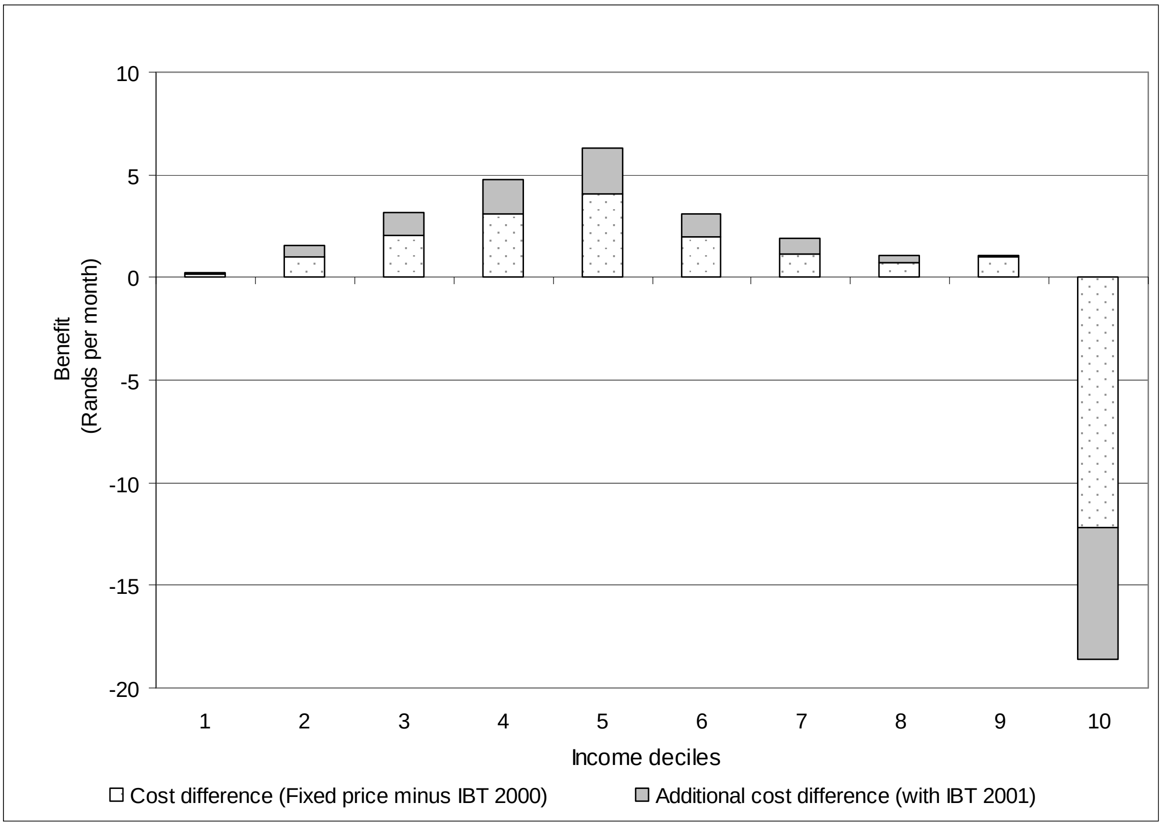


Source: Own calculations

The redistribution effect is shown more clearly in Figures 5.3 and 5.4, emphasising what was already observed in Figure 5.2; the bulk of the cost is carried by households in the richest income decile, while most of the gains accrue to households in the middle income deciles. The vertical axes in Figures 5.3 and 5.4 indicate the net benefit or cost per month when comparing an IBT structure to the fixed pricing structure.

Figure 5.3 enhances the analysis by decomposing the relative cost or benefit accrued by each income decile into two components: (1) that which is due to the IBT structure before the free basic water policy, and (2) the additional cost/benefit as a result of an IBT structure which incorporates the free basic water policy. It shows how the free basic water policy complements the original IBT tariff structure, resulting in a similar redistribution effect. Throughout though, most of the effect can be attributed to the IBT structure before free basic water was introduced, than to the additional benefit of the FBW policy.

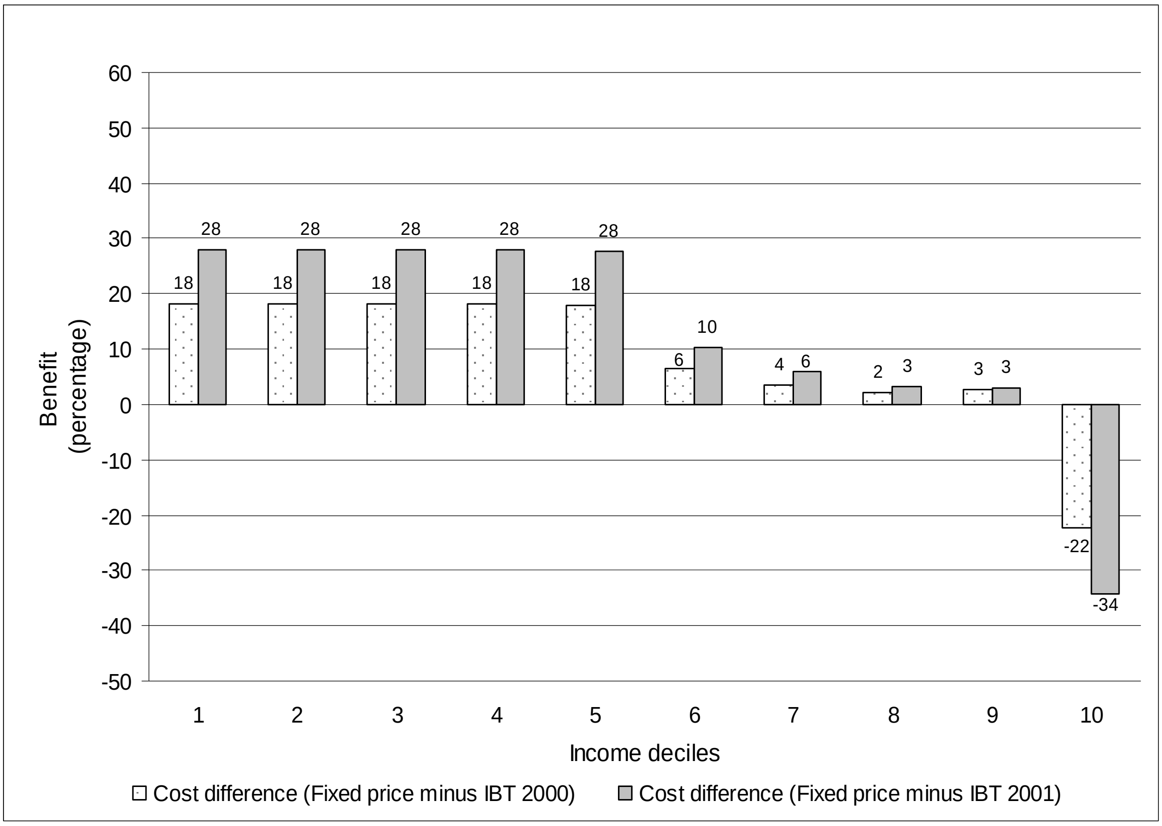
Figure 5.3: Redistribution across income deciles



Source: Own calculations

When the cost differences for both IBT structures are analysed (as a proportion of the initial cost to the households under the fixed tariff structure), the proportional cost differences are similar for the first five income deciles, but then becomes smaller, and turns negative for the last income decile (i.e. rich households pay more under the IBT structures, as compared to a fixed tariff structure). This is illustrated in Figure 5.4.

Figure 5.4: Redistribution across income deciles



Source: Own calculations

The first key finding of the empirical investigation into the efficacy of the IBT structure (as applied by the CCT municipality) in achieving a more equitable distribution of water is that the benefits of the IBT structure do not reach the poorest households, in particular those without access to water. Given the existing water infrastructure and access to metered water connections, the benefit received from households in the richest income decile (which have higher water bills under the IBT structure, as compared to a structure with fixed average prices) is redistributed to households in the middle income deciles and not to those in the lowest income deciles. The second key finding is that even though the FBW policy is implemented by many municipalities in South Africa, the intended benefit of cross-subsidisation to really poor households is not achieved. Even in cases where municipalities (like the CCT) provide free basic water to communal standpipes (in informal settlements), the extent of the subsidy received by residents is less than the FBW provision. A qualitative study by Smith and Hanson (2003) on water access for the urban poor in Cape Town revealed that water consumption in informal settlements ranged from 1.5 to 2 kilolitres per month. Furthermore, Carbonneau, Elbag and Krasinkas (2009) indicated that water infrastructure in informal settlements (i.e. Monwabisi Park in

Khayelitsha, Cape Town) were not fully functional. Many standpipes were vandalised and the ratio of working taps to people at the time was 1:442.

It is therefore evident that if policy-makers want the benefit of free basic water provision to reach the poorest households, they must invest in additional water infrastructure and expand service provision. This may help to achieve the redistribution which the IBT structure aims at. This has been shown in a recent study of Mauritius by Madhoo (2011). This study found that part of the reason for the success of the IBT structure in effecting cross-subsidies can be attributed to the extensive coverage of water metering in both urban and rural areas (which ensures lower blocks).[56] However, the extent of benefits distributed to the poor through the IBT structure remains limited, particularly when it is compared to the benefits received from other social spending programs. A fiscal incidence study on the provision of free water by Van der Berg, Jansen, Burger, Moses and Essop (2009) has revealed that the net gain to the poorest 40% of households are quite small when compared to the benefits received from social spending by government. Using the results from the empirical analysis in Section 5.4, they estimated the aggregate cost of water consumption for households with piped water to be R3.8 billion in 2006[57], which is quite small compared to R177 billion on social spending.

5.5 Alternative strategies of pricing urban water and providing water subsidies

Thus far it has been shown that IBT structures as applied by the CCT are not very effective in achieving cross-subsidisation from rich to really poor households. The literature review and the case study provided evidence that using the IBT structure to make water more affordable for poor households is ineffective in situations where the poor do not have access to metered water. The current design of the rate structure also does not take into account the size of the household and the density of housing (i.e. the number of households using a single water connection), which causes further problems. This is especially relevant for poor households, since they tend to have bigger families and are more likely to share a water connection with other families. The question therefore arises whether water pricing should be used as a redistributive tool, and, if so, how the rate

[56] It must be emphasised, though, that the IBT structure in the study had an initial block of 15 cubic metres (or 15 kilolitres). This is much higher than the FBW policy allocation of 6 kilolitres of water for the first block of consumption.

[57] The estimated cost of water in Section 5.4 was adjusted for inflation to reflect 2006 values.

structure could be amended to improve its efficacy in achieving the intended objectives. Extensive research has been done on alternative rate structures and their distributional implications. This section will provide an overview of the current literature and make some recommendations for the South African situation.

5.5.1 Alternative IBT structures

A number of studies have analysed the equity implications of the IBT structure in its common format and suggested ways of improving its efficacy in achieving the desired outcome. Moilanen and Schulz (2002) show how assumptions adopted by water authorities about the type of social welfare function can lead to different types of tariff structures. Their model assumes that the objective of the local government is to achieve a balanced budget and that the demand for water by poor households is more price inelastic than that of richer households. If a utilitarian social welfare function is chosen (where all households have equal weight), the optimal tariff structure is to apply the marginal cost pricing rule. All consumers will pay the same marginal price for water and the tariff structure is therefore not used for equity purposes. In this instance, redistribution and a more equitable outcome need to be achieved through a lump-sum transfer.

When a weighted utility function is assumed (with proportionally larger weights assigned to the poor, i.e. one that approximates a Rawlsian utility function), the most appropriate tariff structure is non-linear, such as the IBT structure. However, the analysis indicated that a low (but positive price) for the first step (for a low quantity block) combined with a high second step, would be preferable. Thus, there is a clear indication to use positive pricing in all steps of the tariff structure, i.e. with no free basic water.[58] In addition, Moilanen and Schulz (2002) also investigated how the optimal tariff would be affected if the price elasticity of demand were to increase. In the case of the weighted utility function, the more elastic the demand of rich households, the greater the difference in the price steps, with households consuming in the first block paying a lower price and households in the subsequent blocks paying a much higher marginal price.

An empirical study that is closely linked to the findings of this theoretical model is the analysis of Szabo (2009), who investigated the welfare implications of the free basic water

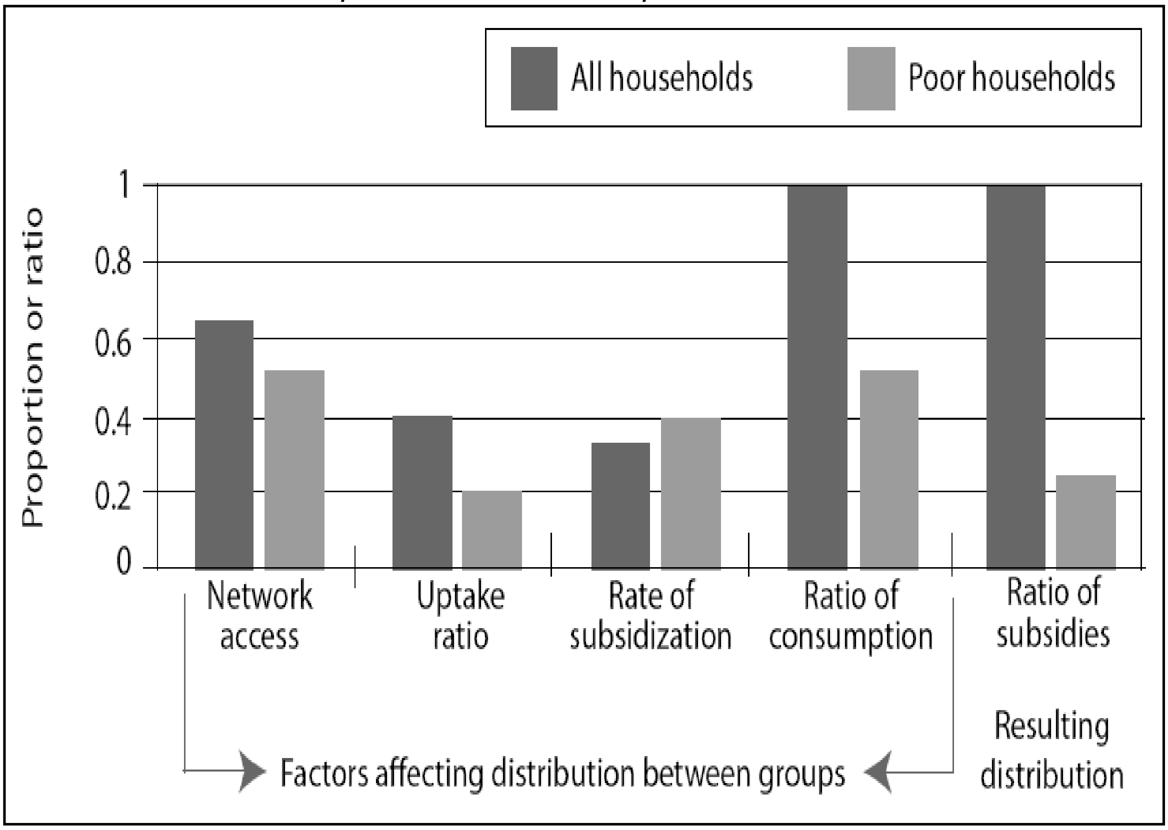
[58] There is a possibility of including free water in the analysis by assuming a social welfare function that emphasises some necessary minimum quantity of water (Moilanen and Schulz, 2002: 15).

policy as it is currently enacted in legislation in South Africa. As discussed in Chapter Four, the first part of this study estimated the price elasticity of demand of households in certain suburbs of Pretoria. The second part of the analysis suggested that an optimal tariff structure could increase the welfare of poor households, given the constraints of achieving revenue neutrality and maintaining water consumption at a specified level. Szabo (2009: 31) compared the welfare effects of two tariff structures; the first included only positive prices and the second allowed for the supply of free water to indigent households. Her findings were that both tariff structures differed from the structure currently in use, in that the marginal prices were lower (but still positive) in the first blocks of consumption, but higher in the upper blocks of consumption. After calculating the compensating variation (given the changes in the tariff structures), her main conclusion was that the most appropriate tariff structure would be one with no free allowance.

The commonly used argument against the use of the IBT structure is that it subsidises households that should not receive this benefit. This may be due to the IBT structure having too many subsidised blocks, and especially a first block of consumption that is relatively large. The decision on the size of the first block depends on how much water is allocated for essential needs. According to Boland and Whittington (n.d.), internationally-cited standards indicate that between four and five kilolitres of water per month would be required per household, assuming a household of five members. However, their evidence for Asia shows that most of the water utilities for which they had information had an initial consumption block of at least 15 kilolitres per month. These large initial consumption blocks and the subsidisation of all households can be ascribed to the influence of political pressure on the design of rate structures (Komives et al. 2005).

The South African case study (earlier in this chapter) showed that those households that have access to the network would receive the subsidy through cross-subsidisation. The importance of having access to water networks was also highlighted earlier by Angel-Urdinola and Wodon (2007b) in their study on water subsidies in Nicaragua. This should be coupled with factors such as the number of households living in an area that have access to the water network and are connected, as well as the quantity of water consumed by households, which influences the distribution of water subsidies between poor and rich households (Le Blanc, 2007: 5). Poor households generally have less access to water networks, and a smaller proportion of these households are connected, even if they are living in areas that have water connections. The poor also generally consume less water than the rich. Empirical evidence illustrating the relevance of these factors in determining the distribution of subsidies is provided by Komives et al. (2007). They use a benefit targeting performance indicator which incorporates the factors mentioned above. An exact definition of their indicator is "the share of subsidy benefits received by the poor divided by the proportion of households in poverty in the total population." (Komives et al. 2007: 669). The results of a case study in Cape Verde are shown in Figure 5.5. It is evident that poor households have less access to the network, that their uptake ratio is lower and that their ratio of consumption is also lower than that of other households, although the rate of subsidisation is higher. All of this result in a subsidy ratio that is much smaller for poor households.

Figure 5.5: Impact of differences in access, connection, and consumption on the distribution of consumption subsidies — Cape Verde



Source: Komives et al. (2005), as cited in Le Blanc (2007)

An experiment to test whether the distribution of subsidy benefits favours the poor – when delivered using an IBT structure rather than a general price subsidy (i.e. charging a uniform volumetric price below marginal cost) – showed that the IBT structure results in little improvement (Komives et al. 2005: 74). A simulation exercise performed for Bangalore and Kathmandu showed that when a switch was made from an IBT structure to a uniform tariff providing the same revenue to the utility, the benefit targeting indicator did not decrease by much (Komives et al. 2005). The beneficiary incidence (i.e. the extent to which poor households receive the benefits of the subsidy) in these examples remained virtually the same as all eligible households (i.e. households that are connected and metered) received subsidies (Komives et al. 2005: 74). As mentioned earlier, the IBT structure in Cape Town provides all households with the first six kilolitres of water free of charge. Even though the CCT has an indigent policy, poor and non-poor households receive the same subsidy for the first block of water consumption. In addition, indigent households qualify to receive a rebate on their property taxes, and electricity and sanitation charges.

Can an alternative design of the IBT structure improve the targeting performance of water subsidies via the tariff structure? According to Angel-Urdinola and Wodon (2007b), even with some modification to IBT design, the access and uptake ratio is still crucial in improving the efficacy of targeting water subsidies. However, they concede that the quantity of the IBT structure's lifeline block at the time of their study on water subsidies in Nicaragua was reasonably high (20 cubic meters). If this was reduced to 10 cubic meters, it could lead to a substantial improvement in targeting performance. Komives et al. (2005: 92) also referred to the size of the first block as being excessively large, and indicated that the average first block of consumption ranges from 13 cubic meters in Asia to 24 cubic meters in Latin America. An improvement in subsidy targeting by reducing the first consumption block can only be achieved if the prices in subsequent blocks are greater than the average cost, as this will ensure that some households become net cross-subsidisers (Komives et al. 2005: 94).

Another possible type of quantity targeting is the volume-differentiated tariff (VDT) structure. This is also an example of explicit targeting via self-selection by consumers. The VDT structure distinguishes water prices by volume (Komives et al. 2005). One could for example have two prices, a lower (flat) price for water users consuming less than a certain volume and a higher (flat) price for those consuming more than this quantity. The VDT structure, however, does not charge the high-volume consumers a lower price for the first volume consumed, i.e. there is no subsidy involved for this group of consumers. As pointed out by Le Blanc (2008: 8), all units consumed are charged at the same price; this price depends on the total number of units of water consumed.

The targeting performance of VDT structures is also influenced by thresholds that determine who is eligible for the lower rate. In the instances where the threshold consumption is too high, most water consumers will receive a subsidy. According to Komives et al. (2005: 94) a shift from an IBT to a VDT structure, or a reduction in the threshold consumption in the case of the latter, could ensure that fewer non-poor households receive the subsidy. Modifications to the IBT structure would be less effective in improving the targeting of water subsidy beneficiaries. This is in contrast to a VDT structure (which works by reducing the threshold); the IBT structure provides limited opportunities to bring about substantial improvements in targeting performance. This conclusion was supported by empirical evidence, as reported in Komives et al. (2005: 95-97). One of the primary reasons for this finding is that, in the case of IBT structures, the prices of the higher blocks are much greater than average cost and few water users consume in these blocks.

Liu et al. (2003: 213) proposed an increasing rate tariff (IRT) structure to take account of differences in household size, since this rate structure has a price which is progressive in consumption; the price paid by the consumer on all the units consumed depends on total water consumption (which is analogous to the VDT structure). According to Liu et al. (2003: 213), the IRT structure is simple to implement and to understand, since the price is determined by total consumption and the water bill merely multiplies this price by the total units of water consumed. In addition, Liu et al. (2003: 213) defined another structure, the IRT-cap, which is an IRT structure based on per capita water consumed. They argued that since the IRT-cap takes family size into account, it is more appropriate in some developing countries where it cannot just be assumed that the poor will consume less water than rich households.

The number of household members is an important aspect that must be considered in pricing policy if targeting is to be effective, since larger households tend to consume more water and are generally also poor (Liu et al. 2003: 213). This is supported by Crase and O'Keefe (2007) who state that larger families will face higher volumetric charges since the demand for water is relatively price inelastic at lower volumes. Martins, Quintal, Barata and Cruz (2010: 9) also refer to the positive impact of household size on water consumption described in the empirical literature. In terms of water conservation, small rich families consume more water since the price is low and they have no incentive to use water sparingly. A case study conducted in Weinan City (China) in which both an IBT-cap and

IRT-cap were tested, revealed that the IRT-cap was more effective in achieving objectives such as simplicity, an equitable outcome, and easier implementation (Liu et al. 2003).

5.5.2 Uniform rate structures with rebate

Thus far the discussion of the most appropriate tariff structure for equity purposes has focused on alternative types of quantity targeting. Given the difficulty of achieving intended objectives, some researchers argue that perhaps the tariff structure should not be used as a subsidy mechanism and that implementing a uniform rate structure in its place will lead to an improvement in efficiency. This has been supported by empirical studies such as that by Hajispyrou et al. (2002), who investigated the welfare effects of alternative rate structures in the case of Cyprus. They argue that estimating these effects is especially important since changes in water tariff structures should also consider equity implications. They calculated the deadweight loss associated with a move from a progressive block pricing system to a uniform pricing structure and found a reduction in deadweight loss. This was explained by the price distortions caused by the use of an IBT structure, which would be reduced if a uniform rate structure were introduced. However, they did point out that this reduction in efficiency loss comes at a price, i.e. it would benefit affluent households more than the poorer households (Hajispyrou et al. 2002: 678).

Some researchers support the idea of applying uniform rate structures, but with the addition of alternative means to directly subsidise the poor. Boland and Whittington (n.d.) suggest implementing a uniform tariff based on marginal cost pricing with a credit or rebate option (i.e. a uniform price with a rebate (UPR)). They argue that it is not obvious why IBT structures are popular in developing countries as this presupposes that a water connection is available to the poor (who would otherwise not be eligible for a subsidy). An alternative would be to charge water users a uniform price that is equivalent to the marginal cost. In the event that water utilities charge uniform rates at the highest marginal price, they will be generating more revenue than is needed to cover their costs. In this case, a rebate could be paid to water consumers such that utilities break even. A uniform tariff rate is suggested (irrespective of the volume consumed) and this would include a rebate. This implies that certain consumers (those who use less than a specified quantity of water) would pay a zero price for water. In their example, Boland and Whittington (n.d.: 20) chose a rebate that would result in the two alternative rate structures (IBT and UPR) providing the same revenue. However, users under the UPR would pay the uniform price (equal to the marginal cost of water) at lower levels of consumption, compared to the IBT structure (where, at lower levels of consumption, the price was set below the marginal cost of water and would only equal the marginal cost at much higher consumption levels).

The advantage of the UPR structure is that most of the poor would receive a lower water bill than would be the case under the IBT structure. In their example, Boland and Whittington (n.d.: 21) found that 38% of households would receive a lower water bill and this would include most of the poor households. In their scenario households with very low water use would face a 'zero' price under the UPR, as compared to a low (positive) price under the IBT structure. Since the assumption is that their demand for water is price inelastic, this decrease in price would not result in increased water wastage. That demand for water can be price inelastic at low levels of consumption has been confirmed by empirical studies (see the results of Szabo (2009), as well as the case study presented in Chapter Four). Boland and Whittington (n.d.: 22) suggest that other more efficient UPR structures could also be considered. In their example, the subsidy was received by all households. However, it is possible to confine the subsidy to only poor households. This would increase the proportion of consumers paying the marginal cost price and therefore increase the subsidy amount to poor households. To apply this kind of pricing structure, however, some way of identifying poor households would be required. This is the focus of the discussion in the next section.

5.5.3 Targeting subsidies and means-testing

When consumer utility subsidies are awarded, a decision must be made on how they will be allocated. Komives et al. (2005) distinguishes two ways of allocating consumption subsidies: (1) untargeted consumption subsidies, where all water users receive the subsidy, irrespective of whether they are part of the intended group; and (2) targeted subsidies, where a distinction is made between implicit and explicit targeting. Implicit targeting is an unintended result of the pricing practices applied by water utilities. Examples include flat fees for unmetered connections, low collection rates without a disconnection policy, and combined water and sanitation tariffs (Komives et al. 2005: 9). Flat rates do not distinguish between different levels of consumption, which implies that high-volume water users will receive a greater subsidy.

In the case of explicit targeting, the water utility makes a conscious attempt to make their service more affordable to certain customers. According to Le Blanc (2008), explicit targeting requires the classification of consumers into categories which enable them to qualify for subsidies based on certain observable variables or characteristics. The ideal would be to identify eligible consumers based on a variable such as household income. However, Le Blanc (2008) indicates that in some countries with large informal sectors, it may not be easy to estimate income. There is also the cost of putting an administrative system in place that will be able to monitor water subsidies. In many developing countries, there is a lack of financial and administrative capacity to administer explicit targeting.

There are three types of explicit targeting. (1) The first category has been the focus of the case study in this chapter, i.e. self-selection by the consumer via quantity targeting. Two examples are the IBT structure (which was the focus of investigation in this chapter) and the VDT structure discussed earlier. (2) The second type of explicit targeting involves service-level targeting; an example is providing free water at public water taps. (3) The third type of explicit targeting is by administrative selection, which includes social tariffs or connections. According to Komives et al. (2005), this requires the classification of poor customers, either according to certain categories (such as pensioners), or a certain area (geographical targeting), or according to whether households can be classified as poor (through means-testing).

Means-testing requires the use of a monetary criterion or other welfare criteria to identify poor households. As discussed previously in Chapter Three, the South African government has also introduced indigent policies at municipal level, aimed at delivering a package of basic services to 'indigent' households.

The implementation of this type of targeting, however, requires water utilities to collect information on households in order to determine who qualifies for the subsidy (Lavallee, Olivier, Pasquier-Doumer and Robilliard, 2010). The information used can be cross-checked with other data sources in an effort to verify accuracy. This process can be very expensive and requires checking mechanisms to ensure that the appropriate households are targeted. It is also possible to determine eligibility on the basis of a score that has been determined from a set of variables which relate to the living circumstances of households, and which require proxy means-testing (Lavallee et al. 2010).

A well-known example of means-testing is the Chilean experience. The government of Chile accepted the principle of treating water as an economic good a long time ago; this is reflected in their Water Code of 1981 (Briscoe, Salas and Pena, 1998). According to Serra

(2000), Chile initially applied water charges at below cost and achieved extremely high rates of access to drinkable water in both urban and rural areas. The move to cost-reflective pricing policies, coupled with privatisation, meant the implementation of some form of explicit subsidy. In 1990 the Chilean water subsidy was implemented. It is the most widely cited programme of a means-tested consumer utility subsidy (Komives et al. 2005: 108).[59] A household is eligible for the subsidy if it has no outstanding debt with the water company, and if it falls within the 20% of poorest households in the region. The instrument used to determine this is called the *ficha* CAS (*Caracterisación Social*), which is a form the government uses to collect information about the household and its assets, and demographic information on the members of the household (Komives et al. 2005). A point system is used to award points based on the information provided. The information is updated every third year. In addition, the information is also used for other types of assistance programmes, as well as for cash transfers.

In addition to the concerns regarding cost, another issue arising from the use of explicit targeting through administrative selection is whether the poor have been properly identified. According to Foster, Gómez-Lobo and Halpern (2000), the crucial aspect of a targeting mechanism is whether it successfully identifies the target group. There are basically two types of targeting errors. (1) Errors of inclusion are found when individuals who are not part of the intended target group are included as beneficiaries. This represents a leakage of the subsidy to unintended beneficiaries and reduces the efficiency of applying the subsidy and places a heavier burden on taxpayers. (2) Errors of exclusion are of greater concern with regard to equity, as these imply that some members of the target group do not receive a subsidy. There are also concerns about implementation as the subsidy provider must have the administrative and financial capacity to ensure that means-tests are conducted timeously and are reflected in households' water accounts.

Another possible administrative selection mechanism is geographic targeting. Komives et al. (2005: 102) define geographic targeting as the identification of neighbourhoods, cities or regions where there is a concentration of poor households; subsidies are then targeted at those areas. One approach is to identify areas from so-called poverty maps. These

[59] Initially the subsidy applied to households that were eligible according to the income means-test, as well as a maximum consumption level. However, the latter requirement was dropped as households that were unmetered or shared connections were excluded and the uptake rate was less than 6% (Komives et al. 2005: 121).

maps can be designed using appropriate data sources such as census and household surveys, as well as geo-referenced data (Lavallee et al. 2010: 15).

One particular example of geographic targeting is the water poverty map, which was investigated in the South African context by Cullis (2005). Water poverty mapping entails the mapping of water poverty indicators that are aggregated to a spatial scale to identify areas of water poverty (Cullis, 2005: i). This can be quite useful if there are areas with higher levels of water poverty, since scarce resources may be more efficiently allocated in this way. Water poverty mapping entails the use of particular welfare indicators to determine a water poverty index. Components include factors such as access to water, a resource component (available yield in the catchment area), capacity (households' ability to manage water, measured by indicators such as education and income), and the use (domestic or agricultural) and environmental integrity of water. A case study of the Eastern Cape at municipal level revealed that water poverty varied greatly between municipalities and resources were not being allocated according to need. A key component driving water poverty was (lack of) access to water (Cullis, 2005).

Categorical targeting can work well if a specific category of a country's population is more affected by poverty than others (Lavallee et al. 2010: 13). Geographic targeting (one form of categorical targeting) may achieve better results if individual households living within particular areas are relatively homogenous. This affects the cost of implementing and administering subsidies. According to Lavallee et al. (2010), there are cost-saving advantages of using this type of explicit targeting. A study by Grosh (1994), as cited in Lavallee et al. (2010), estimated that geographic targeting was three times less costly than individual targeting for thirty programmes investigated in Latin America.

Baker and Grosh (1994: 983) refer to the simplicity of geographical targeting as its main attraction. They argue that service and infrastructure improvement programmes can be developed for identified regions, which means there is no need for complicated mechanisms to select individual beneficiaries. The efficacy of geographical targeting is confirmed by Bigman and Fofack (2000: 126) in cases where there are substantial differences in living circumstances between geographical areas, and where the existence of local authorities reduces the administrative burden. They argue that for geographical targeting to be effective (as compared to other types of targeting mechanisms), it would be appropriate to target the smallest possible jurisdiction, in order to avoid leakage to the non-poor. However, the trade-off is that targeting more narrowly requires additional information on the spatial distribution of poverty and detailed data on individual households within these areas.

One example of geographic targeting in developing countries is the programme in Colombia, which applies this type of explicit targeting for both water and electricity. Neighbourhoods in the country are allocated to one of six strata, which are determined by housing quality. Water and electricity tariffs are designed so that households in the first three strata are subsidised; those in the fourth strata pay cost-recovery prices, whereas households in the fifth and sixth strata pay surcharges of 20% (Komives et al. 2005: 102). In the case of water, this targeting programme is implemented in combination with an IBT structure. An investigation into the efficacy of this programme indicates that very few poor households live in the wealthier areas, although both poor and non-poor households reside in the poorer areas. Despite this, Komives et al. (2005: 102) conclude that the performance indicators they applied to gauge the effectiveness of water and electricity subsidies show that geographically targeted water subsidies in Colombia, combined as they are with an IBT structure, perform better than quantity-targeted subsidies.

5.5.4 Connection subsidies

Connection subsidies are once-off subsidies which reduce the cost of connecting to the network. The connection subsidy can provide long-term benefits to households (that exceed the costs of its provision), since unconnected households have an opportunity to connect to a service which may be less expensive than their existing service. Households that buy water from private water vendors generally pay higher prices than those charged by water utilities. A study of water-vending in Nigeria found that water vendors were responsible for more than 95% of water sales in the city of Onitsha and were charging poor consumers twice the annual operating and maintenance costs, as well as 70% of the capital costs of the new municipal system (McKinney and Schoch, 2003: 229).

Bardasi and Wodon (forthcoming), as cited in Komives et al. (2005: 123), compared the cost of water for households connected to the network with the cost to those that were not connected and found a cost saving for the latter group, once they connected to the network. The net present value of the cost savings would quickly exceed the cost of connecting to the network. Subsidies to connect to water networks can be considered in areas where there is low coverage. However, these types of subsidies depend on utilities which have the means and motivation to extend network access to poor households, and on the willingness of these households to connect (Komives et al. 2007: 661).

A study that proposes the implementation of connection subsidies is an investigation into the determinants of water connections and consumption in Cambodia. Basani, Isham and Reilly (2008) use cross-sectional household data to estimate the elasticities for water connections and water consumption. Of more importance here are their findings on the connection elasticity of demand for access to the network (given the connection fee). The inelastic estimate (-0.39) and positive expenditure (income) elasticity of 0.68 indicated that poor households were less likely to connect to the network. However, a decrease in the fee would increase the number of households opting to join the network (Basani et al. 2008: 963). This is one of the main obstacles that must be overcome to encourage connection to the network. Once this has been achieved, empirical studies have shown a willingness on the part of poorer households to pay for the consumption of water.[60]

The question of whether unconnected households can afford to pay for their water after gaining access to the network through a connection subsidy has already been addressed; a number of studies have estimated the willingness of such households to pay for improved water services. It was argued that these households would generally pay less for water once connected to the water network, even if the price of water were to increase to reflect the full cost of supplying the water.[61] This would have to be taken into account when a network expands services to include poor unconnected households. There would be little chance of external funding, since the increased maintenance and the operational costs of an expanded service roll-out would require additional funding. According to Walker et al. (2000), this would mean that poor households already connected to the network would be worse off. In the South American cities they investigated, poor households spent a greater proportion of their income on water services and were therefore disproportionately affected by increased water tariffs. They asserted that in cases where there is a subsidised tariff

[60] Basani et al. (2008) refer to the following studies which all estimated the willingness of poorer households to pay for improved services, and found that the results indicated a willingness to pay more than would be needed to cover the cost of maintenance and operations. See studies by Foster et al. (2000), Ahmad, Goldar, Misra, and Jakariya (2003) and Brocklehurst and Evans (2001).

[61] The empirical literature indicates that unconnected households have to pay prices for water that are generally higher than those paid by connected households, even if the network were to charge cost-recovery tariffs. See Strand and Walker (2004) and Le Blanc (2007).

structure, a revised tariff structure that applied full cost recovery would adversely affect poor households. For example, in the case of Caracas poor households with connections received water free of charge; this was funded by a central government subsidy and by cross-subsidies from the more affluent areas (Walker et al. 2000: 11). Such a revision would increase prices disproportionately for the poor, and given that their demand for water is price inelastic, they would necessarily experience an increase in water expenditure. Therefore, more targeted subsidies would be required to reduce the impact on these households.

5.5.5 Policy implications

The empirical analysis in this chapter has analysed the distributional implications of the IBT structure in South Africa. One of the main findings was that really poor households do not reap the benefit of an IBT structure, even where the lifeline water consumption block is free of charge (which is the case for the free basic water policy in South Africa). The main reason for this is that these households are not connected to existing water networks and therefore any type of subsidy that is channelled through the pricing structure will not reach the intended beneficiaries. It was also obvious from the literature overview that the IBT structure (in the form currently applied by South African urban municipalities) is an ineffective subsidy mechanism. An IBT structure that does not account for household size will cause large, poor households to consume in blocks higher than the first block. Given the South African requirement of a first block of six kilolitres of water per month, it is likely that many poor households will consume in higher-priced blocks.

The money to finance water subsidies is also limited since there are insufficient funds from the municipalities' tariff structures to allow services to be extended to all. Municipalities are guaranteed a share of state’s centrally collected tax income. However, this is not sufficient to finance the cost of water subsidies. Municipalities must therefore either rely on cross-subsidisation between water users or use their own tax income. This is not a reliable source of financing, especially for municipalities with a weak tax base. In many cases the free basic water component of the tariff structure applies to all households and, unless there are enough households consuming in the highest consumption blocks (with appropriately set block prices), cross-subsidisation will not be sufficient to finance subsidies. Moreover, the equitable share received from the national government is based on the number of poor households within a particular region. If it is not possible to identify indigent households accurately, these allocations will not necessarily be applied to the targeted households. As previously mentioned, in many cases municipalities extend free basic water to all households. This makes it difficult to maintain existing services and/or extend new services. The number of households that would then qualify to receive subsidies does not necessarily correspond to those used in the calculations of the equitable share, as these are based on the 2001 census data.

It is unlikely that means-testing will reduce the number of households receiving the subsidy for the lifeline water consumption block. Indigent policies apply means-testing by using a welfare criterion to identify poor households, who then qualify to receive rebates on basic services and taxes on property. However, as discussed in Chapter Four, indigent policies have not been successful in targeting poor households effectively. Few municipalities have the administrative and institutional capacity to maintain a well-kept indigent register, which is crucial if a means-testing subsidy mechanism is going to be used.

5.6 Concluding remarks

The IBT structure was lauded as a pricing policy because of its ability to address multiple objectives, which include the ability to conserve water and address equity considerations. The main objective of this chapter has been to analyse the efficacy of providing subsidies through the tariff structure.

The primary objective of horizontal and vertical equity in the allocation of water justifies the use of an IBT structure. However, using this structure as a pro-poor policy is not an easy task. Various factors must be taken into account if the intended outcome (i.e. to cross-subsidise from the rich to the poor) is to be achieved. Firstly, households must have access to the water network. However, many households in developing countries are not connected and even where there is access, meters are often not read accurately or on a regular basis. Water leakages also result in unacceptably high water losses, resulting in higher water bills for poor households. The IBT structure also does not consider household size. Even though it is generally assumed that poor households consume less water, a household with a large number of family members may be forced to consume in the higher consumption blocks, and this will reduce the subsidy benefit. In contrast, however, the first consumption block is sometimes too large. This leads to a reduction in the possible cross-subsidisation from high-volume consumers to low-volume consumers.

The case study in this chapter investigated the extent of the benefit provided by an IBT structure (using alternative specifications for the first block, i.e. with and without a zero charge). The empirical analysis found that the IBT structure (with or without the free basic water component) does not benefit the poorest households in South Africa as these households are usually not connected to the water network. Even though there is some cross-subsidisation from richer to poorer households that are connected, the main beneficiaries (in absolute terms) are those households in the middle income deciles.

Alternative tariff structure designs that will improve the delivery of water subsidies are possible. Examples include the Volume Differentiated Tariff structure, the Uniform Pricing with Rebate structure and per capita tariff structures (which take into account household size). Another possibility is the administrative selection of water subsidies, while a further option is geographical targeting. However, it is evident that the tariff structure is first and foremost a water management strategy to conserve water. The goal should therefore be to design a water allocation policy that effectively manages the resource, and that minimises the adverse consequences for the poor, rather than using water pricing as a mechanism for redistribution. Finally, as was evident in the study by Van der Berg et al. (2009), the gain households received from the Free Basic Water policy was relatively small compared to the benefit received from the government's social spending. This emphasises the finding in this chapter of the limited role of redistribution through the water tariff structure.

The dissertation has thus far focused on water pricing as demand management tool in pursuing the objectives of achieving a more efficient use of water resources and making water more affordable to the poor. However, a holistic management approach must also consider the impact of the declining water quality on the value of water as a recreational and environmental good, which is the focus in Part Two of the dissertation.

PART TWO

THE VALUE OF WATER RESOURCES AS RECREATIONAL AND EVIRONMENTAL GOOD FOR URBAN COMMUNITIES

CHAPTER SIX

The value of water as recreational and environmental good

6.1 Introduction

In Part One of this dissertation the focus was on managing water resources to ensure more sustainable use given the water scarcity problem. Water pricing was investigated as demand management tool to reduce water consumption. However, the value of water to society extends beyond its use in productive and direct consumption activities. Water resources such as oceans, lakes and rivers serve an additional purpose, since they provide important recreational and environmental benefits. According to Gibbons (1986), the demand for these activities has increased with population growth and with the desire for more outdoor activities, particularly in urban areas. Water resources also play an important role in the functioning of aquatic ecosystems, which provide benefits to people in the form of appropriately functioning hydrological systems (e.g. flood protection) and by supporting biodiversity (Wallace, Acreman and Sullivan, 2003: 2019). Water bodies therefore have recreational value, but they also possess value which is not related to use. This derives from the value of preserving natural resources in their pristine state (Gibbons, 1986: 65). In the realm of integrated water resource management, the task of the water manager goes beyond only considering the volume of the resource. The quality of water is also important as this affects water resource availability and the additional value that communities receive as a result of water's multiple functions.

The quality of water is, however, seriously affected by pollution. Surface and groundwater[62] can be affected by pollutants stemming from agricultural and industrial discharges and industrial, chemical and nuclear waste (Pandey, 2006). Human activities also result in urban runoff into rivers and streams, and this is exacerbated when urbanisation takes place without the provision of adequate water and sanitation infrastructure. As discussed earlier (in Chapter Two), this problem is especially prevalent in developing countries where existing infrastructure is under enormous pressure from urban population growth. According to Butler and Memon (2006: 182), the influx of people from rural areas to the cities causes a decline in living standards and adversely affects the urban poor in developing countries.

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[62] Surface water refers to the lakes, rivers and oceans that cover the earth's surface (Tietenberg and Lewis, 2009: 464), whereas groundwater refers to water resources that lie beneath the earth's surface.

Although the provision of basic water and sanitation services is a priority in many developing countries, there is less emphasis on addressing the deteriorating quality of the water. This is especially the case where lakes and rivers are primarily used for recreational purposes. Pollution influences the quality of water resources and this in turn affects the welfare of the community. In addition, areas set aside for environmental purposes are often under pressure from urban development, since land is scarce and there are many possible uses for open areas. There is thus a need to improve the quality of water sources, particularly where people live adjacent to these water bodies. It is therefore important to establish the value of improved water quality for recreational and environmental purposes.

This chapter provides a literature review that explains the economic value of water sources and some of the methodologies commonly used to determine it. The discussion emphasises the recreational and environmental value of lakes and rivers. It serves as a precursor to the empirical analysis in Chapter Seven in which the economic value of a specific water resource is estimated. The case study is of a freshwater lake (Zeekoevlei) in Cape Town. Zeekoevlei is an interesting study area, since it is situated in an urban community, and most people in the area are lower-income households. The purpose of this empirical investigation is to establish the economic value of the lake to the communities residing in its vicinity, since they are most likely to benefit from improving the lake's recreational facilities and environmental quality.

Knowledge of the economic value derived from such improvements assists policy makers in deciding how to allocate resources (Birol, Karousakis & Koundouri, 2006). It may also allow for payment for environmental services (PES) as a possible way of addressing market failures associated with water pollution. According to Hengsdijk, Meijerink, Hellegers and Snellen (2008), PES is a comprehensive term which includes market-based instruments to promote environmental conservation, such as the payment of entrance fees at national parks. It is therefore based on the user-benefit principle. They argue that PES can be quite useful in cases where the environmental good or service is endangered, although it is most useful where users of the services are relatively well off. Authorities require information on the value attached to improved environmental services, and this means assessing the willingness to pay for (i.e. the economic value of) these services (Jiang, Jin and Lin, 2010).

Assessing these values, however, is not that easy. The benefits and costs associated with the environment usually do not have definite market prices. To measure economic value, microeconomic techniques are used. These primarily involve an estimation of welfare changes that result from changes in the price, quantity or quality of the good (Renzetti, 2002: 93). This provides an estimate of the willingness to pay for (or to accept compensation for) the change in welfare associated with the improvement (or degradation) of the environmental good.

There are two types of methods that can be adopted to estimate the economic value of environmental goods and services. Indirect methods (or revealed preference methods) such as hedonic pricing involve using information from other markets (e.g. property markets) to determine economic values. In contrast, direct methods (or stated preference methods) ask people directly to state their willingness to pay for changes in the quantity or quality of environmental goods and services. A common technique here is the Contingent Valuation Method (CVM), which creates a hypothetical market for an environmental good and then elicits the willingness to pay for changes in the quantity or quality of the good.

This chapter commences with a discussion of the impact of water pollution, particularly as experienced in developing countries. This is followed by an explanation of PES as a possible mechanism to address the external effects of water pollution. The economic value of water as a recreational and environmental good is the focus of the subsequent section, which is followed by a discussion on methodologies to estimate these values. A more comprehensive discussion of the CVM is provided, since this method is applied in the empirical analysis in Chapter Seven. Some empirical evidence is also presented on the environmental valuation of water quality improvement in developing countries.

6.2 The impact of pollution on water quality

Surface waters are primarily replenished from rainfall and melting snow and ice, and even though they represent a small proportion of the earth's total freshwater resources, they amount to approximately "80 percent of the annually renewable surface and groundwater" (UNESCO, 2006: 125). Lakes store the greatest volume of freshwater, as compared to rivers and wetlands. Groundwater is used primarily for irrigation and drinking purposes, whereas surface waters also serve other purposes, in particular recreational activities such as swimming, surfing and boating.

A range of diverse consumption and production activities leads to the pollution of surface and groundwater. Toxic chemicals and industrial waste from manufacturing and mining activities are examples of production externalities. Surface water pollution can also be caused by household waste (such as litter) and urban runoff from sewerage spills. As discussed previously, water and sanitation infrastructure in developing countries is often inadequate, and rapid urbanisation often causes a growth in informal settlements, which is one of the primary causes of river and lake pollution. Sedimentation is a further problem which adversely affects surface water; it is a product of both natural causes and human intervention, such as land-use changes and agricultural activities (UNESCO, 2006).[63]

Water pollution can result from point source and/or non-point source pollution. The former refers to pollution discharged at a specific location, whereas the latter refers to pollution which has diffuse sources, making it difficult to address. Lakes and rivers are generally receptors of non-point pollution in the form of agricultural and storm-water runoff, as well as urban waste. It is therefore difficult (and costly) to determine and measure the source and extent of this kind of pollution (Shortle and Horan, 2001).

Water pollution has become a serious problem in developing countries where many of the freshwater resources have declined in quality. Markandya (2004) reports that the quality of water is often poor in developing countries and wastewater is often discharged, untreated, directly into surface waters. The United Nations Environment Programme Global Environment Monitoring System (2003: 1) states that 80 per cent of all illnesses and deaths in developing countries are the result of water-related diseases. A specific example of water pollution is the contamination of water bodies in Columbia, where municipal and industrial wastewater flowed untreated into water systems (Kathuria, 2006). The Bogota River was heavily polluted by runoff from industrial waste and untreated sewerage spillages from the city. The response to this problem was the institution of a water pollution tax, which was designed to force polluters to pay for the social costs of pollution (Kathuria, 2006: 417).

[63] For a more detailed explanation on the different sources of water pollution, see UNESCO (2006: 141).

6.3 Payment for environmental services

The intention with payment for environmental services (PES) is to apply a market-based mechanism that will allow the beneficiary of the service to compensate the provider for the service rendered. It is therefore a tool that can lead to the more efficient use of environmental services by allowing external effects to be internalised (Jiang et al. 2010). The payment made by users can provide service providers with the resources needed to implement conservation practices (Engel, Pagiola and Wunder, 2008: 665). The buyers of the service are the actual users, while the providers are usually private landholders who would be compensated for the conservation service they are offering. This means that (from the perspective of its recipients) PES is an environmental subsidy. However, since governments are also landholders (of public land), they are also providers. Therefore PES programs can also apply to public land, such as protected areas (Engel et al. 2008: 667). This is particularly relevant in instances where government support for conservation (both within and outside protected areas) does not receive the necessary attention. As a consequence other mechanisms (such as PES) can be considered as possible ways of financing conservation projects (Turpie, Marais and Blignaut, 2008).

The application of PES programmes needs careful consideration since PES cannot address any type of environmental problem. PES is most appropriate in cases of poorly managed ecosystems, where the benefits are received by parties other than the managers (Engel et al. 2008: 665). Examples of the benefits that may be derived by users include biodiversity and species preservation, conservation of watersheds and improvement of water quality (Kassahun, 2009). A specific example of a PES program is the Working for Water programme in South Africa. According to Turpie et al. (2008), water has become increasingly scarce in South Africa, which makes it (as well as the ecosystems supporting it) a highly tradable good. The Working for Water programme is an initiative of the South African government to clear invasive plant species and was established in 1995. The programme is financed by government through the Department of Water Affairs and Forestry. Payments for improved water conservation are sourced from water consumers through a water resource management fee (these have thus far been applied in 13 of the 19 waste management areas in South Africa). Voluntary payments are also made, in cases where municipalities enter into agreements with the Working for Water programme to clear invasive plant species in their areas (Turpie et al. 2008).

Another example of PES is a pilot programme, implemented in China, to reduce pollution of the Min River, which was polluted by waste treatment plants and agricultural activities (Jiang et al. 2010). The programme was financed by the government. However, concerns about the sustainability of the government's involvement in financing improvements in water quality prompted an investigation into the possibility of raising finance from the users (thereby shifting from a government-funded programme to a user-funded programme). This involved raising funds from water users through increases in water tariffs (Jiang et al. 2010: 4). To determine the extent of this increase it was necessary to find out what consumers would be willing to pay for cleaner water, since this is a key element in setting up a successful PES programme. In other words, it was necessary to find a way of determining the economic value of water.

6.4 The economic value of water as recreational and environmental good

Determining the economic value of water as environmental and recreational good is crucial in promoting integrated water resource management. The main priority of water managers in developing countries is to ensure an adequate supply of safe drinking water. It is therefore not surprising that the pollution and degradation of lakes and rivers that are not the primary contributors of drinking water is not an immediate priority. There is also less involvement by local governments in addressing the degradation of lakes (Mukerjee, 2004). Birol et al. (2006: 107) argue that governments (particularly in developing countries) usually do not become involved in environmental conservation as this is not seen as a high priority. Water quality standards are lower in developing countries and "government intervention in the developing world is often slower due to budget constraints and incomplete or non-existent infrastructure and institutions" (Birol et al. 2006: 107). However, an integrated management approach implies that managers should consider the total economic value of water resources, which includes its value as recreational and environmental good. It is therefore crucial that local authorities be made aware of the effect of the pollution of water bodies such as lakes, rivers and estuaries and of the benefits for communities of improving water quality and recreational facilities. In his paper on the importance of river restoration in the USA, Loomis (2006: 4) referred to the enormous cost of restoring rivers and riparian areas. However, he emphasised the importance of estimating the economic value of these environmental goods, in spite of the fact that the costs involved may lead people to question the relative benefit of these projects. According to Wiseman and Sowman (1992), it is only when awareness of the potential benefits is highlighted that degradation and the activities that cause pollution can be addressed.

The economic value of environmental goods and services can be classified into either use values or non-use values (Turner, Pearce and Bateman, 1994). The former refers to value derived from actually using the environmental good or service, whereas the latter reflects the preferences of people, deriving from their concern for or interest in these types of goods (Turner et al. 1994: 113). An example of a non-use value is existence value (or passive use value). This is the value people attach to an environmental good or service, not for use, but for the benefit that may be derived from knowing that the good or service exists (Carson and Hanemann, 2005: 862). Non-use values can also be linked to the desire to bequeath the environment to future generations, often referred to as a 'bequest value' (Freeman, 1999).

Use values may be further divided into direct and indirect use values. The former refers to direct uses of an environmental good, such as a forest that will be used to harvest timber. Indirect use values refer to the ecological and environmental functions of a resource (Georgiou, Whittington, Pearce and Moran, 1997). The preservation of a wetland, for example, may have direct benefits that include use values such as bird watching. Indirect benefits may result from the pollution cost that will be saved if the wetland is preserved. Most environmental benefits from wetlands are non-consumptive, i.e. they do not deplete the water body. There is also the possibility of using the resource at a later point in time; the option value of the resource is derived from this. Thus, the total economic value of the resource is the sum of its use values, option values and non-use values. Table 6.1 presents an outline of the economic values of water resources.

Table 6.1: Economic values of water resources

Direct use values	Indirect use values
Irrigation for agriculture Domestic and industrial water supply Energy resources (hydro-electric, fuel wood, peat) Transport and navigation Recreation/amenity Wildlife harvesting	Nutrient retention Pollution abatement Flood control and protection Storm protection External ecosystem support Micro-climatic stabilisation Reduced global warming Shoreline stabilisation Soil erosion control
Option values	**Non-use values**
Potential future applications of direct and indirect uses Future value of information regarding biodiversity	Biodiversity Cultural heritage Bequest, existence and altruistic values

Source: Adapted from Birol et al. (2006: 107)

Environmental goods and services are usually classified as a subset of public goods. These exist as a result of non-excludability and non-rivalry.[64] Environmental goods and services often have both these properties and their provision does not usually take place in markets. This is also the case for water as an environmental and recreational good. No markets exist for water quality and it is difficult to obtain estimates of the value associated with its benefits. It is therefore necessary to use non-market valuation techniques to establish use and non-use values of environmental goods and services.

6.5 Environmental valuation - some methodologies

As discussed earlier, most environmental goods and services have no market that provides price information, which is also the case for the goods and services provided by surface water (Wilson and Carpenter, 1999). Since these goods are not sold via the marketplace, they are generally unpriced (Perman, Ma, McGilvray and Common 2003: 399). This necessitates the use of alternative mechanisms to assess their economic values. Environmental valuation measures the preferences of people for environmental

[64] Non-excludability states that no individual can be excluded from the benefit of the environmental good or service, whereas non-rivalry implies that when one person consumes the good or service, this does not mean there is less for the next person to consume.

goods and services (Georgiou et al. 1997: 5) and entails determining willingness to pay, with the aim of estimating the value (or cost) of a proposed environmental change. This monetary measure must reflect the change in utility as a result of the improvement (or damage) to the environment (Perman et al. 2003). Since environmental valuation is an anthropocentric process, it should not be seen as a measurement of the value of the environment, since it reflects people's preferences and reactions to changes in the state of the environment (Georgiou et al. 1997: 5).

Environmental evaluation is based on a microeconomic theoretical foundation. This entails estimating the compensating variation (CV) or equivalent variation (EV) for measuring welfare changes resulting from price changes. These Hicksian monetary measures represent the utility change as a result of price changes. [65] CV measures the change in income required when the individual is in the new situation (after the price change), to place him/her in the same original welfare position (Boadway and Bruce, 1984: 201). EV, in contrast, measures the change in income required in the initial situation to place the individual at the same welfare level as in the new situation (Boadway and Bruce, 1984: 205). CV therefore represents the change in income to compensate for the change in price whereas EV is the change in income equivalent to the proposed change in the price (Perman et al. 2003: 405).

In the case of environmental quality changes (for example, a change in the water quality of a lake or river), there is still a need to measure the resulting utility change. The utility function of the individual can generally be expressed as:[66]

$$U = f(E, X),$$

where E = quality of the environmental good or service, and X = other composite goods consumed. The solution to the expenditure minimisation problem of the consumer yields the Hicksian demand function: $X = f(P_c, U, E)$, where U = some level of utility, and P_c represents prices of composite goods. Using the tools of consumer duality, it is possible to

[65] The Hicksian demand function is derived from the utility maximisation problem, and is also referred to as the compensated demand curve. The compensated demand curve shows the change in quantity demanded as a result of the change in relative prices (i.e. the substitution effect). However, since it is not easily observable, the ordinary demand curve is generally used (Freeman, 1999: 445).

[66] This theoretical exposition is primarily taken from Perman et al. (2003: 442-443).

determine the expenditure function of the individual, $M = f(P, U, E)$. If a change occurs in E (for instance an improvement in quality from E_1 to E_2), the compensating surplus (CS) represents the amount of money that, if the individual were to sacrifice this amount for the environmental improvement in E, would allow him to maintain the pre-change level of utility. The compensating surplus therefore represents the maximum willingness to pay for an improvement in environmental quality (Perman et al. 2003: 409). It can be determined by measuring the change in expenditure as a result of the change in environmental quality:

$$CS = M(P_c, U, E_1) - M(P_c, U, E_2)$$

Since the compensating surplus is linked to the individual's willingness to pay for the change in environmental quality, it allows the researcher to apply either direct or indirect methods to elicit these measures from individuals. Stated preference methods are more direct in that people are presented with information on a hypothetical market, which allows for a valuation of the use and non-use values of the environmental good (Renzetti, 2002: 96). In the case of stated preference methods, people are asked directly what they would be willing to pay for changes in environmental quality. This entails "'conversations' with individuals through structured surveys" (Grafton et al. 2004: 229).

Table 6.2 classifies some of the stated and revealed preference methods.

Table 6.2: Some stated preference and revealed preference methods

Stated preference methods	Revealed preference methods
Contingent valuation	Hedonic pricing
Contingent ranking	Travel cost

Source: Adapted from Nunes and Nijkamp (2007)

The CVM is often used in environmental studies, since it allows for an assessment of the total economic value of environmental goods, i.e. both use and non-use values. However, not many CVM studies isolate economic value according to type, i.e. they do not distinguish use value from non-use value (Pearce and Barbier, 2000).This also applies in the case study presented in Chapter Seven, which explores the total economic value of Zeekoevlei. Furthermore, the CVM has fewer secondary data requirements, which may be difficult to obtain (such as records of accurate property valuations).

The sub-sections below provide an overview of some of the methodologies mentioned in Table 6.2. Various aspects of implementing the CVM (such as the design of the survey questionnaire) are discussed in some detail, since this forms the theoretical foundation for the case study in Chapter Seven. The remaining methods are discussed in less detail. For each method some empirical evidence is presented.

6.5.1 The Hedonic Pricing Method

"Hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them" (Rosen, 1974: 34). The hedonic pricing method entails, for example, the use of property prices or rental differentials in order to determine the value of environmental goods and services. Rent differentials reflect differences in land productivity, which are captured by market prices (Freeman, 1999: 368). Environmental characteristics such as water quality influence land productivity, and this is then reflected in market prices. The price of a house is an indication of important characteristics such as the number of bedrooms, the proximity of the house to schools and shops, and, more importantly for the purpose of measuring the environment benefits, local environmental resources such as water quality, air quality and the level of noise pollution (Birol et al. 2006). In the case of two identical lake-facing properties (situated on different lakes), if the only difference is the water quality of the respective lakes, the difference in price must be ascribed to the implicit price for the better water quality. However, Michael, Boyle and Bouchard (1996) indicate that environmental goods and services such as lakes are heterogeneous and comparisons are therefore not so simple. In most instances adequate controls are required to distinguish the value of improved environmental services from the influence of other factors.

6.5.1.1 Theoretical specification

The hedonic pricing method attempts to use market prices and other characteristics of houses in the neighbourhood to estimate the value of environmental resources. The methodology involves collecting information on characteristics of houses that will affect their prices. A basic model for applying this method is summarised in the equation below (Freeman, 1999):

$$\textit{House Price} = f(S, E, L)$$

S represents a vector of structural characteristics of the houses, such as the plot size, *E* reflects the environmental amenities associated with specific area and *L* is a vector of neighbourhood characteristics such as distance to the nearest shops, crime rates, etc. (Freeman, 1999). Hedonic pricing models also usually attempt to control for other characteristics which may have an impact on the price. The goal is to elicit an implicit price for the different characteristics and for the marginal willingness to pay, which indicates a person's valuation of the marginal value of the environmental resource (Birol et al. 2006: 109).

One of the pertinent issues in estimating the hedonic price function is the selection of the dependent variable. Since the value of the environmental good or service is generally linked to its location, it is the price of the land and not of the structure that is important (Freeman, 1999: 375). In most instances, however, it is difficult to separate these values as they are not traded in isolation. This implies that the hedonic pricing function must include sufficient controls for the effect of properties' structural characteristics. A related concern is the source of the house prices. The preferred choice is to collect data on housing prices that reflect market transactions. However, since few owner-occupied houses are sold during a particular year, there is little available data. Some studies have used census information, in which owners of houses are asked to provide an estimate of the value of their property. However, this information is not entirely accurate, since owners may provide an estimate that is higher or lower than the actual value (Freeman, 1999: 375). Furthermore, census data are not necessarily very detailed in terms of the information that is required on housing and location characteristics (Freeman, 1999). It is therefore preferred that the data be sourced from the actual sales information for each house, as this will include information on the respective characteristics of each house.

In terms of explanatory variables, information is required on the factors which determine house prices. Adequate controls are needed to reflect the impact of structural characteristics, locality and environmental variables. Some of this information may not be readily available. For instance, the distance between the house and local facilities is one of the determinants of the variations in house values. Collecting information can be quite cumbersome, but modern data collection techniques (such as geographical information systems) have made the task of the researcher less daunting (Turner et al. 1994). A further concern is possible multicollinearity[67] between the explanatory variables. Freeman (1999: 378) indicates that there is a trade-off between variable omission bias and imprecise results due to the inclusion of variables that are collinear.

Apart from the difficulties associated with the estimation of the hedonic pricing function, a further criticism relates to its usefulness. The hedonic pricing method is limited in its ability to determine the value of environmental goods and services that lie beyond the individual's place of residence. An example would be determining the economic value people receive from a national park, where this is not a factor in the choice of the location of their residence. This is especially relevant in cases where the choice of locality is not directly linked to a benefit from an environmental good or service.

6.5.1.2 Empirical evidence illustrating the hedonic pricing method

The study by Michael et al. (1996) is an application of the hedonic pricing method to the improvement of water quality. They investigated how the water quality of lakes in Maine (USA) affected property values in the proximity of the lakes. At the time of their study the lakes were polluted by non-point source pollution originating primarily from human activity. This adversely influenced the recreational benefits of the lakes and their ability to support aquatic life. The objective was to make the citizens and property owners of Maine more aware of the impact of water quality on property values and to gain support for regulation to ensure protection of the lakes. The hedonic model regressed the price of lake-front properties against the structural and locational characteristics of these properties and the lakes' water quality. Explanatory variables included the type of heating system, the plumbing of the house, whether there was a garage, the housing density along the lake and the distance to the nearest city. They found that water clarity had a significant influence on the value of lake-front properties (Michael et al. 1996: 14). The values they estimated were useful in public education campaigns to persuade property owners of the benefits they would receive from improvements in the water quality of the lake.

Another example of the hedonic pricing method is the study by Luttik (2000), who investigated the impact of environmental factors on the prices of houses in the Netherlands, with a particular focus on the value added by trees, water and open spaces.

[67] Multicollinearity occurs when an independent variable in multiple regression analysis is highly correlated with another independent variable (Allen, 1997: 176).

The empirical analysis consisted of a two-stage regression analysis. In the first stage house prices were estimated, based on structural characteristics of the houses such as plot size and the number of rooms. The estimated house prices were then compared with the actual house prices and the ratio of the two prices was taken as a proxy for a location indicator, since it was assumed that the differences between the prices were primarily determined by location (Luttik: 2000, 163). The second regression involved regressing the location indicator against location factors which included environmental characteristics.

The results were presented for three towns, each containing districts with differences in their environmental characteristics. For example, in the town of Emmen, Luttik (2000) investigated the value of a wood bordering two districts, while a third district was adjacent to a lake. His findings indicated there was a premium on houses overlooking water or open spaces. The type of landscape was also an important factor. Houses set in more attractive landscapes attracted higher prices than those set in less attractive landscapes. Despite these results, however, Luttik (2000) referred to the limitations of the hedonic pricing method, as the findings only applied in the context of the environmental factors in which they were studied. Reference was also made to the difficulty of making relative comparisons. When a particular environmental characteristic is analysed, the technique requires that districts in the same housing market segment are compared so that the main difference is the environmental characteristic. However, this is not always possible, and this complicates the application of the method.

A recent study by Sander and Polasky (2009) applied the method to valuing views and open spaces in Minnesota, USA. A key reason for their study was the need to provide a value for environmental amenities as these were not considered when decisions on land use and development were made, either because they were not known, or because decision makers were unaware of their relevance. Since open spaces provide communities with positive values such as attractive scenic views and recreational opportunities, their value should be estimated and taken into account in the decision-making process. Sander and Polasky (2009) applied an OLS regression model to estimate the factors influencing house prices for over 5 000 single-family residential houses. Their explanatory variables included structural, neighbourhood and environmental variables. The latter included variables representing the scenic quality of the landscape (i.e. the view) and open space benefits (i.e. property's distance to open space, which is a good proxy for access to open spaces by residents). Their results indicated that people value scenic landscapes and access to open spaces and that people are willing to pay for closer access to parks, rivers and streams. These amenities had a significant influence on the prices of properties in the area.

6.5.2 The Travel Cost Method

The travel cost method is another example of the revealed preference method (Turner et al. 1994) and is based on the assumption that it is possible to infer values of environmental goods and services for visitors by looking at the costs incurred to enjoy them (Perman et al. 2003: 411). This is an indirect method that attempts to establish the benefits derived from non-marketed environmental goods and services (e.g. beaches, parks and tourist attractions) by observing behaviour in related markets. The aim of the travel cost method is to determine an individual's demand curve for a recreational site, where its value is defined as the area below the compensated demand curve for that site (Freeman, 1999: 445).

6.5.2.1 Theoretical specification

The basic premise is that the recreational site and travel are weak complements in that the value of the recreational areas is related to the cost of travelling to the site (Pearce, Atkinson and Mourato, 2006). The assumption is that people spend money to travel to recreational sites and that there is an inverse relationship between visitation rates and travel costs (Fuguitt and Wilcox, 1999). The methodology involves estimating the travel expenses incurred in getting to the amenity; these expenses are then used as a proxy for the price that people are willing to pay to visit the site (Chen et al. 2004). The demand for the amenity can be established by observing the variation in the number of visits to the recreational site as the cost of the private good (i.e. the travelling expense) changes. As the cost of travelling increases, the number of visits to the site decreases (Garrod and Willis, 1999). Changes to hypothetical entrance fees (based on the travel cost to the site) would also affect the number of visits, allowing for the construction of a demand curve. Assuming that households have similar tastes and preferences, the area under this curve represents the economic value of the recreational site to visitors (Chaudhry and Tewari, 2010).

The basic model involves maximising the utility of an individual subject to budgetary and other constraints, given that utility is a function of time spent at the recreational site (Freeman, 1999). The constraints include estimates of the time spent travelling to the site, where the number of trips made is linked to the environmental quality of the site. By solving the utility maximisation problem, the individual demand curve for visits to the recreational site can be determined. A basic representation of the trip-generating function is as follows (Perman, 2003: 411):

$$V = f(C, X)$$

where V = the number of visits by the individual
C = the total cost of a visit
X = other relevant variables

The assumption is that C represents travel costs and any access charge to the recreational site (if a fee is charged). In addition, the model assumes that the inverse relationship observed between the number of visits and the travel costs approximates the manner in which people will respond to changes in admission prices. Furthermore, the model assumes that the trip is solely undertaken to visit the recreational site, and that all visits are equal in terms of time spent at the site (Freeman, 1999: 447).

If trips are undertaken for more than one purpose, this causes problems when the travel cost method is applied. For example, if the method is applied to international visitors to a recreational site, it will be difficult to separate out their expenditure for the various places they will visit on their tour. A solution might be to ask the participants in the survey what proportion of their enjoyment they can assign to a particular recreational site. This can then be used as a weight to determine the proportion of their travel cost to be assigned to the site (Pearce et al. 2006: 98). A related issue concerning travel cost is whether the time costs of travel should be included. Arguably the time spent travelling has an opportunity cost and should be included as part of travel cost (Perman et al. 2003). However, measuring this opportunity cost is complex. One option is to consider the value of taking time off work for a particular period. However, this may not be appropriate in the case of visitors who are not in the labour market. Estimating this value at the wage rate may also not be appropriate if there are predetermined leave allowances. Furthermore, some people receive positive utility from travelling to the site, which implies that the travel time is a negative cost (Perman et al. 2003: 416) or has a smaller positive value. Additional problems can arise from econometric specifications and estimation. The trip-generating function does not necessarily have a linear functional form, and this could have implications for the results and therefore for policy decisions.

Two final issues that may be problematic are the availability of substitute sites and the presence of non-paying visitors. In the case of the former, a problem arises with the accuracy of measuring the value of a particular recreational site if there are no substitute sites available. For example, if two individuals are travelling from different (equally distant) destinations to the recreational site, they may have the same travel cost, but may have different reasons for travelling to the particular site. One of them might be travelling to the site only because there was no other substitute site available. According to Turner et al. (1994: 119), this will yield inaccurate estimations of the site's value.

If there are non-paying visitors to the recreational site, this will also cause incorrect values. The travel cost approach will only capture those individuals who have incurred travel costs, and will thus exclude visitors who live within walking distance of the site. Since these individuals may place a high value on the site, their exclusion will understate the value of the site (Turner et al. 1994). Darling (1973) argues that it is not always an appropriate method to value the benefits of public water parks as the travel distance to the amenity is often negligible, making the travelling cost insignificant. This is especially relevant in the case of urban parks, where people are likely to be within walking distance of the amenity. This is affirmed by More, Stevens and Allen (1988) who state that the use of the travel cost method may not be appropriate since there is little variation in the distance travelled by users. Furthermore, since the travel cost method is used primarily to capture recreational benefits which comprise the use values of environmental goods and services, it will not provide estimates of the non-use values of urban parks (such as existence values).

6.5.2.2 Empirical evidence illustrating the travel cost method

Choe, Whittington and Lauria (1996) made a comprehensive study of the economic benefits of surface water quality improvements in the Philippines. Their paper is a valuable contribution to the debate on the importance of environmental quality for poor people. It is usually assumed that the poor do not regard the environment as important and therefore will not place a high monetary value on environmental quality, since they cannot afford to pay for this. This view has recently been challenged by the argument that economic development and environmental improvement are complementary. Choe et al. (1996) tested this hypothesis, using two environmental valuation methods to establish the value of improved surface water quality of the nearby rivers and the sea. The focus was on estimating the water-based recreational benefits to the community in Davao, Philippines.

Choe et al. (1996) used the travel cost method and the contingent valuation method (CVM) to estimate the recreational value of rivers and the sea to the community.[68] One of their goals was to test whether different estimates of economic value would be obtained from different nonmarket valuation techniques. In this section the application of the travel cost method is discussed. The environmental good considered was the recreational benefit offered by the Davao River and the beaches on Davao Bay. Both the river and beaches were polluted as a result of inadequate sanitation; few residents were connected to the sewerage collection system and most of the wastewater and untreated sewerage ended up in the river and the sea, with some of it washing up on the beaches. Choe et al. (1996: 530) used the travel cost method to estimate the economic benefit of the recreational use of the beaches, before and after the release of information by the government on the health implications of the pollution of the beaches (i.e. before a public health advisory was issued).

A simple travel cost model was employed to estimate the economic benefits. The visitation function depended on a number of factors such as household income, personal preferences, water quality at the beach, the availability of substitute recreational sites and travel cost measurements (estimating the cost of travel to the beach and to substitute sites) (Choe et al. 1996: 530). The travel cost included a round-trip estimate of the cost of transportation to the beach, as well as an estimate of the opportunity cost of the travel time (equal to one half the individual's hourly wage rate). Since two-thirds of the recreational users stopped visiting the beach after the public advisory about the risks of pollution, a tobit model was used to estimate the visitation function (Choe et al. 1996: 530). The regression analysis indicated that travel cost to a substitute site and household income were positively correlated with the number of visits to the beach. The estimated welfare loss to people as a result of the deterioration in the water quality at the beach was estimated at 10 pesos. The authors commented that this low level of willingness to pay for improved water quality indicated that it was not a high priority for poor households.

[68] The application of the CVM is discussed later in Section 6.5.3.2.

Another application of the travel cost method is by Chen et al. (2004: 398), who used it to estimate the recreational benefit of a beach in China. The purpose of their study was to provide local policy makers with information on the value of the beach as a recreational site. This information would help to establish possible entrance fees, which could then be used to protect and manage the environmental resources and to cover the cost of setting up a PES programme. They adopted a zonal travel cost method[69] in which per capita visitation rates and other characteristics were used as explanatory variables, while the dependent variable was the zonal travelling expenses. They collected data using a survey questionnaire. Visitors were asked questions about their origin, the cost of travel, the time taken travelling and other demographic and economic background information. Their findings revealed that the beach brought substantial economic benefits. The decision of local authorities to proclaim the area as one to be used predominantly for tourism and recreation was therefore appropriate (Chen et al. 2004: 405).

6.5.3 The Contingent Valuation Method

The Contingent Valuation Method (CVM) is the most common stated preference method. It involves the creation of a hypothetical market in which people are offered an environmental good and asked to indicate their willingness to pay for it. The objective of the CVM is to determine the amount of compensating surplus. It is an appropriate measure of the welfare change brought about by changes in environmental quality and provides an indication of the willingness to pay for this improvement (Food and Agricultural Organization, 2000). Where a policy change will have an environmental effect, those who benefit (or suffer a disbenefit) are encouraged to reveal their willingness to pay for the policy change (or to pay to avoid it) (O'Doherty, 1993: 1). If the information is accurate, it presents a measure of the compensating surplus.

Certain environmental goods (such as public urban water parks) mainly provide recreational benefits and aesthetic beauty and for this reason are not valued in the market place (Darling, 1973). However, it has been established (see Table 6.1) that water resources also have substantial non-use values. The development of the CVM has enabled the measurement of non-market values (Jakobsson and Dragun, 1996: 93). This is especially relevant where economic values (such as option values or existence values)

[69] The zonal travel cost method is a variant of the travel cost method in which the total area from where visitors originate is divided into different zones. The dependent variable is then the visitation rate for a particular zone (Markandya, Harou, Bellu and Cistulli, 2002: 365).

form a significant component of the benefits derived from the environmental goods or services. The CVM is therefore an appropriate method to estimate the willingness to pay for the preservation of water quality (Stenger and Willinger, 1998).

6.5.3.1 Theoretical specification

The theoretical foundation for the CVM is the measurement of a monetary value for environmental goods which reflects an estimation of changes in welfare resulting from a change in the quantity or quality of the environmental good or service (E) [70]. An individual's utility function is therefore indicated as follows (Carson and Hanemann, 2005):

$$U = f(X, E)$$

where X = other market goods and services, and E = environmental good. From this, the indirect utility function is given as follows:

$$V = f(P_c, E, Y)$$

where P_c = price of composite market goods and services, and Y = income.

Given the assumption of a change in E (from E_0 to E_1), the Hicksian compensating measure (i.e. the compensating variation[71] (C)) is the monetary value of the change to the individual, and is represented as follows:

$$V(P_c, E_1, Y - C) = V(P_c, E_0, Y)$$

[70] The notation is similar to that used earlier in the chapter, which necessitated a slight adaptation to the notation used in Carson and Hanemann (2005).

[71] Perman, Ma, McGilvray and Common (1999: 385) refer to a compensating surplus when discussing a change in the quantity or quality of an environmental service. A compensating surplus is a monetary measure of the utility change associated with a change in environmental quantity or quality (Perman, et al, 1999: 385).

For a positive change in E, C is greater than zero, which is an indication of the maximum willingness to pay for an improvement in the quantity or quality of the environmental good or service (Carson and Hanemann, 2005: 845). This allows a willingness to pay (WTP) function to be defined as follows:

$$WTP(E_0, E_1, P_c, Y) = C(E_0, E_1, P_c, Y) \text{ if } C \geq 0$$

The CVM uses surveys to elicit information on the WTP of individuals for changes to environmental goods and services; this information can then be interpreted using the utility theoretical framework outlined above. According to Carson and Hanemann (2005), researchers use different types of survey question formats and the way these responses are linked to the WTP depends on the type of question asked. Earlier studies used an iterative technique, referred to as a 'bidding game' (Freeman, 1999: 170). This question format commences with a question on whether respondents are willing to pay a specified amount. If they answer 'yes', the WTP question is repeated, but now a larger amount is offered. This process continues until the respondent refuses to accept the offer. A similar process is followed if the initial answer is 'no', which then involves bidding the offer downward. A critique of the bidding game is that the starting point of the bidding can influence the outcome of the process, i.e. there could be starting point bias (Freeman, 1999). This will have an impact on the reliability and validity of the information obtained. According to Perman et al. (2003), survey design should attempt to eliminate potential biases. The aim is to ensure that respondents answer the questions truthfully, but also that their answers reflect their true WTP.

A commonly used hypothetical question format is the open-ended willingness to pay question, i.e. respondents to the survey are asked how much (in monetary value) they would be willing to pay for a specified change in the environmental good or service (Freeman 1999: 165). The response to this question, if there is honest disclosure, will be a direct indication of the value received and therefore will represent a measure for the compensating surplus. The problem with this elicitation format is that it may lead to many non-responses or 'I don’t know' answers (Carson and Hanemann, 2005: 870). Freeman (1999) suggests that this could be related to the unfamiliarity of the situation, i.e. people are not used to being confronted with these questions in the market – they are usually offered a range of goods with listed prices. To address this problem, the payment card system was proposed in which respondents were offered a range of WTP amounts to choose from. According to Carson and Hanemann (2005), the payment card format incorporates an element of uncertainty about the cost of provision of the good, and may produce a more truthful revelation of respondents' preferences.

Another question format is the referendum (closed-ended/dichotomous choice) format. Here respondents are asked whether they are willing to pay a specified amount for the environmental change, for example: Would you be willing to pay *X* amount for the change? If the respondent says 'yes', this means he/she is willing to pay at least an amount as small as *C*, i.e. the compensating variation (Carson and Hanemann, 2005). If the answer is 'no', the amount specified in the questionnaire is seen as an upper bound of the WTP. If the answer is 'yes', this represents a lower bound for the WTP of the individual respondent (Freeman, 1999: 165). Since only one closed-ended question is asked, it is referred to as a single-bound dichotomous question. What is then required is to link the WTP distribution and the response probability distribution (Carson and Hanemann, 2005: 848). The respondent's response to a closed-ended question can be analysed using the random utility framework and appropriate welfare measures can be derived (Freeman, 1999). An alternative model is to define a bid function (Freeman, 1999: 191), which will result in a willingness to pay function model. Depending on the assumptions made about the distribution of the random component of the bid, this will either result in the probit model (assuming a normal distribution), or the logit model (assuming a logistic distribution).

The referendum question is arguably less likely to provide respondents with value cues, which implies there is less chance of starting point bias. Moreover, the referendum question simulates a market setting, where buyers have the choice of saying 'yes' or 'no' to a particular good, which makes the process more familiar. The decision problem for respondents is relatively simple since they only have to choose between 'yes' or 'no'. This is particularly true for the single-bound dichotomous question, as discussed above. One drawback of the single-bound dichotomous question approach, though, is the limited information provided about the respondents' willingness to pay (Carson and Hanemann, 2005: 871). Since it is a once-off question, large numbers of respondents are required to provide sufficiently precise estimates (Carson and Hanemann, 2005: 871).

Another important issue in the case of referendum (dichotomous) questions is the range of prices (bids) to present to respondents. Prices that are too high or too low will lack credibility. Interviewers have indicated that a bid price that is set too high will make them seem uninformed or insensitive, especially since people in developing countries may not be able to afford such prices (Whittington, 1998). Despite these difficulties, Whittington (1998) nevertheless argues in favour of using the CVM in developing countries (compared to industrialised countries), since response rates are generally higher, respondents are more willing to listen to the questions and interviewers are less expensive.

A modified version of the bidding method which incorporates dichotomous questions is the double-bounded dichotomous question. Here the respondents are put through two rounds of bidding (Hanemann, Loomis and Kanninen, 1991: 1255). Thus, the respondent is offered an initial bid and also a second round of bidding, involving either a lower or higher amount, depending on whether the initial bid was rejected or accepted. According to Hanemann et al. (1991), the double-bounded dichotomous questioning format is statistically more efficient than the single-bounded question format. Bateman, Day, Dupont and Georgiou (2004: 1) define statistical efficiency as follows: "that the technique can provide sufficient data in order to permit robust estimation of WTP without recourse to excessive sample size." The double-bounded dichotomous questioning format is also less likely to give rise to problems regarding the starting point. This is because there are only two rounds of bidding and it is less likely that respondents will tire (as would be the case in multiple rounds of iterative bidding, to the extent that this may be the cause of starting point bias).

Since the CVM relies heavily on direct responses, the design of the survey is crucial. Freeman (1999: 170) identified three important aspects of the survey instrument: (1) a description of the choice setting within which the respondent will find him or herself; (2) the choice questions from which environmental values will be inferred (in order to establish an economic value expressed in monetary terms); and, (3) questions to obtain information on the respondents' demographic and socio-economic background that may influence their utility from the goods. With reference to (1), it is imperative that the description of the resource being valued is comprehensive, in order to obtain accurate estimates of values (Loomis, Kent, Strange, Fausch and Covich, 2000). The resource must be described in such a way that it conforms to underlying scientific and engineering realities. However, it must also be comprehensible to a respondent who may have very little knowledge of the resource (Carson and Hanemann, 2005).

The payment vehicle is another important design aspect which can affect the validity and reliability of the information elicited. The payment vehicle refers to the hypothetical means of payment for the hypothetical change in the environmental good or service (Perman et al. 2003). Some typical examples include water rates, park entrance fees, and increased sales or income taxes (Morrison, Blamey and Bennett, 2000: 408). According to Morrison et al. (2000), payment vehicles must be designed and selected according to the cultural and institutional context. Thus, researchers must be aware of the social context within which hypothetical scenarios are presented (Fischoff and Furby (1998), as cited in Freeman (1999: 172)). An effective payment vehicle should also prevent the occurrence of 'yea-saying'. This refers to respondents accepting the bid (even with a referendum-type question), despite the fact that the bid is higher than their willingness to pay (Freeman, 1999).

There are several reasons why respondents might accept a higher bid. Carson and Hanemann (2005: 888) argue that a high proportion of 'yes' responses to the highest bid indicates either a problem with the original choice of bid amounts, or that there is an incentive problem with the payment vehicle. In the latter case, respondents may be aware of the bid amount, but because they believe that they will not have to pay for the good, they may answer 'yes' to the bid question. The incentive to misrepresent values occurs if respondents do not see a link between the provision of the environmental good or service and the required payment. They may believe that the payment is linked to their answer. Alternatively, respondents may believe their responses will influence the level of the public good provided, but will have no effect on the payment needed to bring this about (Freeman, 1999: 183). The payment vehicle must therefore be both plausible and incentive compatible (i.e. free of strategic behaviour) (Carson and Hanemann, 2005). To achieve this, it has to be coercive, so that respondents can be expected to pay independently of whatever decision they opt for. Voluntary contributions result in a lack of real commitment to WTP elicitation questions. In addition, consideration should be given to whether the payment vehicle must be presented as a once-off or a recurring payment. In the case of a water quality improvement, Carson and Hanemann (2005) propose a recurring payment (since the service is ongoing).

The ability of the CVM to provide reliable and valid responses to guide policy-making decisions has been a focal point of discussion, particularly in cases where there needs to be compensation for environmental damage. The National Oceanic and Atmospheric

Administration (NOAA) panel of the US Department of Commerce investigated the reliability of the CVM (Perman et al. 2003), and suggested some key guidelines for contingent valuation studies. These are some of their suggestions (Arrow et al. (1993), as cited in Du Preez and Lee (2010: 161)):

- Use personal interviews instead of mailing surveys.
- Pre-test the survey instrument, i.e. conduct pilot studies and focus groups.
- Indicate clearly the contingency under review.
- Use referendum-type questions in the survey.
- Include follow-up questions in the survey, to explain answers given to the referendum question.

It was initially considered inappropriate to use the CVM in developing countries. However, in recent years many environmental and resource economists have used it in their studies. Whittington (1998) points to some important issues and concerns arising from empirical experiences that must be taken into consideration. One of the main priorities for researchers is to ensure that all relevant parties understand the purpose of the study. In particular, interviewers must understand the concept of WTP.

6.5.3.2 Empirical evidence illustrating the Contingent Valuation Method

A vast literature exists on the specifications of the CVM and its empirical applications, particularly on natural resources. Navrud and Mungatana (1994) use the method to study wildlife viewing. Köhlin (2001) applies the CVM to establish the value of a social forestry project in India. Another study conducted in developing countries is that of Carlsson, Köhlin and Mekonnen (2004), which focuses on community plantations in Ethiopia. They attempt to draw both methodological and policy conclusions using the CVM. The discussion that follows focuses on water-related empirical studies. It commences with a study in an industrialised country; this is followed by studies conducted in developing countries, and in particular a recent study completed in South Africa.

Bateman, Cole, Georgiou and Hadley (2006) used both the CVM and contingent ranking, to estimate the benefits of cleaning up the River Tame, which runs through the city of Birmingham in the UK. Contingent ranking is a method whereby respondents are not directly asked what they would be willing to pay for the environmental improvement. Rather, they are asked to rank or order their preferences for different profiles of the commodity, one of the attributes being the price of the good. This allows utility to be expressed in monetary value, which enables the derivation of the WTP estimates. Their sample was drawn from people residing in the vicinity. Since the focus of the paper was a comparison between two methods, their sampling framework was not designed to constitute a representative sample of the population. However, they used a random process to select the streets from which the respondents were drawn. In the contingent valuation component of their study, they used an open-ended question to elicit the WTP. Their payment vehicle was an annual increase in local authority taxes, which made the instrument seem more realistic (since any improvements would be the responsibility of the local government). However, it should be kept in mind that the *market* and *payment* used in the CVM were *hypothetical*, which could lead to potential biases[72] (Navrud, 1989: 71).

The elicitation process in the study of Bateman et al. (2006) produced a high percentage of zero responses (39%). In the CVM studies it is assumed that zero bidders do not want to pay anything for the proposed (hypothetical) project. However, it is important to distinguish between true zero responses and the responses of those who are opposed to some aspect of the survey, such as the payment vehicle used (Strazzera, Scarpa, Calia, Garrod and Willis, 2003: 133). In the case studied by Bateman et al. (2006), some of the reasons for the zero responses offered by respondents included the proposal that polluters should pay for pollution and that existing funds should be used for cleaning the river. These responses were classified as 'protest responses'. Only a small percentage of respondents indicated they did not care about the river and improving its water quality. The question of whether these protest zero responses should be included has been debated extensively. According to Bateman et al. (2006: 225), those who argue against the inclusion of protest responses are interested in measuring the value of the good, whereas those in favour of including protest responses do so on the premise that they would want to estimate a value that reflects the level of spending approved by a referendum (which is how public policy is usually determined). In the case of the CVM, Bateman et al. (2006) discussed the factors influencing the WTP in their tobit regression, such as WTP decreasing with age (as elderly people earn less income and are less likely to be willing to pay). In fact, they found that those who were employed would be less willing to pay. This was unexpected, as higher income earners will usually be more willing to pay for

[72] Some of these biases have already been discussed, such as the starting point bias. Other potential biases are discussed in Section 6.5.3.3.

environmental improvements. One explanation offered was that those who worked longer hours (such as higher income earners) were less likely to know about and use an environmental commodity.

As discussed previously, Choe et al. (1996) used two methodologies to estimate the recreational value of the rivers and the beaches in Davao, Philippines, namely the travel cost method and the CVM. The results of the travel cost method were discussed in Section 6.5.2.2. The discussion here focuses on the results of the CVM. Using a stratified sampling process, they selected 1 200 households in Davao. Only 777 survey questionnaires were completed, which gave a response rate of 65%. The households were split into two groups and each group was presented with two scenarios. The first scenario described a plan to improve the surface water quality of the rivers and the sea, whereas Scenario 2 also included plans to improve sewer lines and the treatment of wastewater collected. The sample was split in an effort to test for scope (embedding) effects. Embedding effects are present if WTP values differ, depending on whether the good is valued in isolation or as part of a package (Venkatachalam, 2004: 96).

In the case of Scenario 1, households were informed that this involved a plan to clean up the rivers and sea to improve conditions for recreational activities, but no specific details of this plan were provided in the survey. The researchers used a monthly fee as payment vehicle. The WTP question was a referendum-type question, which was followed by further binary questions (if the respondents answered 'yes' to the initial referendum question). A price range of five monthly fees was used and different prices were used in the follow-up questions. If there was a final 'no' answer, respondents were asked to indicate their maximum WTP for the scenario. The researchers used various statistical methods to estimate the WTP.

Using the first referendum question results, they estimated a probit model to determine which factors influenced respondents' willingness to pay for the improvement plan.[73] The results reflected a positive correlation between income and the probability of voting 'yes' to the referendum question, with the same relationship observed in the case of level of education. The higher the bid price offered to respondents, the less likely it was that they

[73] An alternative approach used the answers to the referendum questions to create interval data. Assuming various distributions, survival analysis was applied to estimate the mean WTP (Choe et al. 1996: 524).

would vote in favour of the improvement plan (Choe et al. 1996: 525). In addition, one of the key findings of the paper was that respondents were sensitive to the scope of the environmental good; households that were offered Scenario 2 was prepared to pay more than similar households who were offered Scenario 1 (Choe et al. 1996). Finally, the estimates for WTP were low in absolute terms and also as a proportion of income. This indicated that improved water quality was not a priority for people living in Davao.

The application of the CVM is now also popular among environmental and resource economists in South Africa. Sale, Hosking and Du Preez (2009) used the CVM to determine the recreational value of freshwater inflows into the Kowie and Kromme estuaries in the Eastern Cape. As a result of water abstraction, these estuaries are not effective in delivering environmental and recreational services. The researchers used the payment card system (see Section 6.5.3.1) in order to prevent starting point bias. Their WTP values ranged from R0 to R1 001+ and the payment vehicle was a levy collected by local authorities. The levy included a component for indirect benefits (i.e. a rates component) and a user fee for direct benefits (this would be charged to both residents and tourists) (Sale et al. 2009: 264).

A tobit model was used to predict the willingness to pay to improve the recreational value of the two estuaries. As in other studies, the explanatory variables of education and a measure of wealth (i.e. the value of boats and vehicles owned) were both positively correlated with the WTP. The 'measure of wealth' variable, although significant, had a relatively small coefficient. Further results indicated that respondents who were well informed about the ecology of estuaries were willing to pay more to improve the environmental quality of these estuaries. The researchers estimated a median WTP for the Kowie and Kromme estuaries at R290.14 and R304.38 per annum, respectively.

6.5.3.3 Potential problems with the Contingent Valuation Method

The critique of the CVM is based on two important issues, namely whether the results are valid and reliable (Venkatachalam, 2004). Validity refers to the accuracy of the CVM in measuring the true economic value, i.e. "the degree to which it measures the theoretical construct under investigation" (Mitchell and Carson, 1989: 190). Reliability, on the other hand, refers to variability in the WTP estimates (Bishop and Romano, 1998). These two concepts are related since a valid estimate is also reliable, if the variance of this value is similar to the population variance (Bishop and Romano, 1998: 25). The previous discussion has highlighted some of the problems researchers may encounter when using the CVM and these can affect both validity and reliability. Problems such as starting point bias, embedding effects and payment vehicle bias formed part of the discussion of the empirical studies in Section 6.5.3.2. There are, however, further pitfalls that researchers must consider when conducting a contingent valuation (CV) study.

Since the market created in a CV study is hypothetical, it is possible that hypothetical bias might arise. This refers to the divergence between hypothetical (stated) WTP and real WTP values, which can be caused by several factors. Some individuals would pay a low real WTP in an attempt to take advantage of the payments that others were willing to make (in the case of a public good). Other respondents may indicate a high WTP in the hypothetical scenario to ensure a greater provision of the public good (Yadav, 2007). It is also possible that people might not take their real income into account and provide too high an estimate of WTP. Alternatively they may not take the CV questions seriously, but regard it as a kind of game. Researchers have adopted various methods to reduce the divergence between the stated and real WTP. These include making the respondent aware of budgetary constraints, providing 'real' payment bids or asking respondents whether they are sure about the stated amounts (Ajzen, Brown and Carvajal, 2004: 1110).

Strategic behaviour is also a concern when using the CVM. If respondents believe they can influence the provision of the public good, they may understate or overstate their WTP. According to Garrod and Willis (1999: 153), even though strategic bias is not easy to detect, laboratory experiments have shown that it is not a serious problem. One way of minimising this type of bias is the use of dichotomous questions, and taxes as the payment vehicle (Perman et al. 2003: 424).

Despite the problems associated with this method, the CVM remains an important tool to assist environmental economics researchers in estimating economic value. It is particularly helpful in assessing non-use values (Young, 2005).

6.6 Concluding remarks

This chapter has emphasised that taking into account the economic value of water as recreational and environmental good should form part of any integrated water resource management strategy. Water resources, such as lakes in urban communities, can provide benefits in terms of recreational possibilities and aesthetic appeal. The case study in

Chapter Seven estimates the economic value of a freshwater lake (Zeekoevlei) in an urban setting. This lake is quite polluted and its recreational facilities are degraded. A contingent valuation study is undertaken to estimate the willingness to pay for improved recreational facilities and improved water quality. This provides an estimate of the value of the lake to people living in suburbs surrounding the lake.

The purpose of Chapter Six was to provide a theoretical foundation for the subsequent empirical analysis. The primary aim was to discuss valuation methods that could be used to estimate the economic value of environmental goods and services. The discussion focused on the travel cost method, the hedonic pricing method and the contingent valuation method (CVM). The CVM received particular attention as this is the method employed in Chapter Seven.

One of the reasons for selecting this method was its advantage for estimating both use and non-use values. Furthermore, the CVM is a stated preference method in which people can be asked directly what they would be willing to pay for an improvement in the quality of particular water resources. It is therefore less cumbersome in terms of data requirements than the hedonic pricing method, where property values and characteristics would be required. However, the potential pitfalls associated with the empirical implementation of the CVM have also been highlighted, with specific reference to the biases researchers could encounter. Careful attention should therefore be given to the design and implementation of the survey questionnaire, which was the focus of the discussion in the latter part of this chapter.

CHAPTER SEVEN

The economic value of improved water quality and recreational facilities in an urban setting - the case of Zeekoevlei

7.1 Introduction

In the previous chapter it was argued that water is valuable because it is essential for survival, and it provides valuable recreational and environmental benefits (see Chapter Six). The pollution of water resources is therefore a grave concern, since it leads to a decline in water quality, which in turn affects the economic value of these resources. In South Africa many lakes and rivers are polluted as a result of the external effects of economic activities in surrounding areas, and include pollution from household activities (urban stormwater runoff and waste), agriculture (fertiliser use) and production activities (such as mining).

A lake that is well known for its polluted state is Zeekoevlei, a large (256 hectares) shallow freshwater lake (Harding, 1992) on the Cape Flats in Cape Town. The lake is surrounded by urban settlements, which primarily consist of low- and middle-income households. Zeekoevlei serves a greater catchment area, where agricultural, horticultural and industrial activities take place (Das, Routh, Roychoudhury and Klump, 2008: 2497). There is an enclave on a peninsula of the lake on which relatively more affluent households reside. Some residents live on the edge of the lake, while many others live within walking distance. The lake is used for recreational purposes, such as sailing and fishing, and the Zeekoevlei Yacht Club is an active user of the lake.

Zeekoevlei is, however, heavily polluted with high levels of phosphorus (International Lake Environment Committee, n.d.). The lake is hyper-eutrophic[74] as a result of anthropogenic (human) inputs (Das et al. 2008). As such the lake is very high in nutrients, which has various effects on the water quality of the lake. It reduces the water clarity and causes a proliferation of algae. In addition, the high level of nutrients causes the lake to turn green and the phyto-plankton blooms adversely affect its recreational use (Das, Routh and Roychoudhury, 2009: 509). In fact, residents in surrounding suburbs were urged not to

[74] Hyper-eutrophic lakes are defined as lakes that have high levels of nutrients, high plant production rates and an excess of plant life (United States Environmental Protection Agency, 2010: 44). A definition list is provided later in the chapter.

consume water from the lake and to avoid close contact with the water. In a newspaper interview with *Cape Argus*, the City of Cape Town acknowledged that the standard of water in inland water bodies has declined and specifically urged residents in the vicinity of these wetlands not to have direct contact with contaminated water (Davids, 2008). Zeekoevlei was mentioned as one of these water bodies.

The case study in this chapter aims to estimate the economic value of improved recreational facilities and water quality for urban households residing on the Cape Flats, in a predominantly lower-income area. The goal is to establish the value of the lake for people in surrounding suburbs, i.e. to establish whether there is a willingness to pay for improved water quality for purposes other than direct consumption (i.e. for its recreational and environmental benefit). Since there is no ready market where these values can be established, the methodology chosen is the Contingent Valuation Method (discussed in Chapter Six).

The main contribution of establishing the economic value of Zeekoevlei is to provide evidence that environmental public goods of this nature are beneficial to society and their clean-up and preservation should receive attention. Establishing the economic value of Zeekoevlei is particularly relevant when considering the costs and benefits of possible plans to improve the recreational and environmental quality of the lake. These kinds of project are relatively costly and are not the main priority of local governments, which have other pressing demands such as the provision of housing and basic services infrastructure. Even though water users may not be in a position to fully cover all clean-up costs, some financial contribution can lessen the burden on already cash-strapped local authorities. Knowledge of people's willingness to pay can assist in determining appropriate charges for improved water services.

The chapter commences with a brief overview of the status of the water quality of lakes, wetlands and rivers in Cape Town. This is followed by a discussion of the pollution status of Zeekoevlei, the case study in this chapter. The discussion elaborates on the suburbs surrounding the lake, as well as giving some attention to the influence of crime on the economic value of the lake. Section 7.4 discusses the design of the survey questionnaire, the data collection process and the methodology. It also presents the results of the descriptive and regression analyses. Section 7.5 concludes this chapter.

7.2 The water quality status of rivers and lakes in Cape Town

The water quality of South African rivers and lakes has a significant impact on water users as there is a heavy reliance on rivers to provide the bulk of the water supply. Many rivers in South Africa cannot absorb further pollution as most have been dammed and are already excessively polluted (Day, 2009). One of the most common forms of pollution is eutrophication, which is a result of excessive nutrient loading. This causes the growth of algae and other nuisance plants. Table 7.1 provides a concise typology on the trophic states of lakes.

Table 7.1: Typology of trophic states of lakes

Type of trophic state	Description
Eutrophic	A lake with high levels of nutrients, plant productivity and excessive plant life.
Oligotrophic	A lake with low levels of nutrients, plant productivity and low biomass.
Mesotrophic	A lake whose status falls between eutrophic and oligotrophic.
Hypereutrophic or Ultra-oligotrophic	A lake whose status falls at the extreme end of eutrophic or oligotrophic status.

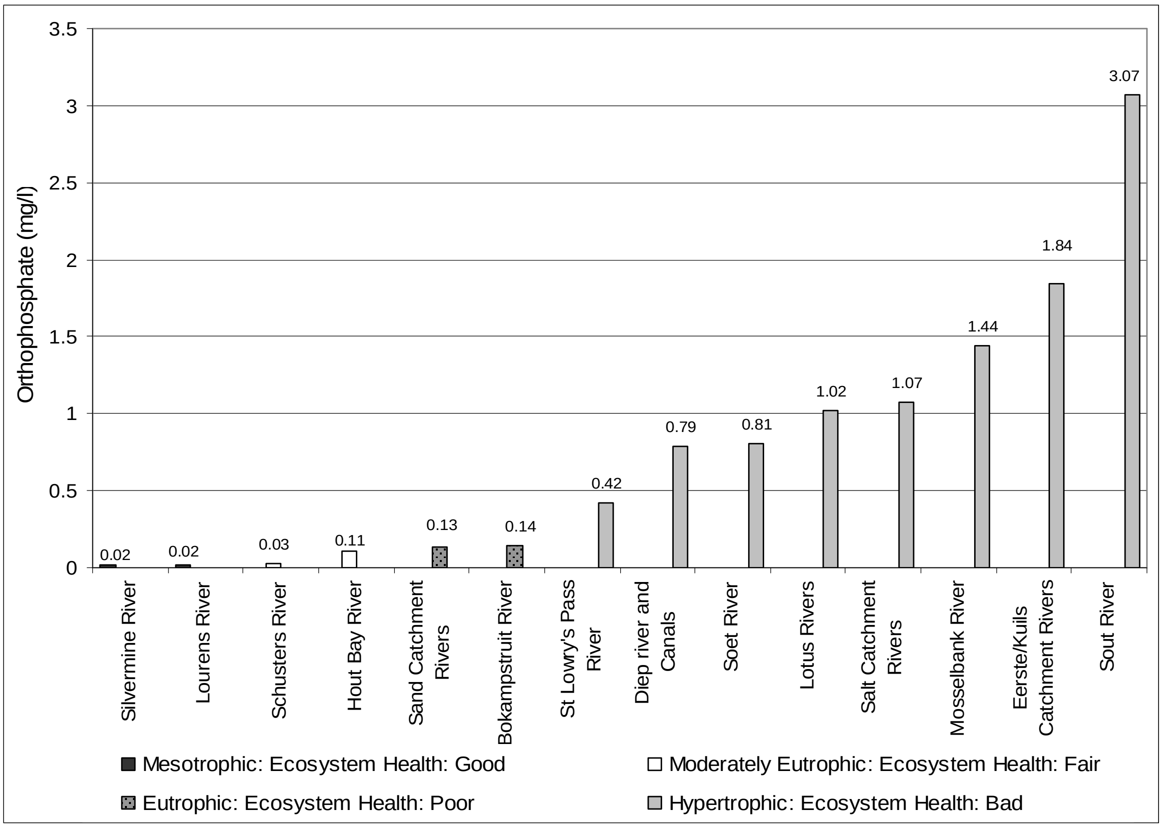
Source: United States Environmental Protection Agency (2010: 44)

The use of water by municipalities and households in South Africa increases eutrophication, which occurs as a result of large quantities of sewerage flowing into rivers in the form of salt and nutrient effluents (Day, 2009). A related problem in South Africa is the loss in dilution capacity as available water resources are fully utilised (Turton, 2008). Increasing levels of treatment will therefore be required to clean water to acceptable standards.

In its 2009 State of Environment Report, the City of Cape Town (2010) indicated that the quality of freshwater in Cape Town has declined. The report investigated the status of rivers and wetlands in the Cape Town region using three sets of guidelines. The first guideline assessed freshwater quality in terms of its trophic state, by measuring the level of phosphorus in order to determine whether a source contains low or high levels of nutrients. A eutrophic state implies that the resource has low levels of biodiversity and high levels of growth of nuisance aquatic plants and algae blooms (City of Cape Town, 2010: 40). Another yardstick is the suitability of the resource for recreational purposes, which uses the guidelines released by the Department of Water Affairs (DWA) for recreational contact with freshwater systems. A third indicator is based on the guidelines set by the River Health Programme in terms of various biological indices, which provide some guide to the health of rivers.

The trophic state of rivers and wetlands in Cape Town is shown in Figures 7.1 and 7.2. They show that the majority of the rivers are hypertrophic[75] and most of the lakes are either eutrophic or hypertrophic, in particular Zeekoevlei (which is the focus of the case study).

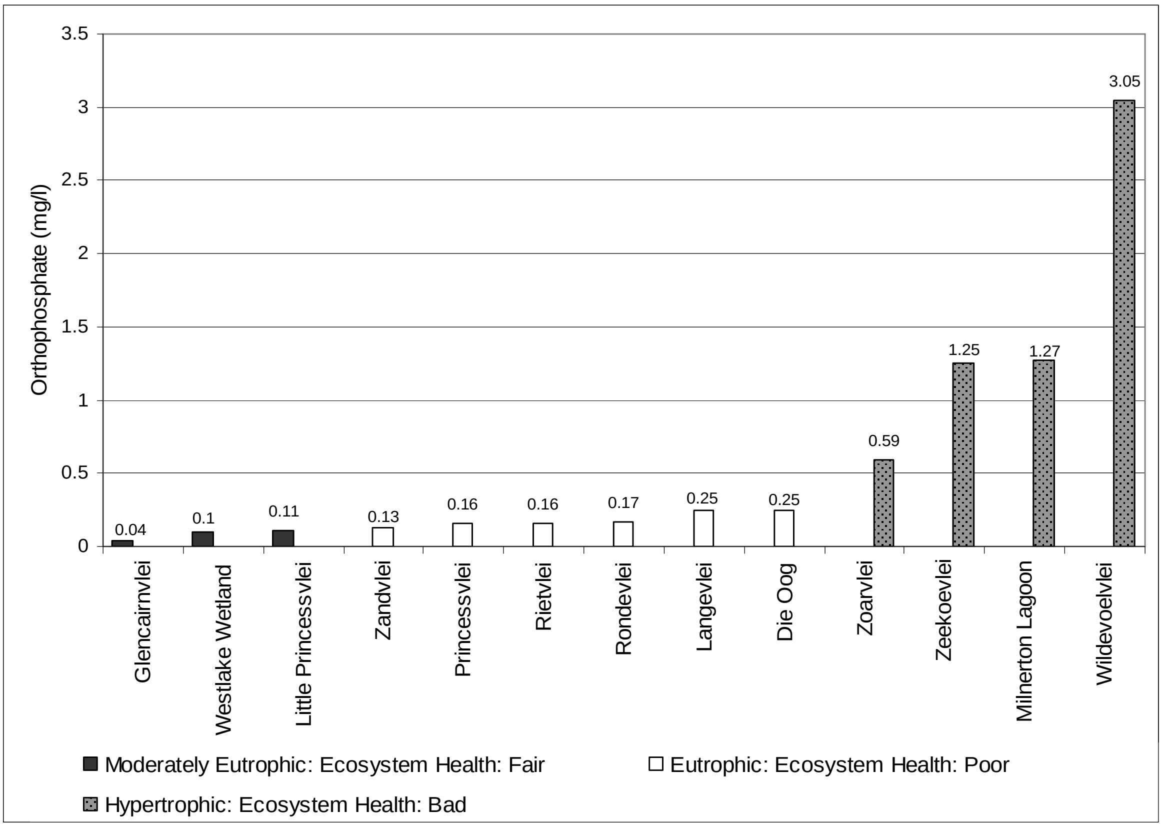
Figure 7.1: Trophic state of rivers in Cape Town, 2008/9



Source: City of Cape Town (2010)

[75] Hypertrophic has the same meaning as hypereutrophic.

Figure 7.2: Trophic state of wetlands in Cape Town, 2008/9



Source: City of Cape Town (2010)

A related finding of the State of Environment Report was that the majority of the wetlands and lakes experienced a decline in their compliance with the DWA's recreational contact standards between 2006 and 2009. This is an indication that pollution is a serious problem for most of these freshwater resources (City of Cape Town, 2010: 43).

7.3 A description of the case study area: Zeekoevlei

Zeekoevlei is a freshwater coastal lake situated on the Cape Flats. It is fed primarily by two rivers, the Big Lotus and Little Lotus Rivers. Both rivers have been identified as highly polluted (see Figure 7.1). The lake is also surrounded by urban development in the form of residential suburbs and has therefore been exposed to human disturbances in terms of nutrient loading and water level regulation (Harding and Quick, 1992: 3). Inputs from urban runoff, agricultural activities and sewerage spillages have resulted in severe pollution and the lake is classified as hypertrophic (see Figure 7.2).

An investigation of the lake's hypertrophic state revealed the following primary causes: agricultural runoff into the Big Lotus River and the Little Lotus River (from farming and horticultural activities); seepages from the wastewater treatment plant (adjacent to the lake); and stock-based sediments in the lake itself (Southern Waters, 2000). This stock pollution has accumulated over the years and at present approximately 25% of the pollution is generated by internal loading[76] from the bottom of the lake. The hypertrophic state of Zeekoevlei has caused it to be covered in algal blooms (predominantly Microcystis cyanobacteria), which can be harmful to both animals and humans (Matthews, Bernard and Winter, 2010: 2071). The dense algae blooms, encroaching bulrushes and thick layers of sediment affect the recreational use of the lake and impairs its ecosystem functioning.

A now somewhat dated survey by Quick and Johansson (1992) was conducted amongst actual users of Zeekoevlei (including both active and passive users, among them local residents). Their survey included questions on the reasons why users visited Zeekoevlei, their perception of the levels of the water pollution at the lake, and the type of activities they were involved in at the lake. Their results showed that most users visited the lake as a result of its proximity to their homes (37% of their sample). Most of their respondents (68%) lived within 10 kilometres of Zeekoevlei. They also found that a variety of recreational activities took place at the lake, such as boating, fishing and picnicking (Quick and Johansson, 1992: 248).

Zeekoevlei is a natural environmental area which is open to the public and primarily used for recreational purposes. Even though the lake can be used for direct recreational activities, such as swimming, its polluted state may not allow it. According to the City of Cape Town (2010: 43), Zeekoevlei experienced a decline in its level of compliance with the DWA's recreational contact standards from 2008 to 2009, decreasing from approximately 75% to 64% compliance. The City of Cape Town (CCT) has expressed concern over the decline in the water quality of its rivers and wetlands as they are important venues for recreation, and are crucial for ecosystem functioning, providing habitats for birdlife and aquatic vertebrates and invertebrates (City of Cape Town, 2010: 44). It therefore seems appropriate to estimate the values ascribed to boating, fishing and bird watching, as well as picnicking or simply relaxing along the shores of the lake. The lake also has value in terms of preserving the natural environment of the area. Quick and

[76] Internal loading refers to the nutrients that are released from the sediment of a lake (i.e. its muddy bottom) (Lakes and Reservoirs, n.d.).

Johansson (1992) confirmed that the activities indicated above are some of the more popular uses of the lake.

Respondents to Quick and Johansson's survey (1992) also answered questions on the water pollution of Zeekoevlei. They reported that the appearance of the lake was the main influence on people's perceptions of pollution, with most respondents referring to the litter, weeds and debris found in the lake. Many respondents also commented on the smell and (lack of) clarity of the water body (Quick and Johansson, 1992: 249). Hence, Quick and Johansson (1992) concluded that both water-based recreation and land-based recreation, such as picnicking, were affected by the visible pollution of the lake. Most respondents indicated that a clean lake implied a lake with clear water, less plant growth and a reduction in unpleasant smells. Most respondents (69%) indicated a willingness to pay an entrance fee if the facilities and the water quality improved (Quick and Johansson, 1992: 251).

The value of the lake for recreational activities may also be influenced by crime. The surrounding residential areas experience high levels of criminal activity.[77] The more remote areas (such as the shores of the lake and surrounding bushes) afford shelter to criminals and the lake area is often avoided due to the risk of exposure to crime. A commissioned study found that crime and fear for personal safety were most commonly given as reasons for stopping or limiting visits to community or neighbourhood parks in the City of Cape Town (CSIR, 2010). Criminal statistics are available for 149 police stations in the Western Cape, released by the South African Police Service (South African Police Service, n.d.). Table 7.2 provides statistics on three police stations in the vicinity of Zeekoevlei (the closest to the lake is Grassy Park).[78] The reported figures show the number of criminal incidents per category, and as a proportion of the total number of incidents in the Western Cape in parentheses.

[77] According to Gie (2009), crime statistics for the City of Cape Town for 2007/08 indicated that the number of murders per 100 000 population was higher (60) than the national average (39). Drug-related criminal activities for 2007/08 were also higher (830 per 100 000 population, compared to 228 for the national average).

[78] Statistics reported for Grassy Park police station include criminal activities that took place in the suburbs closest to Zeekoevlei (i.e. Zeekoevlei, Pelican Park, Grassy Park and Lotus River, discussed in more detail later in the case study). Strandfontein (a sub-section of Mitchells Plain) and Steenberg are two suburbs in the vicinity of the lake.

Table 7.2: Criminal activities by police station in the vicinity of Zeekoevlei (2010/11)

Category	Grassy Park	Steenberg	Strandfontein
Murder	15 (0.6)	36 (1.6)	3 (0.1)
Total Sexual Crimes	125 (1.3)	84 (0.9)	22 (0.2)
Attempted murder	23 (1.1)	54 (2.5)	2 (0.1)
Assault with the intent to inflict grievous bodily harm	274 (1.1)	153 (0.6)	31 (0.1)
Common assault	495 (1.5)	356 (1.1)	138 (0.4)
Common robbery	137 (1.3)	103 (1.0)	28 (0.3)
Robbery with aggravating circumstances	161 (1.3)	102 (0.8)	44 (0.4)
Burglary at non-residential premises	191 (1.6)	54 (0.5)	6 (0.1)
Burglary at residential premises	755 (1.7)	353 (0.8)	157 (0.4)
Theft of motor vehicle and motorcycle	146 (1.6)	70 (0.8)	60 (0.7)
Theft out of or from motor vehicle	688 (1.9)	314 (0.9)	123 (0.3)
Drug-related crime	1 640 (2.3)	1 711 (2.4)	420 (0.6)
Robbery at residential premises	17 (1.4)	3 (0.2)	2 (0.2)
Robbery at non-residential premises	19 (1.5)	8 (0.6)	6 (0.5)

Source: Own calculations. Data obtained from: Crime Statistics (2010/2011). South African Police Service (n.d.)

The number of incidents in each area as a proportion of the total number of incidents in the Western Cape is relatively small. However, it must be kept in mind that the population of each respective area is small compared to the total population in the Western Cape. For example, the 2001 Census data revealed that the population of Grassy Park and surrounding suburbs (i.e. Zeekoevlei, Lotus River and Pelican Park) were approximately 1% of the Western Cape population. Steenberg had a population of 0.08% of the Western Cape Population (City of Cape Town, n.d.).

It is evident that Grassy Park police station had a higher incidence of robberies and burglaries at non-residential premise, drug-related criminal activities and theft out of motor vehicles, as compared to Steenberg and Strandfontein. This provides some evidence that crime is a concern in the area.

Pollution and crime may therefore complement each other in reducing the recreational value of Zeekoevlei. It is likely that crime would only affect the use values of the lake and that non-use values would not be influenced as long as crime only affects the potential use of the lake. However, the estimated non-use values of the lake may be affected if people have difficulty disentangling their interest in the lake from the influence of crime.

The combined effects of pollution, the lack of recreational facilities and crime make the lake less attractive for people living in the area. In addition, the bad smell is partly caused by the pollution of the lake and partly by the sewerage treatment plant next to the lake. These factors are complementary since the negative external effects are bundled. This study does not attempt to separate out these effects, since it is very difficult to ensure that respondents make this separation. However, the study may provide some information on the effect of crime and pollution in reducing the benefit of lakes and rivers for urban communities.

Zeekoevlei is surrounded by the residential suburbs of Grassy Park, Lotus River, Pelican Park and Zeekoevlei. A section of Zeekoevlei suburb is referred to as ‘the Peninsula’ as it is isolated (the residential plots are located on a piece of land surrounded by the lake). The residents living on the Zeekoevlei Peninsula are more affluent (and more racially mixed) than the residents of the other suburbs. Table 7.3 provides a brief overview of the available socio-economic information for these suburbs.

Table 7.3: Socio-economic information on suburbs surrounding Zeekoevlei lake

Category / Suburb	Grassy Park	Lotus River	Pelican Park	Zeekoevlei[79]
Number of households	5 090	7 701	1 535	908
Females (%)	53.0	52.3	51.7	51.0
Black (%)	2.8	1.3	6.6	3.1
Coloured (%)	94.0	97.4	58.5	78.8
Indian/Asian (%)	2.4	0.8	34.0	4.9
White (%)	0.8	0.4	0.9	13.2
Age 18 and above (%)	69.6	66.9	63.4	64.4
Secondary and higher education (%)	42.3	28.2	39.1	57.0
Monthly income above R25 600 (%)	1.0	0.1	1.1	1.6

Source: Own calculations. Data from Census 2001. City of Cape Town (n.d.)

The racial composition of the suburbs indicates that this is primarily a 'Coloured' community, with Pelican Park and Zeekoevlei suburbs showing some racial mixing. The level of education differs substantially between the various suburbs. Zeekoevlei residents are clearly more highly educated, whereas educational levels in Lotus River are relatively low. Zeekoevlei also has more affluent households than the other suburbs.

7.4 Estimating the economic value of Zeekoevlei

The combination of factors influencing the recreational value of the lake (see Section 7.3) makes it difficult to estimate its environmental value. A polluted lake can have a low recreational value even if it is well policed, and a clean lake can have a low recreational value if the area is crime-ridden. All these variables affect the lake’s utility for households in the area and it seems reasonable to assume that the value of the lake may vary with the income and cultural diversity of residents in the neighbouring suburbs. The attitude of a nature enthusiast to the lake may not be shared by other people in the area. In the

[79] The suburb of Zeekoevlei includes those households living on the Zeekoevlei Peninsula. In the descriptive statistics provided later in Section 7.4.2, these households are analysed separately. However, in the regression models (in Sections 7.4.4 and 7.4.5), they are added to the other households residing in the suburb of Zeekoevlei and analysed together.

suburb of Zeekoevlei (especially on the Zeekoevlei Peninsula), some households have direct access to the lake. People living on the Zeekoevlei Peninsula constitute a local community that differs from the rest of the surrounding areas. It can be assumed that these residents' cultural background and income may result in a different attitude towards the lake. Many studies have found income to be a significant indicator of the willingness to pay for environmental quality (see Jiang et al. (2010) and Choe et al. (1996) in Chapter Six).

Factors such as human activity and traffic close to the lake can also influence pollution. In a study of the impact of open spaces in the Cape, Van Zyl and Leiman (2002: 385) interviewed estate agents regarding the influence of open spaces such as Zandvlei (a natural wetland on the Cape Flats). Security was one issue considered by buyers of property around Zandvlei. Furthermore, the distance of households from the lake is probably another factor that could influence its value to residents.

The availability of alternative recreational sites is another factor that could influence people's willingness to pay for improved recreational facilities and water quality. If there are other sites in the vicinity that provide scope for similar recreational activities, households may be less willing to pay for Zeekoevlei's improvement. During focus group meetings it was established that many households used the nearby Zandvlei[80] wetlands for recreation.[81] From these discussions it was evident that Zandvlei provided better recreational facilities and that people generally felt safer taking their families there for an outing, as compared to Zeekoevlei. Zandvlei can therefore be considered as an alternative recreational site to Zeekoevlei.

[80] Zandvlei is approximately 10 kilometers away from Zeekoevlei, thus they are in the same vicinity.

[81] Two focus groups formed part of the initial pilot study that will be discussed in more detail in Section 7.4.1.

7.4.1 Methodology

In Chapter Six it was established that the CVM can be applied when no market for environmental goods exists and where use and non-use values need to be determined. The CVM "has been extensively used to assess the use and non-use value of environmental amenities, and continues to be developed as a tool for this purpose" (Jennings and Curtis, 2002: 1).

As emphasised in Chapter Six, the design of the questionnaire (such as the question elicitation format and the choice of payment vehicle) is crucial in accurately estimating willingness to pay. The questionnaire for this study was based on the existing empirical literature, particularly that of Carlsson et al. (2004) and Loomis et al. (2000). The questionnaire included questions on the social, economic and cultural characteristics of households, their attitudes towards Zeekoevlei as an environmental area and their use and enjoyment of the lake, as well as questions on the non-use value of the lake (see Addendum B and Addendum C for copies of the questionnaires). Questions pertaining to demographic information about households, such as age, household size, income and education, were also included, as well as some questions on the possible impact of crime on the respondents' use of the lake.

The questions on willingness to pay (WTP) were divided into two sections. The first section focused specifically on the recreational use value of the lake, given the facilities available at the lake. Hypothetical questions about the recreational facilities were included, as this was necessary to determine the use value of the lake. The second section focused on the environmental value of the lake and included both use and non-use values, based on the assumption that people would derive value from possible (hypothetical) improvements to the water quality of the lake. For households living in suburbs surrounding the lake (i.e. but not directly adjacent to the lake), there was a risk that some value might not be captured. The questionnaires used for such households therefore consisted of both sections. In contrast, households living next to the lake would generally not use the eastern side of the lake, where most of the recreational facilities (such as picnic facilities and ablution blocks) were located. They had to respond to questions about recreational value based only on improvements in water quality (and not to questions about the recreational facilities), since they had already chosen to buy property next to the lake. For this reason, the questionnaires used in these cases included only the second section.

The format of the WTP questions was primarily referendum-type (i.e. binary choice questions). As discussed in Chapter Six, referendum questions ask the respondent whether he or she would be willing to pay a specified amount for a particular (environmental) improvement. A positive response to the question indicates a willingness to pay equal to or higher than the specified amount. A refusal of the bid offered indicates that the specified amount can be taken as the upper bound of the respondent's willingness to pay. As discussed previously, an advantage of the referendum-type question is that it allows for a simple disclosure of willingness to pay and resembles a market transaction where the consumer can decide whether to pay a particular price.

The referendum questions followed a sequential structure, which Jiang, Jin and Lin (2011: 188) argue is a natural way of asking questions. People would first be asked whether they are willing to pay increased fees, and those who agree would then be asked whether they are willing to pay a specific fee increase. In this case respondents were first asked whether they were willing to pay for improved recreational facilities and/or cleaning of the lake (i.e. the initial WTP question). This was followed by a second referendum question, which asked about their willingness to pay a specified price (the bid amount). In the case of water quality, respondents were asked whether they would be willing to pay a monthly fee (referred to as a 'clean-up fee' in the questionnaire). The questionnaire used four different monthly fees, i.e. R10, R20, R30 and R50. These fees were based on the information gathered from the focus groups and the pilot study. Each respondent had to answer to a particular bid amount and the distribution of the bid amounts in the questionnaires was determined beforehand. The fieldworker therefore had no influence on the selection of the questionnaire or its completion at any particular location.

The payment vehicle of charging a hypothetical 'clean-up fee' was chosen to reduce possible bias arising from people's responses to other types of payment options, such as taxes or donations. To make the hypothetical payment seem more realistic, it was framed within the context of a fixed monthly fee (similar to that charged in a regular municipal bill).[82] However, respondents were informed that payments were hypothetical, i.e. they would not in fact be expected to pay any fees.[83] The second closed-ended question was followed up by asking the respondents to state the maximum amount they would be

[82] This is similar to Stenger and Willinger (1998: 185), who used the water bill as their payment vehicle.

[83] The researchers felt this would elicit a more honest response from respondents, especially since they might have been concerned about a possible increase in their utility bills.

willing to pay to clean up the lake. Using both an open-ended and a closed-ended question makes a comparison of the WTP estimates of alternative methods possible. According to Brown et al. (1996), as cited in Stenger and Willinger (1998), the closed-ended question usually overestimates willingness to pay, as compared to values obtained from open-ended questions.

In the case of improved recreational facilities at the lake, the referendum questions followed the same sequential format. The initial WTP question asked respondents whether they would be willing to pay for improved recreational facilities. The second question asked whether they would be willing to pay a specific entrance fee. Four different fees were used, i.e. an entrance fee of R2, R3, R5, or R10 per person per visit. Once again the fees were based on discussions in the focus groups, as well as a comparison with fees charged by other national parks and lakes at the time. The second closed-ended question was again followed by an open-ended question, which asked for the maximum entrance fee respondents would be willing to pay.

Two focus group meetings and a small pilot survey were conducted before the main survey. One meeting took place with residents from Grassy Park; the other focus group meeting was held at the Zeekoevlei Nature Reserve with residents from the suburb of Zeekoevlei. The meetings were generally informative and the participants were later excluded from the main survey. Five students from the University of the Western Cape were appointed to collect the data. They were all majoring in Economics, and some of them were completing a postgraduate qualification. Most of them had completed a course in Public Economics and were familiar with environmental externalities. All of them were also familiar with the study area, which consisted of four suburbs: Grassy Park, Lotus River, Pelican Park, Zeekoevlei, and those living on the Zeekoevlei Peninsula. This was an important requirement, as experience of the data collection process in the earlier case study (the water demand study in Chapter Four) made it apparent that residents of certain suburbs do not trust outsiders (or 'strangers'). It would, for example, be less effective to send English-speaking fieldworkers into suburbs where the home language was predominantly Afrikaans. This meant that the researchers had to carefully select fieldworkers.

Detailed street maps of the suburbs were demarcated into several blocks, which were then assigned to the fieldworkers. In addition, the fieldworkers were provided with precise information on the areas to be covered and how to react to non-responses. Fieldworkers were given training in the methodology, such as how to approach householders, and how to ensure respondents were not pressurised into providing certain kinds of answers. In particular, they attended a training session where the basics of environmental externalities and valuation techniques were discussed, and the basics of the CVM were explained. Training was provided on the questionnaire itself and on the field work process. Fieldworkers were informed of the relevance of every question in the questionnaire and given guidance on how to approach the hypothetical scenario for the WTP questions.

7.4.2 Descriptive statistics

The total number of questionnaires completed was 384. These consisted of 26 questionnaires to households living adjacent to the lake and 358 questionnaires to households living in the vicinity of the lake. The sample size is approximately 3% of the total number of households (based on Census 2001 data released by the City of Cape Town (n.d.), which gave a total of 15 234 households in the sample suburbs). Although this is a relatively small sample size, it is adequate for the purpose of determining whether residents in suburbs surrounding Zeekoevlei attach value to the lake. This is much larger than the exercise of Birol et al. (2006: 117), who used a sample of 122 respondents to determine whether the public attached non-use value to Cheimaditida wetland in Greece.

Table 7.4 shows the distribution of questionnaires by suburb and income group.

Table 7.4: Percentage distribution of questionnaires completed by suburb and income group

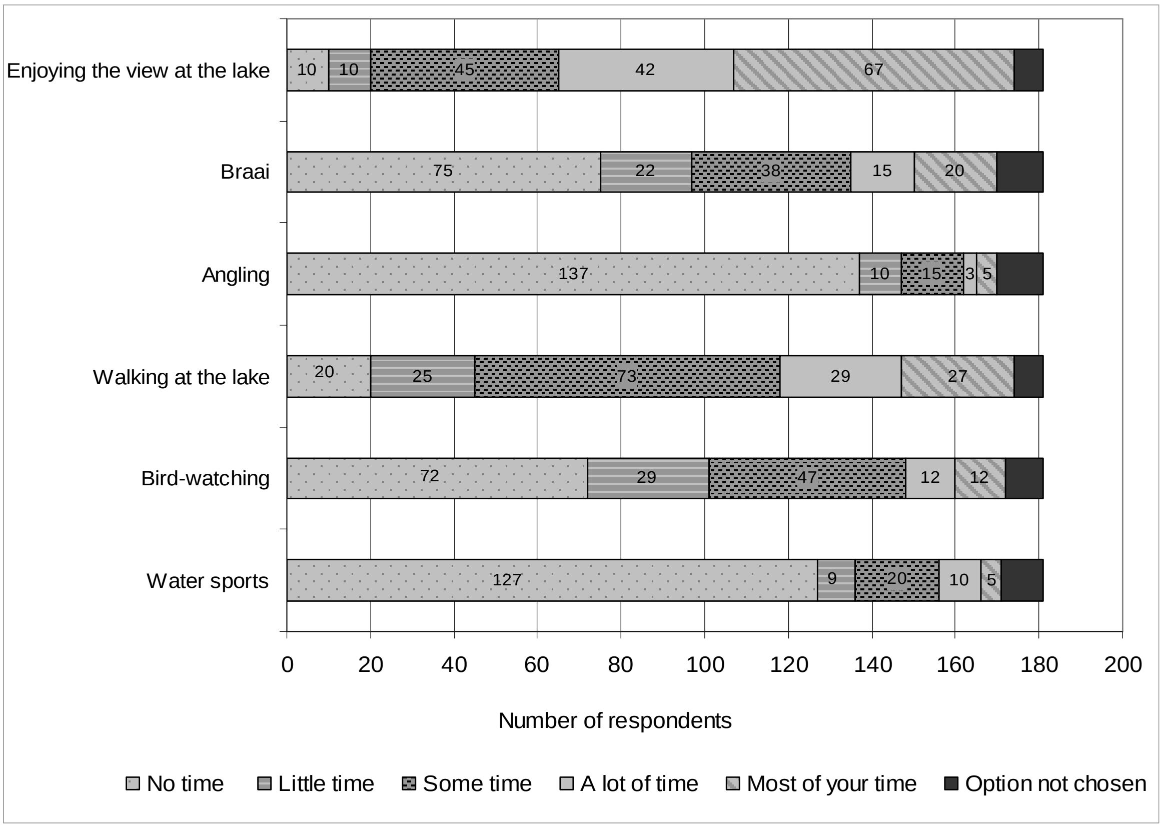
Income Group (Rands per month)	Grassy Park	Lotus River	Pelican Park	Zeekoevlei	Zeekoevlei Peninsula	Total
1) R0 to R1 000	2.4	6.6	4.8	0.0	0.0	3.9
2) R1 001 to R5 000	32.3	33.9	14.5	21.1	5.4	25.8
3) R5 001 to R10 000	31.4	32.2	37.4	26.3	10.8	30.7
4) R10 001 to R20 000	25.0	19.8	33.7	47.4	43.2	28.1
5) Greater than R20 000	8.9	7.5	9.6	5.2	40.6	11.5
Total	100	100	100	100	100	100

Source: Own calculations

More than two thirds of the respondents living in Grassy Park and Lotus River earned less than R10 001 per month, whereas approximately 43% of respondents in Pelican Park earned more than R10 000 per month. Just over half (52.6%) of Zeekoevlei respondents earned above R10 000 per month, as compared to approximately 84% of respondents living on the Zeekoevlei Peninsula. This is a rough illustration of the economic differences between suburbs. The economic profile of the sample is therefore similar to the profile of the suburbs shown in Table 7.3. Zeekoevlei (including the Zeekoevlei Peninsula) was the most affluent suburb, while Lotus River was the poorest suburb.

Of the 384 respondents, 6.7% indicated they lived next to the lake, while 52% were within walking distance. Thus, almost 60% of the respondents lived very close to the lake. Approximately 40% could only reach the lake by car. Respondents were asked whether they actively visited, used or derived enjoyment from the lake, as well as what type of activities they engaged in at the lake. Approximately 53% of the respondents indicated that they did not visit, use or enjoy the lake. However, of those respondents residing next to the lake, 92.3% indicated that they used or enjoyed the lake. In contrast, only 43.8% of respondents not living next to the lake indicated that they visited the lake. The 181 respondents who indicated they used or visited the lake rated the amount of time spent on recreational activities at the lake, on a scale ranging from 'no time' to 'most of your time' for each activity. These results are shown in Figure 7.3.

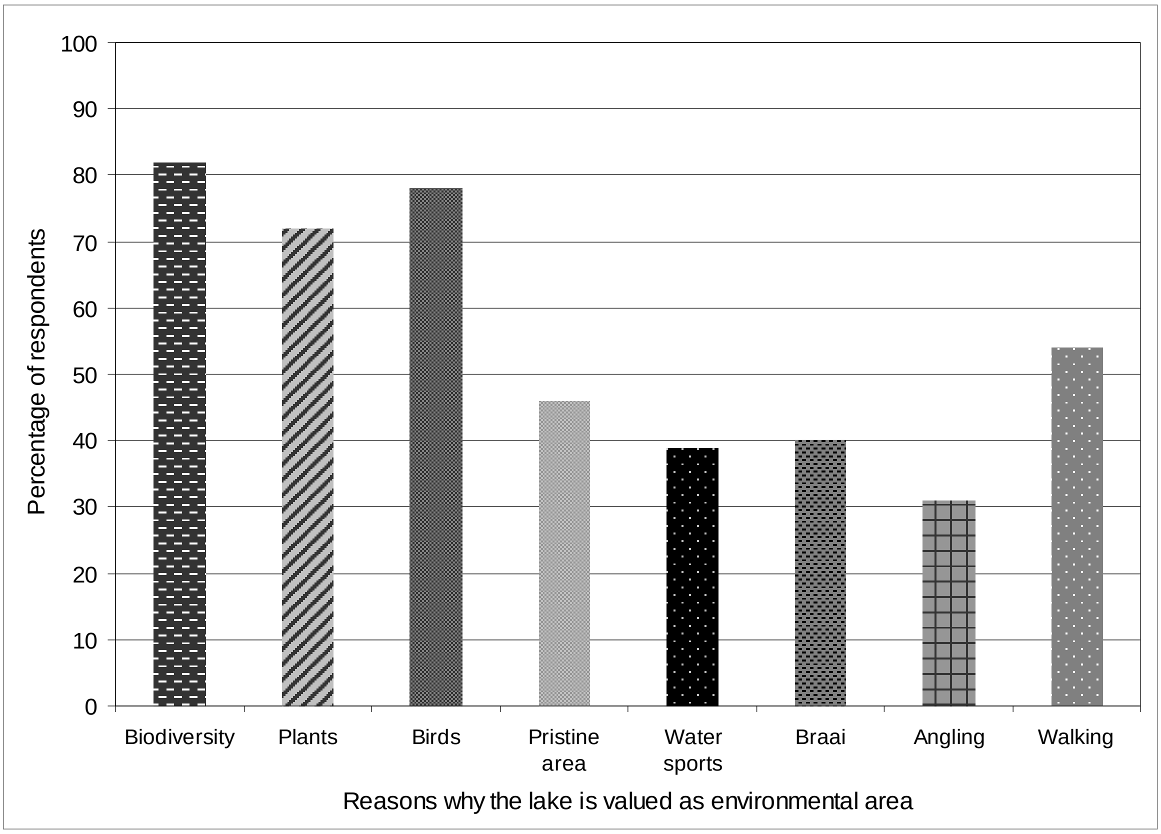
Figure 7.3: Recreational activities at the lake



Source: Own calculations

An important aim of the questionnaire was to ascertain whether Zeekoevlei was valued as an environmental area. Of those respondents who indicated that they used, enjoyed or visited the lake, almost all affirmed that they viewed the lake as an environmental area, i.e. an area that needed to be preserved. Approximately 76% of the respondents who indicated that they did not visit the lake stated that they viewed the lake as an environmental area. This is a crude indicator that there was an option value or non-use value for the lake. In addition, respondents who affirmed that they regarded the lake as an environmental area also gave reasons for their response. These are shown in Figure 7.4. The environmental factors, which were chosen by more than 75% of the respondents, included biodiversity and bird life. Walking at the lake was a popular reason for regarding the lake as an environmental area.

Figure 7.4: Percentage of respondents who value the lake as environmental area for diverse reasons



Source: Own calculations

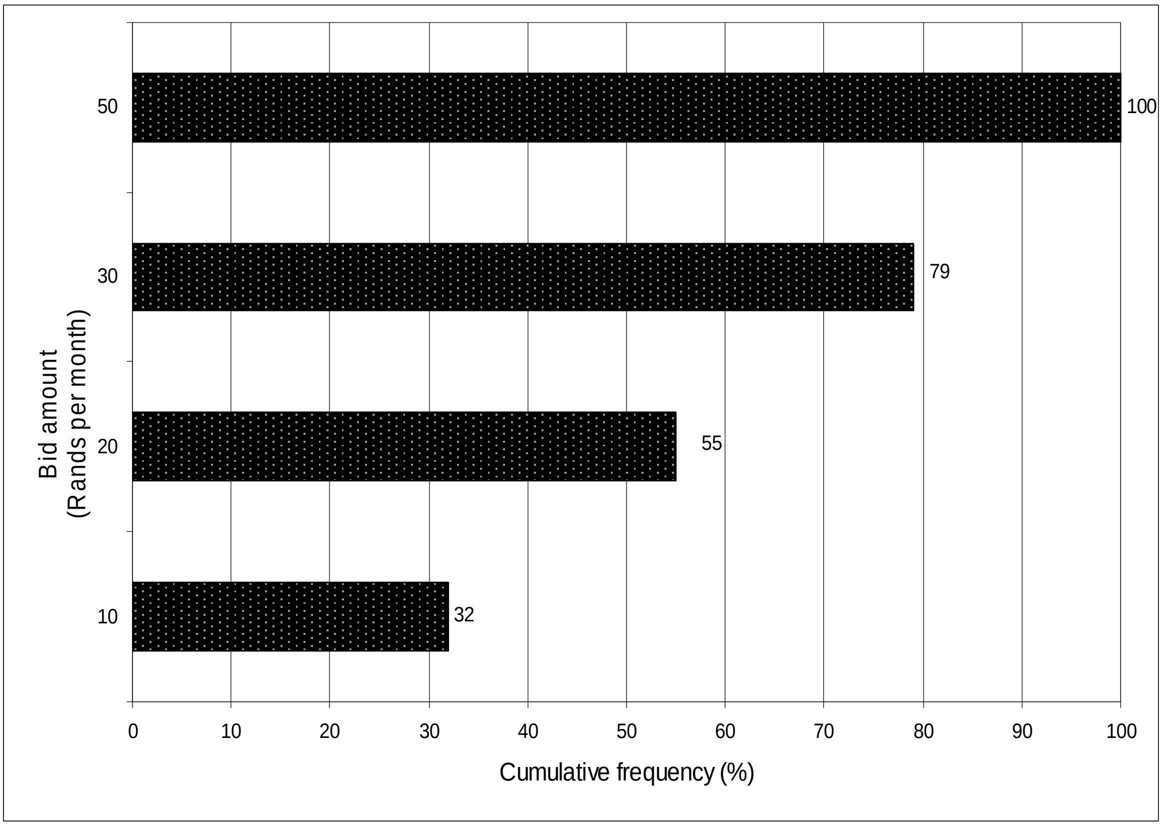
Table 7.5 indicates the proportion of 'yes' responses to the initial WTP question, i.e. whether respondents would be willing to pay for improvements in water quality. Approximately 29% of the 384 respondents answered 'no' to this question. Of the 273 respondents who said 'yes' to the first question, 73.3% (i.e. 200 respondents) were willing to pay the specified bid amount in the second WTP question. Figure 7.5 shows the cumulative proportion of these 'yes' respondents, given the bid offered. Of these 200 respondents, Figure 7.5 shows that 32% (64) accepted the lowest bid (i.e. R10), while 21% said 'yes' to the highest bid of R50.

Table 7.5: Frequency of binary responses to closed-ended WTP questions (Improved water quality)

Binary response	Frequency	Percentage (%)	Cumulative frequency (%)
Initial WTP question			
No	111	28.9	28.9
Yes	273	71.1	100
Second WTP question			
Binary response	Frequency	Percentage (%)	Cumulative frequency (%)
No	73	26.7	26.7
Yes	200	73.3	100

Source: Own calculations

Figure 7.5: Cumulative frequency (%) of 'yes' responses to respective bid amounts (in response to the second WTP question for improved water quality)



Source: Own calculations

Figure 7.5 shows a decrease in the proportion of 'yes' responses as the bid amount increases. This decrease is similar to the findings of Carlsson et al. (2004) in a study examining the determinants of the willingness to pay for community woodlots. In the case of Zeekoevlei, a total of 70 respondents faced the lowest bid, of which 91.4% answered 'yes' to it. In total 75 respondents were offered the highest bid of R50. 56% of these respondents said 'yes' to it. It is therefore evident that the 'choke price' was not chosen appropriately despite discussions and feedback from the focus groups. This indicates a possible design limitation in the questionnaire; higher bid amounts should have been included in the survey.

A similar outcome is found when looking at the WTP questions for improved recreational facilities. Table 7.6 shows the proportion of 'yes' responses to the initial and second WTP questions, while Figure 7.6 indicates the cumulative proportion of respondents who answered 'yes' to the bid offered in the second WTP question. Of the 280 respondents who voted 'yes', Figure 7.6 shows that 28% (78) of these 'yes' respondents accepted the lowest bid (i.e. R2), while 23% accepted the highest bid.

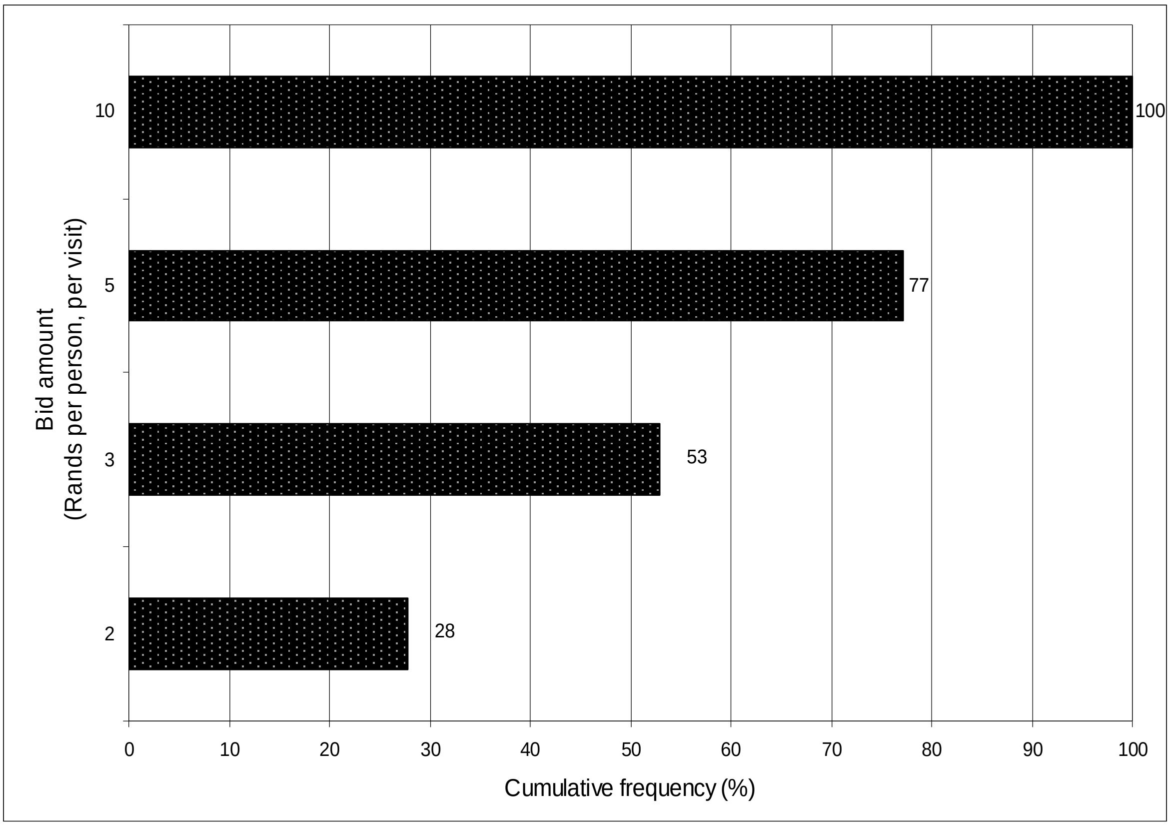
Table 7.6: Frequency of binary responses to closed-ended WTP questions (Improved recreational facilities)

Initial WTP question			
Binary response	Frequency[84]	Percentage (%)	Cumulative frequency (%)
No	54	15.1	15.1
Yes	303	84.9	100
Second WTP question			
Binary response	Frequency	Percentage (%)	Cumulative frequency (%)
No	23	7.6	7.6
Yes	280	92.4	100

Source: Own calculations

[84] In the case of WTP questions for improved recreational facilities, only 357 respondents answered these questions. This is explained in more detail later in Section 7.4.5.

Figure 7.6: Cumulative frequency (%) of 'yes' responses to respective bid amounts (in response to the second WTP question for improved recreational facilities)



Source: Own calculations

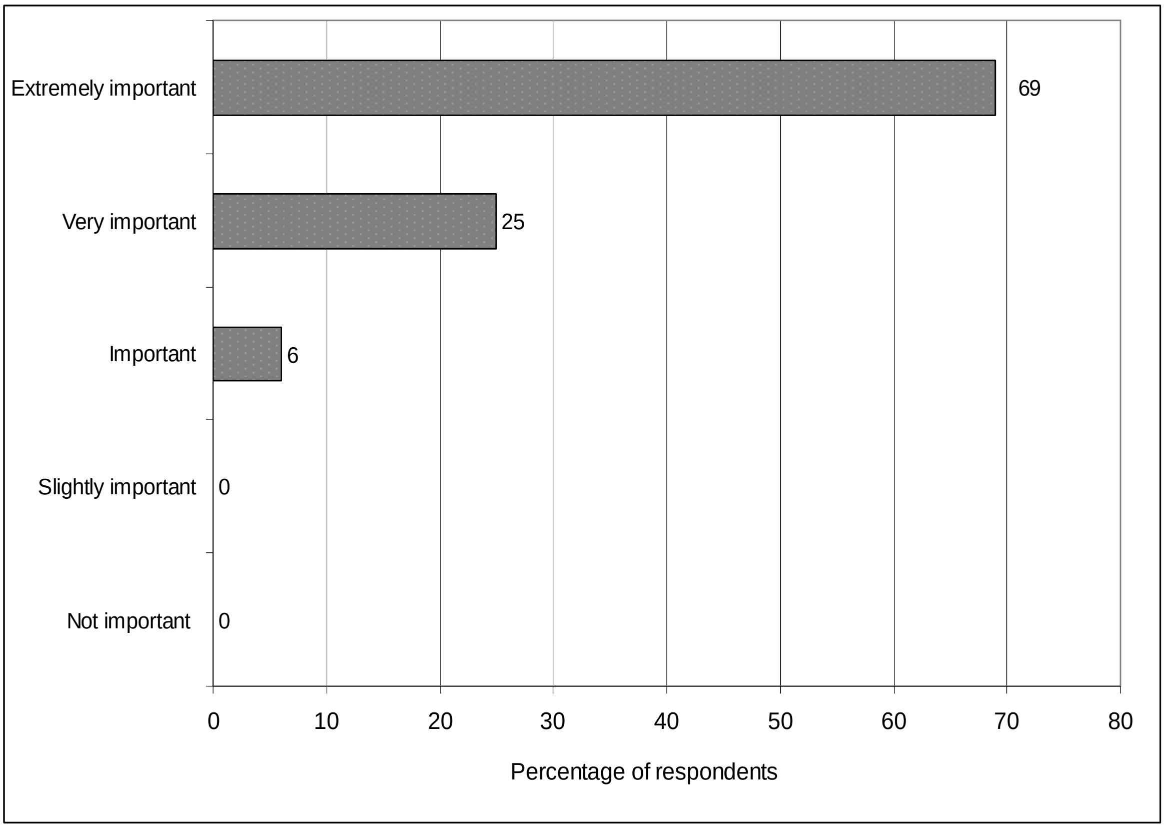
In total 92 respondents faced the lowest bid. Once again 84.8% of these respondents accepted the bid. 94 respondents faced the highest bid of R10, of which 68.1% (64) of respondents said 'yes' to it.

Researchers in developing countries often set the range of referendum prices too narrowly (Whittington, 1998: 24). This can be ascribed to various factors, such as the highly unequal distribution of income. Interviewers in these countries have also indicated that it seems pointless to ask respondents to react to an unrealistically high price, one that respondents will obviously not be able to afford. This is, however, exactly the purpose of including such a price; one needs to establish a 'choke price', one which most respondents would refuse to accept. Similar arguments apply in the case of a price that is set too low; a price should be included which is so low that almost all respondents will accept it. However, the purpose of the contingent valuation study must also be considered. If it is to establish as accurately as possible what revenues would be if a particular project is implemented, then it is pointless to use prices that are too low, which would be more applicable if the purpose it to accurately determine economic benefits (Whittington, 1998: 29).

7.4.3 The impact of crime on attitudes towards Zeekoevlei

Most people in South Africa are concerned about levels of crime and this also applies to people living on the Cape Flats. To determine whether safety at the lake influenced attitudes to its use as a recreational facility, some questions focused specifically on crime and policing. An investigation revealed a strong correlation between willingness to visit the lake and perceptions of crime in the area. Approximately 89% of the respondents indicated that effective policing would increase their willingness to visit the lake and use its facilities. Figure 7.7 reflects the scale of importance of proper policing for the respondents. It is evident that crime is of great concern to most respondents and that effective policing will make a considerable difference to their perceptions of the lake.

Figure 7.7: The importance of effective policing at the lake



Source: Own calculations

As indicated earlier, approximately 53% of all the respondents indicated that they did not visit, use, or enjoy the lake. However, 25% of these respondents also indicated that they did not value the lake as an environmental good. A more detailed investigation of the reasons for this response revealed that pollution and crime at the lake were among the more important reasons for these responses. Table 7.7 provides information on the responses received from these 50 respondents, showing how both pollution and crime make the lake less attractive as an environmental asset.

Table 7.7: Importance of crime and pollution on the environmental value of the lake for respondents who did not value the lake as environmental good (N = 50)

Factors influencing the environmental value of the lake		Scale of agreement	
	Completely agree	Highly agree	Agree
Dangerous at lake	60%	12%	10%
Polluted lake	54%	20%	12%

Source: Own calculations

It is evident that most of these respondents chose crime and pollution as two of the most important reasons for not valuing the lake as an environmental good. The survey questions revealed that 70% of the 50 respondents indicated that both danger at the lake and the polluted state of the lake were extremely important reasons for them not valuing the lake as an environmental area.

7.4.4 Estimating the willingness to pay for improved water quality at Zeekoevlei

The econometric analysis of the referendum questions usually entails estimating the probability that a respondent would pay the amount stipulated in the question (Loomis et al. 2000). In the case of closed-ended referendum questions, the probit or logit model is an appropriate methodology. For some policy issues, however, the WTP questions can generate answers that produce a fat tail distribution, which results in unrealistically high WTP estimates (Ready and Hu, 1995). A possible way of addressing this problem is through censoring. Where a long right-hand tail distribution exists in the WTP data, it can be censored to fall within a realistic share of the household's budget (B); i.e. a maximum amount that respondents would probably be willing to pay can be chosen and included in the analysis.

In this case, an interval regression was used as the main econometric model. This is similar to the empirical models of Jiang et al. (2011), who also used a sequential 'willingness to pay' question structure. They emphasised that an interval regression allows for modelling "the joint probability of the households revealing themselves into respective categories" (Jiang et al. 2011: 188). For the Zeekoevlei case study, the initial WTP question places the respondent in an interval of either [0, B] if they answered 'yes' to this question, or [., 0] if they answered 'no' (assuming in the latter case that respondents might experience a negative WTP[85]). B is the budget share, as explained above. The WTP interval for respondents who answered 'yes' to the initial question can be further divided into the following intervals: if they refused the bid amount offered (i.e. a bid of R10, R20, R30 or R50 per month) their interval is [0, bid] and if they accepted the bid their interval is [bid, B].

The regression analysis in this section focuses on estimating the willingness to pay for an improvement in the water quality of Zeekoevlei. This would mean a reduction in the pollution levels of the lake. An interval regression was applied to estimate the WTP for improved water quality. As explained above, each household either accepted or refused the initial WTP pay question. Those respondents who answered 'yes' then had to accept or refuse a specified bid amount. If the bid was accepted it was used as the lower bound. In applying censoring an upper bound was set at 3 per cent of the household's income[86] (making the assumption that this is the maximum realistic amount the household would be willing to pay as an environmental fee). If the bid is not accepted, the bid becomes the upper bound, while the lower bound is set at zero. A description of the variables used in the regression analyses is given in Table 7.8 and the summary statistics in Table 7.9.

[85] In the case of left censoring, the lower bound of the interval was specified as a point (.), which indicates that the WTP can assume any value below the upper bound (0 in the case of the initial WTP question). Therefore, the WTP may also be negative for some respondents. Even though it is generally assumed that people will not receive a disbenefit with an environmental good, it may be possible that some respondents view improvements at the lake as a disbenefit if more people were to start using it (in addition to a belief that criminal activities in the area will continue). Jiang et al. (2011: 187) also assumed a possible non-positive WTP for respondents who indicated 'no' to the first WTP question.

[86] The midpoints of the income categories were used to determine an income level for each household.

Table 7.8: Variables in regression models

Variable	Description
Bid	Bid amounts for environmental fee, ranging from R10 to R50 per month
Bid entrance[#]	Bid amounts for entrance fee, ranging from R2 to R10 per person per visit
Grassy Park	Dummy variable for suburb: Grassy Park
Lotus River	Dummy variable for suburb: Lotus River
Pelican Park	Dummy variable for suburb: Pelican Park
Zeekoevlei	Dummy variable for suburb: Zeekoevlei
Age	Age of respondent
Male	Dummy variable: equal to 1 if respondent is male
Household size	Size of household
Education1	Dummy variable: no schooling, primary and secondary school (excluding those who have completed secondary school)
Education2	Dummy variable: completed secondary school
Education3	Dummy variable: completed secondary school and higher education
Income1	Income dummy for monthly income of R0- R5 000
Income2	Income dummy for monthly income of R5 001- R10 000
Income3	Income dummy for monthly income of R10 001- R20 000
Income4	Income dummy for monthly income greater than R20 000
Visit / Use	Dummy variable: equal to 1 if respondent indicated he or she visits or uses other lakes
Value	Dummy variable: equal to 1 if respondent indicated he or she values Zeekoevlei as environmental area
Other lake	Dummy variable: equal to 1 if respondent indicated he or she visits or uses Zeekoevlei
Policing	Dummy variable: equal to 1 if respondent indicated he or she thinks effective policing at the lake is important

[#] This variable is only used in the regression models for improved recreational facilities, shown later in Table 7.15.

Table 7.9: Summary statistics of regression variables

Variable	Observations	Mean	Standard Deviation	Min	Max
Bid	384	27.63	15.015	10	50
Bid entrance	357	5.09	3.148	2	10
Grassy Park	384	0.32	0.468	0	1
Lotus River	384	0.32	0.465	0	1
Pelican Park	384	0.22	0.412	0	1
Zeekoevlei	384	0.15	0.353	0	1
Age	384	44.05	15.496	15	78
Male	384	0.46	0.499	0	1
Household size	384	4.42	1.833	1	12
Education1	384	0.43	0.496	0	1
Education2	384	0.24	0.427	0	1
Education3	384	0.33	0.471	0	1
Income1	384	0.30	0.457	0	1
Income2	384	0.31	0.462	0	1
Income3	384	0.28	0.450	0	1
Income4	384	0.11	0.319	0	1
Visit / Use	384	0.47	0.500	0	1
Value	384	0.85	0.359	0	1
Other lake	382	0.49	0.501	0	1
Policing	384	0.89	0.319	0	1
WTP lower bound (water quality)#	273	18.68	16.904	0	50
WTP upper bound (water quality)	384	164.19	196.896	0	678.48
WTP lower bound (recreational facilities)#	303	4.44	3.184	0	10
WTP upper bound (recreational facilities)	357	38.83	33.477	0	113.08

Note these lower bound variables do not include the observations where the lower bounds were specified as (.).

Source: Own calculations

Table 7.10 shows the results for a preliminary interval regression model. The regression equation was weighted according to the number of households in each of the different suburbs.[87]

[87] Since 'stratified' sampling was used so that surrounding suburbs were represented, the mean WTP was weighted. This was done by weighting each suburb according to the actual number of households in that suburb. The statistics on the number of households in each suburb were obtained from the City of Cape Town (n.d.) - see Table 7.3.

Table 7.10: Preliminary interval regression (Improved water quality)

Variable	Coefficient	Z-value
Age	-0.158	*(-0.85)*
Household size	3.282**	*(2.30)*
Male	-11.444**	*(-2.13)*
Education2	19.183***	*(2.74)*
Education3	6.774	*(0.99)*
Grassy Park	18.366***	*(2.59)*
Lotus River	28.400***	*(3.98)*
Zeekoevlei	46.259***	*(4.45)*
Income2	4.734	*(0.70)*
Income3	10.182	*(1.34)*
Income4	-22.440**	*(-2.15)*
Visit / Use lake	4.878	*(0.87)*
Value lake	6.528	*(0.83)*
Other lake	4.394	*(0.82)*
Policing	7.679	*(0.78)*
Constant	-23.457	*(-1.48)*
Number of observations	382[88]	
Mean WTP# (per month)	R25.79	

Z-values in parentheses.
Level of significance: *** - significant at the 1% level, ** - significant at the 5% level, * - significant at the 10% level.
Mean WTP was estimated using the predict function in STATA (predicting WTP to fall within the lower bound and the upper bound values).

Source: Own calculations

The suburb dummies showed that all three suburbs (Grassy Park, Lotus River and Zeekoevlei) were significantly more willing to pay a fee for improved water quality than the reference suburb (Pelican Park). This result was unexpected since Pelican Park is within walking distance from the lake (as opposed to Grassy Park and Lotus River). Pelican Park

[88] There are only 382 observations in total as two observations were excluded due to missing data for one of the explanatory variables ('Other lake').

residents could therefore benefit from improvements to Zeekoevlei, both as a recreational and environmental good. Post-estimation tests of differences between the suburb dummies revealed that there was a significant difference between Grassy Park and Lotus River, as well as between Zeekoevlei and Lotus River. The most significant difference, however, was between Grassy Park and Zeekoevlei.

The income dummies were mostly positive, but insignificant (compared to the reference group, i.e. Income1). However, the highest income group showed a negative and significant coefficient. This is a surprising result, as the empirical literature has shown that high-income households are more likely to demand a cleaner environment and would therefore be more willing to pay a fee. On the basis of this result, this model was discarded and new interval regression models were estimated which excluded income as an explanatory variable. The results for these regression models are shown in Table 7.11.

Table 7.11: Main interval regression models (Improved water quality)

Variable	*Model 1* Coefficient	*Model 2* Coefficient	***Model 3*** Coefficient
Age	-0.248	-0.222	-0.039
	(-1.37)	*(-1.10)*	*(-0.19)*
Household size	2.921*	2.688	2.208
	(1.88)	*(1.54)*	*(1.23)*
Male	-11.136**	-11.693***	-6.373
	(-2.12)	*(-2.03)*	*(-1.05)*
Education2	17.792**	21.610***	21.441***
	(2.49)	*(2.73)*	*(2.66)*
Education3	5.532	7.539	8.878
	(0.86)	*(1.06)*	*(1.20)*
Grassy Park	18.046***	17.902**	22.513***
	(2.61)	*(2.43)*	*(3.12)*
Lotus River	27.393***	27.511***	26.662***
	(4.00)	*(3.67)*	*(3.59)*
Zeekoevlei	43.195***	42.240***	61.114***
	(4.20)	*(3.83)*	*(5.13)*
Visit / Use lake	4.444	5.172	4.262
	(0.80)	*(0.85)*	*(0.69)*
Value lake	5.714	6.453	5.288
	(0.71)	*(0.72)*	*(0.59)*
Other lake	3.753	3.507	4.910
	(0.71)	*(0.59)*	*(0.82)*
Policing	9.233	9.432	8.280
	(0.97)	*(0.94)*	*(0.79)*
Constant	-14.992	-17.796	-22.218
	(-0.98)	(-1.07)	(-1.32)
N	382	358	328
Mean WTP (per month)	R 25.67	R 24.84	R 30.67

Z-values in parentheses.
Level of significance: *** - significant at the 1% level, ** - significant at the 5% level, * - significant at the 10% level.

Source: Own calculations

Model 1 included all observations (apart from the exclusion of two observations due to missing data), but excluded the income dummy variables. The second model (i.e. Model 2) excluded inconsistent responses. An exploration of the answers to the WTP questions revealed that some households provided inconsistent answers. For example, respondents were asked whether they were willing to pay an environmental fee. If respondents answered 'yes', they were offered one of the five bid amounts. In the follow-up open-ended question, they were then asked what their maximum willingness to pay would be. If this latter amount was lower than the bid offered in the referendum question, a respondent was classified as an inconsistent respondent (i.e. giving an inconsistent response). In all 24 respondents were identified as inconsistent respondents. Excluding these from the sample left the total number of households at 358.

A further analysis was to investigate the impact of protest responses on the WTP. As discussed in Chapter Six, protest responses are made by respondents who might place some value on the environmental good, but do not show any willingness to pay. A payment vehicle such as taxes might cause protest respondents to indicate a zero bid. According to Jiang et al. (2011: 183), it is important to address protest responses in CVM studies, since they may have a profound effect on the WTP estimation, and therefore on policy decision-making and implementation.

To determine whether protest responses were present in the Zeekoevlei case study, questions were included to determine why some respondents refused to answer the WTP question. They were asked whether they were opposed to paying a charge. Respondents who indicated 'yes' to this option and also stated that they were either paying enough taxes, or that it was government's responsibility to clean Zeekoevlei, were classified as providing protest responses. Some 30 respondents were regarded as providing protest responses. The interval regression which excluded both inconsistent and protest responses is shown as Model 3 in Table 7.11. The discussion of the regression results below is therefore applicable to the findings of Model 3.

As far as the explanatory variables are concerned, household size had a positive yet insignificant coefficient, which may indicate that larger households were more willing to pay a fee. A possible explanation is that households with larger families (especially those with young children) are more likely to spend time at the lake and would therefore be more willing to pay for improvements in its environmental quality. Male respondents were less willing to pay than females, while older respondents were less likely to pay an environmental fee. Both these explanatory variables, were however statistically insignificant. A possible explanation may be that older respondents are less likely to visit the lake. Only 44% of respondents older than the mean age (i.e. older than 44 years, see Table 7.9) indicated they visited or used the lake.

Respondents who had completed secondary school (i.e. completed Matric) were more willing to pay a fee than less educated households (the Education1 dummy variable is the reference group). More highly educated respondents (Education3) also showed a greater willingness to pay than the reference group, but were less willing than Education2, although the coefficient for Education3 was insignificant. As was the case for the preliminary interval regression in Table 7.10, the suburb dummies showed that all three suburbs (Grassy Park, Lotus River and Zeekoevlei) were significantly more willing to pay a fee for improved water quality than the reference suburb (Pelican Park).

Visiting other lakes and wetlands within the vicinity of Zeekoevlei (such as Rondevlei and Zandvlei) was included as an alternative recreational possibility for households. The coefficient of this variable ('Other lake') was positive, but statistically insignificant. A significant positive coefficient would have suggested that people who visit other lakes value these environmental goods and would therefore be more willing to pay to improve the water quality at Zeekoevlei. The Value variable showed that people who valued the lake as environmental area seemed more willing to pay for its environmental quality improvement, although the coefficient was not significant. The 'Policing' variable had a positive coefficient (although it was statistically insignificant), which may indicate that criminal activity within the vicinity of the lake had an important effect on people's value of the lake. This supports the descriptive statistics in Figure 7.7 and Table 7.7, which reflected the importance that people attached to policing in the vicinity of the lake.

The regression results of Models 1 and 2 were quite similar to that of Model 3, with the exception of the level of significance of some explanatory variables. The estimated mean WTP for Model 1 was R25.67 per month, while Model 2 had a mean WTP of R24.84 per month. The estimated mean WTP for Model 3 was the highest at R30.67 per month per household (when the protest and inconsistent responses were excluded).[89] The higher mean WTP estimate is an important finding since it reveals that protest responses can

[89] The protest responses in Model 3 were defined as those respondents who explicitly stated that the government is responsible for cleaning up Zeekoevlei (i.e. 30 respondents). If the definition of protest responses is extended to include all respondents who indicated they were opposed to paying a fee, 92 respondents would have been classified as protest responses. A regression model excluding these protest respondents and the inconsistent responses reduced the total observations to 266 respondents. The regression results for this model are not reported, but the results are similar to those of Model 3, with the exception of an even greater mean WTP estimate of R41.38 per month.

result in an underestimation of willingness to pay. This is similar to the findings of Jiang et al. (2011), who also arrived at a higher mean WTP after excluding protest responses.

The robustness of the mean WTP results for the respective models was tested by choosing alternative maximum boundaries for income respondents who indicated they were willing to pay for improved water quality. The regression models in Table 7.11 were based on the assumption that respondents' maximum WTP were equal to a maximum of 3% of their income for an environmental fee. Using alternative specifications of the maximum proportion of income (as the upper bound) and applying this to Model 3 revealed that there were no significant differences in the mean WTP estimates. Table 7.12 shows the results of this exercise.

Table 7.12: Mean WTP and Median WTP for alternative specifications of income as upper bound[90]

Assumed proportion of income as upper bound specification	Mean WTP (per month)	Median WTP[#] (per month)
3% of income (base model)	R30.67	R45.05
5% of income	R34.83	R54.99
10% of income	R37.22	R59.07
Infinity	R39.23	R63.53

[#] The Median WTP is determined by taking the predicted WTP at the 50th percentile. The median WTP exceeds the mean WTP since some of the predicted mean WTP values are negative.

Source: Own calculations

It is evident that the mean WTP increases as the proportion of income specified, increases. However, these increases are not proportionally large. For example, a change from the base model specification to an assumption of the upper bound being set equal to infinity resulted in only a 27.9% increase in the mean WTP.

A final aspect of determining the WTP for improved water quality is to analyse the answers to the open-ended question, and compare the estimates with the previous findings. As discussed previously, respondents were asked their maximum willingness to pay after the

[90] Note that the results for these regression models are not reported in the text.

second closed-ended question. A summary of the amounts indicated by respondents is shown in Table 7.13.

Table 7.13: Maximum WTP amounts indicated by respondents for improved water quality

Maximum WTP	Frequency of respondents	Percentage
0	115	30.0
1	1	0.3
2	1	0.3
3	1	0.3
5	9	2.3
10	45	11.7
15	3	0.8
20	60	15.6
25	1	0.3
30	34	8.9
35	2	0.5
40	8	2.1
50	54	14.1
60	1	0.3
100	13	3.4
150	1	0.3
200	4	1.0
500	3	0.8
Missing (.)	28	7.3
Total	384	100

Source: Own calculations

Table 7.13 shows a significant proportion of respondents (approximately 30%) said 'no' to the initial WTP question and were therefore not asked for a maximum WTP value. Their WTP values were set equal to zero. In addition, 28 respondents did not provide an answer to this open-ended question. Given this high proportion of assumed zero WTP values a tobit model was estimated, using the maximum WTP values as dependent variable. The same explanatory variables were used as in Model 3 of the interval regression.[91] Table

[91] A preliminary tobit model was estimated which included the income variables. The findings (in terms of the signs and significance of the coefficients for the income dummies) were, however, similar to the preliminary interval regression results in Table 7.10. The coefficients for Income2 and Income3 were positive, while the coefficient for Income4 was negative.

7.14 shows the results of the tobit regression, after excluding inconsistent and protest responses.

Table 7.14: Tobit regression model for open-ended WTP question (Improved water quality)

Variable	Coefficient	T-value
Age	-0.361	*(-1.20)*
Household Size	1.582	*(1.03)*
Male	-20.077*	*(-1.74)*
Education2	22.231	*(1.61)*
Education3	12.627*	*(1.73)*
Grassy Park	26.847***	*(3.19)*
Lotus River	36.094**	*(2.52)*
Zeekoevlei	86.221***	*(4.28)*
Visit / Use lake	13.442	*(1.10)*
Value lake	11.712	*(1.14)*
Other lake	-2.786	*(-0.30)*
Policing	2.915	*(0.19)*
Constant	-23.412	*(-1.11)*
Number of observations		311
Number of uncensored observations		223
Number of left-censored observations at maximum WTP <= 0		88
Pseudo R^2		0.02
Mean WTP (per month)		R16.86
		[R21.86][#]
Median WTP (per month)		R13.74

[#] This indicates the mean WTP if the predicted WTP values are restricted to be non-negative.
T-values in parentheses.
Level of significance: *** - significant at the 1% level, ** - significant at the 5% level, * - significant at the 10% level.

Source: Own calculations

The results for the tobit regression model are quite similar to those of the interval regression (i.e. Model 3 in Table 7.11). The only exception is the sign of the 'Other lake' variable, which is negative. However, it is statistically insignificant. The predicted mean WTP is much lower compared to the mean WTP in the case of the interval regression (which was R30.67 per month). Restricting the predicted WTP values to non-negative values gives a mean WTP of R21.86 per month. The lower WTP values are expected as the CVM literature indicates lower mean WTP values when an open-ended question is used, as compared to a closed-ended (referendum) question. According to Brouwer, Langford, Bateman and Turner (2004: 217), dichotomous choice questions yield the highest average WTP values. The tendency to have greater numbers of non-responses with open-ended questions and the uncertainty involved in answering WTP questions for non-market goods are some of the reasons indicated for lower WTP values in the case of the open-ended questioning format (Brouwer et al. 2004).

In summary: this section analysed the data in two ways. The first approach was to create an interval within which each respondent's WTP value would fall based on their answers to the closed-ended questions. In the second approach, the WTP values given by respondents to the open-ended question were analysed using a tobit model. Both analyses showed a willingness to pay for improved water quality.

7.4.5 Estimating the willingness to pay for improved recreational facilities at Zeekoevlei

This section analyses the recreational use value of the lake, with an emphasis on improvements to its recreational facilities. As explained earlier, of the 384 households in all, those who had direct access to the lake were now excluded from the analysis.[92] The sample then consisted of 357 households, but since there was missing data for one observation for one of the explanatory variables ('Other lake'), the total sample was 356 households.

The payment vehicle for this WTP question was specified as an entrance fee. As before, respondents were first asked whether they were willing to pay an entrance fee. The WTP interval for respondents who refused to pay was specified as [., 0]. If they answered 'yes' to the initial WTP question, the second WTP question offered them a specific entrance fee (i.e. R2, R3, R5 or R10 per person, per visit). If they accepted the entrance bid the interval was [bid entrance, B*], where B* was assumed to be the maximum proportion of the household's income that the household would spend on an entrance fee (in this case 0.5 per cent of the income). The interval for respondents who refused the entrance bid was [0, bid entrance].

[92] 26 respondents completed the questionnaires that only contained the section on the WTP question with regard to improved water quality. However, one additional household was excluded as the respondent did not answer the willingness to pay question on improved recreational facilities, which means that a total of 27 households were excluded from the analysis.

The identification of inconsistent and protest responses followed a similar process as before, i.e. respondents were classified as inconsistent if their answers to the WTP questions were inconsistent, and as protest responses if they indicated that they were not willing to pay an entrance fee (since they were already paying taxes to the municipality). However, there were few inconsistent answers and protest responses to the WTP questions (only three inconsistent answers and three protest responses).

Table 7.15 shows the results of the interval regression models, which include the same explanatory variables used in the preliminary interval regression for improved water quality. Model 3 reflects the interval regression after excluding inconsistent answers and protest responses.

Table 7.15: Interval regression models (Improved recreational facilities)

Variable	*Model 1* Coefficient	*Model 2* Coefficient	***Model 3*** Coefficient
Age	-0.036	-0.035	-0.011
	(-0.89)	*(-0.87)*	*(-0.28)*
Household size	-0.039	-0.005	-0.015
	(-0.13)	*(-0.02)*	*(-0.05)*
Male	-1.160	-1.162	-0.912
	(-1.02)	*(-1.01)*	*(-0.82)*
Education2	0.760	0.852	0.612
	(0.50)	*(0.55)*	*(0.40)*
Education3	-0.138	-0.096	-0.052
	(-0.10)	*(-0.07)*	*(-0.04)*
Grassy Park	5.553***	5.284***	5.718***
	(3.59)	*(3.38)*	*(3.74)*
Lotus River	4.601***	4.278***	4.408***
	(3.12)	*(2.86)*	*(2.98)*
Zeekoevlei	3.388	3.122	2.993
	(1.39)	*(1.27)*	*(1.24)*
Income2	6.682***	6.442***	6.541***
	(3.92)	*(3.77)*	*(3.80)*
Income3	5.210***	5.201***	5.491***
	(2.63)	(2.62)	(2.80)
Income4	4.742**	4.732**	4.356*
	(2.04)	*(1.99)*	*(1.91)*
Visit / Use lake	0.888	0.941	1.405
	(0.75)	*(0.79)*	*(1.21)*
Value lake	3.318*	3.170*	2.600
	(1.92)	*(1.82)*	*(1.52)*
Other lake	1.665	1.716	1.868*
	(1.50)	*(1.55)*	*(1.71)*
Policing	0.651	0.632	0.619
	(0.32)	*(0.31)*	*(0.30)*
Constant	-0.317	-0.147	-1.140
	(-0.10)	*(-0.05)*	*(-0.38)*
N	356	353	350
Mean WTP (per person per visit)	R9.85	R9.87	R9.99
Median WTP (per person per visit)	R12.22	R12.22	R12.17

Z-values in parentheses.
Level of significance: *** - significant at the 1% level, ** - significant at the 5% level, * - significant at the 10% level.

Source: Own calculations

The results for Model 3 show that older male respondents and larger households were less willing to pay an entrance fee, although their coefficients were not statistically significant. The result for older male respondents makes intuitive sense, since it can be expected that they would be less likely to visit or use the recreational facilities at the lake. As mentioned earlier, less than 45% of all respondents older than 44 years indicated they visited or used the lake. Larger households imply a greater total entrance cost, i.e. it becomes relatively more expensive for these households to pay an entrance fee (especially per person, per visit). This is in contrast to the findings for improved water quality, where the fee was a fixed monthly fee and did not increase with household size.

The coefficients of the education variables were not both positive (compared to the reference group Education1), although neither were statistically significant. It appears as if education level had little impact on the willingness to pay an entrance fee for improved recreational facilities. All the income dummy variables (compared to the reference group Income1) had positive coefficients and were statistically significant, which indicates that richer households were more willing to pay an entrance fee.

All suburbs showed a greater willingness to pay an entrance fee, as compared to the reference suburb (i.e. Pelican Park). This may suggest that residents from Pelican Park (who live close to the lake), feel that they should have free access. However, if this was true, it would have implied a negative coefficient in the case of Zeekoevlei as well (which was in fact positive, although not significant), since some of these residents also live adjacent to the lake and do not access the eastern part of the lake shore. For this reason they would not have been interested in improved recreational facilities for that part of the lake.

The coefficients for the variables reflecting visiting or using the lake and valuing the lake as an environmental good were all positive (but were not statistically significant). The positive coefficient is an expected result, since people who visit or use the lake, and value the lake, would more likely be willing to pay for improved recreational facilities. Respondents who indicated they also visited other lakes were more willing to pay an entrance fee. Respondents who indicated that better policing was important for visiting the lake were more willing to pay an entrance fee (even though this coefficient was not significant). This insignificant result contrasts with the descriptive statistics in which most of the respondents indicated that proper policing would significantly influence their decision to visit the lake. A possible explanation may be that an entrance fee constituted some way of policing the area. The mean WTP for Model 3 was R9.99 per person per visit.

Table 7.15 also shows the results of the additional interval regression models using all observations and excluding only inconsistent responses respectively (i.e. Models 1 and 2). It is evident that there are no significant differences in the results for all three models, as very few (inconsistent and protest) observations were excluded from the analyses. The mean WTP (per person, per visit) remained quite high throughout. The mean WTP for Model 3 was slightly higher than for the other models, which is similar to the earlier results for the environmental fee (where the exclusion of inconsistent and protest responses also produced a higher mean WTP).

A final analysis is to estimate the mean WTP from the answers to the open-ended question, i.e. the maximum entrance fee respondents provided after the second closed-ended question. Table 7.16 shows the maximum amounts respondents indicated they would be willing to pay as an entrance fee (per person, per visit).

Table 7.16: Maximum WTP amounts indicated by respondents for improved recreational facilities

Maximum WTP	Frequency of respondents	Percentage
0	53	14.9
1	1	0.3
2	10	2.8
3	9	2.5
4	2	0.6
5	73	20.5
6	4	1.1
7	4	1.1
8	2	0.6
9	1	0.3
10	116	32.5
12	1	0.3
15	20	5.6
20	38	10.6
25	2	0.6
30	6	1.7
40	3	0.8
50	6	1.7
Missing (.)	6	1.7
Total	357	100

Source: Own calculations

The proportion of respondents who said 'no' to the initial closed-ended question is smaller in this instance (approximately 15%). There were also fewer missing observations, as compared to the non-responses for this question in the previous section (see Table 7.13). Table 7.17 shows the results of the tobit regression model (excluding inconsistent and protest responses), using the maximum WTP values as dependent variable and identical explanatory variables as in Model 3 of the interval regression.

Table 7.17: Tobit regression model for open-ended WTP question (Improved recreational facilities)

Variable	Coefficient	T-value
Age	-0.064*	*(-1.72)*
Household Size	0.003	*(0.01)*
Male	0.280	*(0.23)*
Education2	1.723	*(1.10)*
Education3	0.697	*(0.39)*
Grassy Park	5.471***	*(3.89)*
Lotus River	6.022***	*(3.60)*
Zeekoevlei	5.023*	*(1.88)*
Income2	1.807	*(1.03)*
Income3	1.796	*(0.93)*
Income4	0.729	*(0.35)*
Visit / Use lake	0.497	*(0.41)*
Value lake	1.401	*(0.57)*
Other lake	0.482	*(0.35)*
Policing	-1.113	*(-0.33)*
Constant	4.758	*(1.24)*
Number of observations		344
Number of uncensored observations		294
Number of left-censored observations at maximum WTP <= 0		50
Pseudo R^2		0.01
Mean WTP (per person per visit)		R8.80
Median WTP (per person per visit)		R9.39

T-values in parentheses.

Level of significance: *** - significant at the 1% level, ** - significant at the 5% level, * - significant at the 10% level.

Source: Own calculations

The results of the tobit regression model are somewhat different compared to the results of the interval regression model (i.e. Model 3 in Table 7.15). Firstly, even though the age of the respondent still has a negative coefficient, it is now statistically significant at the 10% level. The coefficients for household size and male respondent are now positive, although they remain insignificant. Education3 also has a positive coefficient, even though it is statistically insignificant. Finally, the 'Policing' variable has a negative, but insignificant coefficient. The mean WTP is estimated at R8.80 (per person, per visit), which is once again a lower value than the result for the interval regression model.

7.5 Policy implications and concluding remarks

The environment is usually assumed to be a 'normal good'; i.e. it is assumed that poor people are less concerned about the environment as a result of their budgetary constraints. In lower-income urban areas this could create serious long-term problems if the environment continues to deteriorate as a result of increased urban pressures. The Zeekoevlei study has demonstrated that even lower-income households are willing to contribute to urban environmental goods. The mean WTP for cleaning up Zeekoevlei, summed over all households in the sample suburbs, results in an annual contribution of R5.6 million. It is important to stress that this result is based on local households only. Visitors to the yacht club or potential tourists to the area (for example, visitors to the nearby nature reserve at Rondevlei) were not included. It is not possible to determine an aggregate monetary value for the entrance fee, as this was specified 'per person, per visit', and there is no information on the number of current and planned visits by households, or on whether the entire household would visit the lake.

Southern Waters (2000) provided an estimate of the clean-up costs for Zeekoevlei valued at R23.4 million (in 2006 prices[93]) over five years, i.e. for reducing pollution and improving water quality. This estimate, however, does not include the cost of improving recreational facilities or recurrent operational and maintenance costs. Thus, even if it was possible to price discriminate and charge each household their respective WTP value, the funds raised would not be nearly sufficient to cover the cost of cleaning up pollution and maintaining the lake. In an announcement about neighbourhood development projects, the City of Cape Town (2006) referred to an estimated cost of R150 million to rehabilitate Zeekoevlei and manage its urban drainage system, which would be partly funded by grants received from national government and possible external funding. Despite not having a definite cost estimate, it is evident that the contribution of residents is small in comparison to the cost.

The willingness to pay for improved water quality and recreational facilities does indicate that residents attach value to Zeekoevlei. It should therefore receive consideration in local government policy, even though the City of Cape Town is unlikely to extract funds from local residents, given the public nature of Zeekoevlei as urban environmental good. The

[93] This cost value is inflated to 2006 prices, to make it comparable to the total willingness to pay estimate, as the survey was conducted in 2006.

study emphasises the importance of preserving environmental recreational sites as urban residents do value their services. Furthermore, since lower-income households tend to be less mobile than their more affluent counterparts, the rehabilitation and maintenance of urban environmental goods, offering recreational and environmental services and situated in the vicinity of low-income areas, become even more important. A further illustration of the importance of urban environmental goods is the objections raised by residents and community organisations against the building of a shopping complex at another wetland site, i.e. Princess Vlei ("Cape Town in bid to halt Princess Vlei mall", 2011).

This case study has shown that water is valued as an environmental and recreational good. Even if residents do not pay for the clean-up themselves, the lake should be seen as a public good because it provides services to the local community. Furthermore, since it will be particularly beneficial to lower-income households who cannot easily travel to other recreational sites, there is also an element of equity involved. It therefore follows that the local government must assume responsibility for improving Zeekoevlei's environmental quality and recreational facilities. The City of Cape Town could consider introducing a low entrance fee, as this would help to make the area secure and more viable as a recreational site. In the announcement by the City of Cape Town (2006) mentioned earlier, it also referred to the possibility of raising tourist-related income once Zeekoevlei has been restored.

It is not an easy task to estimate the value of the lake. Pollution and crime in the area both adversely affect the value of the lake. Unfortunately the empirical analysis does not provide a way to distinguish between these two effects. However, the descriptive statistics from the survey clearly indicate that crime does influence the attitude of households towards the lake. There is some indication that the recreational area will increase in value if there is some form of entrance control, as this will help to deter criminals. More research is needed on the extent to which crime influences the willingness of residents to care for nature. Because of the many background variables, the results of the survey are often not clear-cut. This makes it difficult to conclude that improving quality of the area will support specific interests. Thus, improving the lake is a policy option that seems to have the support of local residents in general. An exception may be households in Pelican Park, who seem to be less interested in improving the area.

This study shows that the improvement of the environmental quality of Zeekoevlei and its recreational facilities will be of benefit to the local communities that surround the lake, particularly to low-income households. Finding support among the local communities to clean up Zeekoevlei shows the need for an integrated management approach, one which considers the value of water resources in their totality. However, the case study has not explicitly addressed the cost aspect in detail. Local governments in developing countries generally have pressing service delivery needs and it may not be easy to set resources aside for the improvement of the environment.

CONCLUSION

CHAPTER EIGHT
Summary and Conclusion

8.1 Introduction

This dissertation was sparked by mounting concern about dwindling water resources, unequal access to them and rising water pollution levels in South Africa. These factors have necessitated revisiting management approaches to this precious resource, as is discussed in Section 8.2.

8.2 Water scarcity and management options

Chapter Two explored the extent of water scarcity in South Africa, as compared to other parts of the world, and showed that the country is fast approaching physical water scarcity. It highlighted demand- and supply-side factors contributing to the problem in South Africa; these included population growth, rapid urbanisation, climate change and pollution. In addition, many poor households also do not yet have access to water and basic sanitation facilities, evidence of economic water scarcity. The extent of water scarcity (both in absolute physical terms and in economic terms) is therefore a threat to human welfare, as it reduces the amount of water available for consumption and production activities. The degradation of water bodies also affects the value of water for recreational and environmental purposes.

In the past the increased demand for water in South Africa was mostly addressed through supply-side management options. However, recent water policy and legislation have diverted attention to the demand side as part of an integrated approach to water management. Water demand management aims to reduce the consumption of water by changing the behaviour of water users. It potentially forms an integral part of water resource management, particularly in regions such as the Western Cape where water scarcity has become a serious problem. However, there has been little economic analysis to determine appropriate water demand management policies and in particular to determine water prices (or tariffs). Part of this research was an attempt to make a meaningful contribution to managing water resources more effectively from an economic perspective.

For the remainder of this summary and concluding chapter it is useful to distinguish three major topics in urban water resource management that were discussed in this dissertation.

The first is the effect of water pricing on water demand (discussed in Section 8.3 below), the second is the impact of such pricing on equity (Section 8.4), and the third is whether low-income households are willing to pay for improving water quality and recreational facilities at a freshwater urban lake (Section 8.5).

8.3 Pricing as water demand management strategy

Chapter Three provided an overview of water demand management and various demand management tools, such as water restrictions, educational campaigns and technology options (e.g. retrofit programs). It also discussed water pricing as an economic instrument that has previously received limited attention in practice as demand management tool. Efficient pricing (i.e. marginal cost pricing) has rarely been applied due to the difficulty in determining the long-run marginal cost of water. Related to this is the failure of water authorities to price water effectively; water prices have generally been set at below full cost.

Setting appropriate water tariffs, however, is a complex task, since water managers usually want to achieve multiple objectives with their tariff structures. Some of their more important goals include the efficient usage of water, revenue sufficiency and equity considerations (since there are obvious socio-economic disparities between users which must be taken into account).

Water tariffs have recently received more attention in policy circles as a potential demand management tool, although most water authorities still under-price water and fail to apply economic principles when setting tariffs. This can be achieved if information on how consumers will react to water prices (i.e. the price elasticity of demand) is used in the tariff-setting process. In developing countries, however, fewer empirical studies on price elasticity of demand have been conducted. In South Africa, of the few studies that have been conducted, most focus on the northern part of the country. To the author's knowledge there has only been one previous study in the Western Cape, which used the Contingent Valuation Method as methodological approach (see Van Vuuren et al. 2004) rather than analysing the relationship between water tariffs and actual consumption.

One contributing factor to the dearth of empirical research is the unavailability of appropriate micro-data for analysing household behaviour. Chapter Four reported on one of this dissertation's unique contributions to the literature; household level data were collected in five suburbs and a panel dataset was compiled using water consumption records from the City of Cape Town linked to household information obtained from the survey questionnaire. This data was used to analyse the factors influencing household water demand.

Drawing on the vast empirical literature on residential water demand studies and the theoretical and methodological specifications, an aspect that received particular attention was the endogeneity of water prices. An instrumental variable approach was used to address this problem. Furthermore, since the IBT structure consists of various marginal prices for each block of consumption (creating a non-linear budget constraint for the consumer), another methodological issue was which pricing variable to use in the demand estimation. Following existing literature, the case study applied marginal prices and a difference variable, which accounted for the implicit subsidy in the case of the IBT structure.

The results showed water demand to be price inelastic for the lower income groups, which accords with findings from the existing empirical literature, though the absolute values of the price elasticity estimates were somewhat bigger than those reported in the literature. However, the majority of the elasticities obtained were nevertheless still smaller than one. Lower price elasticity estimates are one of the reasons cited in the literature for the limited attention given to price as demand management tool. It has been argued that price changes would be ineffective in conserving water, given the small price elasticity estimates. However, it must be kept in mind that this effect is not zero and therefore cannot be ignored.

The demand study revealed that the water demand of lower-income households was more price inelastic than that of higher-income households. Information on the price elasticity of demand of different user groups can be useful in setting tariffs. If higher-income households (which generally consume more water) are more sensitive to price changes,, it is possible to achieve a reduction in water consumption by increasing marginal prices at the upper end of the IBT structure. It would be less appropriate to also increase marginal prices at the lower end of the IBT structure, since lower-income households use less water and their consumption will not decrease by much (given the smaller price elasticity estimate). Poorer households use less water since they do not usually require water for outdoor use. Empirical studies have shown outdoor use to be more price sensitive.

Furthermore, knowledge of the price elasticities of demand is useful when estimating the impact of price changes on the revenue of water utilities.

8.4 Pricing as subsidy mechanism using the IBT structure

The IBT structure is usually preferred to other types of tariff structures because of the belief that it can address multiple concerns. Chapter Five discussed the IBT structure in the context of the provision of water subsidies (i.e. quantity targeting). In the South African context, the IBT structure is seen as an appropriate mechanism to make water available (and affordable) to the poor and it has been re-designed by incorporating the Free Basic Water policy into the IBT structure. Since the IBT structure is a way of cross-subsidising from the rich to the poor, municipalities are expected in accordance with the FPW policy to provide (poor) households with a minimum quantity of water (six kilolitres per month) free of charge.

Using the IBT structure as a subsidy mechanism is not, however, without limitations. If all households were connected to the water network, and assuming that a sufficient number of higher-income households consumed in the upper consumptions blocks, cross-subsidisation from rich to the poorest households could occur. However, in developing countries many poor households do not yet have access to water networks. A subsidy to make water more affordable to the poor will therefore only reach those poor households connected to the network. Chapter Five discussed the empirical literature on this issue and indicated that because of a lack of access to water, subsidies were not reaching their intended target groups, but more often benefited somewhat less poor households.

A further concern is that IBT structures do not usually consider the size of households. Households with a larger number of family members may consume in higher consumptions blocks, especially if the IBT structure design allows for a small minimum quantity of water at a price below cost or even free of charge. In many developing countries shared accommodation also means that a larger number of people are linked to a single water connection point. For example, backyard dwellers are quite common in South African townships and often share a single tap connection. It is also not uncommon for more than one family to share accommodation. All these factors result in higher water usage and therefore higher water bills for poor families, who thus may consume beyond the subsidised quantity.

The empirical analysis in Chapter Five investigated the extent to which cross-subsidisation occurs in South Africa, by using the data from the demand study (in Chapter Four). Using appropriate weighting procedures and taking national water access into account, the Cape Town data was used to model water consumption and costs across the South African income distribution spectrum. Given the low access statistics for the poorest households, the analysis showed that, even though the richest households paid more for water than they would have done under a uniform price structure (one which raised the same revenue as the IBT structure), it was the middle- to lower-income households that gained most from the IBT structure. The poorest households were not connected and therefore did not receive the intended cross-subsidy benefit.

Even though quite a high proportion of households in some urban municipalities had access to water, these included households that used communal taps (i.e. piped water provided to a standpipe). In the case of the CCT, water provided to communal taps is free of charge and households therefore benefit from some subsidy. However, since people have to walk some distance to fetch water and since not all communal taps are in working order (as a result of vandalism or poor maintenance), these households generally consume less than six kilolitres of water per month. Their subsidised consumption is therefore still less than for connected households. Lack of access to piped water therefore renders the IBT structure less effective as a redistributive tool for many of the poorest.

Chapter Five also discussed alternative subsidy mechanisms to improve the targeting of intended beneficiaries. One option is to charge a uniform tariff (to achieve full cost recovery) and to offer a rebate to poor households. Such a tariff structure can work well if the poor can be identified so that errors of inclusion and exclusion can be kept to a minimum. However, this requires water authorities to have the institutional capability to keep an indigent register – something which has proven to be difficult in the South African context. Many municipalities do not yet possess the administrative capacity or skills to run an efficient billing system. Thus, even though indigent policies have officially been accepted as an appropriate mechanism to deliver basic services to the poor, municipalities may experience difficulty in correctly identifying and encouraging beneficiaries to register as indigent households. Moreover, if households do not have access to the water network, there is little benefit in applying for a rebate on these services. Connection subsidies would not alleviate the problem in the South African context, since the government already subsidises connections when it rolls out basic services to the poor. What is therefore needed is the extension of the basic service infrastructure to remedy the lack of access to services. Once connected, affordability of services to the poor must be addressed, and has been the focus of this discussion.

It is therefore evident that the IBT structure in its current form holds limited benefit for the poor, given the state of service delivery in South Africa. Even if this situation were to improve, there are other design aspects of the IBT tariff structure that require attention, such as the size of the subsidised blocks. Thus, even though the IBT structure has been lauded for its ability to realise multiple objectives, this seems achievable only within certain contexts. Water managers in South Africa must therefore revisit the objectives behind their (differentiated) tariff structures and find alternative ways of achieving a more equitable allocation of water to the poor. It must also seriously be considered whether water tariffs are an appropriate tool for affecting equity and income distribution, given the far more effective tools for redistribution available to government (such as the social grant system).

8.5 Do lower-income urban communities attach value to water for purposes other than essential use?

As discussed earlier, the deteriorating quality of water not only reduces the amount of safe water available for consumption and production activities, it also affects human welfare by reducing the environmental and recreational benefits that people derive from water. Chapter Six discussed the economic value to mankind of water bodies such as lakes and rivers, that provide both use and non-use benefits. Recreational activities such as sailing, surfing, boating and swimming are examples of direct use values, whereas indirect use values involve benefits derived from such things as soil erosion control and flood control. People also derive non-use value from water bodies, through (for example) increased biodiversity and from existence value (i.e. the knowledge that the lake or river exists).

Since environmental goods and services are not traded in the market place, non-market environmental valuation techniques must be applied to estimate the economic value people derive from them. Chapter Six discussed some of these techniques. The focus was on a particular stated preference method, i.e. the Contingent Valuation Method, which was then applied in the empirical study in Chapter Seven. This case study involved the estimation of the economic value of Zeekoevlei, a freshwater urban lake in Cape Town.

Chapter Seven outlined the significance of Zeekoevlei as a case study, given the uniqueness of the lake in terms of its location and polluted state. Zeekoevlei is situated in an urban area and surrounded by mainly middle-to-lower income communities. In environmental valuation literature it is generally accepted that richer households place a higher value on environmental goods and services. The CVM study of Zeekoevlei therefore set out to establish whether lower-income households also attach value to water resources for their environmental and recreational benefits.

An aspect that required careful consideration was the design of the CVM questionnaire). The findings indicated that households in some (the more affluent) suburbs were more willing to pay a monthly clean-up fee to improve the lake's water quality than households in lower-income suburbs. However, even lower-income households were willing to pay an environmental fee, i.e. to make some contribution to preserve and improve the environmental quality of the lake. The results provide a clear indication of the value placed on water bodies for environmental and recreational purposes by people in urban areas, including those who reside in lower-income areas.

A related aspect that came to light in the survey was the influence of crime on the value people attach to environmental goods and services. Zeekoevlei is situated in an area that has relatively high crime statistics. From responses to the survey it was evident that people perceived the lake to be unsafe and felt that effective policing were required.

The survey questionnaire also focused on the willingness of respondents to pay for the improvement of recreational facilities at the lake. The results showed that people (particularly those with higher incomes) do attach value to the lake's recreational benefits. Despite this, however, it is unlikely that sufficient funds would be raised from residents to undertake such improvements, given the public nature of the lake. Charging a low entrance fee would make some contribution to clean-up costs and maintenance and may reduce the crime element. However, it seems that government would have to assume responsibility for rehabilitating and preserving the lake. This would be beneficial to surrounding communities, who may have less access to the benefits of other environmental goods.

To summarise: the analysis of the value of Zeekoevlei as a recreational and environmental good provides evidence that urban environmental areas are important to the people residing in the surrounding communities, as is evident from their willingness to contribute towards cleaning up the lake and improving its recreational facilities.

8.6 Concluding remarks

Economics is about scarcity, and both water for own consumption and unpolluted water for recreational use are scarce. It is thus appropriate that economists should study these important issues.

This dissertation set out to provide an economic perspective on the management of water resources. In many instances water resources are managed without considering their economic value, which has resulted in water being used in an unsustainable way. One such example is the price of water, where economic considerations seldom form part of the tariff-setting process. Water managers do not consider the full economic cost of water; prices are therefore generally set too low. However, even though water is essential for survival and safe drinking water and sanitation are necessities, it must be managed within the context of being an economic good.

The studies in this dissertation have shown how economic principles can be applied to improve the management of water, particularly on the demand side. One of the key issues is the extent to which water tariffs can be used to incentivise residential water users across the income spectrum to reduce their water consumption. A key requirement for using pricing as a demand management tool is to obtain sufficient information on the behaviour of water consumers as prices change. Price elasticity of demand estimates can guide the tariff-setting process to achieve reductions in consumption. Despite the fact that empirical estimates of the price elasticity of demand are less than one (in absolute terms), there is still some effect that can be exploited, especially at the upper end of an IBT structure. However, at the same time it is important to recognise that pricing cannot be used in isolation (to reduce water consumption); it should form part of an integrated demand management approach.

A further aspect highlighted in this dissertation is the limited role of water tariff structures in adopting a redistributive function. It has been shown that water subsidies through the IBT structure generally do not reach their intended recipients, given the lack of access to water. Thus, even though the Free Basic Water policy was implemented with the intention of helping the really poor, they are not receiving the benefit. Water authorities should therefore revisit the IBT structure as subsidy mechanism, and consider alternative subsidy mechanisms. Water pricing it seems, is therefore most appropriate to manage water consumption, and other more direct mechanisms should be considered for redistributive purposes.

Regarding water as recreational and environmental good, it emerged that even the urban poor do value such goods quite highly, but even if the perennial issue of how they were to pay for it could be resolved – the non-excludability of public goods is the issue here – what they could contribute financially to the fiscus is greatly limited compared to the cost of providing such goods. Thus public choice considerations indicate that such goods should be provided, even though their public good character means that it would have to be funded through local taxes.

Finally, this dissertation also highlighted the reliance on appropriate data to conduct research in this field. A key feature of this dissertation was the contribution of two micro-level datasets on water-related behaviour. These types of water databases are severely lacking in South Africa, which impedes research activities, and therefore the contribution that these can make to guiding policy making. There needs to be a concerted effort to develop and coordinate a comprehensive national water statistics database. This must be a priority if researchers are to assist in formulating sustainable water management policies.

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ADDENDA

ADDENDUM A: *Water Demand Questionnaire*[94]

WATER DEMAND

RESEARCH QUESTIONNAIRE

Water meter number:

Water Account Number:

SECTION 1

Research Assistant: .... Date: Code:

Time: .... Form No.:

SECTION 2: ACCOMMODATION

a) Suburb: ....

b) Type of accommodation:

House	Flat	Other: ....

c) Does the household own the house?

Yes	No

d) If No to c), is water part of your rental?

Yes	No

e) How is your water metered?

For the household	With other households in the block	Do not know

f) Do you have a borehole?

Yes	No

g) What is the estimated size of your plot? .... m^2

[94] The questionnaire is included in precisely the format as it was presented to the respondents.

SECTION 3: SIZE OF HOUSEHOLD

a) Number of people permanently living in your household: ☐

b) Has the size of your household changed?

In the last 6 months	No change	Decreased	Increased	Increased a Lot
In the last 12 months	No change	Decreased	Increased	Increased a Lot
In the last 24 months	No change	Decreased	Increased	Increased a Lot

c) What are the ages of the members of your household?

MEMBER	AGE
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

SECTION 4: HOUSEHOLD FIXTURES & APPLIANCES

a) Do you have showers or baths (or both) in your house?

Shower	Bath	Both	None
No: ………	No: ………		

b) If None to a), do you use a bucket / basin?

Yes	No

c) Indicate the number of total showers / baths that are taken by all household members.

Approximate number:
(per week)

Showers:	Baths:	Basins:
....	....	....

d) Do you own any water-using appliances? Please tick:

Dishwasher	Washing machine: Automatic	Washing machine: Twintub

e) How often does the household use these appliances?

- Dishwasher:

Every day	Twice a week	Once a week	Other: ....

- Washing machine

Every day	Twice a week	Once a week	Other: ....

f) Do you have a geyser in your house?

Yes	No

SECTION 5: OUT-DOOR USAGE

a) Do you have / own any of the following?

Car	Swimming pool	Garden
No of cars:		

b) How often do you wash your car?

Once a week	Once a month	Twice a month	Other: ....

c) How often do you water your garden?

In summer:	Every day	Twice a week	Other: ....
In winter:	Once a week	Twice a month	Other: ....

SECTION 6: WATER LEAKAGES

a) Are you aware of any major leakages affecting your water consumption? | Yes | No |

b) Have you had any major leakages in the past two years? | Yes | No |

Comments:

....

....

....

c) Are you aware of anyone else using water from your taps? | Yes | No |

SECTION 7: WATER RESTICTIONS

a) Are you aware of water restrictions, when it is applied in your suburb? | Yes | No |

b) In your household, what methods of saving water do you (know and) apply?

Please tick:

IN-DOOR saving methods	OUT-DOOR saving methods
Shower instead of bath	Water garden on alternate days?
Share a bath	Use buckets not hoses to wash the car
Check dripping taps	Pave part of outdoor area
Install reduced-flush cistern / put a brick in the cistern	
Other:	Other: ....

SECTION 8: TARIFF STRUCTURE

a) Do you know what the water tariffs are?

Yes	No

b) Do you know the size of your last water bill?

Yes	No

c) If Yes to b), can you indicate the size of this bill? R ....

d) Do you change your water consumption when the water tariffs change?

A lot	Somewhat	No change

e) Is it easy for you to change your consumption when the water tariffs change?

Very easy	Easy	Difficult

f) Do you feel water is expensive?

Very expensive	Expensive	Cheap

g) Do you think it is reasonable to pay for water?

Yes	No

h) Do you feel it is fair to cut off water when someone has not paid the bill?

Yes	No

Comment:

....

....

i) Do you have a rebate on your water bill?

Yes	No

SECTION 9: HOUSEHOLD INCOME

a) What is the household's average monthly income?

(Please round off the amount): R ....

Alternatively, choose one of the following categories:

R0 - R1 000	R1 001 - R5 -000	R5 001 - R10 000	R10 001 - R20 000	R20 000 >

b) Has your income changed significantly?

In the last 3 months	No change	Less	More
In the last 6 months	No change	Less	More
In the last 12 months	No change	Less	More
In the last 24 months	No change	Less	More

ADDENDUM B: *CVM Questionnaire* (1)[95]

ZEEKOEVLEI QUESTIONNAIRE (Q_{L1}) FOR RESPONDENTS LIVING AT THE VLEI[96]

FORM NO: ☐

RESEARCH ASSISTANT:

1	2	3	4	5
Craig	**Derick**	**Jonathan**	**Liansky**	**Shafeeqa**

ADDRESS OF RESPONDENT:

…………………………………………………………………………………………………

…………………………………………………………………………………………………

INTRODUCTION
Zeekoevlei is the largest (256 ha) freshwater lake in South Africa, situated on the Cape Flats near Cape Town in the Western Cape Province. Zeekoevlei is an important regional recreational venue; it is used for sightseeing and tourism, recreation (sport-fishing, yachting, power-boating and skiing) and bird-watching. It is also a popular braai spot, especially during the summer season.

INTERVIEWER: Show Slide (Location Map), show Slides (Recreational Activities at Zeekoevlei)

Pollution of Zeekoevlei
Studies have shown that Zeekoevlei is highly polluted, with year-round concentrations of nitrogen and phosphorus. Nutrient loading from the catchment occurs during the winter via the Big and Little Lotus Rivers. The lake overflows only during the winter into a canal leading to the sea. There are also seepages from the wastewater plant, situated adjacent to the vlei. All of this leads to a build-up of sediment in the vlei. The consequence is that the water quality of the vlei is negatively affected, and it affects the recreational activities at the vlei.
In addition to the environmental problems, the recreational value of the vlei is affected by the state of current facilities. The picnic spots on the eastern side of the vlei are over-grown by grass and there are garbage dumped along the entrance road. Ablution facilities are also not maintained. *INTERVIEWER: Show Slides (Pollution of Zeekoevlei)*

The Purpose of the Survey
We are interested in estimating the value of Zeekoevlei to communities surrounding the vlei, as well as visitors to the yacht club, the angling association and the educational centres. To do this, we have to ask questions directly to the communities and users of the vlei. We will specifically be asking you a range of questions on how you value the vlei, based on what the vlei currently looks like, and also some hypothetical (mock) scenarios, mainly focusing on improvements in its environmental

[95] The questionnaire is included in precisely the format as it was presented to the respondents.

[96] 'Vlei' is an Afrikaans term used for lake.

quality. These mock scenarios include questions on a hypothetical fee – but please note – **NO POTENTIAL FEE IS PLANNED.** For us to do a proper analysis of the value of the vlei, we request that you answer all questions to the best of your ability. We thank you in advance for cooperating with us.

QUESTIONNAIRE

SECTION 1: Background Information

1.1 Home Suburb

1 Grassy Park	2 Lotus River	3 Pelican Park	4 Zeekoevlei	5 Other: ……………………….

1.2

0 Male	1 Female

1.3 Age of Respondent

1.4 Size of household (number of members)

1.5 Owner of house

0 Yes	1 No

1.6 What is your occupation?

1.7 First Language

1 English	2 Afrikaans	3 Xhosa	4 Other: ……………………….

1.8 Age of household members

Household Member	1 Respondent:	2	3	4	5	6	7	8	9
Age									

1.9 Education (highest) of Respondent

1 No schooling	2 Primary School	3 Secondary School (excluding Matric)	4 Matric	5 Matric & Technikon / College Training	6 Matric & University Training

1.9 Does the household own a car?

0 Yes	1 No

1.10 Income of household (monthly)

1 R0 - R1 000	2 R1 001 - R5 000	3 R5 001 - R10 000	4 R10 001 - R20 000	5 R20 000 >

1.11 How do you normally spend your free time (especially over weekends), and how much time do you spend on it, on a scale of 1 to 5?

Activity	1 No time	2 Little time	3 Some time	4 A lot of time	5 Most of your time
1 Read					
2 Socializing with family & friends					
3 TV					
4 Shopping					
5 Braai					
6 Sports, e.g. soccer					
7 Water Sports (e.g. Power boating, sailing)					
8 Bird-watching					
9 Hiking / Walking					
10 Angling					
11 Other: ………………………..					

SECTION 2: Using Zeekoevlei

2.1 How close do you live to the vlei?

1 Next to the vlei	2 Within walking distance	4 Other: …………………….

2.2 Do you actively use / enjoy the vlei?

0 Yes	1 No

If yes, go to 2,3. If no, go to 2.6.

2.3 If yes to 2.2, list your activities at the vlei, and how much time you spend on it, on a scale from 1 to 5:

Activity	1 No time	2 Little time	3 Some time	4 A lot of time	5 Most of your time
1 Water Sports (e.g. Power boating, sailing)					
2 Bird-watching					
3 Walking at the vlei					
4 Angling					
5 Braai					
6 Enjoying the view of the vlei					
7 Other: ………………………..					

2.4 How often, on average, do you actively use the vlei (bird watching, power boating, sailing, etc.)?

In winter (monthly):

0 Occasionally	1 Once	2 Twice	3 Three times	4 Four times	5 Never	6 Other: …………………….

In summer (monthly):

0 Occasionally	1 Once	2 Twice	3 Three times	4 Four times	5 Never	6 Other: …………………….

2.5 Do you value the vlei as an environmental area?

0 Yes	1 No

2.6 If yes to 2.5, can you say why (choose from the following):

1 Diversity in nature (Biodiversity)		5 Water sports	
2 Plants		6 Braai	
3 Birds		7 Angling	
4 Pristine area		8 Walking	

2.9 If you answered no to 2.5, can you say why you do not value the vlei as an environmental area (choose from the following, on a scale of agreement, from 1 to 5)?

	1 Do not agree	2 Partially agree	3 Agree	4 Highly agree	5 Completely agree
1 No interest in the vlei					
2 Too busy to visit the vlei (work or other recreational activities)					
3 It is dangerous at the vlei					
4 The vlei is too polluted					
5 There is a bad smell at the vlei					
6 Bad facilities at the vlei					
7 Other: …………………………………					

2.8 Do you experience any smell coming from the sewerage treatment system?

0 Yes	1 No

2.9 Do you experience problems with insects such as flies, etc. emanating from the vlei and/or the sewerage treatment system?

0 Yes	1 No

2.10 If yes to 2.8 or 2.9, does this affect how you feel about using the vlei?

0 Yes	1 No

2.11 Will you still actively use the vlei (in its existing state) if you are charged a fee of R10.00 to use the vlei?

0 Yes	1 No

2.12 If yes to 2.11, will you still actively use the vlei if the fee is R20.00?

0 Yes	1 No

2.13 If yes to 2.12, will you still actively use the vlei if the fee is R40.00?

0 Yes	1 No

2.14 Do you visit any of the other vleis in the vicinity?

0 Yes	1 No

2.15 Please indicate which vlei(s):

0 Rondevlei	1 Zandvlei	2 Other: …………………

2.16 If yes to 2.14, can you say why you go to these vleis?

Better recreational facilities	Better water quality of the vlei
Better Security	Other: …………………………………………………..

2.17 If you do visit any of the vleis mentioned in 2.15, do you pay any entrance fee?

2.18 If yes to 2.17, please indicate the amount (per person): R…………….

0 Yes	1 No

SECTION 3: The environmental quality of Zeekoevlei

Zeekoevlei is primarily polluted by leakages from the Cape Flats Wastewater plant, and pollution from the Big and Little Lotus Rivers. This has caused a decline in the water quality of the vlei. The problem is that this affects the natural beauty of the vlei and has negative consequences for wildlife, as well as recreational activities (such as water sports and angling activities). Studies have indicated that dredging the vlei is one possible way of reducing the stock of pollution. Another is to stop the leakages from the wastewater plant. Although there are no actual plans to implement this, we would like to establish the value to people in surrounding communities if there was a reduction in pollution and therefore, an improvement in the environmental quality of the vlei.
The method we use to find this value is based on creating a hypothetical scenario, where we assume that there is a plan to clean up pollution in Zeekoevlei. Hypothetically speaking, this clean-up will improve the natural beauty of the vlei; for example, this can include improved water quality (e.g. less algae blooms), a better functioning ecosystem, and could increase the recreational benefit to you.

Suppose now, hypothetically speaking, a plan is developed to clean up the pollution, given that the hypothetical improvements in recreational facilities (as discussed in section 3) are already in existence? Assume that this involves the initial clean-up and regular clean-ups afterwards. Let us assume that this will improve the water quality of the vlei and also reduce the smell at the vlei. Also assume that the cost of this clean-up is not known at this point in time. However, we are interested in knowing whether you would be willing to contribute some money towards this clean-up. Let us assume **(REMEMBER, NO FEES ARE PLANNED)** that this clean-up fee could not be used for any other purpose.

3.1 Given this hypothetical scenario, which of these improvements are important to you (on a scale of 1 to 5)?

	1 Not important	2 Slightly important	3 Important	4 Very important	5 Extremely important
1 Reducing the pollution – improve environmental quality of the vlei, as described above					
2 Reducing the smell at the vlei					

3.2 Do you think these hypothetical improvements will change how you feel about using the vlei?

0 Yes	1 No

3.3 If yes to 3.2, will you change your usage of the vlei if the hypothetical improvements were to take place?

1 Increase	2 Decrease	3 No change	4 No Visits

3.4 Are you willing to pay for these hypothetical improvements? Remember, this is purely a hypothetical scenario, **AND NO FEE IS PLANNED**.

0 Yes	1 No

If yes, go to 3.5. If no, go to 3.7.

3.5 If you were asked to contribute R10 per month (for as long as it is necessary to clean the vlei), would you be willing to pay the clean-up fee?

0 Yes	1 No

3.6 What would be the maximum amount your household would be willing to pay per month to contribute towards cleaning up Zeekoevlei?

R …………….

3.7 If no to 3.4, can you perhaps say why you are not prepared to contribute towards cleaning up the vlei?

1 I don't think it is necessary to improve the water quality.
2 Although I think it is necessary to improve the water quality of the vlei, I oppose the idea of charging a clean-up fee.
3 Other: ……

3.8 Will some of the following factors still restrict you from using the vlei (indicating your agreement on a scale of 1 to 5)?

	1 Do not agree	2 Slightly agree	3 Agree	4 Highly agree	5 Completely agree
1 Lack of Public Transport to the vlei					
2 Lack of Security at the vlei					
3 Other: …………………………………………….					

SECTION 4: Security at Zeekoevlei

4.1 Will proper policing of the vlei, e.g. patrolling on the vlei and the eastern shore of the vlei, be a crucial factor in determining your use of the vlei?

0 Yes	1 No

4.2 If Yes to 4.1, indicate the how important this is, on a scale of 1 to 5:

1 Not important	2 Slightly important	3 Important	4 Very important	5 Extremely important

SECTION 5: Summary

5.1 Has it been easy or difficult to answer the above questions?

1 Easy to answer	2 Difficult to answer

5.2 How did you find the questions? Check all the items that fit your impression.

1Information on the pollution of the vlei is difficult to understand.	
2 It is difficult to understand to what degree the vlei's water quality will improve.	
3 It is difficult to understand to what degree the facilities will be improved and maintained.	
4 It is difficult to answer the questions by calculating in terms of money.	
5 Others: ……………………………………………………………………………….	

VERIFICATION OF QUESTIONNAIRE

In order for us to verify the completion of the questionnaire by the respondent, we request a contact number of the respondent:

Telephone Number (home): (021) …………………………

or

Cell phone Number: …………………………………

THANK YOU FOR SPENDING THE TIME TO COMPLETE THE QUESTIONNAIRE!

FOR THE INTERVIEWERS ONLY:

Please complete the following section after completing each interview. Please keep this page separate while you are conducting the interview, but fill it in immediately outside the respondent's house. Do not forget to write down the address and questionnaire form number (must correspond with the questionnaire you have just completed):

FORM NO: ☐

RESEARCH ASSISTANT:

1	2	3	4	5
Craig	**Derick**	**Jonathan**	**Liansky**	**Shafeeqa**

ADDRESS OF RESPONDENT:

…………………………………………………………………………………………………

…………………………………………………………………………………………………

1) Did this respondent understand the questions being asked?

1 Not at all	2 Understood to some extent	3 Understood	4 Understood very well	5 Clearly understood excellently

2) Motivate your choice in 1 above:

……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
……………………………………………………………………………………………………

3) How reliable do you think are the answers provided by the respondent?

1 Not reliable	2 Reliable to some extent	3 Reliable	4 Very reliable	5 Extremely reliable

4) Motivate your choice in 3 above:
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
……………………………………………………………………………………………………

5) Any further comments (from you or the respondent)?

……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
……………………………………………………………………………………………………

ADDENDUM C: *CVM Questionnaire* (2)[97]

ZEEKOEVLEI QUESTIONNAIRE (Q_{V1})
FOR RESPONDENTS NOT LIVING AT THE VLEI

FORM NO: ☐

RESEARCH ASSISTANT:

1	2	3	4	5
Craig	**Derick**	**Jonathan**	**Liansky**	**Shafeeqa**

ADDRESS OF RESPONDENT:

………………………………………………………………………………………………………

……………………………………………………………………………………………………

INTRODUCTION
Zeekoevlei is the largest (256 ha) freshwater lake in South Africa, situated on the Cape Flats near Cape Town in the Western Cape Province. Zeekoevlei is an important regional recreational venue; it is used for sightseeing and tourism, recreation (sport-fishing, yachting, power-boating and skiing) and bird-watching. It is also a popular braai spot, especially during the summer season.

INTERVIEWER: Show Slide (Location Map), show Slides (Recreational Activities at Zeekoevlei)

Pollution of Zeekoevlei
Studies have shown that Zeekoevlei is highly polluted, with year-round concentrations of nitrogen and phosphorus. There are seepages from the wastewater plant, situated adjacent to the vlei. Nutrient loading from the catchment occurs during the winter via the Big and Little Lotus Rivers. The lake overflows only during the winter into a canal leading to the sea. All of this leads to a build-up of sediment in the vlei. The consequence is that the water quality of the vlei is negatively affected. This impacts on the natural beauty of the vlei, and it also affects the recreational activities at the vlei.

In addition to the environmental problems, the recreational value of the vlei is affected by the state of current facilities. The picnic spots on the eastern side of the vlei are over-grown by grass and there are garbage dumped along the entrance road. Ablution facilities are also not maintained. *INTERVIEWER: Show Slides (Pollution of Zeekoevlei)*

The Purpose of the Survey
We are interested in estimating primarily the value of Zeekoevlei to communities surrounding the vlei, as well as visitors to the yacht club, the angling association and the educational centres. To do this, we have to ask questions directly to the communities and users of the vlei. We will specifically be asking you a range of questions on the vlei, based on what the vlei currently looks like. We will also create some hypothetical (mock) scenarios where we will assume improvements in the

[97] The questionnaire is included in precisely the format as it was presented to the respondents.

recreational facilities and the water quality of the vlei. Since we want to establish the value of the vlei to you, we will need to ask you to try and set a money amount to these improvements. These mock scenarios will include questions on a hypothetical fee – but please note – **NO POTENTIAL FEE IS PLANNED.** For us to do a proper analysis of the value of the vlei, we request that you answer all questions to the best of your ability. We thank you in advance for cooperating with us.

QUESTIONNAIRE

SECTION 1: Background Information

1.1 Home Suburb

1 Grassy Park	2 Lotus River	3 Pelican Park	4 Zeekoevlei	5 Other: ………………………

1.2

0 Male	1 Female

1.3 Age of Respondent

1.4 Size of household (number of members)

1.5 Owner of house

0 Yes	1 No

1.6 What is your occupation?

1.7 First Language

1 English	2 Afrikaans	3 Xhosa	4 Other: ………………………

1.8 Age of household members

Household Member	1 Respondent:	2	3	4	5	6	7	8	9
Age									

1.9 Education (highest) of Respondent

1 No schooling	2 Primary School	3 Secondary School (excluding Matric)	4 Matric	5 Matric & Technikon / College Training	6 Matric & University Training

1.9 Does the household own a car?

0 Yes	1 No

1.10 Income of household (monthly)

1 R0 - R1 000	2 R1 001 - R5 000	3 R5 001 - R10 000	4 R10 001 - R20 000	5 R20 000 >

1.11 How do you normally spend your free time (especially over weekends), and how much time do you spend on it, on a scale of 1 to 5?

Activity	1 No time	2 Little time	3 Some time	4 A lot of time	5 Most of your time
1 Read					
2 Socializing with family & friends					
3 TV					
4 Shopping					
5 Braai					
6 Sports, e.g. soccer					
7 Water Sports (e.g. Power boating, sailing)					
8 Bird-watching					
9 Hiking / Walking					
10 Angling					
11 Other: ………………………..					

SECTION 2: Visiting Zeekoevlei

2.1 Do you live in the vicinity of the vlei?

1 Next to the vlei	2 Within walking distance	3 Drive by car to vlei	4 Other: ………..…………………..

2.2 Do you visit the vlei?

0 Yes	1 No

If yes, go to 2,3. If no, go to 2.6.

2.3 If yes to 2.2, list your activities at the vlei, and how much time you spend on it, on a scale from 1 to 5:

Activity	1 No time	2 Little time	3 Some time	4 A lot of time	5 Most of your time
1 Water Sports (e.g. Power boating, sailing)					
2 Bird-watching					
3 Walking at the vlei					
4 Angling					
5 Braai					
6 Enjoying the view of the vlei					
7 Other: ………………………..					

2.4 How often, on average, do you visit the vlei?

In winter (monthly):

0 Occasionally	1 Once	2 twice	3 Three times	4 Four times	5 Never	6 Other: ……………………

In summer (monthly):

0 Occasionally	1 Once	2 Twice	3 Three times	4 Four times	5 Never	6 Other: ……………………

2.5 What is the average duration of every visit, in hours?

2.6 Do you value the vlei as an environmental area?

0 Yes	1 No

2.7 If yes to 2.6, can you say why (choose from the following):

1 Diversity in nature (Biodiversity)	5 Water sports
2 Plants	6 Braai
3 Birds	7 Angling
4 Pristine area	8 Walking

2.8 If you answered no **to 2.6**, can you say why you do not value the vlei as an environmental area (choose from the following, on a scale of agreement, from 1 to 5)?

	1 Do not agree	2 Partially agree	3 Agree	4 Highly agree	5 Completely agree
1 No interest in the vlei					
2 Too busy to visit the vlei (work or other recreational activities)					
3 It is dangerous at the vlei					
4 The vlei is too polluted					
5 Getting to the vlei is difficult – no public transport					
6 There is a bad smell at the vlei					
7 Bad facilities at the vlei					
8 Other: …………………………………					

2.9 Do you experience any smell coming from the sewerage treatment system?

0 Yes	1 No

2.10 Do you experience problems with insects such as flies, etc. emanating from the vlei and/or the sewerage treatment system?

0 Yes	1 No

2.11 If yes to 2.9 or 2.10, does this affect how you feel about visiting the vlei?

0 Yes	1 No

2.12 If you do visit the vlei, how much does it cost you (per visit/use)? Here we are thinking about your traveling costs, any entrance fees, maintenance fees and membership fees, equipment use, etc.?

List your costs and the Rand amount per visit:

Cost item	1……….	2……….	3………..	4………..	5………..	
Rand spent	………...	…………	………….	…………	…………	Total: …..

2.13 Will you still visit the vlei (in its existing state) if you are charged a fee of R10.00 per visit / use of the vlei?

0 Yes	1 No

2.14 If yes to 2.13, will you still visit the vlei if the fee is R20.00 per visit / use of the vlei?

0 Yes	1 No

2.15 If yes to 2.14, will you still visit the vlei if the fee is R40.00 per visit / use of the vlei?

0 Yes	1 No

2.16 Do you visit any of the other vleis in the vicinity?

0 Yes	1 No

2.17 Please indicate which vlei(s):

0 Rondevlei	1 Zandvlei	2 Other: …………………

2.18 If yes to 2.16, can you say why you go to these vleis?

Better recreational facilities	Better water quality of the vlei
Better Security	Other: …………………………………………………..

2.19 If you do visit any of the vleis mentioned in 2.17, do you pay any entrance fee?
2.20 If yes to 2.19, please indicate the amount (per person): R…………….

0 Yes	1 No

SECTION 3: Recreation facilities at Zeekoevlei

The recreational facilities at the vlei are run down and not maintained. There is garbage lying around and the ablution facilities are not in working condition. *(INTERVIEWER: Show Slides of current facilities at Zeekoevlei.)*

Improvement in the recreational facilities can include fixing and improving picnic spots, better and well-maintained ablution facilities, improved braai facilities, weekly collection of garbage and maintenance of facilities, as well as improved angling spots and facilities for launching boats spots. It can also include better access to the vlei, such as the provision of improved roads and footpaths to the vlei. An improvement in facilities can be of benefit to you. You will be able to enjoy some relaxation time with your family and enjoy the natural beauty of the vlei. You can also enjoy water sports and do some angling.

What if, **hypothetically speaking**, there are plans to improve the recreational facilities at the vlei? The cost of these improvements is not known in advance. Assume that the cost of these improvements will be paid for by charging an entrance fee **(REMEMBER, NO ACTUAL FEES ARE PLANNED)**.

3.1 Given this hypothetical scenario, which of these improvements are important to you (on a scale of 1 to 5)?

	1 Not important	2 Slightly important	3 Important	4 Very important	5 Extremely important
1 Improving the access to the vlei – roads to the vlei					
2 Improving the access to the vlei – footpaths to the vlei					
3 Regular garbage collection and maintenance of facilities					
4 None of these improvements are important to me					

3.2 Do you think these hypothetical improvements will change how you feel about visiting/using the vlei?

0 Yes	1 No

3.3 Will you change your number of visits to the vlei if the hypothetical improvements were to take place?

1 Increase	2 Decrease	3 No change	4 No Visits

3.4 Are you willing to pay the entrance fee for these hypothetical improvements? Remember, this is purely a hypothetical scenario, **AND NO FEE IS PLANNED**.

0 Yes	1 No

If yes, go to 3.5. If no, go to 3.7

3.5 If you were asked to contribute R2 per person per visit, would you be willing to pay the entrance fee?

0 Yes	1 No

3.6 What would be the maximum amount your household would be willing to pay per person per visit to contribute towards improving recreational facilities at Zeekoevlei?

R ……………

3.7 If no to 3.4, can you perhaps say why you are not prepared to contribute towards recreational improvements at the vlei?

1 I don't think it is necessary to improve the recreational facilities.
2 Although I think it is necessary to improve recreational facilities at the vlei, I oppose the idea of charging an entrance fee.
3 Other: ……

SECTION 4: The environmental quality of Zeekoevlei

Zeekoevlei is primarily polluted by leakages from the Cape Flats Wastewater plant, and pollution from the Big and Little Lotus Rivers. This has caused a decline in the water quality of the vlei. The problem is that this affects the natural beauty of the vlei and has negative consequences for wildlife, as well as recreational activities (such as water sports and angling activities). Studies have indicated that dredging the vlei is one possible way of reducing the stock of pollution. Another is to stop the leakages from the wastewater plant. Although there are no actual plans to implement this, we would like to establish the value to people in surrounding communities if there was a reduction in pollution and therefore, an improvement in the environmental quality of the vlei.
The method we use to find this value is based on creating a hypothetical scenario, where we assume that there is a plan to clean up pollution in Zeekoevlei. Hypothetically speaking, this clean-up will improve the natural beauty of the vlei; for example, this can include improved water quality (e.g. less algae blooms), a better functioning ecosystem, and could increase the recreational benefit to you.

Suppose now, hypothetically speaking, a plan is developed to clean up the pollution, given that the hypothetical improvements in recreational facilities (as discussed in section 3) are already in existence? Assume that this involves the initial clean-up and regular clean-ups afterwards. Let us assume that this will improve the water quality of the vlei and also reduce the smell at the vlei. Also assume that the cost of this clean-up is not known at this point in time. However, we are interested in knowing whether you would be willing to contribute some money towards this clean-up. Let us assume **(REMEMBER, NO FEES ARE PLANNED)** that this clean-up fee could not be used for any other purpose.

4.1 Given this hypothetical scenario, which of these improvements are important to you (on a scale of 1 to 5)?

	1 Not important	2 Slightly important	3 Important	4 Very important	5 Extremely important
1 Reducing the pollution – improve environmental quality of the vlei, as described above					
2 Reducing the smell at the vlei					

4.2 Do you think these hypothetical improvements will change how you feel about visiting/using the vlei?

0 Yes	1 No

4.3 If yes to 4.2, will you change your number of visits to the vlei if the hypothetical improvements were to take place?

1 Increase	2 Decrease	3 No change	4 No Visits

4.4 Are you willing to pay for these hypothetical improvements? Remember, this is purely a hypothetical scenario, **AND NO FEE IS PLANNED**.

0 Yes	1 No

If yes, go to 4.5. If no, go to 4.7.

4.5 If you were asked to contribute R10 per month (for as long as it is necessary to clean the vlei), would you be willing to pay the clean-up fee?

0 Yes	1 No

4.6 What would be the maximum amount your household would be willing to pay per month to contribute towards cleaning up Zeekoevlei?

R …………….

4.7 If no to 4.4, can you perhaps say why you are not prepared to contribute towards cleaning up the vlei?

1 I don't think it is necessary to improve the water quality.
2 Although I think it is necessary to improve the water quality of the vlei, I oppose the idea of charging a clean-up fee.
3 Other: ………………………………………………………………………………………………………

4.8 Will some of the following factors still restrict you from visiting / using the vlei (indicating your agreement on a scale of 1 to 5)?

	1 Do not agree	2 Slightly agree	3 Agree	4 Highly agree	5 Completely agree
1 Lack of Public Transport to the vlei					
2 Lack of Security at the vlei					
3 Other: ………………………………………………..					

SECTION 5: Security at Zeekoevlei

5.1 Will proper policing of the vlei, e.g. patrolling on the vlei and the eastern shore of the vlei, be a crucial factor for you to visit the vlei?

0 Yes	1 No

5.2 If Yes to 5.1, indicate the how important this is, on a scale of 1 to 5:

1 Not important	2 Slightly important	3 Important	4 Very important	5 Extremely important

SECTION 6: Summary

6.1 Has it been easy or difficult to answer the above questions?

1 Easy to answer	2 Difficult to answer

6.2 How did you find the questions? Check all the items that fit your impression.

1 Information on the pollution of the vlei is difficult to understand.
2 It is difficult to understand to what degree the vlei's water quality will improve.
3 It is difficult to understand to what degree the facilities will be improved and maintained.
4 It is difficult to answer the questions by calculating in terms of money.
5 Others: ………………………………………………………………………………………

VERIFICATION OF QUESTIONNAIRE

In order for us to verify the completion of the questionnaire by the respondent, we request a contact number of the respondent:

Telephone Number (home): (021) …………………………

or

Cell phone Number: …………………………………

THANK YOU FOR SPENDING THE TIME TO COMPLETE THE QUESTIONNAIRE!

FOR THE INTERVIEWERS ONLY:

Please complete the following section after completing each interview. Please keep this page separate while you are conducting the interview, but fill it in immediately outside the respondent's house. Do not forget to write down the address and questionnaire form number (must correspond with the questionnaire you have just completed):

FORM NO: [ ]

RESEARCH ASSISTANT:

1	2	3	4	5
Craig	**Derick**	**Jonathan**	**Liansky**	**Shafeeqa**

ADDRESS OF RESPONDENT:

………………………………………………………………………………………………………

………………………………………………………………………………………………………

1) Did this respondent understand the questions being asked?

1	2	3	4	5
Not at all	Understood to some extent	Understood	Understood very well	Clearly understood excellently

2) Motivate your choice in 1 above:

……………………………………………………………………………………………………….…
………
……...

3) How reliable do you think are the answers provided by the respondent?

1	2	3	4	5
Not reliable	Reliable to some extent	Reliable	Very reliable	Extremely reliable

4) Motivate your choice in 3 above:

………
………
……..

5) Any further comments (from you or the respondent)?

………
………
……..