Could catchment conservation be funded through urban water tariffs? A case study of three South African cities

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Table of contents

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Abstract

Water scarcity is a global issue that has traditionally been addressed by over-abstracting surface water and constructing more dams. However, these solutions are environmentally destructive and, in some cases, insufficient to meet future water demands. To secure future water supply, it is necessary to invest in the protection and restoration of catchment areas which have become degraded due to human activities. In many developing countries, catchment management is financed solely by public funding, which is often insufficient to cover the costs of catchment conservation. Supplementary funding sources thus need to be investigated to ensure the future success of these interventions. This study aimed to address whether household water tariff pricing could be used as a mechanism for securing funds for catchment restoration. The objectives of the study were to (i) elicit households' willingness to pay (WTP) for water, (ii) determine factors influencing WTP, and (iii) investigate whether aggregate revenue generated from households' WTP at the municipal scale could cover the costs needed for catchment conservation in that water service provider region. Household surveys were conducted on 1244 households in three coastal metropolitan municipalities in South Africa: the City of Cape Town, Nelson Mandela Bay, and eThekwini. Contingent valuation revealed that average WTP for water across all three municipalities was R540 per household per month, 4.6% more than what households currently pay for water. Factors that significantly influenced WTP included income, age, household size, municipality, and satisfaction with municipal service delivery. Based on the WTP for 11 income categories, aggregate WTP for water amounted to R5.94 billion per year for the City of Cape Town, R5.83 billion per year for eThekwini, and R1.26 billion per year for Nelson Mandela Bay municipality. This translated to a positive consumer surplus of R1.2 billion for the City of Cape Town and R826 million for eThekwini, which is approximately three times greater than the estimated budgets required to cover the costs to restore both of the catchment areas supplying water to these municipalities. Since WTP for water was lower than the amount that residents currently pay in Nelson Mandela Bay, water pricing cannot be considered a mechanism to finance catchment conservation for this municipality. Choice models further revealed that households were willing to pay 34% more than their current water bill to avoid water restrictions, and 22% more to secure water supply through more environmentally sustainable options. These results demonstrate the importance of context and scale when making water investment and pricing decisions over the longer term.

Key words: ecological infrastructure, ecosystem services, restoration financing, water resources management, water pricing

Introduction

Water scarcity across the globe

Water scarcity is a defining feature of the Anthropocene. In many parts of the world, particularly arid and semi-arid countries that are physically water-stressed, the demand for water often exceeds supply. According to Mekonnen and Hoekstra (2016), approximately 4 billion people experience severe water scarcity for at least one month a year. By 2050, this is estimated to rise to 5.7 billion people (WWAP/UN-Water, 2018), which is likely an underestimation (Boretti and Rosa, 2019). Whilst unprecedented growth in human population and urbanisation have caused a significant increase in the demand for water on the one hand, over-abstraction, degradation of water source areas, climate change, and the contamination of freshwater resources have compromised the finite availability of water on the other (Gilbertson, Hurlimann and Dolnicar, 2011; Morokong *et al.*, 2016). Since water is linked to the challenges of poverty reduction, climate change adaptation, and food security, investments in water security are central in achieving global sustainability agendas such as the United Nations 17 Sustainable Development Goals (SDGs).

Water scarcity has traditionally been addressed by increasing water abstraction from surface rivers and investing in 'built' or engineered infrastructure such as dams and inter-basin transfers (Abell *et al.*, 2019). Although these solutions are an essential component of water service delivery, they have detrimental effects to the environment, especially if unregulated (Stafford *et al.*, 2018). The increase in dam construction and water abstraction has been found to modify natural flow regimes, fragment freshwater habitat, and alter the chemical and physical conditions of downstream environments (Dai, Brouwer and Lei, 2021). Such changes have detrimental impacts on both freshwater species and humans across the globe. For example, whilst dams obstruct migratory fish from reaching spawning and feeding grounds (Dudgeon *et al.*, 2006), over-abstraction of surface water has reduced the amount of water available in rivers, which poses a health risk to humans through increased pollution concentrations (Mander *et al.*, 2010). It is thus becoming increasingly apparent that alternative options to supplement water supply infrastructure is necessary, particularly those that minimise environmental damages.

The importance of ecological infrastructure

Investing in ecological infrastructure, is rapidly gaining popularity as a sustainable and cost-effective option of extending the life of existing infrastructure whilst meeting future water demands (Guswa *et al.*, 2014; Abell *et al.*, 2019). Ecological infrastructure, which is defined as 'naturally functioning ecosystems that deliver valuable ecosystem services to people' (SANBI, 2014), is considered a concept that falls under the broad umbrella of nature-based solutions (NBS) which are interventions to sustainably manage, restore, and protect natural or semi-natural ecosystems that address social challenges adaptively and effectively, whilst providing benefits to humans and biodiversity simultaneously (IUCN, 2020). Ecological infrastructure can provide services to society either directly (e.g. through coastal dunes protecting roads from storm surges), or as part of a broader infrastructure system combined with engineered infrastructure (e.g. catchment areas that function together with dams and pipes to provide water to human settlements) (Pringle *et al.*, 2015).

The delivery of hydrological ecosystem services such as water supply, water purification, flood attenuation, and pollution dilution, is heavily dependent on healthy ecological infrastructure (Guswa *et al.*, 2014). However, through human activities, catchment areas have become degraded, with reduced capacity to deliver beneficial ecosystem services (Nesshöver *et al.*, 2017). The main drivers of catchment degradation worldwide are invasive alien plant species, loss of vegetative cover, soil erosion, and bush encroachment (Reid *et al.*, 2019; Turpie *et al.*, 2021). Ecological restoration, which includes interventions to assist the recovery of an ecosystem that has become degraded, damaged, or destroyed, is recommended as a tool to improve the health of ecological infrastructure (Gann *et al.*, 2019). Beyond its ecological benefits, ecological restoration has also been found to generate broader co-benefits to society, including recreation and tourism opportunities, protecting built infrastructure, and buffering communities from climate change related impacts (Jones, Hole and Zavaleta, 2012). Restoring degraded catchment areas is thus considered a cost-effective and environmentally sustainable strategy to improve both water yields and the well-being of society.

Financing ecological infrastructure interventions

A significant impediment to the success of catchment restoration and conservation projects, particularly in the Global South, is funding (Shackleton *et al.*, 2017). Insufficient funding is attributed to multiple factors, one of which is a lack of monitoring and evaluation of restoration interventions, resulting in a weak organisational understanding of the societal, economic, and ecological benefits of such interventions (Rebelo *et al.*, 2021). Another factor is that in many developing countries rely solely on state funding as the only source of financing for these projects. Since Global South nations face higher rates of corruption, crime, unemployment, income inequality, and disease than Global North countries (Odeh, 2010), the budget for ecological infrastructure is generally insufficient to ensure long-term success of conservation initiatives. To mitigate this barrier, alternative funding streams beyond state funding need to be considered (Pringle *et al.*, 2015).

One such funding stream that has gained recent attention is that of water pricing. Worldwide, policymakers are confronted by the difficult balancing act of pricing water at a cost that does not impede people’s right to access it. Consequently, water is often priced far below the cost to produce it, resulting in economic inefficiencies, wasteful use, and infrastructural decay (Grafton, Chu and Wyrwoll, 2020). However, if designed appropriately, water pricing structures can be an effective instrument in achieving financial and economic goals (Mander and Mander, 2021). In recent years, cities have started to explore the potential of using water pricing as a tool to finance the restoration and protection of catchment areas that supply water to them (Turpie *et al.*, 2021). For example, in the City of Cape Town, decision-makers are currently exploring the option of charging municipal water users an additional charge to assist in funding the management and restoration of catchment areas supplying water to the Western Cape Water Supply System (Mander and Mander, 2021). To unlock the potential contribution of key water source areas to South Africa’s water security, the price paid for water will thus have to be increased over time. A recent report by Cartwright (2021) revealed that only a minor increase (1-2.5%) in the net price of water paid by domestic users could contribute significantly to the annual investment in ecological infrastructure interventions. Capturing some of the untapped willingness to pay for water (i.e. consumer surplus) could thus raise enough revenue to safeguard South Africa’s freshwater ecosystems and secure future water supply in the country (Turpie and Letley, no date).

Rationale of study

Numerous studies have investigated the opportunities to mobilise financial resources for the investment into water-related ecological infrastructure within the public and private sectors (Bennett *et al.*, 2014; Gómez-Baggethun and Muradian, 2015; Mbopha *et al.*, 2021; OECD, 2022). Other studies have recommended water tariffs as a potential funding mechanism for catchment conservation (Pegram and Palmer, 2001; Pringle *et al.*, 2015; Cartwright, 2021). However, few if any studies, have established whether the additional revenue generated from aggregate household willingness to pay (WTP) for water would be sufficient to secure funds for catchment conservation.

This study also addresses a crucial knowledge gap regarding how the values of consumers determines their choices using a research paradigm known as 'rational choice theory'. Rational choice theory is based on the assumption that the individual selects the best available choice to them given their personal preferences and beliefs (Satz and Ferejohn, 1994). This study uses rational choice theory to provide novel insight as to how households make certain trade-offs between the cost of water, the protection of environmental flows, and the reliability of water supply in future. According to Liebe and Preisendörfer (2010), predicting ecological perceptions, attitudes, and behaviour at the micro level is useful in guiding environmental outcomes at the macro level. Project questions, objectives, and hypotheses

In this study, interview surveys of residents in the three largest coastal metropolitan municipalities of South Africa were conducted. The overarching question is: Can water tariff pricing for households be used as a sustainable financing mechanism for catchment restoration? To answer this, the study set out to achieve the following objectives: (i) to determine households' WTP for existing water supply (ii) to investigate the socio-economic factors influencing household WTP, (iii) to elicit WTP for more reliable water supply and for more environmentally friendly water service, and finally (iv) to establish whether consumer surplus at the municipal scale will cover the costs needed to finance catchment restoration.

Prior to statistical examination of the data, three hypotheses were developed. First, socio-economic factors including income, education, age, trust in the government, satisfaction in municipal service delivery, and household size, will positively influence WTP. Second, aggregate WTP at the municipal scale will be sufficient to cover the costs needed to restore catchment areas supplying water to that municipality. Third, households will be willing to pay more to avoid future water restrictions than to secure water supply through more environmentally sustainable means.

Literature review

Water pricing as a tool to achieve environmental sustainability

The economic policy instrument of water pricing has been recognised as a powerful tool to pursue different water policy objectives (Dinar and Subramanian, 1998).In the past, water policy objectives were linked to social and economic issues such as protecting populations and economic assets from flooding and drought events, providing water as an input for economic activities, and supplying the domestic population with safe drinking water (Griffin, 2012; Pirard, 2012). However, in more recent years, water policy has incorporated the objective of protecting and managing freshwater ecosystems (Mander and Mander, 2021).

Water pricing is unique in that it has both incentive and revenue effects. High water prices have been found to incentivise consumers to reduce water consumption and invest in water-saving technologies (Schleich and Hillenbrand, 2009). For instance, Schoengold, Sunding and Moreno (2006) discovered that setting the price of water at appropriate levels encouraged farmers to adopt efficient irrigation technologies and to change to more productive cropping patterns. Further, the additional revenue generated from charging higher water tariffs can also contribute to the financing of water resource management, which should include the protection and conservation of water source areas (Wilson *et al.*, 2021). Thus, water pricing can be used as a tool to achieve environmental sustainability.

In most countries, the price of water does not cover the costs of its supply which include the costs of producing, treating, distributing, and managing water resources (Andrés *et al.*, 2021). This is particularly apparent in Global South countries where policies are centred around access and affordability (EUWI-FWG, 2012). However, low water prices have serious implications for the sustainability of water utilities, often leading to a vicious cycle of asset deterioration, poor management, and low quality services (Roldán, Sarmiento and Roldán-Aráuz, 2021). According to a worldwide survey conducted in 2004, only 39% of utilities were charging water tariffs at a rate which allowed them to fully recover both short-run and long-term costs (Le Blanc, 2007). Guaranteeing the sustainability of water supply whilst ensuring access to all is thus considered a significant challenge for government authorities (OECD, 2022). This requires some knowledge of societal preferences and potential welfare outcomes.

The revenue generated from water services are referred to as the three Ts: taxes, transfers, and tariffs (OECD 2009). According to the EUWI-FWG (2012), among the three Ts, water tariffs should be considered the main source of finance for water resource management. This is because water supply is a service, and consumers are generally willing to pay more for efficient and good quality services (Andrés *et al.*, 2021). The gap between what a consumer actually pays for a good or service versus what they are willing to pay is referred to as “consumer surplus”(Wells, 1997). A recent meta-analysis found that in Global South countries, households were willing to pay three times more for water than Global North countries relative to their income (Roldán, Sarmiento and Roldán-Aráuz, 2021). Since developing countries tend to have significantly worse water supply systems, residents are willing to pay a greater percentage of their income towards improving the quality and quantity of their water supply.

Environmental goods valuation

In the absence of viable markets, economists have established various methods to estimate the monetary value of environmental goods (Witt, 2019). These methods include the alternative cost method, the travel cost method, the hedonic price method, the replacement cost approach, and the stated preference approach (Makwinja *et al.*, 2022). These methods are important in measuring the value of ecosystem goods and services and are often used in justifying the conservation of natural resources (Makwinja *et al.*, 2022).

One of the most popular methods to value water is the stated preferences approach which uses respondents' statements about their preferences to estimate change in utility with a proposed increase in quantity or quality of a good or service (Bateman *et al.*, 2002). In contrast to the revealed preference approach which aims to deduce respondents' willingness to pay from observed evidence of how they behave when faced with real choices, stated preferences are based on constructed markets. Through carefully designed surveys, the stated preferences approach involves creating a hypothetical market in which respondents must make choices about the environmental good in question (Carson, 2000). The stated preference approach strongly relies on the honesty and participation of respondents, often cited to be the major downfall of the method (Bostan *et al.*, 2020). Despite this, the approach is often used by decision-makers as a starting point to set water prices (Makwinja, Kosamu and Kaonga, 2019). Two of the most widely applied stated preferences techniques are the contingent valuation method and the choice experiment method, both of which have their own advantages and disadvantages.

Contingent valuation is a survey-based method during which respondents are directly asked how much they are willing to pay in monetary terms for a specified environmental good (Carson, 2000). Willingness to pay (WTP) thus reflects the value the respondent places on the good (Littlefair, 1998). There are three main elements of the contingent valuation method: the hypothetical market (in which no actual transactions are made), the description of the environmental good to be valued (e.g. clean air or water), and the payment vehicle (how respondents are hypothetically expected to pay for the good) (Gyrd-Hansen, 2014). The contingent valuation method is an widely used, easy to understand, and flexible way to collect high volumes of data from the target population (Bostan *et al.*, 2020). However, there are several limitations and biases which researchers need to try and control to ensure the validity and reliability of their results when using this method. One of the most difficult biases to control is the hypothetical bias, which arises because respondents do not have to support their choices with any real monetary commitments (Venkatachalam, 2004). Generally, hypothetical biases arise when respondents give an answer that is socially desirable, rather than true. The interviewer has to therefore accept that the respondents' answers are true, unless they can validate the findings with a real market (Lewis *et al.*, 2018). Strategic bias is another issue linked to contingent valuation studies, whereby respondents either 'free-ride' or 'over-pledge' (Venkatachalam, 2004). Whilst free riding occurs when respondents understate their true WTP on the assumption that other people will pay enough for the good or service, over-pledging occurs when respondents assume that their WTP value will impact the provision of the good or service in reality (Bateman *et al.*, 2002; Venkatachalam, 2004). Controlling these biases can be achieved through careful survey design, developing a convincing hypothetical scenario, and using appropriate eliciting formats and payment vehicles (Carson, 2000).

The choice experiment method is often applied in studies to predict human behaviour (Bostan *et al.*, 2020). The choice experiment, which was developed by (Louviere and Hensher, 1982) states that the utility from a good or service is derived from its individual attributes or characteristics rather than from the good itself. During this technique, the context in which consumers ordinarily make choices is simulated among a set of competing alternatives**,** designed according to several attributes and levels that are independent and systematically varied according to experimental design (Carson *et al.*, 1994). Generally, two or more alternatives are presented as choice tasks to respondents where one option represents the status quo (i.e. describes the current state). Respondents are then invited to select which choice task or scenario they prefer (Koemle and Yu, 2020). The number of choice tasks offered is dependent on the number of attributes and levels (Turpie and Letley, 2018). The assumption is that consumers will select the alternative that will provide the highest utility to them. Including cost or price as one of the attributes is often used to estimate individuals' willingness to pay. The advantages of this method are that it allows the simultaneous analysis of multiple impacts on respondents and is an useful tool for policy and decision-makers (Bostan *et al.*, 2020). However, the downfalls are that the method is time-consuming, and relies on precise pre-testing and statistics (Dai, Brouwer and Lei, 2021).

Over the last few decades, there has been a rise in the number of contingent valuation and choice experiment studies regarding willingness to pay for different purposes and implications. These two methods have been widely used in literature from developing country contexts. For instance, households have been found to be willing to pay more money to guarantee safe and reliable drinking water in Malawi (Makwinja, Kosamu and Kaonga, 2019), Nicaragua (Vásquez, Franceschi and Van Hecken, 2012), and Kazakhstan (Tussupova *et al.*, 2015). Other studies have also demonstrated that people are willing to pay more towards efforts to restore nearby freshwater ecosystems, such as for wetlands in Ethiopia (Asmare, Bekele and Fentaw, 2022), and urban rivers in China (Li *et al.*, 2014; Khan *et al.*, 2019).

Factors influencing willingness to pay for water

In most cases, there is a positive relationship between willingness to pay (WTP) for water and socio-economic factors such as income, education, age, and household size (Littlefair, 1998; Del Saz-Salazar, González-Gómez and Guardiola, 2015; Akinyemi, Mushunje and Fashogbon, 2018). WTP to avoid water restrictions has also been found to be influenced by internal circumstances such as having a garden or a swimming pool, as well as by external factors including the duration and severity of water restrictions imposed on households by the city (Wilson *et al.*, 2021). Few studies have investigated the extent to which institutional trust impacts WTP, but for those that have, a positive relationship has also been reported (Makwinja, Kosamu and Kaonga, 2019; Makwinja *et al.*, 2022). More studies, however, need to be conducted to understand the impact of institutional trust and satisfaction on household WTP, particularly in countries where service delivery is poor, and where factors such as corruption and political instability are common.

Institutional context of water supply and management in South Africa

At present, surface water resources account for 77% of South Africa's water supplies and according to Kanyoka, Farolfi and Morardet (2009), most of these resources are either overdrawn or fully utilised. The dominant water user is agriculture (67%), followed by urban use (18%), mining (5%), and rural households (3%), with the remainder distributed amongst forestry, power generation, and other uses (Mutamba, 2019). Threats to the country's future water security are numerous and include that South Africa is physically water scarce, ranked as the 30th driest country in the world; demand for water is growing due to an increasing population; water infrastructure is aging with high water losses; institutions have failed to adequately and equitably manage water resources and its associated infrastructure; and catchments are threatened by land degradation caused by human activity (Mutamba, 2019). Considering these threats, the demand for water in South Africa is projected to outstrip supply by 2030 unless water pricing is adjusted substantially (Colvin *et al.*, 2016). As such, South Africa needs to efficiently manage and protect its water resources, particularly its catchment areas.

To understand challenges relating to household water supply and security at the local scale, it is necessary to acknowledge the institutional context of water at the national scale. South Africa's long history of inequality in the water sector stems from several pieces of legislation that unfairly allocated water to specific groups' (Madigele, 2018). This was brought about by several pieces of legislation which unfairly allocated water to the white minority, such as the Irrigation and Conservation of Water Act which favoured white farming communities, granting them rights to riparian water whilst limiting access to black farming communities (Jegede and Shikwambane, 2021). As a consequence of these policies, only 59% of the population (38 million people) had access to basic water supplies before 1994 (Adom and Simatele, 2021).

Post-apartheid, the new South African government introduced a series of policy reforms aimed to redress past injustices in the water sector (Hove *et al.*, 2019). In 1996, water was enshrined as a basic human right in section 27(1) (b) of the 1996 Constitution, and in 1997, the Water Service Act (Act 108 of 1997) sought to empower citizens with the right of access to basic sanitation and water supply (Adom and Simatele, 2021). Reforms introduced by the Water Services Act included the establishment of water management institutions such as, water user associations, irrigation boards, and Water Boards (Meissner *et al.*, 2013; Adom and Simatele, 2021). Further the National Water Act (Act 36 of 1998), enacted in 1998, provided the legislative framework to effectively manage water resources in South Africa, placing all water resources in the country under the custodianship of the Minister of the (then) Department of Water Affairs and Forestry (Cartwright, 2021). Under this act, service provision and water supply were devolved from central government to municipalities between 2003 and 2006 (Jegede and Shikwambane, 2021). However, the ambitious decentralisation of water provision came with multiple challenges at the local level including financial distress, inability to raise revenue, debt, financial mismanagement, and corruption of public procurement (Hove *et al.*, 2019).

To alleviate the failing system, 19 Catchment Management Agencies were established across the country to manage water resource planning and management at the catchment level; thus taking up responsibility for local governance (Meissner *et al.*, 2013). However, due to a lack of capacity and accountability as well as poor decision-making, establishment of Catchment Management Agencies has been poor, and to date, only two are operational (Cartwright, 2021). Thus, although these policies and programmes have been internationally regarded as some of the most progressive pieces of legislation on water, they have failed to address challenges in the water sector, particularly regarding governance at the catchment level (Adom and Simatele, 2021).

Although the Department of Water and Sanitation (DWS) is mandated to develop, monitor, regulate and evaluate the water sector, it has transferred its responsibility of implementation to specific municipalities. All municipalities that are considered category A municipalities (metros) are permitted to provide water to the population. Smaller local municipalities (category B) are authorised in some instances, and several district municipalities (category C) are authorised in others (Lehohla, 2016). In total, 169 metropolitan, local, and district municipalities have been designated as Water Services Authorities, which have the responsibility of providing water and sanitation services within their areas of jurisdiction (Cartwright, 2021). Often, authorised municipalities appoint other organisations or municipalities to provide water services on their behalf. These organisations are known as Water Service Providers (National Treasury, 2011). Since 2000, metropolitan municipalities have taken on increasing responsibility and influence in the water sector.

Catchment degradation in South Africa and efforts to address it

According to Le Maitre *et al.* (2019), most of South Africa's rivers and wetlands are currently threatened. Although different catchment areas across the country are exposed to different threats, most have been degraded to some extent by invasive alien plants. Le Maitre *et al.* (2016) estimated that invasive alien plants such as wattles and pines reduce mean annual runoff (MAR) by up to 1 444 million $m^3 \cdot a^{-1}$, lowering annual water availability by approximately 4%. Restoration through the removal of alien plants, as well the establishment of indigenous vegetation is thus urgently needed to improve water yields. Beyond invasive alien plants, other drivers of catchment degradation in South Africa include soil erosion and sedimentation due to inappropriate farming practices such as wood harvesting and overgrazing (Mhangara, Kakembo and Lim, 2012); bush encroachment as a result of poor land management, mainly overgrazing and the exclusion of fires (Turpie *et al.*, 2021); and pollutants from agriculture and urban settlements which enter rivers and reduce water quality (du Preez and van Huyssteen, 2020).

These challenges are likely to be exacerbated by climate change, with projections indicating more intense and frequent droughts (Otto *et al.*, 2018), as well as increased evaporation, irregular rainfall, and progressive drying over much of the country (Dieppois *et al.*, 2016). Water shortages in South Africa have already resulted in negative economic impacts on key sectors of the economy. Between 2015 and 2016, a severe drought across much of South Africa significantly impacted the agricultural sector, which resulted in job losses, increases in food insecurity, production declines, and a decline in the Gross Domestic Product (Baudoin *et al.*, 2017). Since most of South Africa's freshwater ecosystems are degraded to some extent, high levels of investment into the protection and restoration of these systems are required to secure future water supply in the country.

To address the water challenges in South Africa, the government has acknowledged the importance of investing in water-related ecological infrastructure (Mbopha *et al.*, 2021). In addition to increasing ecosystem services, these interventions have also been identified as a key element in South Africa's transition towards a green economy, providing unskilled employment opportunities and other socio-economic co-benefits (Blignaut *et al.*, 2010; Coldrey, 2020; Mbopha *et al.*, 2021). This has partially been achieved through the government-funded Natural Resource Management (NRM) programme, which launched the country's "Working for" programmes (e.g. Working for Water), the LandCare programme, and the Land User Incentive Programme (Le Maitre *et al.*, 2016; Letley and Turpie, 2022). The largest NRM programme, Working for Water, is reported to have cleared an average of

200 000 condensed hectares of invasive alien plants every year since 2010, and has attracted over R15 billion in investments since its establishment in 1995, largely owing to its social upliftment mandate (Turpie *et al.*, 2021).

However, despite the notable success of such programmes, the scale and value of investments in ecological infrastructure are small compared to what is needed, and implementation thus far has been piecemeal (Letley and Turpie, 2022). A further criticism of such programmes is the focus on meeting employment targets rather than on ensuring the long-term success of ecological restoration. According to Turpie *et al.* (2021), this has led to weak implementation, monitoring and follow-up interventions, resulting in the re-invasion of areas. Consequently, invasive alien plants remain a serious threat to freshwater ecosystems and water security in South Africa.

Donnenfeld, Crookes and Hedden (2018) argue that the most fundamental constraint preventing the effectiveness of water policies in South Africa is that water is significantly under-priced, resulting in a failure to cover the costs of water resource management at the catchment level. However, since water is a basic need, it must be priced at a level that does not impede people's right to access it. Pricing water in South Africa is therefore a complicated balancing act, and as a result, the DWS are reluctant to increase water prices to reflect full-cost accounting due to the risk of alienating water users. The scope for raising water prices is also limited by the institutional capacity to collect money at current prices and spend additional money efficiently. The DWS (2019) reported that across South Africa, "non-revenue water" resulting from leaks, illegal connections, and the under-collection of tariffs, accounted for 41% of the water distributed by Water Service Authorities, representing a loss of R9.9 billion in 2018.

To combat the challenge of affordability in South Africa, the government has implemented an inclining block tariff (IBT) structure for water which aims to recover the costs of constructing and maintaining infrastructure whilst protecting the poorest households from unaffordable water prices (Walsh, Shai and Mbangata, 2019). Regarded as a pro-poor tariff structure, the IBT is a volumetric form of non-linear pricing whereby low-consuming households pay lower prices for water (Le Blanc, 2007). This is based on the assumption that high-income households tend to consume water at higher levels than low-income households. IBTs thus intend to capitalise on wealthier households' higher willingness to pay for water to cross-subsidise the cost of water for the poorest households.

In most municipalities in South Africa, the first 'block' (6 kl/month) is provided free to indigent households under the Free Basic Water policy of 2002 (Mpofu, Kruger and Reddick, 2020). Individual municipalities have the authority to decide (i) the cost of the water tariff charged per litre above the first block, (ii) the amount of water that is free above 6 kl per month (i.e. some provide as much as 14 kl free), and (iii) which households are considered indigent. To date, 136 out of the 169 Water Service Authorities provide free water to some residents that have been identified as indigent by that municipality, 29 provide free basic water to everyone (rich or poor), and four small municipalities do not supply free water to any of their residents (Colvin *et al.*, 2016).

Although IBTs have been successfully implemented in some large municipalities, the design of the system has received some criticism. For most utilities in South Africa, the operating and maintenance costs are generally recovered from the highest block users, but not for the lowest block users (Dikgang *et al.*, 2019). This is a serious issue for poorer municipalities that do not have enough customers in the higher-use blocks to cross subsidise the lower-use blocks (National Treasury, 2011).

The failure of IBTs to recover costs has resulted in inadequate investment in water-related infrastructure and management, which has led to water supply shortages in municipalities such as Makhanda in the Eastern Cape (Pamla, Thondhlana and Ruwanza, 2021). Additionally, the system discriminates against low-income households that consume high amounts of water due to large household sizes and age composition (Grafton, Chu and Wyrwoll, 2020). Lastly, due to the arbitrary guidelines of the IBT structure, water is currently considered affordable for high-income households, but not so for low-income households (Dikgang *et al.*, 2019). This was revealed during the recent droughts experienced by the Western Cape and Eastern Cape, whereby the biggest users of water were from affluent suburbs. With the country expected to face more frequent droughts in future, it is necessary to design the IBT in a way that will maximise the ability of the richer households to pay for water. Investigating household willingness to pay (WTP) for water at the municipal scale will be important first step in redesigning the tariff structure of South Africa.

Methods

Ethics statement

The methods used in this study were approved by the University of Cape Town Faculty of Science Research Ethics Committee under the approval number 'FSREC 017 – 2022'. Prior to fieldwork involving in-person interactions with human participants, approval from the Departmental COVID-19 compliance officer and Head of Department was obtained. Additionally, permission to conduct surveys outside Home Affairs offices was granted by the Directorate of Research Management for the Department of Home Affairs.

Study area

Three coastal metropolitan municipalities in South Africa were selected as survey sites: the City of Cape Town in the Western Cape, Nelson Mandela Bay in the Eastern Cape, and eThekwini in KwaZulu-Natal **(Figure 1).** These municipalities were selected as they represent three of the eight largest municipalities in South Africa, are dependent on strategic water source areas for their municipal water supply, have made initial investments towards catchment restoration, and have unique socio-economic, water supply and water service provision contexts. Additionally, water funds, which are "funding and governance mechanisms that enable collective action between the public and private sector to employ nature-based solutions such as catchment restoration", have already been established, or are in the process of being established in all three municipalities (Bonthuys, 2019). In 2016, these three municipalities had a combined population of 8 334 502 people, which is approximately ~16% of the total South African population (Small, 2017).

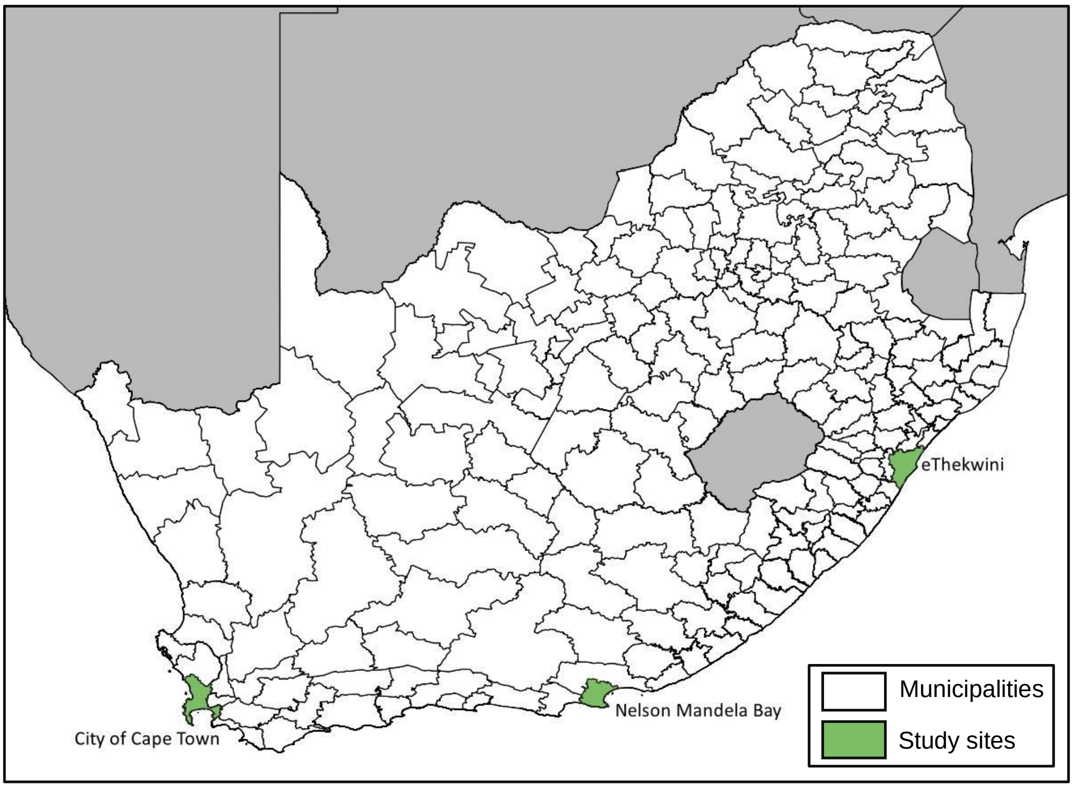

Figure 1: Map of the three coastal municipalities selected as study sites in South Africa.

City of Cape Town Municipality

The City of Cape Town is a coastal municipality in the Western Cape. In 2016, the city had a total population of 4 million people (Small, 2017). The region experiences a Mediterranean climate, with cool wet winters and hot dry summers (Enqvist and Ziervogel, 2019). The mean annual rainfall is 749 mm, and most precipitation is experienced between May and August (Otto *et al.*, 2018). Cape Town receives 98.4% of its surface water from three of South Africa's 22 strategic water source areas: the Boland mountains, the Groot Winterhoek, and Table Mountain (Le Maitre *et al.*, 2019). Water is transferred from these catchment areas via a system of dams and pipelines which is referred to as the Western Cape Water Supply System (WCWSS). The WCWSS is run by the City of Cape Town and the Department of Water and Sanitation (DWS) (Colvin *et al.*, 2016). There are six major dams in the WCWSS, predominately situated within the upper regions of the Berg and Breede River catchments (Adams, Jones and Du Preez, 2018).

The Table Mountain strategic water supply area is approximately 90 000 ha in size and of this, only 19.7% is formally protected. Since Table Mountain is located within a city, much of the land cover has been transformed into urban and light industrial areas and alien plantations have replaced a large extent of the native vegetation. The larger Boland and Groot Winterhoek mountains cover just over 600 000 ha and are more extensively protected (46%). Although the Boland strategic water surface area is mostly natural vegetation, 20% of the area is under cultivation, and most of the catchments have been invaded by invasive alien plants to some degree. Le Maitre *et al.* (2019) estimated that at present, baseline invasions are reducing water yields by 38 million $m^3 \cdot a^{-1}$ in the WCWSS. If no efforts are made to clear these invasions, these reductions in yield will increase to 130 million $m^3 \cdot a^{-1}$ in 45 years' time. During periods of low rainfall, impacts of invasive alien species are felt most acutely.

Between 2015 and 2017, three consecutive years of below average rainfall brought Cape Town close to reaching "Day Zero", a day when the city was predicted to run out of water. The City's response was to limit water users to 50 litres per day, as well as to invest in alternative options to meet demand such as water recycling, groundwater, and desalination (Colvin *et al.*, 2016; Le Maitre *et al.*, 2019). However, many of these projects have since been decommissioned due to high operating costs (Otto *et al.*, 2018). The city also made initial investments in clearing invasive alien plants in the catchments above the main water supply dams to enhance water security.

More recently, a non-governmental organisation, the Nature Conservancy, established a Business Case for the Greater Cape Town Water Fund, a project which aims to pool funding from multiple sources to restore and maintain ecological infrastructure in the WCWSS (Stafford *et al.*, 2018). The Business Case revealed that an investment of R372 million would be sufficient to generate more than 55 billion litres in water gains over six years, increasing to 100 billion litres over 30 years. This corresponds closely to the estimate provided by Le Maitre *et al*. (2019) of 130 million $m^3 \cdot a^{-1}$ required over 45 years. This will be necessary to alleviate water scarcity in the city, whilst creating jobs through alien plant clearing.

Nelson Mandela Bay Municipality

The Nelson Mandela Bay Metropolitan Municipality is situated in the Eastern Cape, one of the most rural and populous provinces of South Africa. Nelson Mandela Bay includes one of South Africa's largest cities: Gqeberha (previously Port Elizabeth), as well as the smaller towns of Kariega and Despatch. In 2016, the population of Nelson Mandela Bay was 1.26 million people (Statistics South Africa, 2018a).

The climate of Nelson Mandela Bay is warm and temperate, with mean annual precipitation ranging from 500 to 650 mm per year (Nelson Mandela Bay Municipality, 2022). Around 1.1 million people in the municipality receive water for domestic use from the Algoa Water Supply System which is subdivided into the Western, Central, and Eastern systems. The Western System supplies water to approximately 70% of the residents in Nelson Mandela Bay municipality and is made up of three important catchment areas: the Baviaanskloof, Kromme and Kouga. The Central and the Eastern systems supplement the Western System through a system of dams, transfer schemes and springs (DWA, 2011).

Although a significant portion of the Kouga river catchment is protected, there has been significant degradation outside of these areas. Pine trees have invaded most of the Tsitisikamma Mountains in the south, and capital-intensive deciduous fruit farms in the Langkloof valley have resulted in an increase in the construction of illegal dams, as well as overextraction of water from nearby rivers. Degradation of these catchments have led to an increase in regional floods and water shortages (Nelson Mandela Bay Municipality, 2015).

At present, the municipality is experiencing one of its worst recorded water shortages to date (Mahlalela *et al.*, 2020). Experts have attributed the current water crisis to a variety of factors including seven years of well-below average rainfall due to climate change, municipal mismanagement of funds, budget and procurement bottlenecks, a lack of diversified water sources, and a growing population (Nelson Mandela Bay Municipality, 2022). As of June 2022, combined dam levels were at 12.26%, and emergency schemes were being put into action.

Mander *et al.* (2010) found that restoring 225 000 ha of invaded and overgrazed land in the Kromme, Kouga, and Baviaanskloof catchments could increase water yields and baseflows by 11 and 14 million $m^3 \cdot a^{-1}$ respectively, and reduce sediment loads by 22 million $m^3 \cdot a^{-1}$. Predictions from this model also indicated that restoring these catchments would also result in a bundle of co-benefits including biodiversity-based tourism, and carbon sequestration. In 2015, the municipality estimated that R252 million over 30 years would be needed to restore these three catchments, primarily through alien clearing, revegetation, and fire management (Nelson Mandela Bay Municipality, 2015). However, to date, Nelson Mandela Bay municipality has spent most of its drought relief fund on constructing and maintaining grey infrastructure and on demand management measures (Pietersen, 2021).

eThekwini Municipality

In 2016, eThekwini metropolitan municipality had a population of 3.7 million people, which is approximately 33.5% of the total population of KwaZulu-Natal province (Statistics South Africa, 2018b). In contrast to the other metropolitan municipalities, eThekwini is situated in a high rainfall area, receiving over 1000 mm of precipitation per year (Olanrewaju and Reddy, 2022). The municipality frequently experiences flooding events, which are expected to increase in magnitude as a consequence of climate change (Mander *et al.*, 2017).

The major cities of Durban and Pietermaritzburg receive most of their water from the Greater uMngeni catchment, a relatively small but significant catchment (Gokool and Jewitt, 2019). Despite being less than 5% of the surface area of the KwaZulu-Natal province, the catchment provides water to over 42% of the population (Pringle *et al.*, 2015). However, at present, the available yield of the catchment (383 million $m^3 \cdot a^{-1}$) is not enough to meet the demand for water (406 million $m^3 \cdot a^{-1}$). As a result, the catchment has been fully developed to accommodate this demand, with four storage dams constructed over the years (Umgeni Water, 2021). Water supply is further augmented by transfers from the Mooi River through the Mooi-Mgeni Transfer Scheme (Pringle *et al.*, 2015).

Land use and land cover activities have significantly altered the Greater uMngeni catchment. Intensive commercial afforestation and agricultural land are the dominant land use activities characterising the upper reaches of the catchment (Gokool and Jewitt, 2019). These activities have led to the encroachment of sugarcane crops and livestock farming into riparian zones and wetland areas, as well as siltation of dams and soil erosion (Cartwright, 2021). Further downstream, the catchment is characterised predominantly by industrial and densely-populated urban areas which have led to pollution from urban areas, and the invasion of invasive alien plants (Mander *et al.*, 2017). Riparian invasions are estimated to reduce mean annual runoff in the Greater uMngeni catchment by around 90 million $m^3 \cdot a^{-1}$ (Le Maitre *et al.*, 2019).

The eThekwini municipal government are aware of the current risks to the Greater uMngeni catchment and have recognised the importance of maintaining and restoring ecological infrastructure. Stakeholders including the municipality, the Department of Water and Sanitation, SANBI and WWF have formed an alliance to enhance ecological infrastructure in the Greater uMngeni catchment with the aim of improving water quality and quantity. This group has over 36 signatory members and is formalised as the uMngeni Ecological Infrastructure Partnership (UEIP) (Hughes *et al.*, 2018).

An estimated R250 million is required over five years to eradicate invasive alien plants from the Greater uMngeni Catchment to improve water yields in the short term and to buffer communities from climate change in the long-term (Cartwright, 2021). However, Umgeni Water has not allocated a single cent of its Water Resource Management levy, which is approximately R16 million, towards alien clearing.

Data collection

Data for this study were collected between 21 March and 14 April 2022 from household residents in the three municipalities. Willing participants were only interviewed if they were over 18 years old, lived in the surveyed municipality, considered themselves a financial contributor or a decision-maker in their households, and received piped municipal water to their house (hereafter referred to as the 'interview criteria'). Face-to-face interviews were conducted in three localities over three days in Cape Town, in two localities over four days in Nelson Mandela Bay, and in two localities over three days in eThekwini.

In each municipality, a team of local postgraduate students were hired and trained to enumerate the interviews (hereafter, referred to as ‘enumerators’). Answers to questions were captured on electronic tablets using an application called Kobo Collect (Kobo Inc., 2021). During training sessions, the questionnaire was pre-tested by enumerators and supervisors. Pre-testing is essential before conducting formal surveys to improve the flow of questions, to reword ambiguous questions, and to exclude any variables that may be irrelevant to the study (Majumdar and Gupta, 2009). In this study, pre-testing was also necessary to correct any formatting errors in the electronic questionnaire as well as to ensure that any context-specific questions accurately reflected the current situation in each municipality.

Surveys were conducted in waiting queues outside of several offices of the Department of Home Affairs (DHA) in the home language of each participant (English, Afrikaans, Xhosa, and Zulu). Due to time constraints, only a few DHA offices in each municipality could be visited. Three DHA offices were selected as survey sites in the largest municipality (City of Cape Town) and two DHA offices were selected from the smaller two municipalities. To broaden the geographical representation of the sample in each municipality, one DHA office had to be located in the central business district (CBD), and at least one other DHA office had to be located more than 15 kilometres from the CBD. Sites selected in the City of Cape Town included one in CBD of Cape Town (Barrack street), one in the northern suburbs (Bellville), and one in the southern suburbs (Wynberg). In eThekwini, the main survey site was located in the CBD of Durban (Umgeni road), and the other site was located in the urban outskirts (Pinetown). In Nelson Mandela Bay, one DHA office was located in the centre of town (Govan Mbeki Avenue), and the other in Cleary Park.

The DHA’s core functions are to issue identification documents, issue travel documents and passports, manage birth, death, and marriage certificates, grant citizenship, issue residency permits to foreigners, and to administer admissions into the country. Due to the range of identification services that the DHA offers to the citizens of South Africa, these queues are frequented by a wide representation of household residents. Although surveying people in a queue is a form of convenience sampling which could be subject to unknown biases, it can also be considered a cost-effective and an efficient alternative to conducting *in situ* household surveys. Further, the authors have also previously experienced a wealth bias when conducting door-to-door surveys in South Africa, since wealthier people are generally unwilling to conduct these types of surveys (Turpie and Letley, in review).

Questionnaire design

The survey questionnaire, which took between 12 and 15 minutes to administer, was divided into five main themes including: (i) general household characteristics, (ii) willingness to pay (WTP) for existing water use, (iii) WTP for security of supply and environmental flows, (iv) trust in municipality, (v) socio-economic status (see questionnaire in **Appendix 1**).

Similar to Turpie and Letley (in review), the first section covered general information about the respondents’ household such as their suburb, household size, and whether their property had a garden, swimming pool, borehole, wellpoint, rainwater tank and/or pumped greywater system. Respondents were also asked about their average household monthly electricity and water bills, how they pay for their utilities (if at all), and how confident they felt about their reported utility bills (since respondents could not access their actual bills during the interview). Confidence was indicated on a five-point Likert-scale from "Not at all confident" to "Extremely confident".

The second section dealt with WTP for existing water use. The most widely used contingent valuation techniques to elicit WTP are the dichotomous choice, payment card, bidding game, and open-ended formats (Bateman *et al.*, 2002). Following similar studies by Welle and Hodgson (2011), and Makwinja, Kosamu and Kaonga (2019), this study employed the dichotomous choice format. The dichotomous choice format is often referred to as the 'take it or leave it' approach and can either be single-bounded or double-bounded. In the single-bounded dichotomous choice method, respondents are posed with a single question for which they must answer either yes or no. For example, 'Would you be willing to pay R100 for the water you are currently using'. With the double-bounded dichotomous choice format, a follow-up question is asked to reduce the variance in WTP estimates (Lee, Ma and Cheung, 2021). If the respondent answers positively to the first bid, the second amount offered is higher. However, if respondents reject the initial bid, the second amount offered is lower. Four possible outcomes thus arise: both answers are yes (yes-yes); yes followed by no (yes-no); no followed by yes (no-yes); and both answers no (no-no). The double-bounded dichotomous choice question format reduces estimate uncertainty and provides more information about the respondents' WTP. Due to this, the double-bounded dichotomous choice format is more statistically efficient and thus a more popular approach than the single-bounded dichotomous choice (Van Song *et al.*, 2019).

In most contingent valuation studies, bid amounts are finalised prior to surveying, and are generated randomly (Carson, 2000). However, this may lead to starting point bias (Majumdar and Gupta, 2009). This study aimed to mitigate this bias by offering an initial bid that was 1.5 times respondents' current water bill, thus offering a bid within the respondent's range. This is a similar approach to Makaudze (2016) who used the average water bill of the study area as the initial bid. If the response to the initial bid was 'yes', the subsequent bid was increased to double the respondents' current water bill. However, if the response to the initial bid was 'no', the subsequent bid was lowered to 1.25 times their current water bill. If respondents did not have any idea of how much they were paying for water per month, a random starting bid was generated. These bids ranged from R200 to R800. Similarly, if the respondent accepted the random starting bid, the follow-up bid was increased by 1.5. However, if the random starting bid was rejected, the follow-up bid was decreased to 1.25 times the random starting bid. Households that currently receive free water (i.e. those who are part of the indigent support programme) were excluded from the dichotomous choice questions ($n = 119$) to ensure that the analysis only included households who currently pay for water. Outliers were also removed from the dataset (those with a current water bill of ≥ R3000; $n = 11$). Similar to Peletz *et al.* (2020), the dichotomous choice questions were followed with an open-ended question asking respondents to state their maximum WTP for water. This offers an opportunity to check whether respondents answers were consistent across both questions (Majumdar and Gupta, 2009).

The choice method was used in the third section to elicit WTP for security of supply and environmental flows. This method was conducted on a randomly selected subset of the overall sample. Attributes are described in **Table 1**. Two of the three attributes (characteristics) had four levels, and one of the attributes had three levels.

Table 1: The three attributes and associated levels used in the choice experiment

Attributes	Levels
Condition of rivers and estuaries	Poor, Fair, Good
Frequency of water use restrictions	0 of the next 10 years, 1 of the next 10 years, 2 of the next 10 years, 3 of the next 10 years
Increase in monthly water bill	R20, R80, R150, R300

In introducing the choice question, respondents were presented with the following information:

To reduce the risk of water restrictions in the future, the municipality will need to increase its investments in water supply infrastructure and in keeping the mountain catchment areas in good condition. This would of course increase the cost of water. The cheapest option is to build more dams and extract more water from rivers, but this will leave our rivers and estuaries in a poor condition. Or we could invest in alternative sources of water, like groundwater, recycled water or desalination, and protecting and restoring rivers. This is a bit more expensive but would help to keep our rivers and estuaries in a good condition.

In the next four questions, I'm going to show you two different future situations – A and B – and I'd like you to choose which situation you prefer most. If neither situation is attractive to you, then you can choose the 'current situation'. The first block represents the condition of rivers and estuaries, the second block represents how frequently you would tolerate water restrictions over the next ten years and the third is how much you would be willing to pay for water on top of your current bill.

After receiving this information, respondents were presented with four choice tasks, each of which contained three options, one of which was a status quo option referred to as the 'current situation'. The status quo option was the same in every choice task. The dcm.design function, part of the choiceDes package in Rstudio, was used to create choice sets. An orthogonal, main effect experimental design involving three attributes was constructed based on (Burgess and Street, 2003). This design aims to minimise correlations between attribute levels in the choice questions (Turpie and Letley, 2018). An example of a choice task is provided in **Figure 2**.

Attribute	Situation A	Situation B	Current situation
Condition of rivers and estuaries	Good condition	Poor condition	Fair condition
Frequency of water use restrictions	0 of the next 10 years	1 of the next 10 years	3 of the next 10 years
Increase in monthly water bill	R150	R80	R0

Figure 2: An example of one of the 24 choice tasks presented to respondents

The fourth section included questions about the respondents' degree of trust and satisfaction in the municipality. Respondents were asked to indicate their level of satisfaction with the way the municipality manages water supply and sanitation in their neighbourhood on a five-point Likert scale, from "Very dissatisfied" to "Very satisfied". Respondents were also asked whether they think the municipality should be charging more for water, and whether they would be able to trust that their municipality would use the funds to improve water security if they increased the water price. Lastly, respondents were asked whether they would be able to trust that their municipality would use the funds to improve water security if they increased the water price.

The final section dealt with the socio-economic background of respondents. Data were collected on income, race, age, and education. Income categories for the questionnaire were based on the 2011 Census income groupings.

Statistical analysis

Simple data analysis techniques were used in Excel to analyse the responses to the open-ended WTP question. To model the responses from the double-bounded dichotomous choice format, the utility difference approach was employed (Hanemann, 1984).

The function "dbchoice" in the "DCchoice" package of R 4.0.2 was used to carry out the analysis of the study (Nakatani, Aizaki and Sato, 2021; R Core Team, 2022). This package employs the generalised linear model (GLM) function which contains a binomial logit argument (i.e. log-logistic distribution). The outputs from this function include three estimates of WTP: expected mean WTP based on the unmodified error distribution, truncated mean WTP calculated under the assumption that the error distribution is truncated at the maximum bid, and median WTP. The summary output also included the assumed error distribution, Akaike's information criterion (AIC), value of the log-likelihood at estimates, and the likelihood ratio statistic for the current model.

Bootstrapping was used to estimate the confidence intervals for the estimates of WTP (Krinsky and Robb, 1986). For each of the four WTP estimates, this method generated a lower and upper bound of the interval. To validate the results, the data were examined in terms of variables including municipality, household income, gender, age, satisfaction with municipality, trust in municipality, and highest educational level of the respondent.

The choice experiment was analysed using the mixed multinomial logit model a widely used method which takes the heterogeneity of the population into consideration. The "mlogit" package was used to carry out the analysis in R Studio (Croissant, 2020). Estimated coefficients were used to estimate marginal willingness to pay (MWTP) for the different non-monetary attributes, thus representing the change from one attribute level to another. For the model, MWTP estimates were calculated using the formula:

$$MWTP = -\frac{\beta attribute}{\beta price} \qquad (k = \text{non-monetary attribute})$$

where MWTP is the estimated marginal willingness to pay of respondents for the attribute level l (*l* = 1,…L), βattribute is the estimated coefficient of attribute level l, and βprice is the estimated coefficient for price.

Results

Descriptive statistics of respondents

Among the 1959 individuals who were approached, 1500 agreed to complete the interview (77% response rate). Of these, 1244 individuals met the interview criteria.

Table 2: Demographic characteristics of sample (n = 1244)

	Cape Town	Nelson Mandela	eThekwini	All municipalities
Income category[1] (%)				
No income	3.0	17.3	2.3	8.3
R1 – R400	3.5	2.5	5.0	3.5
R401 – R800	3.8	4.7	3.7	4.1
R801 – R1 600	8.4	11.7	8.3	9.7
R1 601 – R3 200	8.7	15.4	15.6	12.8
R3 201 – R6 400	12.3	16.2	12.8	13.9
R6 401 – R12 800	14.7	11.2	14.2	13.3
R12 801 – R25 600	17.4	9.2	8.7	12.3
R25 601 – R51 200	12.5	8.7	13.8	11.3
R51 201 – R102 400	7.4	1.7	6.4	5.0
R102 401 – R204 800	4.1	0.3	2.3	2.2
R204 801 or more	4.1	1.1	6.9	3.6
Race (%)				
Black	28.0	78.1	46.0	49.9
Coloured	55.5	5.2	43.9	36.1
White	15.6	6.8	9.2	10.5
Other	0.9	9.9	0.9	3.5
Education level (%)				
None	0.8	1.4	0.9	1.0
Primary	3.0	4.4	4.7	3.9
Secondary	25.7	16.7	34.7	26.7
Matric	34.0	39.9	38.5	37.0
Tertiary	36.5	37.5	21.2	31.3
Gender (%)				
Male	40.1	47.5	36.2	40.7
Female	59.9	52.5	63.8	59.3
Age group (%)				
18-29	20.9	26.5	16.5	20.8
30-39	29.8	31.8	29.7	30.3
40-49	26.5	24.7	31.1	27.7
50-59	16.8	9.9	16.5	14.9
60-69	5.6	6.2	5.7	5.8
>70	0.4	0.9	0.5	0.6

[1] *Income measured in Rand per household per month*

Across all municipalities, the average age of respondents was 42, and more than half of the respondents were between the ages of 18 and 39 (51.1%) **(Table 2)**. Respondents came from a total of 276 suburbs, and mean household size of respondents was 4.6 (±2.1, range 1-10). A quarter of respondents did not disclose their household income level, and 4.1% did not disclose their highest level of education (i.e. chose 'Prefer not to say'). Prefer not to say categories were not included in the calculations for **Table 2**. 35.5% of those who did disclose their education had passed matric (final school year), and 30% had a tertiary level qualification (either a degree or diploma). Mean income per household per month was R39 038 in eThekwini, R34 987 in the City of Cape Town, and R12 637 in Nelson Mandela Bay.

In terms of income representation per municipality, there were significant differences in household monthly income for respondents in both Cape Town and eThekwini compared to that of the most recent census (Statistics South Africa, 2012) **(Figure 3)**. eThekwini's population differed the most ($X^2 = 118.2$, $p < 0.001$), followed by the City of Cape Town ($X^2 = 58.1$, $p < 0.001$). There was, however, no significant difference between that of the income categories collected for Nelson Mandela Bay in this study compared to the national census ($X^2 = 6.1$, $p > 0.05$). When the lowest income category was removed, there were no longer significant differences between the census population and that of this study. The lowest income category was thus considered to be households earning between R1 and R400 per month.

There were significant differences in race composition of the sample for Nelson Mandela Bay ($X^2 = 23.3$, $p < 0.001$) and the City of Cape Town ($X^2 = 8.7$, $p < 0.05$), with a bias towards coloured and away from black households in both municipalities compared to the national census (Statistics South Africa, 2012). The sample from eThekwini, however, accurately portrayed the race composition of the population ($X^2 = 6.3$, $p > 0.05$) (Statistics South Africa, 2012). In terms of education, the samples were biased towards respondents who had completed higher education (i.e. matric or tertiary level) and away from respondents who had only completed secondary school across all three municipalities.

64% of respondents owned their property as opposed to renting, 80.9% lived in a house, 40.7% had a garden, 17.3% had a rainwater tank, 9% had a swimming pool, 5.5% had a greywater system, and 4.6% had their own borehole or well-point.

Contextual information – municipal trust and satisfaction

Most respondents in eThekwini (91.7%) did not think the municipality should be charging more for water. This was also the case for majority of respondents in Nelson Mandela Bay (90.4%), and Cape Town (88.2%). The reasons for not wanting the municipality to increase the water price included the inability to afford higher water tariffs (43.3%), not believing it would make a difference to service delivery (39.1%), as well as other reasons (7.4%). Other reasons specified were that "water should be free since it is a basic need", "the municipality is corrupt and is charging too much already", "there is a surplus of water so it should be free", and "our water bill does not match our use, so we do not want to pay for it".

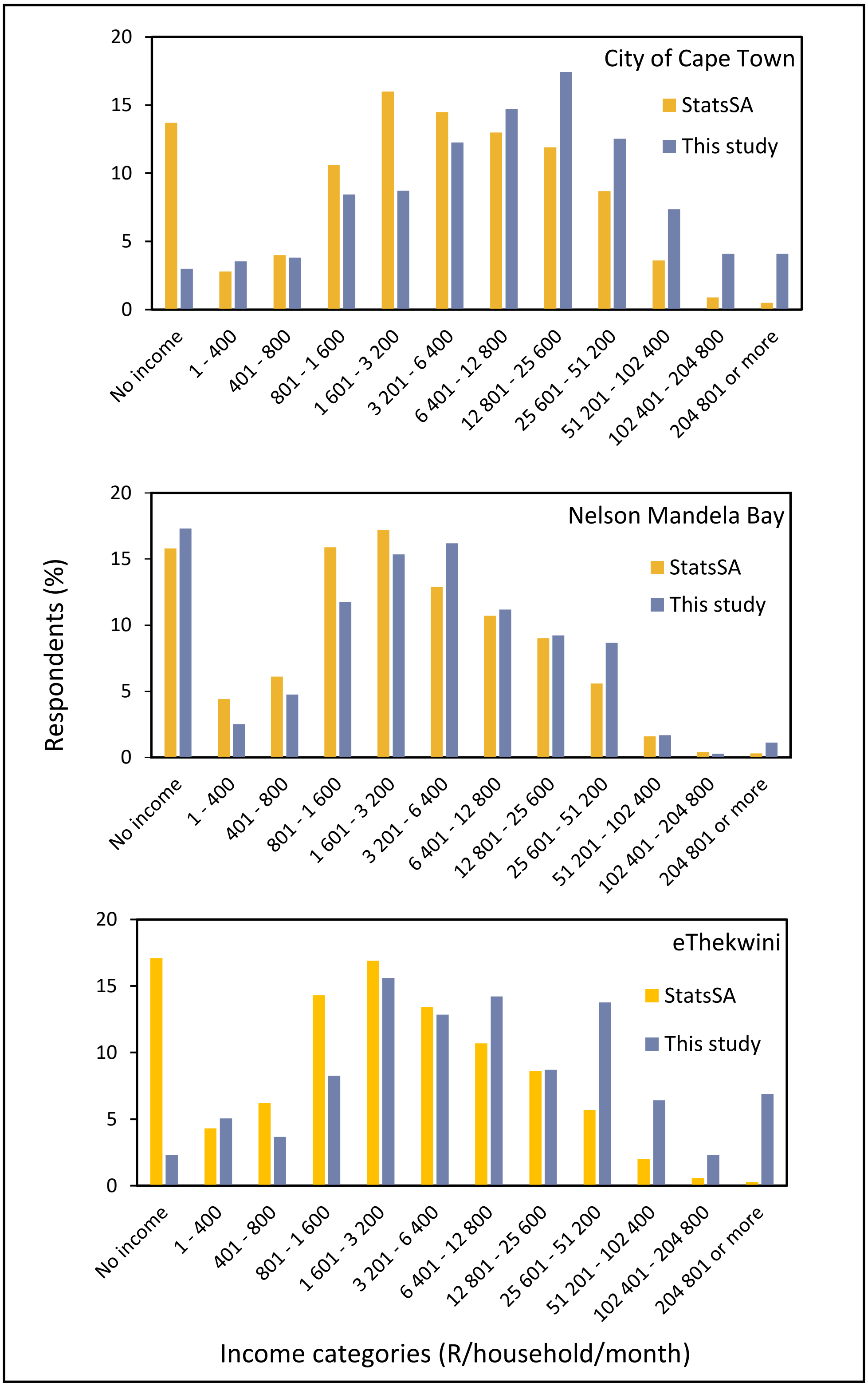

Figure 3: Comparison of household income categories between the population in this study versus that of the most recent national census of 2011

Nearly 70% of respondents from Nelson Mandela Bay expressed some level of dissatisfaction towards municipal water service delivery, with 45% claiming to be 'very dissatisfied' **(Figure 4)**. In eThekwini, the proportion of dissatisfied households was far fewer, with more than half claiming they were either very dissatisfied (27.5%) or just dissatisfied (27.5%). Only 27.8% of respondents in the City of Cape Town felt some level of dissatisfaction with municipal service delivery in their neighbourhood.

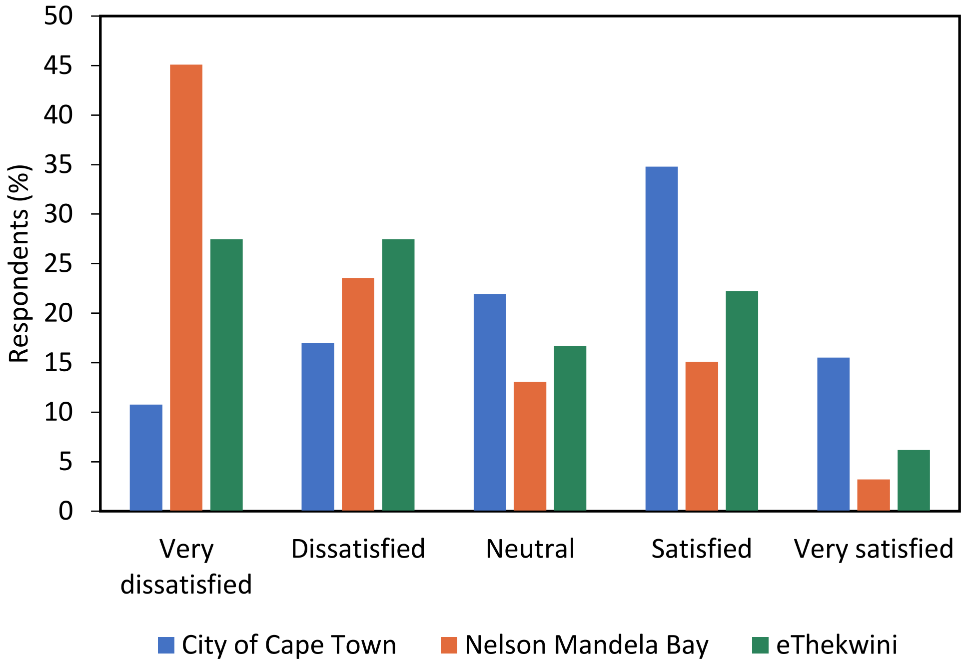

Figure 4: Respondents degree of satisfaction with the way the municipality manages water supply and sanitation their neighbourhood

Contextual information – water and electricity bill

Respondents were asked an open-ended question as to what they currently pay for electricity per month, and how confident they were about this value on a Likert Scale. Respondents were then asked to indicate how much they pay per month for water, and how confident they were about this value using the same Likert scale as for electricity. In South Africa, electricity is generally much more expensive than water, thus this question was asked first to get respondents to reflect on the relative price of water.

Fewer respondents could provide an estimate of their monthly water bill (71%) compared to their monthly electricity bill (88.3%). The average water bill for respondents across all municipalities was R516.12 per household per month and the median was R400.00. At the municipal scale, the average water bill ranged from R488.22 in the City of Cape Town to R541.30 in eThekwini **(Table 3)**. In contrast, the mean electricity bill was significantly higher than the mean water bill for all three municipalities, with residents from Nelson Mandela Bay having the lowest average electricity bill (R601.95) and residents from the City of Cape Town having the highest (R909.45).

Table 3: Mean and median monthly reported water bill per household per month (n = 833) compared to the mean and median electricity bill per household per month (n = 1090) across the three metropolitan municipalities: the City of Cape Town, Nelson Mandela Bay, and eThekwini.

	Water bill			Electricity bill	
	Mean	Median		Mean	Median
City of Cape Town	488.22	350.00		909.45	700.00
Nelson Mandela Bay	526.21	400.00		601.95	450.00
eThekwini	541.30	368.50		895.16	600.00
All municipalities	516.12	400.00		794.83	500.00

As expected, across all three municipalities, there was a strong positive relationship between water bill and household income (R^2 = 0.90) **(Figure 5)**.

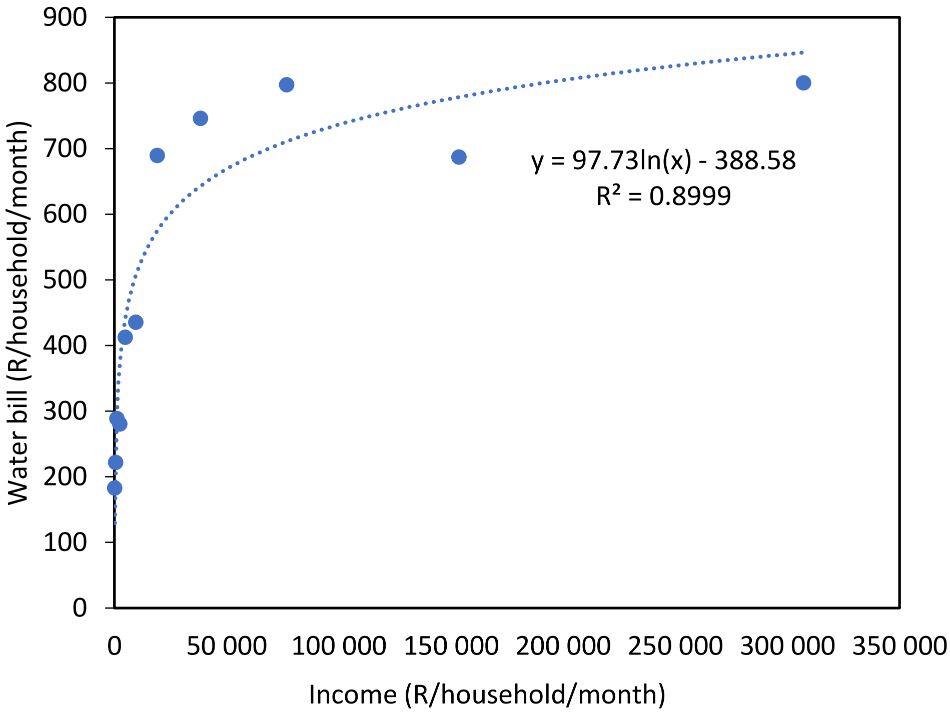

Figure 5: Mean water bill per income category midpoint for all three municipalities combined

Half of the respondents who could provide an estimate for their average monthly electricity bill (without looking at their actual bill) felt extremely confident about the amount they had reported (52%), whilst only a small proportion reported some degree of uncertainty about their estimated bill (3.4%) **(Figure 6a)**. Interestingly, respondents had similar levels of confidence in their reported water bill as they did in their electricity bill **(Figure 6b)**. Respondents from Nelson Mandela Bay were the most confident about their reported electricity and water bills compared to the other two municipalities. The reason for such high confidence in respondents' utilities bills could be because a large proportion of the sample pay their utilities directly to the municipality (65.4%) and thus have a handle on how much they spend per month. Another plausible reason may be because 83% of respondents have a prepaid electricity meter which track usage and costs. Such a high degree of confidence in the estimated monthly cost of respondents' water bills was beneficial to the study because these values were used to calculate the initial bid of the double-bounded dichotomous choice questions.

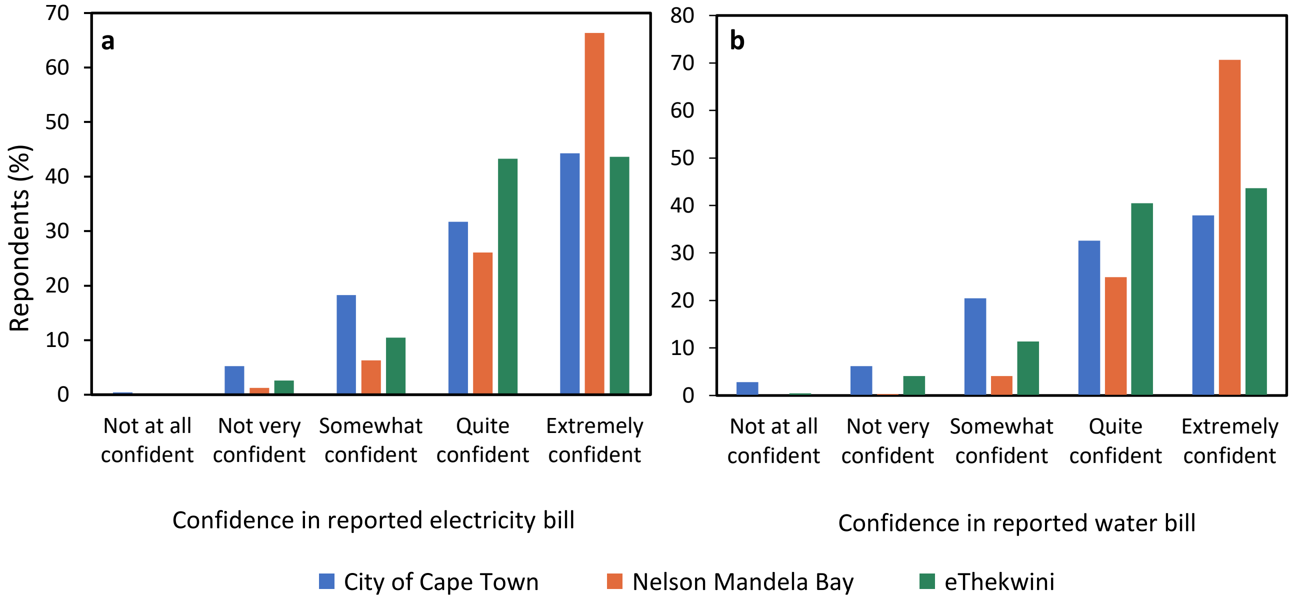

Figure 6: Degree of confidence in reported monthly **(a)** electricity bill per household per month (n = 1090) versus **(b)** water bill per household per month (n = 833).

Willingness to pay – double bounded dichotomous choice

When asked if they were willing to pay more for water than what they currently are, more than half of the respondents (57%) rejected both the initial bid as well as the lower follow up bid (No-No) **(Figure 7)**. This was most pronounced for Nelson Mandela Bay, followed by eThekwini and Cape Town. 25% of respondents in all three municipalities agreed to pay the initial bid but were unwilling to pay the higher follow-up bid (Yes-No). This was greatest in Cape Town (23.7%), closely followed by eThekwini (22.8%). 15.3% of respondents declined the initial bid but agreed to pay the lower second bid (No-Yes), and only a small group of respondents (8.3%) were willing to pay both the initial and the follow-up bid (Yes-Yes). This was as little as 4% in Nelson Mandela Bay.

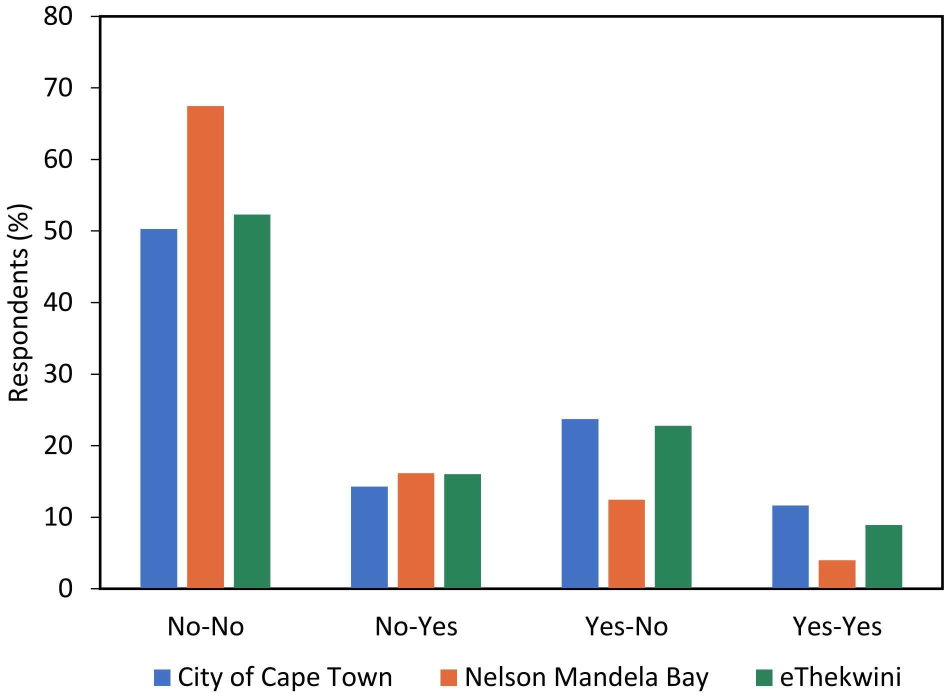

Figure 7: Percentage of respondents who (i) rejected both WTP bids (No-No), (ii) rejected the first and accepted the follow-up bid (No-Yes), (iii) accepted the first and rejected the follow-up (Yes-No), (iv) or accepted both bids (Yes-Yes). Outliers were removed and only positive willingness to pay values were included (n = 1114). Bids ranged from R30 to R4200.

Probability of saying yes

The contingent valuation questions were used to estimate how much respondents were willing to pay for water. The WTP probability distribution plotted from the survey data depicts how the likelihood of paying the proposed bid amount decreases as bid amounts increase **(Figure 8)**. Since the initial bid offered to each respondent was 1.5 times their current water bill (or a randomly generated value if they could not recall their water bill), 77 initial bid amounts were generated ranging from R30 to R4 200. Thus, to visualise the WTP probability distribution, the final bid offered to respondents were categorised into four groups: R1 – 400, R801 – R1 600, R1601 – R3200, R3201 – R6400. Across all three municipalities, 34% selected 'yes' to bids in the lowest bid group (R1 – R400), and only 1% selected 'yes' to bids in the highest bid group (R3201 – R 6400). The fit of the overall model was strong with an R^2 of 0.86 ($p < 0.001$). The probability of selecting yes for the different bid amounts varied slightly across the three municipalities with residents from the City of Cape Town having a lower probability of selecting yes to the higher bid amounts compared to eThekwini and Nelson Mandela Bay. However, in general, all three municipalities demonstrated similar results across all the bid groups. The greatest difference between two municipalities was for the R801-R1600 bid category, whereby a higher proportion (25%) of residents from Nelson Mandela Bay accepted the bid amount compared to the City of Cape Town (19%).

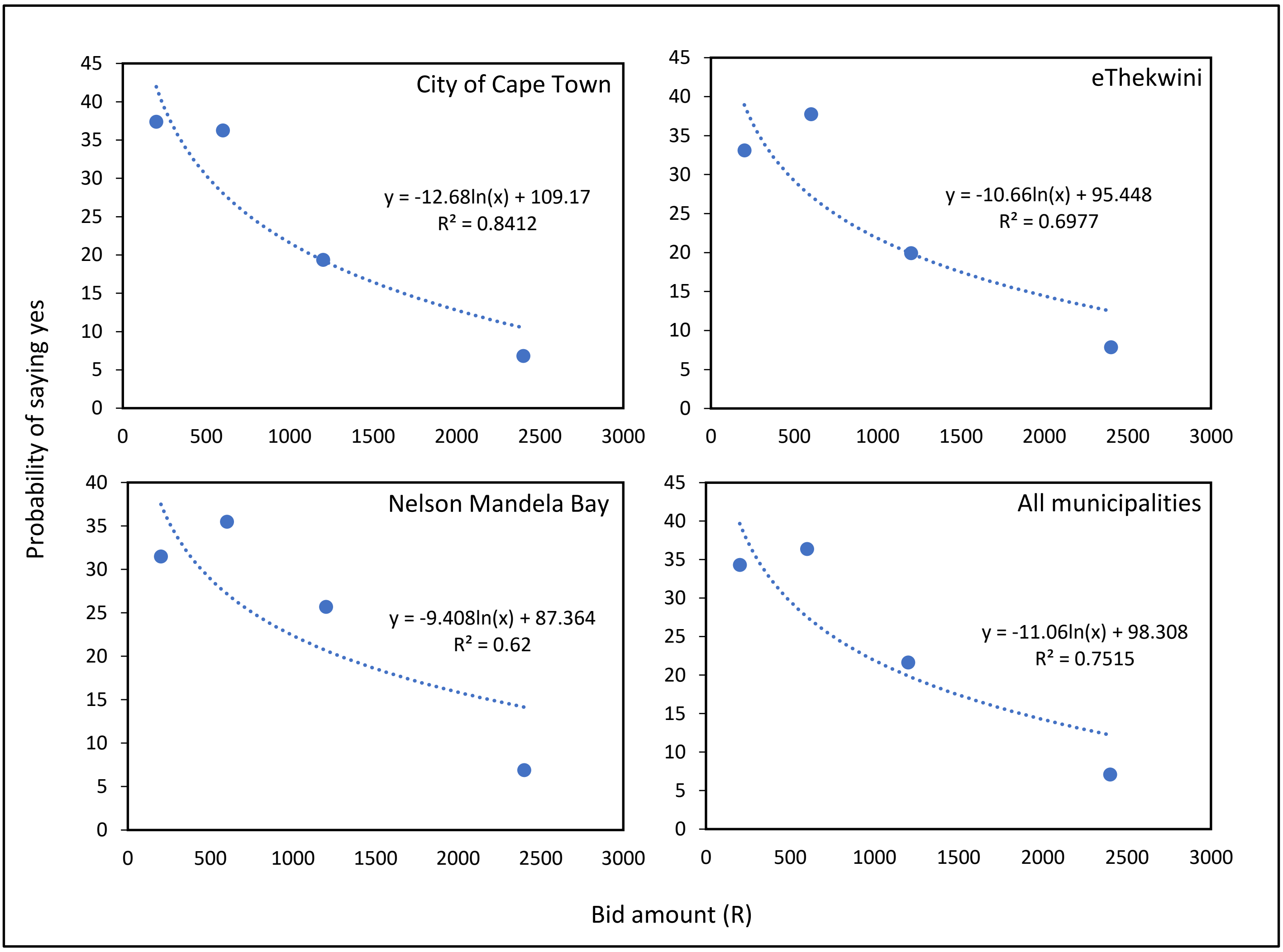

Figure 8: WTP probability distribution plotted from survey data for each municipality and for the overall sample. Outliers were removed and only positive willingness to pay values were taken into consideration (n = 1144). The model was plotted against the midpoint of each bid group.

Model estimation results

The results from the generalised linear model for validating the double-bounded dichotomous choice questions are presented in three models in **Table 4**. The number of observations differed per model, since questions about education and income had "prefer not to say" categories which were not included in the analysis. Model 1 represents the constant-only model, Model 2 includes several covariates, and Model 3 represents the estimation results when all non-significant predictors were removed from Model 2 as recommended by Jiang *et al.* (2019).

The results followed expectations in that the coefficients of the bid variable were negative across all three models, indicating that as the bid amount increased the probability of a respondent selecting 'yes' declined, which is in line with **Figure 8**. After removing the non-significant covariates, Model 3 shows that the significance and magnitude of each variable did not change much compared with Model 2, verifying the robustness of the statistical model. Model 3 was considered the best model of the three because it had the lowest AIC value of the three models, indicating the best fit.

Table 4: Estimate results of the double-bounded dichotomous choice models

Variables	Model 1	Model 2	Model 3
Intercept	9.574 (0.411)***	8.158 (0.724)***	8.550 (0.618)***
Municipality: Cape Town		0.210 (0.201)	0.267 (0.199)
Municipality: eThekwini		0.556 (0.226)*	0.563 (0.225)*
Age		-0.015 (0.007)*	-0.015 (0.007)*
Satisfied with municipality_Yes		0.420 (0.176)*	0.489 (0.171)**
Trust in municipality_Yes		0.191 (0.295)	
HH income		0.213 (0.043)***	0.220 (0.035)***
Education		0.092 (0.119)	
HH Size		0.133 (0.039)***	0.126 (0.035)**
log(Bid)	-1.683 (0.067)***	-1.789 (0.087)***	-1.790 (0.087)***
Log-likelihood (LR-test statistic)	-1468.410	-938.954	-946.843
Akaike information criterion (AIC)	2940.820	1997.908	1909.687
No. obs	1114	726	734

Robust standard errors in brackets, ***p < 0.001, **p < 0.01, *p < 0.0.5

Age, income, municipality, satisfaction with municipality, and household size significantly influenced willingness to pay. Age had a negative influence on WTP, indicating that as the age of the respondent increased, the probability of selecting 'yes' to a proposed bid amount decreased. As expected, WTP was directly proportional to income, meaning that wealthier households were willing to pay more for water than poorer households. Similarly, those who were satisfied with municipal water supply were willing to pay more for water compared to those who were dissatisfied or neutral. Interestingly, as the size of respondents' households increased, the probability of selecting 'yes' to a proposed bid increased (i.e. bigger households were willing to pay more for water compared to smaller households). There was a significant difference between WTP in eThekwini compared to the WTP in Nelson Mandela Bay, but not between the City of Cape Town and Nelson Mandela Bay. On the other hand, education and trust in municipality had no significant influence on willingness to pay.

Based on the outputs of Model 3, the mean WTP per household per month in all three municipalities ranged from R456 – R633 and the unadjusted mean willingness to pay was estimated to be R540 **(Table 5)**. Median WTP ranged from R274 – R331, with an estimate of R302. Whilst mean WTP was two times higher in eThekwini compared to Nelson Mandela Bay **(Table 4)**, median WTP was similar across all three municipalities with a range of R240 – R 369. Across all income categories, unadjusted mean WTP in eThekwini (R794) was about 47% higher than the reported water bill of that municipality. For the City of Cape Town, the mean WTP across all income categories (R549) was 12.5% more than the reported water bill. WTP amounts, however, differed per income category. Depending on income level, households were willing to pay 1.27-108% more than the amount they currently pay for water in the City of Cape Town, and between 10-55% more in eThekwini. On average, respondents in Nelson Mandela Bay had a lower WTP than the reported water bill, indicating that people feel they are already paying too much for their water. This was the case across most of the income categories for Nelson Mandela Bay, with exceptions only for the highest and second highest income categories who were willing to pay 47% and 224% more for water respectively.

Table 5: Estimated willingness to pay (Rand/household/month) for water from the best fitted double-bounded dichotomous choice (Model 3)

	Mean WTP of all municipalities			Mean WTP per municipality		
	Estimate	Lower bound	Upper bound	City of Cape Town	Nelson Mandela Bay	eThekwini
Mean	539.92	480.78	632.72	549.34	391.75	794.16
Truncated mean	498.30	456.01	553.47	510.01	372.80	660.37
Median	302.48	274.32	331.44	335.03	240.06	369.74

WTP per income category for each municipality was also calculated to understand the effect of income on WTP at the municipal scale. This was done through the Krinsky and Robb (1986) approach which uses the mean of the outputs from the double-bounded dichotomous choice model (Model 3) **(Table 4)** for each of the 11 income categories. Household income had a powerful influence on mean willingness to pay at the municipal scale **(Figure 9)**. The range in WTP from the lowest income category to the highest income category was greatest for eThekwini (R403.16 to R1 229.39), followed by Nelson Mandela Bay (R215.82 to R735.66) and the City of Cape Town (R314.43 to R574.11). Although eThekwini had the highest mean WTP for each income category compared to the other two municipalities, the relationship was strongest for Nelson Mandela Bay (R^2 = 0.98). The relationship was much weaker for the City of Cape Town (R^2 = 0.57) owing to respondents from the two highest income groups having low willingness to pay.

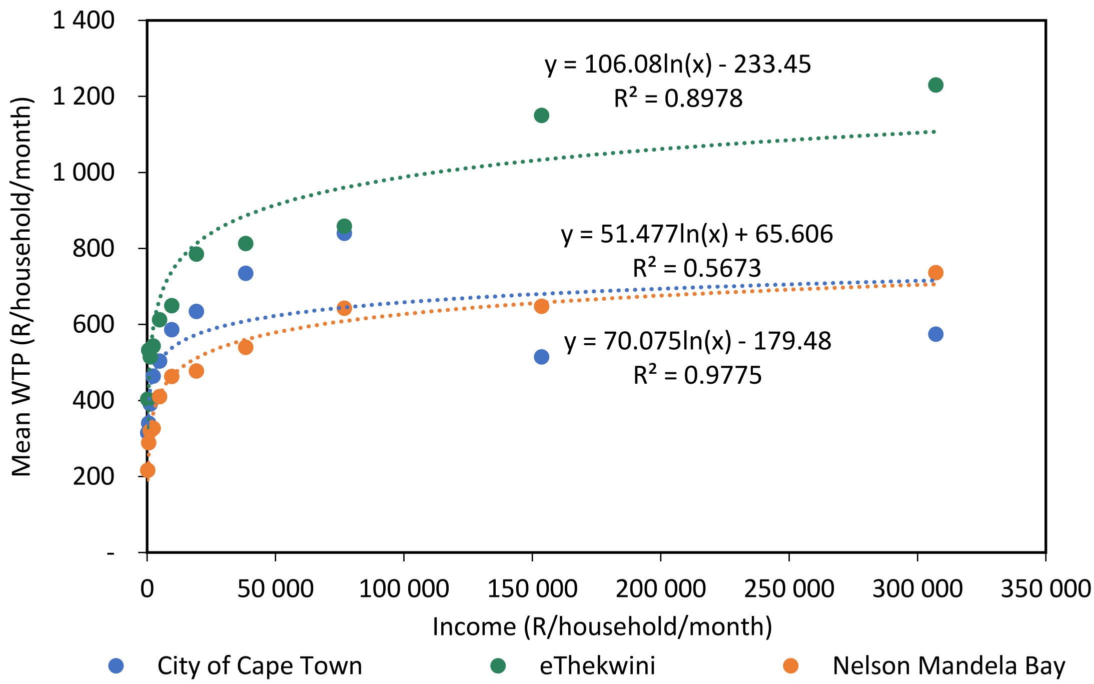

Figure 9: The average willingness to pay for water (R/household/month) calculated with the double-bounded dichotomous choice Model 3 outputs for each household income category per municipality: City of Cape Town, Nelson Mandela Bay, and eThekwini. 11 income categories were used as per the national census (Statistics South Africa, 2012)

It is common practice to identify protestors in studies that aim to inform policy, since these responses have been found to bias the sample (Majumdar and Gupta, 2009; Makwinja, Kosamu and

Kaonga, 2019). Protestors are considered individuals who indicate a zero WTP amount, not because they cannot afford it, but because they are unwilling to spend money on water because they either think it should be free or are unsatisfied with municipal service delivery (du Preez, Tessendorf and Hosking, 2010). **Table 6** shows the distribution of household WTP responses classified as positive, genuine zero, protest, and no response. These categories were determined by investigating respondents' water bills in relation to their open-ended maximum willingness to pay answers. 94% of respondents gave a positive value for both water bill and maximum willingness to pay ('positive response'), indicating that they were willing to pay for water. If respondents gave a value of zero for both their water bill and open-ended maximum willingness to pay, their responses were considered 'genuine zero' responses (i.e. those who receive free water because they cannot afford it). 37 respondents gave genuine zero responses (3.0%). 2.2% of respondents were considered 'protestors' for reporting positive water bill values, but zero values for maximum WTP. Lastly, only 12 respondents declined to give a maximum WTP value ('no response'). These responses were not included when estimating WTP.

Table 6: Distribution of willingness to pay (WTP) responses for the open-ended WTP question

Type of response	Number of respondents	Percentage of respondents
Positive response	1168	93.89
Genuine zero	37	2.97
Protest	27	2.17
No response	12	0.96
Total	1244	100

The open-ended WTP follow-up question solicited the maximum amount that respondents were willing to pay for water. The total number of observations used to investigate variation in WTP with the open-ended question was 1205 when protest responses were excluded. The effect of including protest responses generally lowers the WTP value, creating a bias in the true valuation of the good (Gyrd-Hansen, 2014). In contingent valuation studies, the standard procedure is to exclude protest responses from the analysis (Dziegielewska and Mendelsohn, 2007). Thus, the mean stated WTP per household per month across all municipalities was R473.93 **(Table 7)**. Although this value is lower than the mean of the double-bounded dichotomous choice method, it still falls within the lower and upper bounds of the truncated mean WTP output from the logit model **(Table 5)**. This indicates that respondents' answers were consistent across both questions, which validates that the respondents were consistent when answering the double-bounded dichotomous choice questions.

Table 7: Distribution of the open-ended willingness-to-pay with and without protest responses (R/household per month)

	Mean WTP (open-ended)	
Municipality	**Without protest responses**	**With protest responses**
City of Cape Town	474.76	470.77
Nelson Mandela Bay	465.21	453.37
eThekwini	484.44	466.50
All municipalities	473.93	463.54

Aggregate willingness to pay

To calculate aggregate willingness to pay at the municipal scale, average willingness to pay per year was multiplied by the total number of households in each income category as per the national census (Statistics South Africa, 2012). Aggregate WTP for water was R5.94 billion per year for the City of Cape Town, R5.83 billion per year for eThekwini municipality, and R1.26 billion per year for Nelson Mandela Bay municipality **(Appendix 2)**. This translated to a consumer surplus of R1.22 billion for the City of Cape Town, and R826 million for eThekwini **(Appendix 3)**. There was no consumer surplus for Nelson Mandela Bay, indicating that residents were not prepared to pay more than what they are currently paying for water.

Choice models estimation

The choice method was used to elicit WTP for security of supply and environmental flows. Estimation results of the main effect variables from the multinomial logit model for the choice experiment are shown in **Table 8**. A positive coefficient reveals that decision-makers prefer a qualitative improvement or a quantitative increase in the attribute, whilst a negative coefficient suggests the opposite. As predicted, the coefficient of the price attribute was negative, indicating that respondents received less utility from higher prices (Ceschi, Canavari and Castellini, 2018). Residents therefore prefer the less expensive alternative. Since price was a continuous variable, only one coefficient was estimated. For the attribute named 'River in poor condition', the coefficient was also negative and significant to the 1% confidence level. With all other things equal, respondents thus experienced less utility from situations with a poor river condition. On the other hand, estimated coefficients for 'no water restrictions in the next 10 years' and 'river in a good condition' were both positive and significant, meaning that participants received greater utility from choosing these options. Combinations that provided respondents with the greatest utility were scenarios where rivers were in a good condition and water restrictions were absent for the next 10 years, with water sold at the lowest possible price.

Table 8: Multinomial logit estimated coefficients for price, environmental condition of river, frequency of water-use restriction, and the Alternative Specific Constant (ASC)

	Estimated coefficients	Std. Error	z-value	Pr(>|z|)	
Price	-0.004	0.0007	-4.894	9.84E-07	***
River in poor condition	-1.012	0.159	-6.373	1.85E-10	***
River in good condition	0.397	0.168	2.360	0.0183	*
Water restrictions in 0 of the next 10 years	0.634	0.219	2.895	0.004	**
Water restrictions in 1 of the next 10 years	0.167	0.197	0.849	0.396	
Water restrictions in 2 of the next 10 years	0.204	0.198	1.029	0.304	
ASC	0.314	0.203	1.546	0.122	
Log-Likelihood:	774.01				

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

ASC is the alternative specific constant which describes the choice of no action ("Current situation"). However, since the ASC was not significant, indicating that respondents were more likely to select alternative situations over the status quo. Residents' choices were therefore centred around keeping rivers in a "good" condition and avoiding water restrictions.

Estimation of willingness to pay values elicited from the choice experiment

Table 9 reports the marginal WTP (MWTP) or implicit prices for each of the attributes (condition of rivers and estuaries; frequency of water use restrictions water restrictions; increase in monthly water bill) which were calculated using the gmnl 'willingness to pay' package in RStudio. Specifically, the model estimated a marginal WTP of R177 for the attribute 'no water restrictions in the next 10 years', indicating that households are willing to pay R177 per month on top of their existing water bill for a three-fold reduction in water restrictions (i.e. an improvement from water restrictions in 3 of the next 10 years to none of the next 10 years); this is equal to approximately 34% of the average water bill of households.

Table 9: Marginal willingness to pay (R/household/month) for attributes

Attribute	MWTP estimate	Std Error	t-value	Pr(>|t|)	
River in poor condition	-283.469	61.913	4.579	4.68E-06	***
River in good condition	111.180	46.741	-2.379	0.017	*
Water restrictions in 0 of the next 10 years	177.426	57.497	-3.086	0.002	**

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The model also found that people would be willing to pay an additional R111 to improve rivers from a fair condition to a good condition, which corresponds to about 22% more than the existing water bill. On the other hand, households were willing to pay an additional R283 on top of their current water bill (54.8% more) to avoid the deterioration of rivers from a fair to a poor condition.

Discussion

Although many countries have recognised the potential of investing in the restoration, rehabilitation, and protection of freshwater ecosystems to secure future water supply services, there is a lack of sustainable financing mechanisms to fund these interventions, particularly in developing countries (Dikgang *et al.*, 2019). This has resulted in further degradation of these ecosystems, threatening future water supply. One financing mechanism which has not yet received much attention, is that of water pricing. If regulated correctly, water pricing policies can have both incentive and revenue effects. Whilst water pricing has been found to encourage users to manage their water consumption (Dikgang *et al.*, 2019); increased water tariffs can generate increased revenue that can be used to fund water resource management and/or investment in ecological infrastructure. However, since water is a basic need, reforming water pricing policies must be based on a comprehensive understanding of consumers' demand for water services and conservation (Makwinja, Kosamu and Kaonga, 2019).

Using three South African cities as a case study (the City of Cape Town, Nelson Mandela Bay, and eThekwini), this study set out to establish whether consumer surplus at the municipal scale is sufficient to cover the costs required to restore catchments supplying water to the municipalities in question. The results from this study show that in two of the three municipalities, the additional revenue that could be generated from household willingness to pay (WTP) for water (i.e. consumer surplus) is more than sufficient to cover the estimated costs required to restore catchment areas supplying water to those municipalities. Factors that were found to significantly influence WTP included socio-economic factors such as age, income, and household size, as well as institutional satisfaction (Welle and Hodgson, 2011; Makwinja, Kosamu and Kaonga, 2019; Wilson *et al.*, 2021). Further analysis revealed useful information about household preferences, particularly pertaining to WTP for non-use related water conservation benefits as well as for use-related water security benefits (i.e. avoiding future water restrictions). This study is novel in that it demonstrates to policymakers that there is significant potential to raise revenues from water tariffs in municipalities that have a good service delivery track record, a relatively high average household income, and a low average age. This study is particularly pertinent given that coastal cities in South Africa are expected to face more frequent water shortages in future due to climate change (Otto *et al.*, 2018).

Although the sample of Nelson Mandela Bay was representative of its population (Statistics South Africa, 2012), the sample was biased away from poorer households and toward wealthier households in the City of Cape Town and eThekwini. This mismatch in wealth resulted from underrepresentation in the lowest income category compared to population statistics from each municipality retrieved from the most recent national census. This wealth bias is likely due to the sampling strategy used. Since one of the main services provided by the Department of Home Affairs (DHA) is issuing travel documents (visas and passports), the queues outside of these localities are often frequented by people who can afford to travel. There is also the possibility that the selection of DHA localities for this study may have affected the wealth representation of the sample. For example, the sampling sites in eThekwini and the City of Cape Town may have been inaccessible to poorer residential areas. However, since most no-income households rely almost exclusively on free basic water, it is therefore unlikely for people in this group to be realistic about their willingness to pay. Thus, to avoid overstating willingness to pay, respondents that reportedly had no income were excluded from the analysis of mean and aggregate WTP.

Willingness to pay for current water supply

It is somewhat misleading to compare the results of this type of study to studies of a similar nature in other countries due to differences in socio-economic context and water service provision history. Thus, to mitigate this, Latinopoulos (2014) recommend comparing the results with findings of other recent stated preference approaches carried out in the same country. Thus, in accordance with previous contingent valuation studies in South Africa, this study reveals that at the national scale, household residents are willing to pay higher water tariffs for the water they are currently receiving, despite having high levels of dissatisfaction in water service provision (Snowball, Willis and Jeurissen, 2008; Kanyoka, Farolfi and Morardet, 2009; Rananga and Gumbo, 2015; Makaudze, 2016; Nkoana *et al.*, 2019). Of these, the WTP of households in this study correspond closest to that of Makaudze (2016) who measured WTP for water of residents living with HIV and AIDS in three districts (urban, peri-urban, and rural) across South Africa and found it to be R428.60 per month (R564.81 at 2022 price levels). These figures are comparable to this study, whereby the average WTP of households across the three urban municipalities was R540 per month.

However, when analysed at the municipal level, there was a wide range in the WTP of households between municipalities. Households in eThekwini had the highest WTP on average, which was R794 per month, corresponding to about 47% more than the existing water bill of the municipality. This was followed by households in the City of Cape Town, who were willing to pay R549 per month (12.5% more than the current water bill of the municipality). The reason for such a high WTP in eThekwini could be attributed to the survey period coinciding with a flooding event that was caused by heavy rains. This flood, which has since been considered the worst the region has seen in three decades, was responsible for damaging raw water pipelines between the Nagle Dam and the Durban Heights Water Treatment Plant, resulting in majority of households in eThekwini not having access to water during the survey period. Thus, during the time of the interviews, people were likely desperate for water and were thus willing to pay more. On the other hand, the reason for a higher WTP for water in the City of Cape Town could be attributed to high levels of satisfaction towards municipal water service delivery.

Interestingly, the WTP of Nelson Mandela Bay was half that of eThekwini, with residents only willing to pay R392 for water, which is 26% less than the existing water bill of the municipality. When WTP is less than or equal to the real price of the good or service, this indicates that people are not willing to pay a higher price for that particular good or service (Li *et al.*, 2014). Although there were some households with high WTP in Nelson Mandela Bay, it seems that most households in Nelson Mandela Bay are already paying the maximum amount that they are willing to pay for water. To understand why Nelson Mandela Bay residents are not willing to pay more for water, it is necessary to consider the contextual findings of the study. At the time the surveys were conducted, Nelson Mandela Bay was currently experiencing one of its worst droughts to date. To encourage households to consume less water during the crisis, the municipality has raised domestic water tariffs and imposed severe water restrictions on the population (Pietersen, 2021). This has had two noticeable impacts. First, relative to income levels, households in Nelson Mandela Bay are paying significantly more for water than the other two municipalities, which is evident when comparing the average water bill and income level of households in Nelson Mandela Bay to the other municipalities. By illustration, whilst the average water bill of households in Nelson Mandela Bay was similar to the other two municipalities (only ~3% less than the average water bill of eThekwini and 7% more than the average water bill of City of Cape Town), the average income of respondents in Nelson Mandela Bay was 68% less than eThekwini and 64% less than the City of Cape Town. Second, due to the mismanagement of water supply, residents in Nelson Mandela Bay are extremely frustrated with the municipality. This was demonstrated through the much greater proportion of households in Nelson Mandela Bay who were dissatisfied with municipal service delivery compared to households in eThekwini and households in the City of Cape Town. By comparison, nearly 70% of residents in Nelson Mandela Bay expressed some level of dissatisfaction with the municipality, whilst only 55% were dissatisfied in eThekwini and 28% in the City of Cape Town. This is in accordance with a recent study by Nkoana *et al.* (2019) who discovered that 73% of residents in a local municipality in South Africa were dissatisfied with the provision of water and electricity services. In this study, residents commented that they were dissatisfied with the mismanagement of services, which has in part, caused the current water crisis that the municipality is currently experiencing. Since residents in Nelson Mandela Bay are paying a lot of money towards a service they are generally dissatisfied with, people were not willing to pay any more for water than what they currently were paying (Andrés *et al.*, 2021).

Factors influencing willingness to pay for urban domestic water

As other studies have done, this study provides insight into how socio-economic factors and institutional context influence household WTP (Welle and Hodgson, 2011; Makwinja, Kosamu and Kaonga, 2019; Wilson *et al.*, 2021). As hypothesised, there was a significantly positive relationship ($p < 0.001$) between WTP and income across all three municipalities. This suggests that wealthier households were prepared to pay more for water than poorer households. This finding is consistent with international WTP studies in both developed and developing countries (Halkos and Matsiori, 2014; Latinopoulos, 2014; Akinyemi, Mushunje and Fashogbon, 2018; Makwinja *et al.*, 2022). This is largely a matter of affordability, with lower-income households less able to tolerate increases in water tariffs compared to higher-income households. This is illustrated by Grafton *et al.* (2011) who found that across 10 countries, the proportion of household income spent by two lowest income groups is two to three times higher than the proportion spent by the richest. .

At the municipal scale, whilst the positive relationship between income and WTP was clear for both eThekwini (R^2= 0.90) and Nelson Mandela Bay (R^2= 0.98), the relationship was far weaker in the City of Cape Town (R^2 = 0.57). This can be explained by the highest two income categories showing a lower willingness to pay than the previous income categories. The only plausible explanation for this trend could be linked to mistakes in enumeration, timing of queues in relation to context, or locality of the DHA queues.

To address the issue of affordability in South Africa, the government has established an inclining block tariff (IBT) structure which is designed to provide affordable water to low-volume users, who are generally lower-income households without swimming pools and gardens (Dikgang *et al.*, 2019). Whilst eThekwini and the City of Cape Town have both divided the water tariff into five volumetric blocks, with the first 6 kilolitres free to indigent households, Nelson Mandela Bay has divided the water tariff into six blocks, with the first 8 kilolitres free to indigent households. Higher-use blocks are thus meant to cross-subsidise tariffs in the lower-use blocks (National Treasury, 2011). However, in municipalities that do not have enough customers in the higher-use blocks to subsidise those in the lower-use blocks, the costs to produce and manage water are seldom recovered. This results in asset deterioration, poor management, and low-quality services, which causes water shortages. This is the case for Nelson Mandela Bay population who were significantly poorer on average than the other two municipalities.

By contrast, age of the respondent had a significantly negative impact on WTP ($p < 0.05$), indicating that younger respondents were willing to pay higher prices for water compared to older respondents. This finding is consistent with several other contingent valuation studies on water (Makwinja, Kosamu and Kaonga, 2019; Mu *et al.*, 2019; Kim *et al.*, 2021; Makwinja *et al.*, 2022). Halkos and Matsiori (2014) proposed that older respondents tend to have worse health, higher economic dependence, and higher expenditures on food, resulting in lower WTP for water since their disposable income is more stretched. Vásquez, Franceschi and Van Hecken (2012) speculated that the relationship may be because older respondents have an 'accumulated dissatisfaction' from low quality services over a longer period of time. It must be noted that the relationship between age and WTP, however, is not always negative (see Akinyemi, Mushunje and Fashogbon, 2018).

Results indicated that residents' level of satisfaction for the way the municipality manages water supply in their neighbourhood had a significant positive influence on WTP ($p < 0.01$). Thus, those who were more satisfied with the municipality were willing to pay higher prices for water. This was anticipated, since consumers tend to be willing to pay more for services they are satisfied with (Andrés *et al.*, 2021). This was clearly illustrated by households in Nelson Mandela Bay, who had the highest levels of dissatisfaction towards the municipality, and the lowest WTP for water. Many stated that paying more for water would not improve the service they were getting, so there was no point in paying more. However, if the question was phrased 'would you be willing to pay more for an improved water supply', the reverse would probably be true (i.e. those less satisfied would be willing to pay more).

Another factor that had a direct relationship on willingness to pay was household size ($p < 0.01$); this implies that households with more members were more likely to accept a given bid. A similar observation was made by Wilson *et al.* (2021) who found that in Brisbane, bigger households were willing to pay more than smaller households to avoid water restrictions. This was also true for a contingent valuation study which estimated WTP for water quality improvements in the Bac Ninh Province of Vietnam (Van Song *et al.*, 2019). The reason for this relationship may be because larger households generally consume more water, and people tend to justify higher water costs with this.

Although institutional trust also had a positive impact on WTP, the relationship was not significant. This finding is similar to that of Roldán, Sarmiento and Roldán-Aráuz (2021) who found that developing countries are generally willing to pay more for water, but do not trust their governments. In this study, nearly 59% of people did not trust that their municipality would use the funds appropriately if water tariffs were increased. Distrust is common in South Africa and is borne out of high levels of corruption in the country and a lack of capacity (Lehohla, 2016), which has resulted in frequent water interruptions, failing infrastructure, and poor water quality in all three municipalities. Education also did not have a significant impact on households' WTP; this may be because the question asked was focused on WTP for households' current water supply, rather than for improved water supply. One would expect more educated people to be willing to pay higher prices for water supplied through more environmentally sustainable alternatives (i.e. catchment restoration, water recycling, groundwater extraction), since more educated people tend to be better informed about the impact of environmental degradation (Khan and Ahmed, 2013).

Consumer surplus

Increasing water tariffs to generate additional revenue for catchment conservation can only be implemented in areas where households are willing to pay higher prices for water. Consumer surplus, which is the difference between what a person is willing to pay versus what they actually pay, was established by calculating the difference between aggregate WTP and aggregate water bill per income category for each municipality. Interestingly, the results indicated that whilst both the City of Cape Town and eThekwini had a positive consumer surplus of R1.22 billion and R826 million respectively, Nelson Mandela Bay had a negative consumer surplus. This indicates that water tariffs have significant potential to be raised in the City of Cape Town and eThekwini, but not in Nelson Mandela Bay municipality, where households are not willing to pay any more than what they currently are paying for water.

At present, water pricing cannot be used as a tool to secure funding for the restoration and maintenance of catchments supplying water to Nelson Mandela Bay and alternative funding sources must be secured such as private-public partnerships or through market-based instruments (e.g. Payments for Ecosystem Services schemes or carbon credits) (Mander and Mander, 2021). However, for the two municipalities that had a positive consumer surplus, there is potential to increase the water tariff to cover the costs of catchment conservation. Stafford *et al.* (2018) proposed that R372 million would be sufficient to generate water gains over 30 years in the City of Cape Town, with initial costs of clearing estimated at R225 million and a further R147 million required for follow-up. If the domestic water tariff was raised in accordance with WTP, R1.22 billion in additional revenue could be generated in just one year, which is more than three times the estimated amount required to clear invasive alien plant species from the catchments that supply water to the City of Cape Town over 30 years. Similarly, the additional revenue that could be generated in one year from untapped WTP in eThekwini (R826 million per year) was also three times greater than the estimated cost required to remove invasive alien plants from the Greater uMngeni catchment over five years (R250 million per year) (Cartwright, 2021).

According to Cartwright (2021), financing ecological infrastructure interventions could be achieved through a 2.5% increase in the net price of water paid by industrial and domestic users in the City of Cape Town, and a 1% increase in eThekwini. As mentioned previously, this study found that households were willing to pay an average of 12.5% more for water in the City of Cape Town, and 47% more in eThekwini. Depending on income level, households were willing to pay 1.27%-108% more than the amount they currently pay for water in the City of Cape Town, and between 10-55% more in eThekwini. This indicates that raising the domestic water price in accordance with the inclining block tariff (IBT) would be tolerated by all income categories included in the study. Increasing water tariffs, however, would need to be accompanied by the improvement of water revenue collection, as well ring-fencing the additional revenue for the maintenance and restoration of ecosystems (Mpofu, Kruger and Reddick, 2020).

Willingness to pay for improved water supply services and improved river conditions

Similar studies have used stated preferences approaches to demonstrate that residents are willing to pay more to avoid water restrictions into the future (Tapsuwan *et al.*, 2007; Tussupova *et al.*, 2015; Wilson *et al.*, 2021). Other studies have also shown that households are also willing to pay higher prices for the restoration of degraded catchment areas (Lee, Ma and Cheung, 2021; Obeng and Aguilar, 2021; Makwinja *et al.*, 2022) and to avoid environmental damages in securing water supply (Turpie and Letley, in review). However, few, if any studies, have simultaneously investigated how consumers value water supply improvements and improvements to freshwater ecosystems.

In line with Turpie and Letley (in review), this study revealed that securing water supply through environmentally sustainable options (i.e. catchment restoration, water recycling, groundwater extraction), is important to urban household residents. Despite high inflation rates in the country (Statistics South Africa, 2022), households are willing to pay higher water tariffs for both improved water supply and protection of environmental flows. Results from the mixed multinomial model indicated that residents across all three municipalities were willing to pay 55% more than their current water bill to prevent rivers and estuaries from deteriorating, 34% more than their current water bill (an additional R177 per month) to avert water restrictions over the next 10 years, and 22% more than their current water bill for improvements to the condition of freshwater ecosystems (an additional R111 per month). This indicates that if water tariffs were raised, the public would prefer for the additional revenue to contribute to improving future water supply through more environmentally sustainable options (e.g. catchment conservation, water recycling initiatives, desalination, groundwater extraction).

Limitations

This study faced some limitations. First, many respondents refused to report their household monthly income (selecting the “prefer not to say” option), which reduced the sample size used in the model. Respondents generally refuse to answer questions relating to income when they fall in the highest or lowest income categories, thus, this may be why the study is biased away from these income categories (Makwinja, Kosamu and Kaonga, 2019). This was, however, mitigated by removing the lowest income category from the analysis to ensure the sample was representative. Second, when respondents were asked whether they were willing to pay a certain amount for water, respondents may have felt obliged to answer ‘yes’ when truthfully they wanted to say ‘no’. This was probably most prominent amongst respondents that fell within the indigent group, as they would not have been expected to pay anything for their water (up to a certain amount). This is relatively common in survey responses and is referred to as the ‘yea-saying’ bias which arises when respondents answer positively to please the enumerator (Heinzen and Bridges, 2008). This bias was controlled through rigorous training, whereby enumerators were trained how to ask questions in a way that did not influence the answers of interviewees. Third, although the findings are meaningful and indicate that many households are willing to pay more for water, many municipalities face the problem of residents not paying their water bill. Lastly, the legacy of apartheid is such that there still exists a geographic segregation between the rich and poor, with the rich living in wealthier suburbs that are better serviced while the poor are still located in marginal areas that receive a minimum level of services (Sartorius and Sartorius, 2016). Richer areas tend to be better serviced because municipal planners often prioritise the rich because of their political power and ability to pay for services (Ajwad and Wodon, 2007). Thus, there may have been a correlation between the income and satisfaction with spatial variables, which was not investigated in this study.

Further research

Going forward, more studies need to be undertaken across the country to elicit the WTP, particularly in smaller municipalities. This would be useful in establishing whether similar trends exist in smaller municipalities, as well as whether there is capacity to increase water tariffs in these municipalities. By widening the geographic scale of the study, researchers would be able to make broader policy recommendations as to which municipalities would be able to tolerate water tariff increases and which cannot. Further, it would be interesting to investigate the influence of disaster events such as droughts or flooding on WTP for water. Hopefully, the data generated in this study can be used for comparative purposes in future.

Future analysis should also consider the ‘ability to pay’ (affordability to pay) of households, which is considered the amount that households can actually afford in practical terms. This is necessary to understand whether households can actually afford the prices they say they are willing to pay, since several studies have found that people tend to inflate their willingness to pay (Fujita *et al.*, 2005; Akinyemi, Mushunje and Fashogbon, 2018). This could be achieved through a revealed preferences approach, which utilises actual income and expenditure data.

Conclusion and policy implications

To determine whether revenue generated from urban willingness to pay (WTP) can cover the costs of catchment management and conservation, the WTP of households was estimated using the contingent valuation approach. Surveys in three metropolitan municipalities of South Africa were conducted to elicit WTP at both the national and local (municipal) scale. The results obtained from the double-bounded dichotomous choice model indicated that at the national level, households had a higher willingness to pay for water and that WTP was positively influenced by household income, age, and satisfaction with municipal water service delivery. This was corroborated by respondents who revealed that their lack of willingness to pay higher water tariffs was either because they had a low confidence in the municipal governments' ability to manage water supply services, or an inability to afford higher water tariffs. However, at the municipal scale, WTP differed significantly between municipalities, largely due to differences in satisfaction and income. Further, when presented with a choice experiment that included a trade-off between WTP for use-related water security benefits and non-use related water conservation benefits as well, residents preferred to spend significantly more money on preventing river condition from deteriorating and on improving the security and reliability of water supply. This revealed that respondents are conscious of protecting the environment and would prefer for their water to be supplied through more expensive, yet more environmentally sustainable options.

Since WTP for water was not uniform across the three surveyed municipalities, decision-makers must acknowledge the municipal context when setting water tariffs in that water service provider region. This study showed that there is significant potential to raise water tariffs in municipalities that have higher average income levels, younger populations, more satisfied residents, and good water service delivery track records. More importantly, this study shows that residents would want to see the additional revenue generated from increased water tariffs go towards improving the supply of water through more environmentally sustainable options (e.g. catchment restoration, water recycling initiatives, and desalination). More effort should be put into informing residents about the importance of such projects through education campaigns and public awareness programmes (Lee, Hosking and du Preez, 2014). However, it is important to note that if water tariffs are raised, measures need to be put in place to prevent corruption, and to ensure that revenue is collected. Most importantly, funding from the additional water revenue generated from tariffs must be ring-fenced for catchment conservation and management.

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Appendices

Appendix 1: *Interview schedule*

Location: _____________ Date: ________ Interviewer: _____________ Supervisor______________
Hello, my name is XXXX. We are undertaking a short survey for the University of Cape Town to investigate public opinion on the price of water. The survey is anonymous. Would you be willing to answer some questions on behalf of your household? It will take about 15 minutes. Thank you/No problem.
If refused, check the box and close.

1. Do you live in the Cape Town [/Nelson Mandela Bay/eThekwini] Metro area? Yes ☐ No ☐
2. Are you a decision maker or financial contributor in your household? Yes ☐ No ☐
3. Do you have a municipal water supply (piped water to your house)? Yes ☐ No ☐

☐ ***If NO to any of the above, END the interview and tally.***

4. Are you here for ☐ a passport/travel documents or ☐ for something else (e.g. ID, birth certificate etc.)?

About your home

5. Which suburb do you live in? ___________________________ (choose from drop down list)
6. Including you, how many people live in your household? _______adults (≥ 18) _____ children (< 18)
7. Do you rent or own your property? ☐ Own ☐ Rent
8. Do you live in a house, apartment or shack? ☐ House (includes semi-detached) ☐ Apartment ☐ Shack
9. Does your property/complex have a:
    a. Garden ☐ Yes ☐ No
    b. Swimming pool ☐ Yes ☐ No
    c. borehole or wellpoint? ☐ Yes ☐ No ☐ Don't know.
    d. rainwater tank(s)? ☐ Yes ☐ No ☐ Don't know.
    e. grey water system? ☐ Yes ☐ No ☐ Don't know.
10. If you receive water from other sources, can you estimate what % of your water used is municipal water? ___%
11. Does your property have a water demand management device? Yes ☐ No ☐ Don't know
12. How does your household pay for its water use? ☐ Directly to the municipality ☐ included in rent ☐ included in building levies ☐ part of the indigent support programme ☐ Don't know

Willingness to pay for existing water use

13. Roughly how much does your household pay per month for electricity at present? R____ ☐ Don't know
14. How confident are you that you indicated the correct amount that you pay for electricity every month?

☐ Extremely confident ☐ Quite confident ☐ Somewhat confident ☐ Not very confident ☐ Not at all confident

15. Roughly how much does your household pay per month for water at present (directly or via rent or levies)?
    R____☐ Don't know (use this value for next WTP questions)
16. How confident are you that you indicated the correct amount that you pay for water every month?

☐ Extremely confident ☐ Quite confident ☐ Somewhat confident ☐ Not very confident ☐ Not at all confident

17. Would your household be willing to pay R 1.5x current water bill per month for the water you are currently using?

20a) If yes --> Would your household be willing to pay R 2x current water bill per month for the water you are currently using?

20b) If no --> Would your household be willing to pay R 1.25x current water bill per month for the water you are currently using?

18. What is the most your household would be willing to pay monthly for the water you use at present? _______(open ended) ☐ Don't know

Willingness to pay for security of supply and environmental flows

To reduce the risk of water restrictions in the future, the municipality will need to increase its investments in water supply infrastructure and in keeping the mountain catchment areas in good condition. This would of course increase the cost of water. The cheapest option is to build more dams and extract more water from rivers, but this will leave our rivers and estuaries in a poor condition. Or we could invest in alternative sources of water, like groundwater, recycled water or desalination, and protecting and restoring rivers. This is a bit more expensive but would help to keep our rivers and estuaries in a fair condition.

I'm going to show you three options and I'd like you to choose which option you prefer most. One of the options displays the current situation and the other two options show different future situations. The first block represents the condition of rivers and estuaries, the second block represents how frequently you would tolerate water restrictions over the next ten years and the third is how much you would be willing to pay for water on top of your current bill.

19. Ok, so please consider the following options and indicate which one you prefer. (*Explain the options*). (4 choice sets randomly selected from a total of 24)
20. If we were to avoid further impacts on rivers, we would have to rather use more expensive sources of water like groundwater, desalination and recycled water. If you had a choice, would you prefer to:

    - ☐ Keep prices low and accept that rivers will deteriorate **OR**
    - ☐ Accept higher water prices to reduce further impacts on rivers and estuaries **OR**
    - ☐ Don't know

      What was the main motivation for your choices? ☐ Concern about environmental quality ☐ Minimising the chance of water use restrictions ☐ Keeping the costs of water as low as possible ☐ Don't know

Trust in municipality

21. Please indicate your level of satisfaction with the way that the municipality manages water supply and sanitation in your neighbourhood, on a scale from 1-5 where 1 = extremely dissatisfied, 2 = dissatisfied, 3 = neutral, 4 = satisfied, 5=extremely satisfied _____
22. Do you think the municipality should be charging more for water? ☐ Yes ☐ No ☐ Don't know
23. Why yes? ☐ to improve water security ☐ To increase municipal revenues for service delivery generally ☐ Other _____
24. Why no? ☐ Difficult to afford. ☐ It won't make any difference to service delivery. ☐ Other __
25. Do you trust that your municipality would actually use the funds to improve water security if they increased the price of water? ☐ Yes ☐ No

Environmental attitude

26. What was the main motivation for your choices? ☐ Concern about environmental quality ☐ Minimising the chance of water use restrictions ☐ Keeping the costs of water as low as possible ☐ Don't know
27. Please rate these statements on a scale of 1 to 5 where 1 = completely disagree and 5 = completely agree:
- Maintaining rivers and wetlands in a good condition is worth spending taxpayers' money on.
- The frequency of droughts will increase in this city in the future
- The conservation of mountain catchment areas is important for water security.
- Supplying water cheaply to residents is much more important than the conservation of rivers and estuaries.
- The price of water is high in South Africa

Socioeconomic status

Finally, I need some information about you and your household:

28. Please indicate your highest level of education

☐ None ☐ Primary ☐ Secondary ☐ Matric ☐ Diploma ☐ Degree ☐ Prefer not to answer

28.Please indicate your **household's** total **monthly income before tax** in Rands? ***(tick one option)***

0-400	☐	12 801 - 25 600	☐
401-800	☐	25 601 - 51 200	☐
801 - 1 600	☐	51 201 - 102 400	☐
1 601 - 3 200	☐	102 401 - 204 800	☐
3 201 - 6 400	☐	204 801 or more	☐
6 401 - 12 800	☐	Prefer not to answer	☐

29. What is your age? ____

For enumerator only:

Rate the quality of the interview ☐ High ☐ Medium ☐ Low

Race of respondent: ☐ Black ☐ White ☐ Coloured ☐ Other

Gender of respondent ☐ Male ☐ Female ☐ Other

Appendix 2: *Mean WTP (per month), the number of households in each income category from the municipal census, and the aggregate WTP per year. Aggregate WTP per year was calculated by multiplying the mean WTP by 12 (months) and then multiplying that figure by the number of households per income category. Total aggregate willingness to pay per municipality in one year is indicated in bold.*

	City of Cape Town			Nelson Mandela Bay			eThekwini		
Income categories (R)	Mean WTP	Number of hh	Aggregate WTP per year	Mean WTP	Number of hh	Aggregate WTP per year	Mean WTP	Number of hh	Aggregate WTP per year
1 - 400	314.43	29397	110 919 585	215.82	14204	36 786 769	403.16	40662	196 719 503
401 - 800	339.51	42427	172 852 689	288.56	19782	68 499 527	532.06	58920	376 187 702
801 - 1 600	390.25	113271	530 448 093	319.9	51542	197 859 430	514.40	136856	844 784 717
1 601 - 3 200	464.09	170820	951 310 246	326.18	55837	218 554 952	542.97	161391	1 051 565 655
3 201 - 6 400	503.36	154433	932 824 739	409.57	41944	206 148 049	612.38	128220	942 232 363
6 401 - 12 800	585.90	139347	979 720 888	462.9	34608	192 240 518	649.54	102148	796 190 543
12 801 - 25 600	633.95	126608	963 157 699	477.48	29309	167 933 536	785.11	82545	777 682 859
25 601 - 51 200	734.24	92860	818 178 317	539.48	18128	117 356 321	812.34	54269	529 018 554
51 201 - 102 400	839.43	37999	382 770 007	642.67	5296	40 842 964	858.39	19203	197 803 958
102 401 - 204 800	513.92	9720	59 943 629	647.48	1344	10 442 557	1 149.58	5522	76 175 769
204 801 or more	574.11	5007	34 494 825	735.66	894	7 892 160	1 229.38	3068	45 260 854
TOTAL			**5 936 620 715**			**1 264 556 784**			**5 833 622 478**

Appendix 3: *Aggregate mean WTP (per year) versus aggregate mean water bill (per year) for each of the 11 income categories per municipality. Total amounts are indicated in bold. Consumer surplus at the municipal scale was generated by calculating the difference between the aggregate mean WTP and the aggregate mean water bill.*

	City of Cape Town		Nelson Mandela Bay		eThekwini	
Income categories (R)	Aggregate mean WTP	Aggregate mean water bill	Aggregate mean WTP	Aggregate mean water bill	Aggregate mean WTP	Aggregate mean water bill
1 - 400	110919585	103477440	36786769	14488080	196719503	262269900
401 - 800	172852689	165465300	68499527	71452584	376187702	296956800
801 - 1 600	530448093	327722811	197859430	371175165	844784717	600602331
1 601 - 3 200	951310246	665651376	218554952	299671403	1051565655	955434720
3 201 - 6 400	932824739	848223253	206148049	286771128	942232363	606993480
6 401 - 12 800	979720888	471789129	192240518	253208414	796190543	634339080
12 801 - 25 600	963157699	910983093	167933536	289776809	777682859	973777015
25 601 - 51 200	818178317	815969806	117356321	180466254	529018554	409681615
51 201 - 102 400	382770007	310900909	40842964	85795200	197803958	177947800
102 401 - 204 800	59943629	57153600	10442557	3225600	76175769	59637600
204 801 or more	34494825	39355020	7892160	5364000	45260854	29978265
Total	**5 936 620 715**	**4716691737**	**1 264 556 784**	**1861394637**	**5 833 622 478**	**5007618606**