Scope effects in contingent valuation: an application to the valuation of irrigation water quality improvements in Infulene Valley, Mozambique

By

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DECLARATION OF ORIGINALITY

I hereby declare that this dissertation which I submit for the degree of MSC Agric (Agricultural Economics) at the University of Pretoria is my own work and it has not been previously submitted by me for a degree at this and for any institution of higher learning.

Signature ---

Manjate Graça

Date ---

Approved by:

Signature ---

Prof E.D. Mungatana

DEDICATION

This work is dedicated to my parents the late Samuel Manjate and Ana Elias Macuacua, thank you for always lifting up my life to the throne of God's grace through prayer every morning. It is also dedicated to my beloved husband René Abílio, for his support and encouragement during the whole period of my study. God bless them abundantly.

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ABSTRACT

This study uses the double-bounded bid elicitation format to test whether the willingness to pay (WTP) of 244 randomly selected residents of Maputo and Matola cities for wastewater quality improvements in the Infulene Valley is sensitive to internal and external scope. The Infulene Valley was selected because its wastewater is used as an input in vegetable irrigation. WTP was elicited and compared when the level of wastewater treatment was 100 % and when it was 50 %. The results show that the majority of those interviewed display high levels of knowledge regarding the risks associated with poor quality irrigation water, and that they have attitudes and perceptions receptive to a policy that aims to improve irrigation water quality. The WTP responses passed the bottom up (t= 15.28, p=0.000) and top down (t=14.07, p=0.000) internal and external (t=13.43, p=0.000) scope tests, suggesting that the level of wastewater treatment significantly influences households' WTP. The following variables were statistically significant in the WTP model: income, age, education level, household size, gender, whether the household considers water scarcity as a priority issue, knowledge of the unsuitability of Infulene Valley water for vegetable irrigation, and whether the household is aware that the Infulene Valley is an important supplier of fresh vegetables to Maputo and Matola residents. The study concluded that the level of water treatment (high quality of treated wastewater) is a significant factor of preference over the alternative policy in wastewater treatment. The following recommendations derive from the study: policy makers should consider wastewater treatment planning and they should develop an irrigation water pricing system, as well as conservation practices to manage pollution problems at Infulene Valley. While this study provides an estimate of household values for irrigation water quality improvements in the Infulene Valley, is ultimately up to policy makers at the city and country levels to implement any changes.

Key words: Recycled wastewater reuse, irrigation, willingness to pay, scope effects in contingent valuation, double- bound dichotomous choice bid elicitation format, Mozambique

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LIST OF ACRONYMS

ANOVA	- Analysis of Variance
ARA-SUL	- Mozambique Regional Administration of Waters in the South
BU	- Bottom Up
CVM	- Contingent Valuation Method
DNA	- Directorate of National Water
DBDC	- Double Bound Dichotomous Choice
DC	- Dichotomous Choice
FAO	- Food and Agricultural Organization
GDP	- Gross Domestic Product
INE	- Institute Of National Statistics
IID	- Identically and Independently Distributed
IWRM	- Integrated Water Resource Management
MT	- Metical, the currency of Mozambique
NOAA	- National Oceanic and Atmospheric Administration
OECD	- Organization for Economic Co-operation and Development
PRONASAR	- National Rural Water Supply and Sanitation Program
Pr	- Probability
TC	- Travel Cost
TD	- Top Down
USEPA	- United States Environmental protection Agency
UNESCO	- United Nations Educational, Scientific and Cultural Organization
UNEP	- United Nations Environment Programme
UN-HABITAT	- United Nations Human Settlements Programme
UNDP	- United Nations Development programm
WTP	- Willingness to Pay
WTU	- Willingness to Use
WTA	- Willingness to Accept
WHO	- World Health Organization

CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND

Globally, the problem of declining water quality is of growing concern, thus demanding urgent policy intervention (USEPA, 2002). The majority of wastewater reuse projects in the world are implemented for agricultural irrigation purposes and are driven by increasing agricultural water demand and water scarcity (Lazarova et al., 2011). Wastewater reuse for agricultural irrigation purposes is employed in countries that have adverse weather variations; for example, in Israel it is estimated that by 2040, wastewater reuse will become the main source of irrigation that will supply about 70 % of the total irrigation schemes. Moreover, Australia is recognised as a major food-producing country and is land abundant, but recently it has experienced drought that has impacted negatively on agricultural and food production substantially, and over this period Australia realised a 43 % reduction in water supply which resulted in food production declining (Goesch et al., 2007). Due to these supply shortages, the volume of water reuse has had a steady increase in agriculture, and currently in Australia, around 11.5 % of total wastewater generated is reused (ABS, 2010).

Water quality is a complex and diverse construct that deserves urgent global attention, from the management point of view. Water quality can be defined in terms of its preferred end use, and as being clean and safe (WHO, 2008). The world faces a water quality crisis at the beginning of 21st century, attributable to continuous population growth, urbanisation, increased living standards, industrialisation, agricultural practices, poor water use practices and wastewater management strategies (World Water Council, 2012). Because of the growing concern over water shortage problems, economists proposed the alternative means of conserving water through the reuse of wastewater (Asano, et al., 2007; USEPA, 2012). This is further indicated by Hanjra (2012) to the effect that water reuse is justified on economic and agronomic grounds due to its potential importance as a viable source for agricultural irrigation. Due to the increased water quality crisis, wastewater reuse has become a recognised part of the water supply in several parts of the world (UN-Water, 2013). For example, UNESCO (2012) has indicated that there has been worldwide expansion of wastewater reuse in recent years in agricultural irrigation, urban green spaces, and for industrial and domestic uses.

The agriculture sector is taking a lead, globally, in the reuse of wastewater for irrigation due to the high demand for food, driven by high rates of population growth (Jimenez & Asano, 2008). Irrigated agriculture accounts for about 70 %, industry for 22 %, and municipal consumption of drinking water for 8 % of global water use (Lazarova et al., 2011; Molden et al., 2007). For example in the US, the water reuse practice is high, with an estimated 2.6 billion gallons of wastewater per day being reused, and the volume of water reuse is growing at a rate of 15 % per year in the US. The use of wastewater is associated with crop irrigation and golf courses, as well as industry and indirect potable reuse (USEPA, 2000). About 65 % or more of the total municipal sewage production in Israel is reused for irrigation purposes (Haruvy, 1996; Friedler, 2001).

The regions where water reuse is a growing practice in agriculture include the European Union, the US, Australia, India, and the Middle East (Miller, 2005). For example, agricultural irrigation comprises 41 % recycled water in Japan, while in California, 60 % of recycled wastewater has been used for irrigation since the 20th century and wastewater use is branching to other parts of the US (Westcot & Ayers, 1985; FAO, 1996). Moreover, the use of wastewater for irrigation is considered a traditional practice in France, where it is used for irrigation of golf courses and landscape areas in addition to agricultural irrigation purposes (UNEP, 2010). Wastewater reuse from an economic view point, together with agronomic and water management sustainable practices, has many advantages associated with it as it combines the benefits of fresh water conservation, expands irrigated agriculture, increases yields, and reduces waste disposal, thus protecting the environment and public health. Moreover, water reuse in agriculture reduces the use of fertilisers due to nutrients it contains, hence resulting in savings in the value of fertiliser (Hussain et al., 2002; Lazarova et al., 2013; Miller, 2005; Menegaki et al., 2007). According to Ensink et al. (2004) and WHO (2006), recycled wastewater use is becoming more important and this will force planners to consider it as an alternative reliable source of water because of its benefits for protecting the environment and public health, as well as it being a source to meet water shortages in agriculture irrigation.

Despite the above advantages, wastewater re-use is also associated with a myriad of challenges which limit the capacity for reuse. The challenges of water reuse include: the irrigation method used which might spread pathogens (drip irrigation system is recommended), the social acceptability regarding how receptive consumers will be to the process and to the resulting product quality irrigated with recycled water, groundwater contamination due to heavy metals, nitrates and organic matter, and the fact that excess nutrients in wastewater can reduce crop productivity (Hanjra et al., 2012). This requires governments to devise policies that would encourage greater wastewater reuse.

Improving water reuse depends on an improvement in public awareness and attitudes towards it, the reduction of health and environmental hazards effects by setting standards for reuse, increasing the reliability of reused water as an alternative source to ground water for irrigation (improvement of storage capacity), the provision of reliable information on the value of water reuse, the proper training of farmers, and definitions of clear policies (Ndunda, 2014; WHO, 2006; Miller, 2005; TYPSA, 2013; Menegaki et al., 2007 and Lazarova et al., 2013).

In many developing countries, the issue of wastewater reuse is a critical challenge, as compared with most developed countries (Qadir et al., 2010). The reason is that developed countries are classified as high-income countries, which status enables them to bear the treatment costs of wastewater. For example, according to Sato (2013), a country's treatment capacity depends on the country's level of income; thus, the treatment capacity in high-income countries averages about 70 % of the total wastewater generated, while low-income countries have capacity to treat only 8 %.

Consequently, untreated wastewater use has debilitating effects on both the environment and the health of the people who stay nearby the source of wastewater. The OECD (2012) has indicated that disregarding the management of wastewater leads to two principal water quality impacts, namely chemical contamination and microbial pollution. The environmental conditions arising from the absence of, or inadequate, management of wastewater pose significant threats to human health, well-being and economic activity (Drechsel et al., 2010). For example, Brown and Farrelly (2009) stated that the use of raw or minimally treated wastewater in agricultural food crop irrigation has health effects for farm workers who regularly use poorly treated wastewater for irrigation, and this has provided evidence of infectious disease transmission.

Mozambique is located on the East Coast of Southern Africa and is well known for its high water supply, as compared with other sub-Saharan Africa countries; the availability of surface water resource is approximately 5 550 m3/year. However, the demand for water has been increasing dramatically and in the near future it will pose challenges for water needs (World Bank, 2005). It is estimated that more than 60 % of the rural population, and approximately 55 % of the urban population, do not have access to an adequate water supply (USAID, 2008). The major constraints that the water sector faces are: limited funding, poor clarity of policies, and a lack of institutions to effectively address the demand of the sector itself (MOPH, 2012). Over the past 20 years, the government of Mozambique has implemented and planned a number of reforms in the public sector to ensure a national and sectorial public policy framework that is oriented to ensure access to water. This framework includes the National Programme for Water Supply and Rural Sanitation (PRONASAR), which is part of the implementation of the Strategic Plan for Water Supply. In 2007, the government of Mozambique approved the revised water policy and other legal documents of the water sector, designed to promote principles to increase the water coverage to meet basic needs and to ensure the Integrated Water Resources Management (IWRM). The IWRM concept was included as an important component to achieve sustainable development (CIP, 2013; MOPH, 2012; Gallego-Ayala et al., 2011). The supply of reliable and safe water to the urban and rural population is one of the main development priorities of the government of Mozambique, was projected the increase in water coverage by 2015 of about 250 hm3/year in total by utilisation of small reservoirs in rural areas, while in Maputo and Beira cities the increment in water supply will require larger infrastructure solutions. In the case of improving water supply to Maputo and Matola cities, this will involve the construction of the Moamba major dam on the Incomati River (World Bank, 2005). Consequently, there is a need to implement a study that investigates the cost and benefits of wastewater reuse in Mozambique, as a response to the water supply shortages, since wastewater reuse, especially in agriculture, could mitigate the water supply shortage.

In the next section, the problem statement and the research questions are presented, followed by the objectives of the study in section 1.3, while section 1.4 presents the study hypothesis, and the relevance of the study is presented in section 1.5.

1.2 PROBLEM STATEMENT

Maputo is the capital and the largest city of Mozambique, with a total population of about 1,094 million inhabitants, and it is projected that about 40 % of all the urban population of Mozambique live in Maputo city, which produces 20.2 % of the National GDP (INE, 2007). Maputo is a relatively dry city; the rain season starts in November, going through to March. Due to its location on the Indian Ocean, Maputo is mostly susceptible to climate shocks such as cyclones, flooding and sea level rises (Maputo Municipality, 2008). The main source of water supply in Maputo and Matola cities is the Umbelúzi River, followed by ground water, with ground water being mostly used in the peri-urban areas of the city, where a central supply system is not present or is in poor condition (Bhatt, 2014). Agricultural activities comprise one of the main activities in Maputo city and are developed at the Infulene Valley, also known as Maputo green belt, which is an important supplier of fresh vegetables to Maputo and Matola cities, and is a greater source of employment for poor households (UN-Habitat, 2010).

Maputo is the capital city and, together with neighbouring Matola city, is projected to grow from about 2.5 million to more than 4 million inhabitants by 2025 (INE, 2007). According to Raschid-Sally (2008), the high growth rate of the urban population is directly associated with a high demand for food and water in many cities; therefore, water reuse is a viable solution for overcoming the water supply and demand imbalances.

Maputo and Matola are two closely adjacent cities, separated by a distance of about 10 km. Due to the growing population in these two cities, the demand for vegetable production has gained momentum. In order to respond to this demand challenge, the government of Mozambique allocated land of 2 300 ha to more than 13 thousand low-income farmers to grow vegetables in the Infulene and Mohotas valleys. The commitment of the government to urban agriculture started during the 1980s, and although Maputo has grown exponentially and is disorganised, the areas for vegetable production were not affected. This is because they are protected by the Maputo municipality council under the strategy of the Mozambican government for a green revolution that includes development of urban agriculture, designed to meet urban demand for fresh food throughout the year and to provide jobs for poor families (FAO, 2013).

Under this vegetable scheme, the areas are divided into lots of 300 m² which are labour intensive, with about 40 000 people being employed on the farms, and the main vegetables grown are Portuguese cabbage, lettuce, onions, tomatoes, garlic, pepper, spinach, beetroot, green beans, and pumpkin leaves (FAO, 2013). The main challenge associated with this vegetable scheme is the poor quality of irrigation water from the nearby river which is used as a source of irrigation. The water from the Infulene River is subject to various sources of pollutants, as its banks are highly populated, and the river also receives water from the municipal drainage system, which is an open canal along Joaquim Chissano Avenue that transports water from Maxaquene, Mavalane and other municipal districts to the Infulene river and finally to the sea. Accordingly, the levels of nitrates and ammonia are high due to fertiliser use and the dumping of domestic untreated sewage and industrial effluents into the river (ARA-Sul, 2011b). According to Serra and Cunha (2008), the issue of poor sanitation in urban areas is quite worrying, and the drainage and sanitation systems are not working, with the result that the water is contaminated. Moreover, latrines are often built on unsuitable land, causing contamination of ground water and contributing to the emergence of cholera and other diarrhoeal diseases. Additionally, the quality of vegetables emanating from the poor treatment facilities is a public concern. For example, many farmers use watering cans to irrigate vegetables due to lack of funds to buy water pumps, thus relying on unsuitable practices (Sitoe, 2008).

As a response to this health hazard and the environmental impact of improper dumping of untreated sewage, the government of Mozambique, through the municipality of Maputo, has launched a treatment facility for wastewater. This treatment plant is located in the valley of the Infulene River. The treatment plant collects water partially from the urbanised city centre of Maputo where 14 % of the population lives (SEED, 2010). In addition, trucks deliver wastewater to the treatment facility where the water is biologically treated in stabilisation ponds (DHV, 1984).

However, the treatment plant is not working to its expected capacity as it is in poor quality of operation. The imperfection of the treatment plant is caused by lack of maintenance funds and experts to secure the proper working of the plant. According to DNA (2004), the treatment plant served 10 % of the population in 2004. Consequently, the lives of the farmers and consumers who eat vegetables irrigated with the less-treated water are at risk. For example, according to Serra and Cunha (2008), the risks to human health are immeasurable, especially for those people who eat vegetables from the Infulene valley in raw form.

The health and environmental hazards associated with the untreated water reuse have led to emergence of this study, because this untreated wastewater is normally used by farmers to grow vegetables. Therefore, by understanding their preferences for vegetables irrigated with recycled wastewater, we will be able to argue to the policymakers that improved irrigation water at the Infulene Valley is essential. This study is guided by the gaps in the literature. For example, a previous study in Mozambique by Waddington et al. (2009) concluded that water supply interventions would significantly reduce diseases through improvements in water quality. Irene Caltran (2014) implemented a study addressing the key objective of decreasing water shortages by allowing the local water sector in Maputo to include wastewater reclamation and reuse in the overall urban water system design and planning, so that water scarcity could be alleviated by water reuse, with the treated water being made available for particular categories of local uses, such as irrigation.

However, neither of these studies considered the consumers' awareness of the vegetables produced with reused water or the perceptions or attitudes towards wastewater reuse and how consumers, as indirect users, value the reuse of water in vegetables irrigation. Moreover, consumers do not know the status of vegetables they consume because they are not informed about the quality of water used to irrigate the vegetables and the risks associated with it. Accordingly, creating consumer awareness of the status of vegetables consumed and understanding consumers' behaviour and their valuation of water reuse in vegetable irrigation will be an important tool for reducing information asymmetry. The findings of this study, therefore, will form a basis for making recommendations to policymakers on the importance of wastewater reuse programmes to ultimately secure a reliable source of water that meets required health and environmental standards, and as to the actual value of wastewater. Therefore, this study employed a CVM approach to find out the value that residents of Maputo and Matola cities place on irrigation water improvements for the Infulene Valley. The study endeavours to answer to the following questions:

1. Do the factual attitudes, perceptions and knowledge of the residents of Maputo and Matola cities regarding current water supply shortages show that they are concerned about the problem that they currently facing?

2. Do the factual attitudes and knowledge of the residents of Maputo and Matola cities towards and regarding recycled wastewater reuse affect the irrigation water improvement at the Infulene Valley?

3. Does the factual knowledge of the residents of Maputo and Matola cities regarding the current suitability of Infulene Valley water affect the irrigation water improvement at Infulene Valley?

4. How much are Maputo and Matola residents WTP for improved irrigation water?

5. Are WTP estimates sensitive to variations in the quality of irrigation water improvements in the Infulene Valley?

1.3 OVERALL OBJECTIVE

The overall objective of this study is to estimate the WTP of residents of Maputo and Matola cities for irrigation water improvements in Infulene valley.

1.3.1 *Specific objectives*

More specifically, the study will:

1. Determine whether WTP estimates are sensitive to the quality of irrigation water (sensitive to scope effects);

2. Determine the factors that affect respondents' WTP for irrigation water improvements;

3. Assess respondents' attitudes, perceptions and knowledge regarding wastewater reuse for vegetable irrigation; and

4. Based on the analysis derived from the above objectives, the study will draw policy recommendations for suitable wastewater management in Maputo and Matola.

1.4 RESEARCH HYPOTHESES

i. The awareness, perceptions and knowledge of residents regarding the water supply shortage problems are expected to have an effect on WTP for improved irrigation water decisions. A study conducted by Marwan et at. (2010) in Palestine shows that knowledge plays an important role in the decision to use and pay for treated water, and that study further found that over 80 % of respondents (farmers and consumers) knew that it is important to participate in decision making and that the knowledge regarding health risks represented the most important factor. Furthermore, the level of factual knowledge that the respondents have towards the water supply services problems affecting the respondents' community result in more value being attached to the improved services (Ntshingila, 2006). Thus, this study was conducted to test the following hypothesis:

1. *The levels of knowledge, perception and attitudes do not significantly affect respondents' WTP for irrigation water improvement.*

ii. Socio-demographic factors, namely gender, age, education and income, among other factors, provide important information on which demographic individuals are more likely WTP. McKay, Hurliman and Georgantzis (2003) showed that people aged from 50 years and over were less likely WTP and use recycled water, while Tsagarakis (2003) reported that people with high levels of education were WTP more for recycled water. Gender and age have significant effects on WTP for irrigation water improvements, which is in line with findings (Menegaki et al., 2007; Bakopoulou et al, 2009) that reveal that younger people are more WTP for products irrigated with recycled water, and that the probability of females being WTP and WTU products irrigated with recycled water is lower than that of males. Furthermore, Moffat et al. (2011), Jurado et al. (2012), and Kanayo et al. (2013) found that the income of respondents had a positive and significant effect on WTP. This indicates that higher-income households prefer high-quality water supply services and are more likely WTP than lower income households are, which is consistent with the demand theory which states that the demand for normal goods has a positive relationship with income. Hence, the study tests the following hypothesis:

2. *The WTP for irrigation water improvements is independent of respondents' socio-demographic factors.*

iii. Economic theory states that the utility function is represented by individuals' preferences, and their main goal is to maximise utility level. Therefore, in estimating the values for environmental improvement, the economic analysis focuses on the individual behaviour with the trade-offs. This study will determine the economic value of irrigation water improvement benefits, at the Infulene Valley, which improvements render the water safe for irrigation and other uses. Scope concerns a change in utility function. Therefore, a good is considered scope sensitive if the quantity of that good increases or decreases, i.e. when respondents sensitively react to the extent of proposed environmental improvements. The focus on scope sensitivity is due to findings, reported by Desvousges et al. (1992), Diamond et al. (1993), Fisher (1996), and Svedsater (2000), to the effect that the hypothesis test revealed that respondents were not sensitive to scope of the good valued. However, other studies (by Carson et al., 1993; Carson, 1997; Smith et al., 1996) have found significant evidence of respondents' sensitivity to scope. The respondent insensitivity to scope is attributable to unfamiliarity with the payment vehicle of the environmental goods in hypothetical markets that leads to constructed preferences (Brouwer, 2009). Therefore, this study tests the following hypothesis:

3. *The level of wastewater treatment at Infulene Valley does not significantly influence the respondent's WTP for irrigation water improvements.*

1.5 THE RELEVANCE OF STUDY

The rationale behind conducting this study is to explore the fact that recycled wastewater reuse in agriculture has many benefits for farmers and for the environment by reducing pollution, while it also reduces demand for fresh water to use in agriculture. Most of the studies on wastewater reuse have placed more focus on improvements of the water quality, while very little attention has been given to the economic and social valuation of wastewater reuse in agriculture. Such an economic valuation would provide relevant information on the costs and benefits of wastewater reuse, which would lead to developing sound decision making regarding water resource management in Maputo. Ultimately, this study will put wastewater treatment on the policy agenda and will help policymakers in ascertaining what aspects negatively affect respondents' WTP, and WTU products related to recycled water should be given attention in policy design.

The remainder of this dissertation is divided into four chapters. Chapter Two gives a review of theoretical and empirical literature on the use of CVM to value the improved irrigation water in Infulene valley. Chapter Three describes the study area, the research design, data analysis procedures, and the household characteristics of the sample, while Chapter Four outlines the results and discussions of the study. Finally, Chapter Five presents the conclusions and recommendations of the study.

CHAPTER TWO
THEORETICAL AND EMPIRICAL LITERATURE

2.1 INTRODUCTION

The main focus of this chapter is to present the theoretical and empirical literature on the valuation of wastewater reuse and the provisioning of wastewater treatment services and vegetable production support. This will be done with the intention of identifying knowledge gaps and to ultimately highlight the contribution of the study.

This chapter is organised into four main sections. Section 2.2 reviews the theoretical literature, which is subdivided as follows: Subsection 2.2.1 outlines the economic theory of valuation, 2.2.2 presents the Contingent Valuation Method (CVM), 2.2.3 outlines the importance of using CVM, 2.2.4 presents the CVM elicitation techniques, 2.2.5 presents the payment vehicle, 2.2.6 presents the issues and limitations surrounding the use of the CVM, and 2.2.7 presents the suggested solutions to the problems related to CV approach. Section 2.3 presents the theoretical framework, 2.4 presents the overview of recycled water use and acceptability, 2.5 reviews the empirical studies, and section 2.6 presents the knowledge gaps. Lastly, the concluding remarks for this chapter are presented in section 2.7.

2.2 THEORETICAL LITERATURE

2.2.1 *Economic theory of valuation*

Barbier and Strand (1998) have defined economic valuation as an approach to assigning values to goods and services that often have no market prices. These kinds of goods are normally called public goods. Generally, individuals are assumed to have preferences. Based on preferences and relative cost within a bound set of alternatives, individuals can maximise their utility. The value therefore, arises from utility maximisation. The economic value of a market good or service is a monetary measure of the wellbeing associated with its production and consumption. The value is determined by demand and supply in a perfectly competitive market, assuming the theorems of welfare economics hold. However, for most public goods and services there are missing markets, and the economic value is revealed by WTP and the societal value is the summation of individual valuations (Mukama, 2010). WTP (willingness to pay) is defined as the area under the demand curve (Pearce et al., 1990). Contextually, it is the shadow price for wastewater reuse improvement, which implies that it is the amount that consumers are WTP for vegetables irrigated with treated wastewater in Maputo, Mozambique.

Economists use two methods to elicit WTP: market valuation and non-market valuation. Market valuation is applied where we have market prices for goods and services; thus, we assign values using direct market valuation. Where markets do not exist for a good, the shadow price is normally used to assign an economic value to such good. Non-market valuation involves stated preferences and revealed preferences methods. A revealed preference method looks at related or alternate markets in which the environmental good is traded, although implicitly. They have the capability of yielding both use and non-use values of goods and services. They are used where revealed preference is not applicable or they can be applied together (Tietenberg, 2003).

The economic valuation of natural and environmental resources entails assessing the preferences of society with regard to an environmental resource or public good. The valuation of natural and environmental goods has grown in importance in recent years. This has been mainly attributable to efforts by governments to increase resource allocation efficiency and sustainability in the face of increased human pressures. Moreover, natural resources also include resources such as labour and capital, and they thus should be properly managed and sustainably used. According to Pearce (1993), important conservational and sustainable strategies for natural resources and public projects are rightfully addressed when economic values are identified.

Most natural resources and public goods are provided freely and thus have missing markets. Whittington et al. (1991) pointed out that non-market or environmental goods are public goods, which cause externalities. Consequently, markets cannot efficiently allocate such goods with pervasive externalities, or for which property rights are not clearly defined (Haab and McConnell, 2002). Thus in solving for externalities, it is important that economic values be attached to public goods. Because of missing markets, resources are mismanaged and inefficiently allocated as the values of goods and services are not being revealed (Kadekodi, 2001).

2.2.2 *Contingent valuation method (CVM)*

Of the many methods used to assign economic values to non-market goods, CVM seems to be widely used and accepted among the environmental valuation practitioners, and the outstanding feature is that it is far reaching in its practical application in valuation. According to Arrow et al. (1993), the CVM is a valuation based on carefully designed and administered sample surveys which create a chance for participants to evaluate a public or nonmarket good. CVM is the more common and appropriate valuation technique used in the valuation of public goods. The exercise of estimating a hypothetical market provides relevant information about the characteristics of the demand for a good that is not currently traded (Mitchell & Carson, 1989).

Historically, the CVM dates back in 1963, when it was published for the first time by Davis (1963) in a study of hunters and tourists. From then, the CVM has grown in importance and has been used to measure various environmental goods like wetlands, recreational parks, wild life reserves, air and water quality, game parks, etc. The earlier use of the CVM by most researchers was, however, mainly based on use values, but as the theory of non-use was introduced, the CVM was extended to estimate both (Randall, 1991). CVM, as a stated preference method, thus can also derive information about people's preferences which cannot be observed through individual action, like non-use values.

With a strong foundation in constrained utility maximisation theory (McFadden 1999; Johanesson 1993), the stated preference technique has become the most widely used tool for estimating benefits associated with providing non-marketed goods and services, especially in environmental economics literature. The use of CVM has the flexibility of measuring both use and non-use values of a variety of goods (Carson et al., 1999). It is for this reason that the CVM has been used beyond the conventional environmental goods. Recently, the CVM has been applied in the field of health economics to measure people's WTP to avoid certain health issues like obesity (Smith, 2000; Cawley, 2008).

The goal of a CVM is to quantify compensating and equivalent variation of a resource or environmental quality. CV is more appropriate when the respondent is required to pay for the good, like paying for improvement of wastewater quality for reuse in irrigation. On the other hand, equivalent variation is mainly used when the respondent might potentially lose the good, thus it is the minimum compensation that the individual will accept in lieu of the loss (Perman et al., 2003). Both techniques can be elicited by asking the WTP/WTA from the respondents.

2.2.3 *Importance of using CVM*

CVM has many advantages over the other methods of environmental valuation, which include the travel-cost (TC) and hedonic pricing techniques. The CV method has the ability to quantify non-use or passive use benefits, which quantification is out of reach of other methods. This method was given priority and recognition by the US Water Resources Council as a useful valuation technique that can measure a variety of benefits. Essentially, CVM is able to measure passive use values; hence, it is gaining popularity among applied environmental economists (Hanemann, 1991). This is in accord with the findings of Bishop et al. (1983) who in their study stated that CV estimates have grown in credibility when compared with estimates from other models, such as travel costs, costs and prices of substitutes, and property values.

2.2.4 *CVM elicitation techniques*

As already highlighted, CVM mainly relies on stated preferences from respondents, and there are a number of formats for eliciting WTP or WTA. One traditional method is the open-ended elicitation format, which entails asking respondents the maximum amount of money they are WTP or WTA without any referendum. With advantages like being quick to administer and avoiding the "anchoring effect", this method has proved not to be in line with economic theory (Wattage, 2001). Moreover, this elicitation technique has proved to result in high non-response rates (Desvousgas et al., 1983) and large numbers of questionably high or low values (Chien et al., 2005). In an attempt to improve the CVM elicitation format, researchers have introduced the following elicitation formats:

- Checklist (payment card) format
- Bidding game format

- Dichotomous discrete choice
- Dichotomous discrete with follow-up question.

In recognition of the bias arising from the open-ended format, Mitchell and Carson (1989) introduced the payment card method which involves putting WTP or WTA questions to respondents by providing them with a range of estimates from which to choose. This is method is more cumbersome than the open-ended method as it presents several problems. Although improving the number of non-protest answers and outliers, this method has brought concerns like anchoring effects, decisions of bids used, and the size of the intervals in the values (Cameron & Huppert, 1989, as cited in Chien et al., 2005). The method justifies its use in that, unlike the bidding and dichotomous methods, the payment card avoids the "starting point" bias while also providing a reference point to the respondent.

Used in the first published CVM study by Davies (1963), the bidding game method involves presenting an initial value to respondents and asking what they would accept, and then iterating higher or lower values, depending on the responses received through bidding. An upward iteration will mean 'yes' to the initial bid offered, and likewise, a downward iteration means that the respondent answered with a 'no' to the initial bid. Although not avoiding the starting point bias, the bidding game has shown to more likely produce maximum WTP or WTA values from respondents than the other methods do (Cummings et al., 1986).

Bishop and Heberlein (1979) developed a dichotomous discrete choice method, which involves a take-it or leave-it format type. This format simply asks respondents whether they are willing to pay or accept a certain amount given a scenario. The main improvement of this method, compared with the other methods, is that it abridges the respondent's task in a similar way to the bidding game without going through the iterative process. Moreover, the respondent, just like any other consumer, only has to make a judgement about a given price (Wattage, 2001). The method still suffers from the starting point bias problem and it also needs large sample sizes and proper model specifications for statistical precision on WTP estimates (Cameron & Huppert, 1989).

The above methods have been shown to suffer from compatibility problems, in which survey respondents could influence the potential outcome by revealing values other than their true willingness to pay. Accordingly, the discrete dichotomous double-bound method was introduced in an attempt to increase precision on estimates. Hanemann (1985) originally developed the double-bound method, the goal of which is to ask respondents ‘yes or ‘no’ questions to WTP where the bid price in the second question and follow-up question is higher (lower) if the first question has a positive answer. This method, compared with the single question method, was found to produce more efficient CV estimates (Hanemann et al., 1991; Watson & Ryan, 2007).

In spite of the potential bias that the double-bound CVM comes with, it has been noted that the method is justified as it produces lesser mean square errors, which in-turn leads to more conventional WTP estimates by lessening the confidence interval of the WTP measures (Alberini, 1995; Banzhaf et al., 2004). As the incentive incompatibility bias is mainly controlled by using the WTP estimates from the first bid, anchoring effect bias can be moderated by making sure that the first proposed bid to the respondent is as close to the actual but unobserved WTP as possible. Accordingly, and for the same reasons, this study used the dichotomous double-bound method to estimate WTP for improved wastewater irrigation services.

2.2.5 *Payment vehicle*

In contingent valuation studies, the choice of payment mechanism is crucial. Valuation question needs a realistic institutional context – usually an appropriate payment (or bid) vehicle (mechanism). The payment vehicle is usually specified as a means of securing an environmental or other outcome (Cummings et al., 1986). WTP and WTA estimates are obtained through utilising a payment vehicle mechanism. These vehicles include levies on income taxes, electricity or water bills, increased sales taxes and prices of goods.

Following Mitchell and Carson (1989), the payment mechanism needs to be compatible and should therefore satisfy five conditions, namely familiarity, credibility, empathy, feasibility and universality. To reduce problems regarding plausibility, respondents have to be familiar with the payment vehicle, also have to be credible in representing a realistic situation. The ability to receive the funds to deliver the environmental improvement, as well as ensuring that the payment vehicle will affect all respondents or households, is equally important.

The way in which respondents answer elicitation questions is influenced by the payment vehicle and other aspects of the CVM scenario. Therefore, the choices made by respondents may depend on when the mode of payment collection and when is due. These aspects do not point to the existence of bias, so long as the payment vehicle aspects are appropriate for the context of the study (Stevens et al., 1997).

According to Mitchell and Carson (1989), ‘payment vehicle bias’ is due to either misperceptions of it or is being valued in a way not intended by the researcher. The study is based in the rural areas, and payment vehicles like taxes could elicit bias as some rural household heads are without formal employment. Therefore, this study will use monetary contributions as the payment vehicle, or any monetary equivalent source of payment.

2.2.6 *Issues and limitations surrounding the Use of the CVM*

The CVM approach has been widely used for many years to estimate passive-use values. A number of academic papers related to CVM has led to an increasing and growing interest internationally in connection with environmental problems and policies (Arrow et al., 1993). However, there is controversy surrounding the validity of the CV technique in estimating lost passive-use values because the CV estimates do not depend only on the valuation scenario presented to the respondent, but also on other aspects, namely how the respondents perceive it, the payment vehicle used, the method of conducting the survey, and the elicitation method used (Carson et al., 2000). Moreover, the study by Bateman et al. (1995) suggested that the differences in CV estimates arising from different elicitation formats could be explained by economic theory and psychology.

According to Diamond and Hausman (1994), Cummings et al. (1995) and Arrow et al. (1993), the unreliability of CV estimates is a basis for criticism of the CV approach, and is due to:

2.2.6.1 *Hypothetical bias*

The reliance on respondent answers for hypothetical questions in CV studies, rather than the observed economic choices, which leads to hypothetical answers, is the main cause of hypothetical bias (Seller, Stoll, & Chavas, 1985). According to Harrison et al. (2008), the source of hypothetical bias is strategic over-bidding, since respondents have no expectation of any payments from the provision of the good. Moreover, the low level of understanding of what it is that a respondent is being asked to value may lead the respondent valuing a different good to what the researcher was intending to measure (Mitchell & Carson, 1989; Carson et al., 2000).

2.2.6.2 *Strategic bias*

The respondents provide a biased answer to influence the outcome. They might either overstate or understate their bids in their favour, and in doing so, they might influence a policy decision by not giving true answers to valuation questions. The distribution of WTP responses analysis is a test to detect the existence of strategic bias. Schultze et al. (1981) and Bishop et al. (1983), in a review of six CV studies, concluded that revealing 'strategic bias' in consumer preferences 'is not likely to be a major problem. Grether and Plott (1979) had earlier reported findings which support this conclusion.

2.2.6.3 *Starting point bias*

The use of iterative bidding in CV studies is the main source of 'starting point bias', when the first bid influences respondents' final bids. They may understand that the amount of bid one is an indication of the value that the interviewer expects from them. If the amount of bid one is too high or too low in relation to the respondents' true WTP amounts, they may prematurely change their responses to quickly finish the questionnaire before the true WTP is revealed, hence saving their time (Brookshire et al., 1981; Mitchell & Carson, 1989). Whittington et al. (2014) stated that the 'starting point bias' exists if the first bid amount affects the respondents' final WTP. They noted in regard to the 'bidding-game' question format, that when the enumerator starts the questioning at an initial price, those who are not certain of an appropriate answer might interpret the initial price as a hint as to the correct bid.

The study on water quality conducted by Desvousges et al. (1983) found evidence that the starting bids may have influenced respondents' final bids. Moreover, Mitchell and Carson (1985) have argued that a study by Greenley, Walsh, and Young (1982) had a starting point problem; accordingly, Greenley and his associates had contended that the starting point problem was attributable to the different hypothetical instruments used to collect the bids.

2.2.6.4 *Sensitivity to scope*

The inadequate scope sensitivity of WTP estimates have raised much debate in the non-market valuation literature. Respondents may not be sensitive to the quantity and quality of the proposed environmental change, i.e. not sensitive to scope (Diamond & Hausman, 1994; Ready et al., 1997). A study conducted by Boyle et al. (1994) found that the respondents' mean WTP for the programme that avoided the loss of 2000, 20 000 and 200 000 migratory birds was not statistically different, and concluded that the respondents were not sensitive to scope. Furthermore, Arrow et al. (1993) have suggested that the studies that were found to be not sensitive to scope may be defective; the choices were not clearly presented to respondents, and they viewed the alternatives as being essentially similar, leading them to give the same value to different policy alternatives.

2.2.7 *Proposed approaches to resolving identified biases with the CVM*

Bishop and Heberlein (1979) suggested the use of a referendum CV format for dealing with strategic bias. The method was recommended by NOAA (1994), and for the same problem, Mitchell and Carson (1989) and Schulze et al. (1981) suggested undertaking an ex-ante visual inspection of the frequency distribution of the WTP responses to find out whether a bi-modal clustering of values at abnormally high and/or low levels exists.

The remedies for scope insensitivity problems are straightforward, but the implementation in practice is often difficult and expensive. The respondent must: (first) have clear understanding of the characteristics of the good he/she has been asked to value, (second) find the elements of the CV scenario plausible, and (third) give meaningful answers to CV questions. Kopp et al. (1997) and Carson and Flores (1993) used data from Diamond et al. (1993) which accepted the null hypotheses of scope insensitivity (x^2= 0.42, P-value= 0.52). Following this result, Carson and Flores then fitted the model with no constant, and a further test of scope clearly rejected the scope insensitivity hypothesis at $p<0.001$. Carson and Flores (1993) then concluded that Diamond et al. (1993) had also asked about WTP to Selway without wilderness areas being developed. The solution suggested by Mitchell and Carson (1989) for the scope insensitivity issue is to present a more understandable good description and good CV scenario.

Mitchell and Carson (1981, 1984) studied applied ‘anchored payment cards’, and when they tested the results for anchoring effects on the final bid, they found that there was no evidence of any influence of starting point bias. To test for starting point bias, Whittington et al. (2014) used a bidding game approach and decided to randomly distribute three different versions of the questionnaire to the sample population, with each version of the questionnaire having different initial bids. Their study found that by using this approach, there was no hint of starting point bias. Their study further suggested that CV surveys in developing countries might prove to be a viable source of information on individual WTP for a wide range of public projects and services.

Is difficult to measure hypothetical bias for non-marketed resources, and to do so, the analyst needs to know the true WTP. There are, however, many theories and credible hypotheses on how to overcome the problem of strategic bias. To reduce hypothetical bias by survey design, Carson and Groves (2007) suggested including an ex ante approach, with an ex post recoding of WTP responses to eliminate hypothetical bias of the stated WTP. Carson and Groves (2007) further suggested including three features in a survey in order for a hypothetical constructed market to be potentially incentive compatible. Firstly, the survey should have a potential effect on respondent’s future utility; second, a binary dichotomous choice question format is suitable; and third, the payment vehicle has to be compulsory (such as by price increase), as this condition rules out the use of donations as a payment vehicle.

For a strategic bias problem, Carson et al. (1994) suggested the use of a DBDC (double bounded discrete-choice) elicitation format because this method reduces the respondent’s opportunity to bias the answers. For the scope and non-zero intercept issue, the study by Ready et al. (1997) suggested an estimation of a flexible value function from CVM data which allow for a statistical test for positive slope and intercept without zero. Carson and Mitchel (1995), Boyle et al. (1994), and Neil et al. (1994) have stated that respondents should be familiar with the environmental good being valued, and this familiarity can be achieved by designing a good CV questionnaire. In addition, the study should define the boundaries of the contingent good (specification of the initial and target levels of improvement of the environmental good associated with the proposed plan) – Fishhoff et al. (1998).

2.3 THEORETICAL FRAMEWORK

The study used CVM, which is a non-market valuation approach to estimate the economic value of wastewater reuse improvement. This method has been used successfully to estimate public WTP for water quality improvements in various other studies (Ahtian, 2007; d'Arge & Shogren, 1989; Loomis et al., 2000; Shrestha & Alavalapati, 2004). With the current property rights and institutions, water in the rural areas is a public good, so non-market valuation is appropriate for estimating WTP. The theoretical foundation of economic values for environmental and public goods like community water is defined in the perspective of their effects on human welfare (Krieger 2001; Agudelo, 2001). The environmental good change can affect individuals' welfare through changes in prices they pay for other private goods in the market, and in changes in the quantities of non-marketed environmental goods such as water.

Contingency valuation surveys can apply both WTP and WTA. Harrod and Willig (1991) have pointed out that asking about WTP or WTA depends on property rights. If the respondents do not own the right to a good, such as an improved wastewater irrigation service, then WTP should be asked. Conversely, if the respondents own the good, then WTA is the relevant measure (Harrod & Willig, 1991). Both compensating and equivalent variation can be elicited by queries using WTP. It is therefore for this same reason that this study used compensating variation to estimate WTP for irrigation water improvements.

As already highlighted, the theoretical underpinnings for the contingency valuation approach lie in micro-economic welfare theory. The indirect utility function and the expenditure functions are used to measure welfare change (Haab & McConnell, 2002). Households maximise utility subject to budget constraints, or they minimise expenditure subject to a utility constraint (Hanley & Spash, 1993). Following McFadden et al. (1993), we assume that households have a well-behaved utility, based in a random utility theory function as given below:

$$U = U(x, w) \tag{2.1}$$

where U is the utility function, x is the composite of all market goods, and w is the environmental good (water). Thus, the utility function above provides households' preferences for goods in both market and non-market goods. Households generally will want to maximise their utilities by choosing quantities of both x and w subject to a budget, and time and household labour constraints. Minimising expenditure, the expenditure function is given below as:

$$e(p, w, u) \tag{2.2}$$

where e is the expenditure function, p is a vector of market prices, and u is utility. The amount of money that the household should give up to attain the given level of utility is measured by the expenditure function. The expenditure function represents an increasing function of prices and utility, and decreasing function in water quality 'W'. As the household is faced with minimising costs while keeping utility constant, it is appropriate to use the expenditure minimisation problem, which is given below as:

$$\min(P.x + P.w)\ s.t\ \ U = U(x, w) \tag{2.3}$$

where (P.x = 1), that is, a price of composite goods which is equal to one. Solving this minimisation problem, we use Lagrange's Multiplier, specified as follows:

$$\mathcal{L} = P.x + P.w + \lambda\big(U - U(x, w)\big) = 0 \tag{2.4}$$

Where λ is the Lagrange multiplier. The first order conditions of the Langrage can be computed as given below:

$$\frac{\partial \mathcal{L}}{\partial X} = P_x - \lambda \frac{\partial U(x, w)}{\partial X} = 0$$

$$\frac{\partial \mathcal{L}}{\partial w} = P_w - \lambda \frac{\partial U(x,w)}{\partial w} = 0 \tag{2.5}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = U - U(x, w) = 0$$

The last condition represents the constraint. We can rearrange the first two equations and divide the first equation by the second equation to get the technical rate of substitution, which must be equal to price ratio (Varian, 1992). Solving further the cost minimisation problem, we get the Hicksian demand function, which is a function of prices for both private goods, water, and utility:

$$h_i = h_i(P_x, P_w, U^*) \tag{2.6}$$

To determine the minimum expenditure function, we substitute the values of the equivalent Hicksian demand in the minimum expenditure function:

$$e^* = e(p, w, u^*) \tag{2.7}$$

In the above equation, *e* is the minimum expenditure required to attain the given fixed level of utility (u) and using the quality of irrigation water (w), and is the function of price of other goods, the fixed level of utility, and the quality of irrigation water itself. The derivative of expenditure function with respect to price gives a corresponding Hicks compensated demand function for the good under consideration, which is water:

$$\frac{\partial e}{\partial p_i} = h_i(P_x, P_w, U^*) \tag{2.8}$$

Therefore, we can thus estimate WTP for the improvement in irrigation water services by integrating marginal WTP to achieve water quality change from the current status quo (q_0) to the improved status (q_1):

$$WTP = -\int_{q_0}^{q_1} \frac{\partial e(w, u^*)}{\partial w}\, dw \tag{2.9}$$

We model WTP as an expense to current income in order to improve irrigation water services in the future. WTP is the maximum amount of money that households should give up in order to enjoy the improvements of irrigation water services. In light of the change in the public good (water) caused by policy or government, WTP for the improved change is the difference between the expenditure functions. It thus follows that WTP, in order to sustain current utility status, is given by:

$$WTP = e(\boldsymbol{p}, w_{\boldsymbol{0}}, U_0; \boldsymbol{Q}, \boldsymbol{T}) - e(\boldsymbol{p}, w_{\boldsymbol{1}}, U_0; \boldsymbol{Q}, \boldsymbol{T}) \tag{2.10}$$

where p is price vector, q_0 is the public good being changed, U_0 being the current status quo or the level to which respondent is assumed to be entitled, $\boldsymbol{Q}$ is a vector of other public goods assumed not to change, and $\boldsymbol{T}$ is a vector of household characteristics. As the expenditures required to attain the utility level with the increment are not more than income, WTP is positive. The corresponding WTP value defined with the indirect utility function is:

$$V(p, w, y) = V(p, w_1, y - WTP) \tag{2.11}$$

2.4 OVERVIEW OF RECYCLED WATER USE AND ACCEPTABILITY

The increases in population, as well as increasingly growth of economic activities which require water as an input such as for irrigation in crop production, industries, domestic, livestock, fisheries and other activities, have increased pressure on water resources (Seckler et al., 1999). The practice of cleaning and reusing water can contribute to ecosystem protection and alleviate conditions for those communities that have been experiencing water shortages and have invested in facilities for treatment and reuse, (AATSE, and USEPA, 2004). The acceptability of recycled water depends on various factors that play an important role, namely the source of recycled water, which is associated to the extent, and perceptions of risk (Po et al., 2005). However, the safe use of recycled wastewater will require an indication of its source due to health risks associated with it, when compared with tap water (Toze, 2006).

The level of acceptance of recycled water is determined by factors such as the country's political context; the terminology used in recycling when communicating with the public; the level at which the public is involved in developing the recycling strategy; and the degree of education on the recycled issues involved. The areas that suffer from water shortages may easily accept recycled water (Dishman et al., 1989). Furthermore, due to risk perceptions, the acceptability of recycled water can decline as the uses move from public areas to more personal uses (Hurlimann et al., 2005). However, the cost of recycled water plays an important role in encouraging people to use it: Hatton et al. (2004) have reported that people were WTP 76 % of the price of fresh water for recycled water.

2.5 EMPIRICAL STUDIES

2.5.1 *Review of CV studies*

Over the last few decades, an increasing the number of studies have used the contingent valuation method to measure the value of environmental and health-related outcomes from policies, projects and regulations in developing countries (Carson et al., 2012). Carson believes that the findings of many of these contingent valuation (CV) studies are inaccurate and unreliable; thus he urges a need for improvements to the quality of CV studies being conducted in developing countries. The fact that the CV approach relies on a hypothetical market has been a source of debate (Alberini et al., 2003). Another controversy is whether the WTP and WTA estimates are sensitive to scope effects, i.e. whether WTP and WTA increase or decrease satisfactory with changes in quality or quantity of the environmental good being valued (Carson, 1997; Svedsater, 2000). Despite the above-mentioned challenges, the CV approach is a viable solution when prices do not exist. Since we cannot attach price to an environmental good like wastewater, the contingent valuation approach is a unique solution for estimating the value of wastewater reuse.

Accordingly, several studies have been published using a contingent valuation method to estimate the value that people place on a clean environment where a market value does not exist. The study conducted by Wittington (1993) in Kumasi, Ghana, endeavoured to determine the WTP value for improved sanitation. The objective of the study was to demonstrate how information on household demand for improved sanitation services can be collected using CV surveys and how that information can be used for policy purposes.

Another study by Whittington (1991) used CVM research on water vending and the WTP for improved water quality in Onitsha, Nigeria. The study successfully completed 235 face-to-face household interviews throughout Onitsha, and the bidding game technique of elicitation was used. The study results show that the household WTP covered the costs of providing the service of improved water supply. On average, 5 % of income was spent on water and this increased during the dry season.

Loomis et al. (2000) conducted a CVM study that estimated households' WTP for five ecosystem services associated with the restoration of a section of the Platte River in Colorado. The study used a dichotomous-choice WTP question to determine if residents would pay for increases in these ecosystem services through an increase in their water bill. The study found that households were WTP a monthly fee $20 per month to protect water quality in rivers.

Mesa-Jurado et al. (2012) conducted a study using CVM to assess the value that farmers placed on a guaranteed water supply for irrigation in Guadalbullon River sub-basin. The study found that farmers were willing to increase their annual payment on irrigation community, and, to guarantee an increment in water supply, they were willing to cut the average monthly income for their administrative water allowance.

Weldesilassie et al. (2009) conducted a CV study on the economic value of improved wastewater irrigation in Addis Ababa, Ethiopia. The study used primary cross-sectional 2006 data, and used a double-bounded dichotomous format with an open-ended follow-up question to elicit farmers' WTP for improved wastewater for crop irrigation. The full DB questions were estimated using a bivariate probit. The study found that farmers attach a positive value to wastewater; furthermore, the study assessed the content validity by testing whether the explanatory variables were in line with economic theory, and the results show that income, age, initial bids, awareness and education are statistically significant in determining the WTP.

Basarir et al. (2009) applied a CV technique in Turkey to analyse farmers' WTP for improved irrigation water. The survey implemented a face-to-face interview technique with 130 randomly vegetable producers to elicit their WTP. Since the data were censored to zero, the study applied Tobit and Heckman models for data analysis. The study found that male producers with larger areas of vegetable land and faced with polluted water were WTP more for increased irrigation water quality.

Bui et al. (2012) applied double-bounded CVM to value rural piped water supply services in Vietnam. The study analysed a random sample of 217 households and concluded, and emphasised, that there is a need for policymakers to pay attention to the factors that affect households' WTP. In addition, the authors suggested the use of CB (cost benefit) analysis, based on CVM estimation, to design a suitable programme for water supply services.

In 2013, Ndunda conducted a CV study on wastewater reuse in urban and peri-urban irrigation in Nairobi, Kenya, and found that socio-economic factors have a positive influence in determining health risks in using untreated wastewater for irrigation.

Menegaki et al. (2007) investigated the WTP and WTU of farmers and consumers for crops irrigated with recycled water in Crete, Greece. The study employed a multinomial logit model to analyse farmers' WTU and ordered logit to rank consumers' likelihood of buying products irrigated with recycled water. Farmers were approached in their houses or on the streets, while consumers were randomly selected in busy streets of the city. Both farmers and consumers were first asked the question about their intention to pay before the WTP question. The model passed the parallel slopes test. The following variables were statistically significant, at 5 %, in influencing WTP and WTU: income, education, information, gender, age, LACKW (degree of seriousness consumers attach to water shortage), ACTIONS (environmental actions involved), children, and household knowledge.

In 2007, Bakopoulou et al. conducted a CV study based on personal interviews with 107 farmers in Thessaly, Greece, to investigate farmers' WTP for irrigation with recycled water. The questionnaire was divided into three sections; the first section dealt with socio-economic characteristics of the respondent (age, education, sex, and income), and the second part aimed to inform farmers about wastewater terms, treatment and recycling, and the risks and benefits associated with wastewater uses. The third part was designed to elicit farmers' WTP. The logit regression method was used to estimate farmers' WTP, subject to a set of socio-economic and environmental factors. The study found that sex, education, and income of farmers were statistically significant, and that farmer income had a negative sign, thus decreasing the likelihood that a farmer would be WTP for recycled water when fresh water is available. To our knowledge, there has been no study published concerning Mozambique using the CVM approach to estimate the value of wastewater reuse irrigation, and this leads us to believe that this will be the first study applying a CVM technique to value wastewater resources in Mozambique.

2.5.1.1 *Review of scope sensitivity in CV studies*

The CV approach employs a survey technique that directly elicits households' preferences. This technique requires the researcher to construct a contingent market in respect of which respondents will reveal their WTP or WTA for an environmental good provision (Whittington & Swarna, 1994; Arrow et al., 1993; Bateman et al., 2002). Due to the hypothetical nature of the environmental goods, Mitchell and Cason (1989) advocate the assessment of a theoretical validity test, which involves contingency table analysis. However, Diamond et al. (1993) have suggested hypothesis tests of WTP estimates from different levels of provision that affect consumer welfare, i.e. tests of hypothesis about expected variations in estimated WTP values with respect to changes in the level of environmental improvements (scope sensitivity tests). Several studies have been done to determine whether the respondents are sensitive to good scope. Soto et al. (2006) conducted a study on sensitivity to scope in households' WTP for continued and improved water supply in the urban area of Mexico City. The key objective was to investigate the WTP for the continuation of, or improvements in, the then current levels of provision. The sensitivity to scope test was dependent on the level of a household's income, and it was expected that the households with high income levels would exhibit larger WTP to maintain the current scenario than to improve the scenario, since the maintenance scenario would avoid a substantial loss in provision. The study confirmed that households with high levels of income enjoyed better levels of actual provision than lower income households did, and therefore the study passed the scope effect test. Banzhaf et al. (2004) conducted a Valuation of Natural Resource Improvements Study in the Adirondacks Park with the objective to quantify the change in total economic value that would result from an improvement in the ecological attributes of the Adirondack Park. In order to determine WTP estimates, a double-bounded referendum format CV survey was administered to a random sample through the internet and mail. The study passed an external scope test and a test of sensitivity to bid. Ndambiri et al. (2016) conducted a CV study that evaluated whether the WTP estimates were sensitive to changes in magnitudes of motorised emission reductions in the city of Nairobi. The study applied bottom-up and top-down approaches to test a hypothesis on within (internal) and between (external) respondents' WTP to see whether the respondents were internal- or external-scope sensitive. The study found that respondents were internal and external sensitive to scope, therefore they passed internal and external scope tests.

2.6 KNOWLEDGE GAP

The items of literature reviewed above show a research gap in the empirical studies concerning consumer preferences for the consumption of vegetables irrigated with reused wastewater. Most of the studies assess the WTP of farmers using reused wastewater, rather than looking at the consumers as indirect users of reused wastewater through the consumption of products irrigated with it. It is important to survey this duality because there is no reason for farmers to produce crops using recycled wastewater that consumers will not be ultimately willing to buy. In this regard, this leaves a gap for this study to be conducted in Maputo because public perceptions and acceptance of wastewater reuse and the products related to it play an important role in the success of any reuse policy. Tsagarakis et al. (2006) claim that policymakers would like to respond to variables that negatively affect consumers' WTP because recycled water is viewed as a low-quality product, compared with fresh water; therefore, a WTP estimate is expected to provide a basis for a reconstruction of water prices. This is also true in Maputo, Mozambique.

2.7 CONCLUDING SUMMARY

The objective of this chapter was to survey theoretical and empirical literature, and the knowledge gap. It can be justified that there is a need for assessing the economic value of wastewater reuse in the interests of conservation and management of the Infulene Valley as a valuable irrigation scheme for vegetable production in Maputo and Matola cities.

CHAPTER THREE
METHODOLOGY

3.1 INTRODUCTION

This chapter outlines the methods used to achieve the study objectives, and provides information on data collection, procedures, description of the study site, and data analysis procedures. Section 3.2 describes the study area and the location of Infulene Valley. Section 3.3 presents the survey design and the sampling methods used to collect data for this study, while Section 3.4 describes the pre-test and survey implementation. Section 3.5 presents the elicitation format, the payment vehicle, and valuation scenario used in this study. Section 3.6 presents the data analysis of the study and the socio-economic characteristics of the surveyed households. Section 3.7 presents the empirical estimation of WTP and the factors affecting willingness to pay. The empirical and econometric models used are presented in Sections 3.8 and 3.9, respectively, while Section 3.10 presents the concluding summary.

3.2 DESCRIPTION OF THE STUDY AREA

Maputo is the capital city, located in the southern region of Mozambique, which is divided administratively into seven urban districts, and the population of the city is about 1.3 million inhabitants, living within an area of 675 km^2, which represents 20 % of the country's urban population (UN-HABITAT, 2010).

The main feature of Maputo City is that it is responsible for 20.2 % of the GDP of Mozambique, and the sectors of trade, transport and communications, and manufacturing are the most significant, accounting for 29.6 %, 29.5 % and 12.4 %, respectively, of national production (UNDP, 2006).

The land in Maputo City is mostly used for residential, industrial, commercial and farming (especially along the Infulene river) purposes. However, Maputo City suffers from a water shortage, especially during the summer season, which shortage is mostly attributed to climate variations. The current system of water supply from the Umbelúzi river does not satisfy the existing demand and this leads to the need to use other sources of water (Munguambe et al., 2010). The main types of vegetables grown in Maputo City include lettuce, amaranth, Portuguese cabbage, sweet potato leaves, okra, pumpkin leaves, egg plants, cowpeas, and beetroot.

This vegetable scheme was chosen for examination under this study because farmers use water from the Infulene River to produce vegetables for both market and own consumption, and this river is subject to various sources of pollutants since it serves as a drainage channel for the waste from the city. This practice of irrigating vegetables with river water that is polluted is associated with adverse effects for the environment, farmers and consumers.

The production of vegetables plays an important role in the provision of income, food, and employment for families. According to Mlozi (1995), peri-urban agriculture is mainly practised by people from various socio-economic statuses, including the urban poor, and it is considered one of the most important informal activities in many cities that urban dwellers are involved in. The growing practice of urban agriculture is attributable to the proximity of markets as well as the availability of market information (Obuobie et al., 2006). It is clear that the potential for wastewater reuse in Maputo is very high: the reuse of wastewater will relieve vegetable growers from water shortage problems and would reduce the imbalances between supply and demand by freeing up fresh water for domestic uses.

3.2.1 *Climate*

The weather in Maputo City is tropical, consisting of two seasons, namely summer and winter. The summer season is also considered a rainy season, is hot and humid, lasting from November to March. The winter season is cold and dry, lasting from May to September. April and October are transitional months between seasons. According to data from the Maputo Meteorological Station, the annual average precipitation in Maputo is 768 mm.

3.3 SURVEY DESIGN

3.3.1 *The environmental good to be valued*

The improvement of wastewater reuse for vegetable irrigation in the Infulene Valley was the environmental good of interest in this study. In this study, we tested internal and external scope sensitivity: the internal test of scope approach analysed the within respondents, bottom-up and top-down mean WTP for irrigation water improvements, and the external test of scope analysed the between mean WTP estimates. Respondents were asked to value 50 % of irrigation water improvements, followed by 100 % of irrigation water improvements, bottom-up approach, and for the top-down approach, the respondents were asked to value 100 % of improvements, followed by a question on how much they were WTP for a 50 % irrigation water improvement. The following hypotheses were formulated for the internal test of scope:

1. H0: WTP TD (100 %) = WTP TD (50 %);
2. H0: WTP BU (50 %) = WTP BU (100 %).

The within respondents mean WTP for 50 % (100 %) wastewater improvement is equal. As for external test of scope, we formulated the following hypothesis:

1. H0: WTP TD (100 %) = WTP BU (50 %)
2. WTP BU (100 %) = WTP TD (50 %).

The mean WTP for 50 % wastewater improvement is equal to mean WTP for 100 % wastewater improvement between respondents. We expected that respondents would be, on average, WTP higher amounts for a programme that improves irrigation water totally, than for a lower quality improvement programme.

3.3.2 *Survey instrument and sample size design*

To elicit respondents' preferences using the CVM approach requires a carefully designed survey, including the choice of the method to collect data and the use of a random sample (Bateman et al., 2002; Whittington, 2002). The questionnaire was organised into seven sections, namely (1) requiring respondent's demographic information; (2) probing respondent's perception and knowledge about the management of water supply shortages; (3) probing respondent's knowledge, attitudes and perceptions towards recycled wastewater reuse; (4) describing wastewater reuse for irrigation; (5 & 6) presenting valuation and debriefing questions; (7) eliciting respondent's information on socio-demographic and economic characteristics.

The contingent valuation study requires the use of primary data and in this regard, the study applied the method proposed by Mitchell and Carson (1989) and NOAA (1993), who both proposed the use of personal interviews which present a high ability for providing relevant information to interviewers.

Following Bateman et al. (2002), a random sampling technique was employed in order to select households to participate in the survey. We approached respondents in their houses where we informed them about the research objectives and asked if they were willing to participate in the survey. To secure the homogeneity of the sample, all people who presently reside in Maputo and Matola municipalities were given a chance to participate in the survey. The population of Maputo and Matola municipalities is approximately 2,717.447 people, and the proposed study sample for the household interviews was calculated by the methodological approach proposed by Glenn Israel (1992) based on the tentative formula presented below.

$$n = \frac{\mathrm{N}}{1+\mathrm{N}(\mathrm{e})^2} \tag{3.1}$$

Where: n = the sample size,

N = the total population and

e = the level of precision required which in this case is 95%.

Using the above presented formula a sample size of 385 was obtained. However, the study collected randomly the data from 244 households in the seven administrative divisions of Maputo Municipality, and five administrative divisions from Matola Municipality. The simple random selection was because the main feature of the region is that a high percentage of the population buys and eats vegetables produced in the Infulene Valley. The 244 respondents was selected taking into account the CV survey that requires proper administration in order to produce high quality results. Therefore, due to time and resources constraint a sample size of 385 respondents could have been poorly administrated hence lead to poor quality CV survey.

3.4 PRE-TEST AND SURVEY IMPLEMENTATION

The study conducted a pre-test of the survey questionnaire on 10 respondents. The key goal was to test the suitability of the questions and the bid amounts were also generated from the pre-test survey where respondents were asked the maximum WTP for vegetables irrigated with recycled water in order to improve the irrigation water at Infulene Valley. Based on the pre-test survey, we determined the minimum, mean, and the maximum WTP values. Moreover, the final draft of the questionnaire was prepared based on the respondents' responses and comments. We trained three enumerators on the contents and the administration of the questionnaire.

Face-to-face interviews were conducted in Maputo and Matola in urban and peri-urban areas. The enumerators assigned themselves to specific villages for each one of them and the survey covered seven villages in Maputo and five villages in Matola. The enumerators moved from house to house, together with the village leaders, implementing the study. The interviews took 30–45 minutes per interview, on average. The interviews that took a relatively long time per interview were special situations where respondents took time to understand questions, and the interviewer had to ask the questions using the local language.

The respondents were more collaborative than the researcher had expected, because of the intensity of the challenge of the water supply shortage and the quality of water used to irrigate vegetables in the Infulene valley. The respondents found it useful to contribute their ideas to the survey and this made their responses more reliable, as they were modest and willingly allocated their valuable time to participate in, and express their gratitude to be part of, the study.

Before presenting the valuation scenario, there were a series of questions on the knowledge, attitudes and opinions regarding the water supply shortage and recycled water uses. Respondents were then asked the valuation questions to state their WTP amounts for irrigation water improvements on two different levels (50 % and 100 %) for improvements in irrigation water at Infulene Valley. The bid amounts presented three different values: 55,00Mt, 60,00Mt and 65,00Mt followed by the maximum bids of 52.5Mt, 62,5Mt and 67,5Mt. Depending on the response given to bid one, the minimum bid question was asked after receiving ‘no’ to the first bid, where the minimum bid values were 52.5Mt, 57.5Mt and 62.5Mt. The valuation scenario was followed by certain follow-up questions on affordability and financial situation to ascertain the validity and reliability of responses, and that was also complemented by the debriefing questions in the last section of the questionnaire.

3.5 ELICITATION FORMAT AND PAYMENT VEHICLE

The study used a DBDC (Double-Bounded Dichotomous Choice) format to elicit respondents’ WTP, and the reason behind the use of this format is that the given function is fitted with more data sets due to the increased number of responses. The noise and yes–no responses for sequential bid yield clear bounds on WTP estimates, and from the yes–yes and no–no combinations, there is a gain in efficiency because they truncate the distributions where the respondents’ WTP are expected to exist (Hanemann et al., 1991).

The suitable selection of a payment vehicle is crucial for minimising a respondent’s strategic behaviour that might lead to inaccurate WTP estimates. Mitchell and Carson (1989) argued that the choice of payment vehicle requires balancing realism against the rejection of payment vehicle. Because, the likelihood that the payment vehicle will produce responses that protest the vehicle may increase as realism also increases. Following Kontoleon et al. (2005), the study employed price increase of vegetables, and this payment vehicle was selected because it is compulsory. The study by Carson and Groves (2007) pointed out that for the payment vehicle used when valuing a public good to be incentive compatible, it must be compulsory.

3.5.1 *Valuation scenario*

The valuation section of the questionnaire presented the respondents with relevant information to ensure that they understood the status quo of the Infulene Valley. Maputo is relatively dry, with a short rainy season. The green belt (the Infulene Valley) is an important supplier of fresh vegetables, and the water from the Infulene Valley is subjected to various sources of pollutants because it receives untreated sewage from the municipal districts through the drainage channel, as well as untreated domestic sewage, thus placing human health and the environment in danger.

The following hypothetical improvement scenario was presented to respondents to ensure that they understood what they are paying for: “Suppose that the government and private agencies are planning to improve the quality of water flowing through the river, thus making it safe for humans and environment. Therefore, the Municipality comes up with a plan to collect water from the valley, process it in a modern wastewater treatment plant and then pump it back to the valley, where it can be used for various purposes including irrigation by farmers.” The municipality would then levy a charge on farmers who might want to use safe and recycled water for irrigation, and this will imply that the cost of vegetables that consumers pay will increase. This payment is to continuously provide the wastewater treatment services.

Respondents were then asked the valuation questions to state their WTP amounts on two different levels (50 % and 100 %) for improvements in irrigation water at Infulene Valley, through top-down and bottom-up valuation questions. The bid amounts took on three different values: Metical (Mt) 55,00; 60,00; and 65,00, followed then by the maximum bids of 52,5; 62,5; and 67,5. These values were obtained from a pre-test survey, based on dichotomous questions with a follow-up question.

3.6 DATA ANALYSIS

The data from 244 household interviews was analysed using STATA software, version 12. The purpose of the analysis was to estimate the mean WTP of Maputo and Matola residents for irrigation water improvements at Infulene Valley, to identify the factors that determine WTP, and to test whether the level of water improvement, fully or partially, had a significant impact on the WTP estimates (WTP estimates are scope sensitive). Descriptive statistics were employed to achieve the first objective and these included the use of summary statistics, chi square magnitudes, and p-values. Percentages were used to determine and explain proportions, while t-tests were used to test significant differences between the socio-economic characteristics of the respondents.

The distribution of the bid one analysis was done through that summary of statistics, while the estimate for the WTP for improved irrigation water was modelled in the Random utility framework, where the respondent was assumed to have two choices: to choose either paying or not paying for the improved irrigation water. The study endeavoured to identify the factors that determine the respondents' WTP for the proposed improvement programme, and to do this analysis, the study employed the double-bounded models because of the DBDC elicitation format used in this study. The paired t-test was used to test within respondents mean WTP, while an unpaired test was applied to test between respondents mean WTP

3.6.1 *Socio-economic characteristics of households*

This subsection describes the main variables that were used in the analysis. The main dependent variable used in the binary model is WTP for improved irrigation water. Table 3.1 below presents the results of the descriptive statistics in terms of frequencies and percentages of socio-economic and demographic characteristics of the households.

Table 3.1: Descriptive results of respondents' socio-economic and demographic characteristics

Variable	**Top down(TD)**	**Bottom up(BU)**	**Total**
AGE			
18-35	35 (28.93 %)	40 (32.52 %)	75 (30.74 %)
35-64	78 (64.46 %)	71 (57.72 %)	149 (61.07 %)
>64	8 (6.61 %)	12 (9.76 %)	20 (8.19 %)
GENDER			
1 = female	55 (45.45 %)	58 (47.15 %)	113 (46.31 %)
0 = Male	66 (54.55 %)	65 (52.85 %)	131 (53.69 %)
EDUCATION LEVEL			
1= No formal education	1 (0.83%)	1 (0.81)	2 (0.82 %)
2= University	46 (38.02 %)	41 (33.33 %)	87 (35.66 %)
3= Primary	17 (14.05 %)	23 (18.70 %)	40 (16.39 %)
4= Secondary	51 (42.15 %)	50 (40.65 %)	101 (41.39 %)
5= High school	6 (4.96 %)	8 (6.50 %)	14 (5.74 %)
HHSIZE			
Average household size	6	6	

HHINCOME			
1= below 5.000	13 (10.74 %)	12 (9.76 %)	25 (10.25 %)
2= 5.000-15.000	36 (29.75 %)	35 (28.46 %)	71 (29.09 %)
3= 15.000-25.000	29 (23.97 %)	33 (26.83 %)	62 (25.41 %)
4= 25.000- 35000	28 (23.14 %)	24 (19.51 %)	52 (21.31 %)
5= 35.000-50.000	10 (8.26 %)	9 (7.32 %)	19 (7.79 %)
6= above 50.000	5 (4.13 %)	10 (8.13 %)	15 (6.15 %)
HHFINCOME Household head certainty about future income:			
1= Yes	109 (90.08 %)	108 (87.80 %)	217 (88.93 %)
2= No	12 (9.92 %)	15 (12.20 %)	27 (11.07 %)
HHSTATUS Household financial status: 1=Rich			
2= With middle level of	0 (0.0)	1(0.81 %)	1(0.41 %)
income	84 (69.42 %)	90 (73.17 %)	174 (71.31 %)
3= Poor			
	37 (30.58 %)	32 (26.02 %)	69 (28.28 %)
INADWSUPPLY Awareness of inadequate supply of water			
1= Yes	117 (96.69 %)	122 (99.19 %)	239 (97.95 %)
2=No	4 (3.31 %)	1 (0.81 %)	5 (2.05 %)
IMPORTSUPPLY Awareness that Infulene Valley is an important supplier of fresh vegetables. 1= Yes			
2= No	116 (95.87 %)	115 (93.50 %)	231 (94.67 %)
	5 (4.13 %)	8 (6.50 %)	13 (5.33 %)

Source: Author's elaboration

Note: The frequencies are shown outside the brackets, while the percentages are shown inside the brackets

As shown in Table 3.1 above, the majority of respondents were aged between 35 to 64 years, accounting for the largest share of the sample (61 %), followed by those aged between 18 to 34 years, giving a 31 % share of the total sample. Moreover, most of the respondents had attained secondary school level of education, about 41 % of the total sample, followed by those who had attained a university degree, about 36 % of the total sample, and the average household size was six people. The average monthly income of 5 000 to 15 000 Mt was recorded for a large share of respondents (29 %), followed by incomes of 15 000 to 25 000 and 25 000 to 35 000 Mt (25 % and 21 %, respectively). A large share (89 %) of the sample of respondents were certain about their future income, and the majority of respondents considered their households as having a middle level of income (71 % of the total sample). A large share of respondents (98 %) are aware that the city suffers from an inadequate water supply, and they are aware that the Infulene Valley is an important supplier of fresh vegetables (95 % share of the total sample).

3.7 EMPIRICAL ESTIMATION OF WTP

As noted earlier, the CVM was used to elicit WTP for irrigation water improvements in the Infulene Valley. This method was chosen due to its suitability in measuring use and non-use values, as compared with other non-market valuation methods like the travel cost method (TCM) which undermines the importance of preservation of an environmental or public good, in this case, vegetables being irrigated with recycled wastewater.

Moreover, the study used a dichotomous double-bounded CVM method. Respondents were asked a number of questions that lead to the generation of WTP values. The DBDC technique was developed by Hanemann et al. (1991) and the main objective is to ask respondents ‘yes’ or ‘no’ WTP questions where the bid price in the second or follow-up question is higher (lower) if the answer to first question is positive (negative). This method is preferred because when compared with the single-bound method, it produces more efficient estimates (Hanemann et al., 1991; Watson & Ryan, 2007). Haab and McConnell (2002) found that with open-ended questions, respondents often gave “protest answers”, as compared with a bounded response. Therefore, researchers have preference for this method because it is more helpful in eliciting information of WTP than the single-bound method (Hanemann et al. 1991; Arrow et al. 1993).

As already mentioned, the study relied upon on answers from two dichotomous choice questions to elicit WTP from a household. Respondents were asked if they were willing to vote in favour of paying a certain amount for consumption of vegetables irrigated with recycled wastewater. An agreeing response shows that WTP is at least as large as the initially specified amount. This thus prompts a follow-up question which asks the respondents if they are willing to vote in favour of paying a greater amount. A disagreeing response to the first question, however, suggests that WTP is less than the specified amount. This again prompts a second question asking if they are willing to vote for a lesser amount than that already specified.

From these two sets of responses, the study classified each respondent into a payment interval ($Y_{iL} – Y_{i\,U}$) where the lower bound value (L) can be a negative infinity for a respondent who says 'no' both times or the lowest payment presented and accepted (if a respondent's first 'no' response is followed by a 'yes' response). The upper bounds are defined in a similar way – either the highest payment requested and accepted (if they first say 'yes', followed by a 'no') or plus infinity (if they said 'yes' both times). This means that the true WTP for some respondents will fall within an interval of real values, while this interval will be left-censored for the respondents who said 'no' twice, and right-censored for the respondents who said 'yes' twice.

3.7.1 *Factors affecting willingness to pay*

As already mentioned, this study used the dichotomous double-bounded CV approach to estimate WTP for irrigation water improvements. Following Cameron and Quiggin (1994) and Haab (1997), this study employed the probit bivariate normal density function for double-bounded models because it allows for non-zero correlation, while the logistic distribution does not. Moreover, the DB econometric model starts with the above equation (4), which then characterises the household j's unobserved true WTP:

$$WTP_{ij}^{*} = \boldsymbol{\mu_i} + \varepsilon_{ij} \tag{3.2}$$

where WTP_{ij} denotes not observable households' j^{th} WTP for irrigation water improvements and i=one, two represents the respondent's response to bid one and bid two questions; and μ_1 and μ_2 are the means of bid one and bid two responses. Suggesting that $\boldsymbol{\mu_{ij}} = \mathbf{X'_{ij}}\, \beta_i$ allowing μ1 and μ2 means to be dependent on respondents characteristics, which are household size, average income, education of household head, age of household head, gender and more, which are discussed later.

The mean WTP potentially differs across questions, but we will assume that it is equal for all respondents. The likelihood function can be developed by first deriving the probability of the observed bid one and two response orders: yes-yes, yes-no, no-yes, and no-no. The probability of answering ‘yes’ to the first bid question and ‘yes’ again to the follow-up question is given by:

$$\Pr(yes, yes) = \Pr\left(WTP_{1j} > Y_1, WTP_{2j} \geq Y_2\right)$$
$$= \Pr(\mu_1 + \varepsilon_{1j} > Y_1, \mu_2 + \varepsilon_{2j} \geq Y_2\mu) \qquad (3.3)$$

The probability of respondent j answering ‘yes’ to the first bid question and ‘no’ to the second bid is given by:

$$\Pr(yes, no) = \Pr\left(WTP_{1j} \geq Y_1, WTP_{2j} < Y_2\right)$$
$$= \Pr(\mu_1 + \varepsilon_{1j} \geq Y_1, \mu_2 + \varepsilon_{2j} < Y_2\mu) \qquad (3.4)$$

The other no-yes and no-no sequence of responses can be analogously formulated. Hence, following Haab and McConnell (2002), the likelihood function to households’ j[th] contribution is specified as:

$$L_j\left(\frac{\mu}{Y}\right) = \Pr\left(\mu_1 + \varepsilon_{1j} > Y_1, \mu_2 + \varepsilon_{2j} < Y_2\right)^{YN} * \Pr\left(\mu_1 + \varepsilon_{1j} > Y_1, \mu_2 + \varepsilon_{2j} > Y_2\right)^{YY} *$$
$$\Pr\left(\mu_1 + \varepsilon_{1j} < Y_1, \mu_2 + \varepsilon_{2j} < Y_2\right)^{NN} * \Pr\left(\mu_1 + \varepsilon_{1j} < Y_1, \mu_2 + \varepsilon_{2j} > Y_2\right)^{NY} \qquad (3.5)$$

where a yes-yes answer equals to one (YY=1), 0 otherwise; a no-yes answer equals to one (NY=1), 0 otherwise; a yes-no answer equals to one (YN=1); and no-no answer equals to one (NN=1), 0 otherwise. This formulation is known as the bivariate discrete choice model. Assuming normal distributed errors with mean 0 and corresponding variances of $\sigma_1^2$and σ_2^2 and correlation coefficient ρ, then WTP_{1j} and WTP_{2j} have normally distributed bivariate with means μ_1 and μ_2, and normal distributed variances with means μ1 and μ2, variances σ_1 and σ_2, and correlation coefficient ρ. Assuming the DC responses to each question, the normally distributed model is known as the bivariate probit model. Therefore, to derive the likelihood function for the bivariate probit model, we use the probability of all four possible response sequences. Moreover, the probability of Y-Y response is specified as:

$$\Pr(\mu_1 + \varepsilon_{1j} > Y_1, \mu_2 + \varepsilon_{2j} \geq Y_2) = \Phi_{\varepsilon_1\varepsilon_2}(-\frac{Y_1-\mu_1}{\sigma_1}, -\frac{Y_2-\mu_2}{\sigma_2}, \rho) \tag{3.6}$$

That is, $\Phi_{\varepsilon_1\varepsilon_2}(.)$ the standard bivariate normal cumulative distribution functions with means zero, correlation coefficient ρ and unit variance. The probability of a Y-N response is specified as:

$$\Pr(\mu_1 + \varepsilon_{1j} \geq Y_1, \mu_2 + \varepsilon_{2j} < Y_2) = \Phi_{\varepsilon_1\varepsilon_2}(-\frac{Y_1-\mu_1}{\sigma_1}, \frac{Y_2-\mu_2}{\sigma_2}, \rho) \tag{3.7}$$

The other two response sequences of probabilities can analogously be formulated. Letting y_{1j}= 1 if the first question response is 'yes' and 0 otherwise, y_{2j}=1 if the second question response is 'yes' and 0 otherwise, the resulting likelihood function for a bivariate probit is specified as:

$$L_j\left(\frac{\mu}{Y}\right) = \Phi_{\varepsilon_1\varepsilon_2}(d_{1j}\left(\frac{Y_1-\mu_1}{\sigma_1}\right), d_{2j}\left(\frac{Y_2-\mu_2}{\sigma_2}\right), d_{1j}d_{2j}\rho) \tag{3.8}$$

where:

$\Phi_{\varepsilon_1\varepsilon_2}(.)$ = standard bivariate normal cumulative distribution function

d_{1j} = y_{1j} – 1 and d_{2j} = y_{2j} – 1

σ_1 *and* σ_2 = standard deviation of errors

ρ = correlation coefficient.

3.7.2 *Mean WTP*

The mean WTP will be calculated following Haab and McConnell (2002) formula, that is:

$$mean\, WTP = -\frac{\alpha}{\beta} \tag{3.9}$$

Where α is constant term coefficient, and β represents the coefficient of bids that were given to respondents.

3.8 EMPIRICAL MODELS

The ANOVA and Chi-square tests were applied in this study in order to see the potential influence of socio-economic characteristics, which comprise age, gender, education and income, on respondents' knowledge, attitudes and perceptions toward water supply shortages and wastewater reuse in Maputo and Matola cities. However, for the economic valuation of respondents' mean WTP, the study used the double-bounded and the arithmetic mean to estimate the mean WTP for double bound for the two samples. In order to obtain the results of one-way ANOVA, Chi-square and double bonded (interval data model) tests, STATA 12 software was used.

3.8.1 *One-way ANOVA model*

The one-way ANOVA method was used in this study to verify the potential influence of socio-economic characteristics, such as income, gender, education and age, on respondents' knowledge, attitudes and perceptions towards wastewater reuse and water supply shortages. This model was chosen because of the two main assumptions that support this method, namely homogeneity of variance and the normal distribution of the dependent variable for each category of independent variable.

3.8.1.1 *Specification of one-way ANOVA model*

The one-way ANOVA model uses F-distribution to determine the relationship between two variables. The following Table 3.2 shows the specification of the one-way ANOVA.

Table 3.2: ANOVA table

Source of variation	Sum of squares	df	Mean square	F-Statistics
ESS	SS Between	J-1	$\frac{SS\ \ Between}{\text{J-1}}$	$\frac{MSS\ \ Between}{MSS\ Within}$
RSS	SS Within	N-1	$\frac{B\text{B}\ \ Within}{\text{N-1}}$	
TSS	SS Total	N-1		

Source: Gujarati (2004)

Where:

SS = Sum of squares

DF = Degree of freedom

J = Number of explanatory variables

N = Total number of observations

MS = Mean of squares

3.8.2 *Chi-square test model*

The study used a one-way Chi-square model to verify the potential influence of the socio-economic characteristics of the households, namely age, gender, education and income variables, on respondents' knowledge, attitudes and perceptions towards water supply shortages and wastewater reuse.

3.8.2.1 *Specification of chi square model*

$$x^2 = \frac{(\text{Observed}-Expected)^2}{\text{Expected}} \qquad (3.10)$$

where:

x^2 – Chi square statistics.

Under the null hypothesis, x^2 statistic has a t-distribution with *n*-1 degrees of freedom, where *n* is the number of observations.

3.8.3 *The t-test (test of significance) model*

This study used a t-test to determine the statistical differences of the mean WTPs from the two samples for TD (100 %) and BU (50 %) improvement programme. The t-test was used to test a null hypothesis, which says that the mean WTP from the two improvements proposed TD (100 %) and BU (50 %) are equal. The decision rule, whether to reject or fail to reject the null hypothesis, was based on the statistic test value obtained from the sample data.

3.8.3.1 *Specification of t-test model*

$$t = \frac{\widehat{(\beta}2\text{-}\beta 2)}{Se(\hat{\beta}2)}$$

$$= \frac{\hat{\beta}2\text{-}\beta 2\sqrt{\sum Xi^2}}{\hat{\alpha}} \qquad (3.11)$$

where:

$\widehat{\beta 2}$ - Estimated beta value from the sample

$\beta 2$ - True better value

se -Standard error of estimated beta

Xi - Explanatory variables.

Under the null hypothesis, the t-Test follows t distribution with $n-2$ degree of freedom, where n represents the sample size.

3.9 ECONOMETRIC MODEL SPECIFICATION

The general formulation of WTP for the DBDC model can be expressed as:

$$WTPij = \mu i + \varepsilon ij \tag{3.12}$$

where WTP_{ij} is an unobservable respondent WTP, i denotes the responses to the first and follow-up bids, respectively. The follow-up bid is contingent upon the response to the first bid: if the response to the first bid (B1) is 'no' (B2<B1) and a higher bid follows a 'yes' response to the first bid (B2>B1). Thus, the DBDC generates four sets of responses on the respondents' WTP, namely yes-yes, yes-no, no-yes, and no-no. The binary categories of respondents' responses allow a probabilistic definition of WTP, and the WTP distributional specifications allow the estimation of the probability that sample responses fall within any of the above-described four set of responses: suppose that the WTP distribution is characterised as function of H_c (B; θ), where B is the bid amount and θ is the vector of parameters. This implies that the probability of a yes-yes response is given by 1- H_c (B2; θ) and that of a yes-no response is [1- H_c (B2; θ)] – [1- H_c (B1; θ)]. Linking up the two with the sample characteristics such that μ i = $X' \ \beta$, and assuming that that εij is (IID) identically and independently distributed with zero mean and variance σi^2, WTP can be completely calculated by recovering the parameter estimates through the method of maximum likelihood. Alternatively, the WTP can be estimated following Cameron and Quiggin's (1994) modelling approach where the first and follow-up responses are modelled as a latent regression, introducing index functions for the unobservable WTP.

The Logit model takes the following form:

$Yi^* = \beta Xi + \varepsilon i$, $Yi=1$ if $WTP \geq B1$, 0 otherwise (3.13)

where:

Yi^* = not observable households WTP for irrigation water improvements.

B = is a vector of unknown parameters of the model,

Xi = is a vector of explanatory variables.

3.9.1 *Model specification of WTP for top-down approach*

$$\gamma * = \beta 0 + \beta 1 X1i + \beta 2 X2i + \beta 3 X3i + \beta 4 X4i + \beta 5 X5i + \beta 6 X6i + \beta 7 X7i + \beta 8 X8i + \beta 9 X9i + \beta 10 X10i + \beta 11 X11i + \beta 12 X12i + \beta 13 X13i + \beta 14 X14i + \beta 15 X15i + \beta 16 X16i + \beta 17 X17i + \beta 18 X18i + \beta 19 X19i + \beta 20 X20i + \beta 21 X21i + \beta 22 X22i + \beta 23 X23i + \beta 24 X24i + \beta 25 X25i + \beta 26 X26i + \varepsilon i \quad (3.14)$$

where:

Y^*= Latent variable for Willingness to pay variable for irrigation water quality improvement

$\beta 0$ = constant

β = Coefficient of the X variable

εi = Unobserved random component

Gender X1: A dummy variable, male=0 or 1= female

HHsizeX2: Age of the respondent

Age X3: Household size of the respondent

Educ2 X4: Attainment of university degree by the respondent

Educ4 X5: Attainment of secondary school level by respondent

Educ5 X6: Attainment of high school level by the respondent

Income1 X7: Household monthly income below 5.000 (dummy variable: 1 if HHincome is below 5.000, 0 otherwise)

Income2 X8: Household monthly income between 5.000-15.000 (dummy variable: 1 if HHincome is between 5.000-15.000, 0 otherwise)

Income3 X9: Household monthly income between 15.000-25.000(dummy variable: 1 if HHincome is between 15.000-25.000, 0 otherwise)

Income5 X10: Household monthly income between 35.000-50.000 (dummy variable: 1 if HHincome is between 35.000-50.000, 0 otherwise)

Income6 X11: Household monthly income above 50.000 (dummy variable: 1 if HHincome is above 50.000, 0 otherwise)

NEWQ15_11X12: Water is a scarce resource (dummy variable: 1 if strongly agree, 0 otherwise)

NEWQ15_12 X13: Water is a scarce resource (dummy variable: 1 if agree, 0 otherwise)

NEWQ16_52 X14: Farmers should use irrigation practices that conserve water, (dummy variable: 1 if agree, 0 otherwise)

NEWQ16_53 X15: Farmers should use irrigation practices that conserve water, (dummy variable: 1 if neutral, 0 otherwise)

NEWQ16_54 X16: Farmers should use irrigation practices that conserve water, (dummy variable: 1 if disagree, 0 otherwise)

NEWQ16_62 X17: The water distribution infrastructure should be improved to reduce the water that is wasted through leakages, (dummy variable: 1 if agree, 0 otherwise)

NEWQ16_63 X18: The water distribution infrastructure should be improved to reduce the water that is wasted through leakages, (dummy variable: 1 if neutral, 0 otherwise)

IMPORTSUPPLY X19: Infulene valley is an important supplier of fresh vegetables, (1=Yes, 2=No)

INADWSUPLY X20: More than half of urban population have no access to adequate water supply, (1=Yes, 2=No)

NEWQ26_1WNOSUITATALL1 X21: Water from Infulene valley is not suitable at all for vegetable irrigation, (dummy variable: 1 if strongly agree, 0 otherwise)

NEWQ26_1WNOSUITATALL2 X22: Water from Infulene valley is not suitable at all for vegetable irrigation, (dummy variable: 1 if agree, 0 otherwise)

NEWQ26_1WNOSUITATALL3 X23: Water from Infulene valley is not suitable at all for vegetable irrigation, (dummy variable: 1 if neutral, 0 otherwise)

NEWQ26_2WSUITABLE1X24: The water from the Infulene valley is suitable for vegetable irrigation, (dummy variable: 1 if strongly agree, 0 otherwise)

NEWQ26_2WSUITABLE2 X25: The water from the Infulene valley is suitable for vegetable irrigation, (dummy variable: 1 if agree, 0 otherwise)

NEWQ26_2WSUITABLE3 X26: The water from the Infulene valley is suitable for vegetable irrigation, (dummy variable: 1 if neutral, 0 otherwise)

3.9.2 *Model specification of WTP for bottom-up approach*

$$\gamma * = \beta 0 + \beta 1X1i + \beta 2X2i + \beta 3X3i + \beta 4X4i + \beta 5X5i + \beta 6X6 + \beta 7X7i + \beta 8X8i + \beta 9X9i + \beta 10X10i + \beta 11X11i + \beta 12X12i + \beta 13X13i + \beta 14X14i + \beta 15X15i + \beta 16X16i + \beta 17X17i + \varepsilon i \quad (3.15)$$

where:

Y^*= Latent variable for Willingness to pay variable for irrigation water quality improvement

β0 = constant

β = Coefficient of the X variable

εi = Unobserved random component

Age X1 **-** Age of the respondent

HHsize5 X2 **-** Household with children bellow 5 years' old (dummy variable: 1 if HH have children bellow 5 years old, 0 otherwise)

Educ2 X3 - Attainment of university degree by the respondent

Educ3 X4 - Attainment of primary education level by respondent

Educ4 X5 - Attainment of secondary school level by respondent

Income2 X6 - Household monthly income between 5.000-15.000 (dummy variable: 1 if HHincome is between 5.000-15.000, 0 otherwise)

Income4 X7 - Household monthly income between 25.000-35.000 (dummy variable: 1 if HHincome is between 25.000-35.000, 0 otherwise)

Income5 X8 - Household monthly income between 35.000-50.000 (dummy variable: 1 if HHincome is between 35.000-50.000, 0 otherwise)

NEWQ26_1WNOSUITATALL1 X9 - Water from Infulene valley is not suitable at all for vegetable irrigation, (dummy variable: 1 if strongly agree, 0 otherwise)

NEWQ26_1WNOSUITATALL4 X10 - Water from Infulene valley is not suitable at all for vegetable irrigation, (dummy variable: 1 if disagree, 0 otherwise)

NEWs4_Q21_23 X11 -Wastewater reuse irrigation leads to food contamination, (dummy variable: 1 if neutral, 0 otherwise)

NEWs4_Q21_25 X12 - Wastewater reuse irrigation leads to food contamination, (dummy variable: 1 if strongly disagree, 0 otherwise)

NEWs4_Q21_24 X13 - Wastewater reuse irrigation leads to food contamination, (dummy variable: 1 if disagree, 0 otherwise)

IMPORTSUPPLY X14 - Infulene valley is an important supplier of fresh vegetables, (1=Yes, 2=No)

NEWQ13_WSDserious4 X15 - Degree of seriousness the respondent place on the problem of water supply shortages, (dummy variable: 1 if less serious, 0 otherwise)

INADWSUPLY X16 - More than half of urban population have no access to adequate water supply, (1=Yes, 2=No)

sec3_Q17 X17 - Is possible for the government to collect wastewater, process it to a level that is safe for human and avail it to households for reuse, (1=Yes, 2=No)

3.9.2 *The mean WTP estimation of the double-bound model*

In both the random effect probit model and the interval data model, after the estimation of the parameters and assuming that WTP follow normal distribution, the mean WTP is estimated following Hanemann's (1984) formula to compute the value of mean WTP, which is:

Mean WTP = $(1/B1) * \ln(1 + e^{B0})$ (3.16)

And $WTP = -\frac{\beta 0}{\beta 1}$= WTP*= Mean WTP (3.17)

Hence, this study used Equation (3.16), which is commonly used in the computation of mean WTP to avoid the anchoring bias in using Equation (3.17).

3.10 CONCLUDING SUMMARY

This section presents the methodology approach used to achieve the study objectives. Infulene Valley is wetland, located in the urban and peri-urban area of Maputo province. This makes the valley a suitable place for vegetable production, and due to its location, it is exposed to many sources of pollutants, thus threatening human health. In order to value the irrigation water, this study used random sampling for selecting 244 vegetable consumers from Maputo and Matola cities. The top-down and bottom-up approach was used, and the two sample groups were developed, which represent the households that answered valuation questions from 100 % irrigation water improvements, followed by valuation of 50 % improvement, and households that answered valuation questions from 50 % irrigation water improvements followed by valuation of 100 % improvement TD (100 %) and BU (50 %) sub-samples. The reason was to test whether a respondent's WTP is influenced by the level of irrigation water improvement, i.e. whether the WTP estimates are scope sensitive to the good being valued. The binary responses were collected using a contingent valuation DB format, and STATA 12 software was used to analyse the data.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents the results and discussions, and is organised as follows: Section 4.2 covers the knowledge, attitudes and the perceptions towards water supply shortages and Section 4.3 is on the knowledge, attitudes and perceptions towards recycled wastewater reuse. Section 4.4 presents the willingness to pay for improved irrigation water; Subsection 4.4.5 presents the sensitivity of WTP estimates to internal scope effect; Subsection 4.4.6 presents the sensitivity of WTP estimates to external scope effect**,** Subsection 4.4.7 presents the assessment of the survey quality; and subsection 4.4.8 presents the concluding summary.

4.2 KNOWLEDGE, ATTITUDES AND PERCEPTIONS TOWARDS WATER SUPPLY SHORTAGES

The respondents were given statements designed to assess their levels of knowledge, attitudes and perceptions towards water supply shortages in Maputo and Matola cities. The purpose was to assess whether respondents factually know about the problem of water supply shortages, and to ascertain whether the degree of knowledge and how serious who perceive the problem have influence on a household's WTP. The respondents evaluated the statements using a five-point Likert scale. The respondents were required to evaluate the statements using the scale of 1 to 5, with 1 indicating "strongly agree" with the statement, 2 - agree, 3 - neutral, 4 - disagree and 5 indicating "strongly disagree".

4.2.1 *Knowledge, attitudes and perceptions towards water supply shortages*

The purpose of this section was to determine whether the respondents were aware of the problem of the water supply shortages in Maputo and Matola cities. In order to establish the degree of knowledge of the households, the respondents were presented with the following statements: water is a scarce resource; the cities should enact policies to address current water supply shortages; we are all responsible to use water carefully; I would like to stay informed about Maputo/Matola cities' water supply shortage issues; my household is willing to use less water to help other households in my community to have access to water; farmers should learn to reduce the amount of water they use for irrigation; and the cities should enact policies to address future water supply shortages. The statistical results are presented in Table 4.1 below.

Table 4.1: Respondents' knowledge, attitudes and perceptions towards water supply shortages

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Water is a scarce resource.	85 (34.8 %)	135 (55.3 %)	18 (7.4 %)	6 (2.5 %)	0 (0 %)
Maputo/Matola cities should enact policies to address current water supply shortages	39 (15.9 %)	188 (77.1 %)	16 (6.7 %)	1 (0.4 %)	0 (0 %)
My household can use the same amount of water even if the price of water was to double	7 (2.9 %)	97 (39.8 %)	18 (7.4 %)	115(47.1 %)	7 (2.9 %)
We are all responsible to use water carefully	60 (24.6 %)	172 (70.5 %)	3 (1.2 %)	8 (3.3 %)	1 (0.4 %)
My household will reduce water use if the price of water was to double.	9 (3.7 %)	115 (47.1 %)	35 (14.3 %)	80 (32.8 %)	5 (2.1 %)
I would like to stay informed about Maputo/Matola cities' water supply shortage issues.	43 (17.6 %)	199 (81.6 %)	2 (0.8 %)	0 (0 %)	0 (0 %)
My household is willing to use less water to help other households in my community to have access to water.	28 (11.5 %)	178 (73.0 %)	25 (10.3 %)	12 (4.9 %)	1 (0.4 %)
Farmers should learn to reduce the amount of water they use for irrigation	31 (12.7 %)	140 (57.4 %)	33 (13.5 %)	37 (15.2 %)	3 (1.2 %)
Maputo/Matola cities should enact policies to address future water supply shortages	59 (24.2 %)	181 (74.2 %)	4 (1.6 %)	0 (0 %)	0 (0 %)

Source: Author's elaboration

Note: The frequencies are shown outside the brackets, while the percentages are shown inside the brackets

A number of key messages flow from Table 4.1. Households either agree or strongly agree that water is a scarce resource (over 90 %), which should be used carefully (over 96 %). Households either agree or strongly agree that the current water supply scarcity is serious enough to warrant policy attention (over 90 %), to the extent that almost all households would like to be kept abreast of issues touching on water supply shortages. Looking ahead, almost all households agree that public policy ought to be concerned about the possibility of future water supply shortages. Table 4.1 suggests that households view water pricing as having potential to induce behavioural change: over 50 % of households either disagree or strongly disagree that they can afford to use the same amount of water if its price doubles. Over 50 % of households either agree or strongly agree that they will reduce their water use when the price doubles. There is also evidence to show that households consider water as either a merit good or community good: over 80 % of households either agree or strongly agree that they are willing to use less water so that others in the community could have access to water. Finally, households generally view the irrigation sector as having great water saving potential: over 70 % of households either agree or strongly agree that the irrigation sector should learn to reduce the amount of water it uses. On the basis of the above results, it can be concluded that the respondents have high levels of knowledge about the water supply shortage problems, suggesting that policy stands to the current benefit from a study of that look at the feasibility of using recycled water.

To further investigate the robustness of the results, chi-square (x^2) tests and a one-way analysis of variance (ANOVA) were applied in order to verify the influence of socio-economic variables, such as age, education, gender and income, on respondents' knowledge of water supply shortage problems. The variables education, gender and income are statistically significant, as the results of the x^2 tests fail to reject the null hypothesis of equal variation of households' knowledge with socio-economic variables. The chi-square (x^2) was used where the two variables are categorical, while the ANOVA F-test was used where one variable was categorical, while the other variable was continuous, and in this case, age was a continuous variable. The results of the x^2 tests and F-test, along with the p-values in brackets, are displayed in Table 4.2 below.

Table 4.2: Influence of age, education, gender and income on the respondents' knowledge, attitudes and perceptions towards water supply shortage problems

Statement	Age	Education	Gender	Income
Water is a scarce resource.	0.980 (0.871)	0.506 (0.973)	0.054 (0.816)	2.516 (0.774)
Maputo/Matola cities should enact policies to address <u>CURRENT</u> water supply shortages	0.900 (0.970)	12.539 (0.006)***	1.823 (0.177)	8.223 (0.144)
My household can use the same amount of water even if the price of water was to double	1.140 (1.000)	3.520 (0.318)	0.235 (0.628)	0.852 (0.974)
We are all responsible to use water carefully.	1.180 (0.163)	32.954 (0.000)***	8.513 (0.004)***	12.812 (0.025)**
My household will reduce water use if the price of water was to double.	1.130 (0.999)	3.972 (0.410)	0.145 (0.704)	4.451 (0.486)
I would like to stay informed about Maputo/Matola cities' water supply shortage issues.	0.870 (1.000)	22.433 (0.000***)	0.0830 (0.773)	9.572 (0.088*)
My household is willing to use less water to help other households in my community to have access to water.	1.160 (0.077)	7.986 (0.046)**	24.769 (0.000)***	34.169 (0.000)***
Farmers should learn to reduce the amount of water they use for irrigation	0.89 (0.989)	3.75 (0.440)	0.282 (0.595)	3.796 (0.579)
Maputo/Matola cities should enact policies to address <u>FUTURE</u> water supply shortages	0.720 (1.000)	7.118 (0.068)	0.328 (0.567)	3.019 (0.690)

Source: Author's elaboration

*Note: *, ** and ***show the statistical levels of significance, at 10 %, 5 % and 1 %, respectively*

The results from the above table show that education, gender and income were found to be statistically important in influencing the knowledge of water supply shortage problems in Maputo and Matola cities. This is shown by chi-square and the one-way ANOVA chi-square, together with their p-value in brackets.

From the above results, education appears to be the most important in determining a respondent's knowledge of water supply shortage problems. Educated people are more likely to be interested in saving water by using it carefully so as to help others to have access to water in their communities (x^2=7.99, p=0.046) and they are also more interested in the enactment of policies that address the current problem of water supply shortages (x^2=12.54, p = 0.006). From the above table, the large chi square value for the variables of the household's responsibility to carefully use water (x^2=32.95, p=0.000) and the households being kept informed about the cities' water supply shortage issues (x^2=22.43, p=0.00), revealed that those variables are more strongly related with education.

Moreover, the results found a positive relationship of gender on influencing knowledge of households on water supply shortage problems. This implies that females are more likely to be interested in saving water by using it carefully so as to help others to have access in their communities (x^2= 24.77, p = 0.000). The results also revealed a strong and positive relationship with income, implying that households with high income levels are also more likely to be interested in saving water by using it carefully so as to help others to have access in their communities, and the strong relationship is shown by the high value of (x^2= 34.17, p = 0.000). On the basis of the above results, it can be concluded that the variables of education, gender and income have to be considered important in influencing households' behaviour in the future on aspects related to the careful use of water and in reducing the quantity of water that households use so as to help others in the community to also have access to water.

4.2.2 *Potential policy measures to mitigate water supply shortages*

The purpose of this section was to find whether the respondents factually know that the problem of water supply shortages can be mitigated by the implementation of potential policy actions in the cities of Matola and Maputo. The following statements were put to respondents to establish their knowledge on the potential policy instruments: 1 - The cities of Maputo and

Matola should implement policies to mitigate water supply shortages; 2 - The City should implement communication and education campaigns to raise household awareness of strategies to reduce amount of water consumed per day; 3 - The City Council should pass laws that require households to conserve water; 4 - The City Council must install technologies that collect effluent water from households, cleanse the effluent water to a level that is safe for human re-use, and return it to households for reuse; 5 - The City Council should price water appropriately to avoid water wastage by households that think water is cheap; 6 - Farmers should use irrigation practices that conserve water; 7 - The water distribution infrastructure should be improved to reduce the water that is wasted through leakages, and the City should restrict water supply to households to six days a week; 8 - The City should restrict water supply to households from seven to five days a week; and 9 - Farmers should be prohibited from using water for irrigation. The results of this analysis are presented in Table 4.3 below and the above-mentioned variables were used to construct the respondents' knowledge.

Table 4.3: Respondents' knowledge of potential policy measure to mitigate water supply shortages

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The City should implement communication and education campaigns to raise household awareness of strategies to reduce amount of water consumed per day	51 (20.9 %)	183 (75 %)	8 (3.3 %)	2 (0.8 %)	0 (0 %)
The City Council should pass laws that require households to conserve water, for example a law that requires households to install water-saving shower heads	26 (10.7 %)	178 (73.0 %)	28 11.5 %)	12 (4.9 %)	0(0 %)
The City Council must install technologies that collect effluent water from households, cleanse the effluent water to a level that is safe for human re-use, and return it to households for reuse.	26 (10.7 %)	169 (69.3 %)	29 (11.9 %)	19 (7.8 %)	1 (0.4 %)
The City Council should appropriately price water to avoid water wastage by households who think water is cheap	24 (9.8 %)	141 (57.8 %)	15 6.2 %)	61 (25 %)	3 (1.2 %)
Farmers should use irrigation practices that conserve water (e.g. drip irrigation)	31 (12.7 %)	188 (74. 2 %)	20 (8.2 %)	12 (4.9 %)	0 (0 %)
The water distribution infrastructure should be improved to reduce the water that is wasted through leakages	86 (35.3 %)	150 (61.5 %)	7 (2.9 %)	1 (0.4 %)	0 (0 %)
The city should restrict water supply to households to six days a week	0 (0 %)	4 (1.6 %)	29 (11.9 %)	168 8.9 %)	43 (17.6 %)
The city should restrict water supply to households from seven to five days a week	0 (0 %)	4 (1.6 %)	30 (12.3 %)	165 (67.6 %)	45 (18.4 %)
Farmers should be prohibited from using water for irrigation	0 (0 %)	7 (2.9 %)	70 (28.7 %)	127 (52.1 %)	40 (16.4 %)

Source: Author's elaboration Note: The frequencies are shown outside the brackets, while the percentages are shown inside the brackets

The conclusion drawn from the above results is that respondents are aware and know which potential policy instruments should be implemented by the city to mitigate the problem of water supply shortages that the people of Maputo and Matola cities currently suffer. These include information, regulation and pricing instruments. However, according to a 5-point Likert scale, the majority of households (over 90 %) either agree or strongly agree that the city should implement education and communication programmes in order to increase people's awareness so as to reduce the amount of water used per day, and this will require households to use technologies that conserve water, to which over 80 % of households agreed or strongly agreed. From the Table 4.3 results, there is an evidence to show that households consider recycled water as an alternative source, as long as it is safe for reuse, to overcome the actual problem of water shortages; over 80 % of households either agree or strongly agree that the City Council should install technologies that collect effluent water from households, cleanse the effluent water to a level that is safe for human re-use, and return it to households for reuse.

The results also show that households view water pricing as having potential to induce behavioural change: over 60 % of households either agree or strongly agree that the City Council should price water appropriately to avoid water wastage by households who think that water is cheap. However, a regulation policy regarding water restriction for household consumption and irrigation uses is not desirable, with over 60 % of respondents either disagreeing or strongly disagreeing that farmers should be prohibited from using water for irrigation. Furthermore, over 80 % of households either disagreed or strongly disagreed with a water supply restriction from seven days to five or six days per week. This implies that even though the respondents have clear knowledge about the problem of water supply shortages, they were not aware that the excessive use of water for both domestic and productive uses could actually worsen the status of the water supply. This suggests that the City Council should use such policy restrictions with caution because this policy is not desirable by households.

Table 4.4: Influence of age, education, gender and income on the respondents' knowledge of potential policy measure to mitigate water supply shortages

Statement	Age	Education	Gender	Income
The City should implement communication and education campaigns to raise household awareness of strategies to reduce amount of water consumed per day.	1.140 (0.729)	3.521 (0.475)	1.695 (0.193)	7.669 (0.175)
The City Council should pass laws that require households to conserve water, for example a law that requires households to install water-saving shower heads	1.290 (0.438)	11.039 (0.012)**	0.007 (0.934)	3.397 (0.639)
The City Council must install technologies that collect effluent water from households, cleanse the effluent water to a level that is safe for human re-use, and return it to households for reuse.	1.280 (0.489)	5.225 (0.265)	0.609 (0.435)	10.818 (0.055)*
The City Council should appropriately price water to avoid water wastage by households who think water is cheap	1.370 (0.994)	1.845 (0.605)	2.968 (0.085)*	2.781 (0.734)
Farmers should use irrigation practices that conserve water (e.g. drip irrigation)	1.150 (0.751)	57.789 (0.000)***	0.874 (0.350)	6.991 (0.221)
The water distribution infrastructure should be improved to reduce the water that is wasted through leakages.	1.050 (0.998)	0.216 (0.975)	2.463 (0.117)	4.515 (0.478)
The city should restrict water supply to households to six days a week	0.860 (0.685)	6.696 (0.153)	10.547 (0.001)***	3.752 (0.586)
The city should restrict water supply to households from seven to five days a week	0.750 (0.715)	8.227 (0.084)	9.540 (0.002)***	6.226 (0.285)
Farmers should be prohibited from using water for irrigation	0.960 (0.974)	5.008 (0.286)	0.199 (0.663)	7.070 (0.215)

*Source: Author's elaboration. Note: *, ** and ***show the statistical levels of significance, at 10 %, 5 % and 1 %, respectively*

The results in the Table 4.4 suggest that the statements used to construct the respondents' knowledge indicate that the variables education, gender and income were statistically significant in influencing the knowledge of potential policy measures to mitigate the problem of water supply shortages. These results show that the more a respondent is educated, the more likely the respondent will be to be interested in regulation policies that conserve water, namely the law that requires the households to use technologies to conserve water, farmers' irrigation practices that conserve water, and the positive and strong relationship between education and regulation policy that forces farmers to use conservation water irrigation practices, is shown by high (x^2=57.79, p = 0.000). Gender appears to have a statistically significant relationship with water restriction regulation policy, from which it can be concluded that the sex of the respondent plays a significant role in determining the likelihood of knowing about the policies of water supply restrictions (x^2=10.55, p = 0.001). This is not surprising, as females are more concerned with water supply problems since are the ones who deal with daily household domestic activities that require water consumption.

The results in Table 4.4 lead us to conclude that education, gender and income are the most important variables for influencing households' behaviour on policies related to water saving technologies, irrigation practices that save water, recycled water reuse, and water restrictions for the households.

4.3 KNOWLEDGE, ATTITUDES AND PERCEPTIONS TOWARDS RECYCLED WASTEWATER REUSE

The purpose of this section was to determine the respondents' knowledge, perceptions and attitudes towards recycled wastewater reuse in Maputo and Matola cities, and to reveal whether the respondents are familiar with recycled wastewater reuse. In the statistical analysis presented earlier, the study showed that the respondents factually know about the threats affecting water supply and about the problem of water supply shortages. This high level of knowledge was demonstrated on those aspects, as shown by statistical analysis. Therefore, it becomes reasonable for this study to ask questions exploring their knowledge, perceptions and attitudes towards the reuse of recycled wastewater because of its importance as a part of water resource management, and we are aware that wastewater reuse is a possible policy option. To further address this objective, the study asked respondents if they were aware of the possibility of government collecting wastewater, processing it and making it available to households for reuse. The study found that 72 % of respondents were familiar with the reuse of wastewater.

We then asked respondents to indicate their level of agreement with the statements regarding wastewater reuse and their level of happiness, using a Likert scale with the following choices: strongly agree, agree, neutral, disagree and strongly disagree. The statistical results regarding this analysis are reported in Table 4.5 below.

Table 4.5: Knowledge, perceptions and attitudes towards recycled wastewater reuse

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Recycled water should be used for industrial processes. E.g. cooling water for power plants and oil refineries	23 (13.1 %)	139 (79 %)	9 (5.1 %)	5 (2.3)	0 (0 %)
Recycled water should be used for agricultural irrigation of food crops. E.g. vegetables	10 (5.7 %)	132 (75 %)	17 (9.7 %)	16 (9.1 %)	1(0.6 %)
Recycled water should be used to irrigate areas that humans use for recreation, including parks, lawns and sport fields, and school fields	18 (10.2 %)	128 (72.7 %)	17 (9.7 %)	13 (7.4 %)	0 (0 %)
Recycled water should be used for domestic uses, e.g. car washing, and garden/lawn irrigation	25 (14.2 %)	131 (4.4 %)	14 (8.0 %)	12 (2.9 %)	1 (0.0 %)
Recycled water should be used for groundwater recharge	5 (2.8 %)	61 (34.7 %)	61 (34.7 %)	36 (20.5 %)	13 (7.4 %)
Recycled water should be used for construction activities. E.g. concrete mixing	39 (22.2 %)	127 (2.2 %)	6 (3.4 %)	4 (2.3 %)	5 (0.0 %)
Recycled water should be used to create or enhance wetlands	7 (4.0 %)	72 (40.9 %)	80 (45.5 %)	16 (9.1 %)	1 (0.0 %)
Reusing wastewater reduces the pollutants discharged into the environment. E.g. oceans, rivers, and other water	19 (10.8 %)	120 (68.2 %)	25 (14.2 %)	11 (6.3 %)	1 (0.0 %)
Reusing wastewater has potential health hazards for human beings	2 (1.1 %)	75 (42.6 %)	46 (26.1 %)	50 (28.4 %)	3 (1.7 %)
I will be happy washing my car with recycled wastewater	8 (3.3 %)	204 (83.6 %)	13 (5.3 %)	19 (7.8 %)	0 (0 %)
I will be happy using recycled wastewater in my toilet, if that would be possible	4 (1.6 %)	191 (78.3 %)	14 (5.7 %)	34 (13.9 %)	1 (0.4 %)
I will be happy using recycled wastewater in my garden and filling ornamental ponds	6 (2.5 %)	203 (83.2 %)	16 (6.6 %)	19 (7.8 %)	0 (0 %)
I will be happy using recycled wastewater for fishing and farming	4 (1.6 %)	171 (70.1 %)	29 (11.9 %)	38 (15.6 %)	2 (0.8 %)

Source: Author's elaboration. Note: The frequencies are shown outside the brackets, while the percentages are shown inside the brackets

The results show that the respondents were familiar with wastewater reuse and that they have positive attitudes towards recycled wastewater reuse. This is shown by the results, with the majority of respondents either agreeing or strongly agreeing that recycled water should be used for agricultural irrigation of food crops (over 75 %), for recreational parks (over 70 %), and for industrial uses and construction activities (over 70 %). The results in Table 4.5 also show that the majority of respondents (over 80 %) either agreed or strongly agreed that they will be happy using recycled wastewater to wash their cars and in toilets, if that is possible. This implies that the respondents consider the recycled water as an alternative option due to their positive attitude and knowledge displayed. However, the respondents displayed low levels of knowledge on the potential health issues regarding wastewater reuse; over 40 % either agreed or strongly agreed, over 25 % either disagreed or strongly disagreed, and 26 % of respondents were neutral when considering whether reusing wastewater has potential health hazards for human beings. This implies that the City Council/Municipality should promote communication and education campaigns to raise people's knowledge and awareness of the health and environmental aspects related to the reuse of wastewater.

To further investigate the robustness of the results, chi-square (x^2) tests and a one-way analysis of variance (ANOVA) were used to verify the potential influence of the socio-economic variables of age, education, gender and income on the knowledge, perceptions and attitudes of the households towards recycled wastewater reuse. The results are reported in Table 4.6 below.

Table 4.6: Influence of age, education, gender and income on knowledge, perceptions and attitudes towards recycled wastewater reuse

Statement	Age	Education	Gender	Income
Recycled water should be used for industrial processes. E.g. cooling water for power plants and oil refineries	0.760 (0.402)	9.418 (0.024)	1.375 (0.241)	8.313 (0.140)
Recycled water should be used for agricultural irrigation of food crops. E.g. vegetables	0.910 (0.807)	3.001 (0.392)	1.246 (0.264)	19.375 (0.002)***
Recycled water should be used to irrigate areas that humans use for recreation, including parks, lawns and sport fields, and school fields	0.980 (0.544)	9.953 (0.019)**	1.468 (0.226)	14.802 (0.011)**
Recycled water should be used for domestic uses. E.g. car washing and garden/lawn irrigation	1.460 (0.602)	11.068 (0.011)**	0.084 (0.772)	1.419 (0.922)
Recycled water should be used for groundwater recharge	0.710 (0.760)	6.415 (0.093)*	0.009 (0.921)	3.919 (0.561)
Recycled water should be used for construction activities. E.g. concrete mixing	0.700 (0.927)	24.096 (0.000)***	0.012 (0.913)	17.868 (0.003)
Recycled water should be used to create or enhance wetlands	0.990 (0.771)	0.156 (0.984)	4.990 (0.025)**	5.136 (0.400)
Reusing wastewater reduces the pollutants discharged into the environment. E.g. oceans, rivers, and other water	1.230 (0.758)	3.709 (0.295)	0.641 (0.424)	14.547 (0.012)**
Reusing wastewater has potential health hazards for human beings	1.160 (0.994)	0.701 (0.873)	0.134 (0.714)	0.408 (0.995)
I will be happy washing my car with recycled wastewater	0.820 (0.370)	15.022 (0.002)***	0.151 (0.698)	21.057 (0.001)***
I will be happy using recycled wastewater in my toilet, if that would be possible	0.720 (0.852)	2.127 (0.546)	0.904 (0.342)	2.702 (0.746)
I will be happy using recycled wastewater in my garden and filling ornamental ponds	0.610 (0.154)	9.418 (0.024)**	1.377 (0.241)	22.405 (0.000)***
I will be happy using recycled wastewater for fishing and farming	0.850 (0.767)	1.117 (0.773)	1.985 (0.159)	8.999 (0.109)

Source: Author's elaboration. *Note: *, ** and ***show the statistical levels of significance, at 10 %, 5 % and 1 %, respectively*

According to the Table 4.6 results, the age variable was found to be statistically insignificant in determining respondents' knowledge and attitudes toward recycled wastewater reuse. This is not surprising, as the age variable was also found to be insignificant in the studies conducted by Mahlalela (2014) in capturing attitudes, since these attitudes are determined by the individual's underlying preferences. Moreover, the important variables that influence respondents' attitudes towards recycled wastewater reuse are found to be education, gender and income. This result implies that respondents with a high education level are more likely to use recycled water to irrigate parks, wash cars, to irrigate gardens, and in construction activities. The results also revealed a statistically significant (at 1 % level) and positive strong relationship of the education variable and the variable related to recycled water uses for construction activities, with the high value of (x^2=24.09, p = 0.000). Similar findings were reported by Tsagarakis and Georgants (2003), to the effect that more-educated people are more willing to use recycled water. The results also revealed a positive and strong relationship of the households' happiness with using recycled water for car washing.

Moreover, high-income households are more likely to have high knowledge and a positive attitude about recycled wastewater use for agricultural irrigation (x^2=19.34, p = 0.002) and the irrigation of parks, schools and sport fields (x^2=14.80, p = 0.011), and they also know that reusing wastewater reduces environmental pollution (x^2=14.55, p = 0.012). The results also suggest that income has a strong positive relationship with a household's happiness in using recycled wastewater to wash cars and in their garden, which is supported by the high values of (x^2=21.06, p = 0.001) and (x^2=22.405, p = 0.000).

The variable of age was found to have the expected positive sign, although it is statistically insignificant in determining respondents' attitudes and knowledge toward wastewater reuse, since attitudes are determined by an individual's underlying preferences and not by the individual's age. This result contradicts the findings of Hurlimann and McKay (2005) and Menegaki et al. (2007) whose studies found that age influences peoples' attitudes and that the high opposition to wastewater reuse was observed from people over 50 years old.

The results in Table 4.6 show that the variables education, gender and income are the most important in influencing a household's knowledge, perceptions and attitudes towards recycled wastewater reuse in agriculture, irrigation of parks and school fields, for domestic uses (car washing, gardens), in construction, and for reducing pollutants in the environment.

4.3.1 *Wastewater reuse for irrigation*

The objective of this section was to capture the respondents' attitudes and perceptions regarding the reuse of wastewater in agricultural irrigation and the value they attach to the safe use of recycled wastewater for irrigation. In order to address this objective, we asked respondents to indicate their level of agreement with the following statement: I will be happy buying vegetables irrigated by recycled wastewater, and I will be happy using recycled wastewater for fishing and farming. The Likert scale offered the following choices: strongly agree, agree, not sure, disagree and strongly disagree, and the statistical results for the aforementioned variables were used to capture the construct attitudes and perceptions towards wastewater reuse in agriculture.

Based on the sample results, the study established that the respondents have adequate factual knowledge about recycled wastewater reuse. Therefore, the study can confidently conclude that the respondents have positive attitudes towards wastewater reuse for irrigation. This is shown by the results where the respondents either agreed or strongly agreed that they will be happy buying vegetables irrigated with recycled wastewater (over 65 %), and that they will be happy using it for farming (about 70 %).

The results show that the respondents are familiar with, and have positive attitudes towards, recycled wastewater reuse in agricultural production. This brings the study to conclude that wastewater reuse is a possible policy option for mitigating the consequences of increased water demand, thus allowing us to exploit other sources of water before depleting the scarce fresh water supply (Menegaki at al., 2007). The importance of recycled wastewater reuse has been recognised worldwide due to its implications for water resource management.

4.3.2 *Challenges regarding recycled wastewater reuse in irrigation*

The purpose of this section was to find out whether the respondents are aware that the use of recycled wastewater for irrigation is associated with adverse effects, depending on the level of treatment. The perception of risk due to the use of recycled wastewater is associated with health threats, and people worry about their own safety when recycled wastewater is used for agricultural purposes. Although the willingness to use recycled wastewater is high, the acceptability declines as the use moves from the public to the private sector due to perceived risk (Tasman & Hurlimann, 2005).

To achieve this objective, the respondents were asked to rate the statements in Table 4.7 below on a scale of agreement and disagreement: wastewater reuse irrigation has potential health risk, wastewater reuse irrigation leads to food contamination, wastewater reuse irrigation leads to groundwater contamination, and wastewater reuse irrigation leads to soil degradation. The results regarding this analysis are presented in Table 4.7 below.

On the basis of the results obtained, it can be concluded that the respondents worry about the challenges regarding wastewater reuse for irrigation, as it can be observed from the results that respondents either agreed or strongly agreed that wastewater reuse irrigation has potential health risk (over 50 %), which leads to food contamination (over 40 %). The rates of responses were mixed, and these results are not surprising at all because even though households are familiar with wastewater reuse in agriculture problems, the information available is not sufficient to help them make the right decisions and it may be the case that the benefits that households perceive for wastewater reuse outweigh the challenges associated with it. To verify the robustness of the results, chi-square (x2) tests and a one-way Analysis of Variance (ANOVA) were used to verify the potential influence of socio-economic variables on challenges regarding recycled wastewater reuse in irrigation. The results of the x2 and F-test are reported in Table 4.8 below.

Table 4.7: Challenges regarding recycled wastewater reuse in irrigation

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Do not Know
Wastewater reuse irrigation has potential health risks. E.g. dysentery, diarrhoea	11(4.5 %)	120 (48.2 %)	26 (10.7 %)	53 (21.7 %)	8 (3.3 %)	26 (10.7 %)
Wastewater reuse irrigation leads to food contamination	5 (2.1 %)	107 (43.9 %)	32 (13.1 %)	66 (27.1 %)	6 (2.3 %)	27 (11.5 %)
Wastewater reuse irrigation leads to groundwater contamination	3 (1.2 %)	52 (21.3 %)	54 (22.1 %)	58 (23.8 %)	9 (3.7 %)	68 (27.9 %)
Wastewater reuse irrigation leads to soil degradation. E.g. land salinity and land sealing	3 (1.2 %)	39 (16.0 %)	56 (23.0 %)	46 (19.0 %)	7 (2.9 %)	93 (38.1 %)

Source: Author's elaboration.
Note: The frequencies are shown outside the brackets, while the percentages are shown inside the brackets

Table 4.8: Influence of age, education, gender and income on the respondents' challenges regarding recycled wastewater reuse in irrigation

Statement	Age	Education	Gender	Income
Wastewater reuse irrigation has potential health risk. E.g. dysentery, diarrhoea	1.320 (0.964)	7.185 (0.126)	5.611 (0.018)**	16.113 (0.007)***
Wastewater reuse irrigation leads to food contamination	1.580 (0.777)	4.826 (0.306)	4.565 (0.033)**	15.575 (0.008)***
Wastewater reuse irrigation leads to groundwater contamination	1.260 (0.998)	1.158 (0.763)	0.547 (0.459)	2.868 (0.720)
Wastewater reuse irrigation leads to soil degradation. E.g. land salinity and land sealing	1.100 (1.000)	3.467 (0.381)	0.527 (0.468)	1.033 (0.960)

Source: Author's elaboration.
*Note: ** and ***show the statistical levels of significance, at 5 % and 1 %, respectively*

The results in Table 4.8 above show that the most important variables that influence respondents' knowledge on challenges regarding recycled wastewater reuse in irrigation are gender and income. This implies that females are aware that wastewater reuse in crop production has potential health risks (x^2=5.61, p = 0.018), which may lead to food contamination (x^2=4.57, p = 0.033).

High-income households are also aware that wastewater reuse irrigation has potential health risks (x^2=16.11, p = 0.007). Therefore, when trying to influence households' awareness on recycled wastewater potential risks, the variables of gender and income should be considered.

Education and age appear to have no influence on the respondents' challenges regarding recycled wastewater reuse in irrigation. The results suggest that the awareness of challenges regarding recycled water reuse for irrigation is independent of education and age. These results are in contradiction with the findings of Hurlimann and McKay (2003) and Menegaki et al. (2007), who have suggested that a participatory approach with education and information contributions from the authorities is crucial for persuading the public of the safety and other issues related to recycled water.

4.3.3 *Suitability of water from the Infulene Valley for vegetable irrigation*

The purpose of this section was to find out whether residents of Maputo and Matola cities are aware that the water supply shortages is a problem, and if they know about the source of irrigation water at Infulene Valley. To achieve this objective, we asked the respondents questions about their awareness of the inadequate water supply, whether the respondents know that the Infulene Valley is an important supplier of fresh vegetables, whether the respondents know how farmers grow the vegetables (irrigated or rain fed), and about the suitability of water from the Infulene valley used to irrigate crops.

The results showed that over 98 % of households are aware that more than more than half of the urban population in Maputo and Matola cities do not have an adequate water supply. Over 90 % of respondents are also aware that the Infulene Valley is an important supplier of fresh vegetables to the residents of Matola and Maputo cities, and over 95 % of respondents are aware that the vegetables supplied from Infulene Valley are irrigated. However, despite this awareness, the results from Table 4.9 below show that over 80 % of respondents are generally in agreement that the water from the Infulene Valley is not suitable at all for vegetable irrigation.

Table 4.9: Current suitability of the water from Infulene Valley

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The water from the Infulene valley is not suitable at all for vegetable irrigation	74 (30.33 %)	127 (52.05 %)	18 (7.38 %)	25 (10.25 %)	0 (0.0 %)
The water from the Infulene valley is suitable for vegetable irrigation	0 (0.0 %)	22 (9.02 %)	42 (17.21 %)	146 (59.84 %)	34 (13.93 %)
It does not matter to me whether the water from the Infulene valley is suitable for vegetable irrigation or not	0 (0.0 %)	3 (1.23 %)	61 (25.00 %)	156 (63.93 %)	24 (9.84 %)
The water from the Infulene valley is not suitable for vegetable irrigation	35 (14.34 %)	165 (67.62 %)	22 (9.02 %)	22 (9.02 %)	0 (0.0 %)
The water from the Infulene valley is very suitable at all for vegetable irrigation	1 (0.41 %)	11 (4.51 %)	49 (20.08 %)	143 (58.61 %)	40 (16.39 %)

Source: Author's elaboration.
Note: The frequencies are shown outside the brackets, while the percentages are shown inside the bracket

4.4 WILLINGNESS TO PAY FOR IMPROVED IRRIGATION WATER QUALITY

The purpose of this section is to estimate the welfare change from the status quo at Infulene valley. This will be described by the WTP for vegetables irrigated with recycled wastewater, which will require a policy change towards improving the irrigation water status. The WTP scenario is based on two scenarios, a top-down and a bottom-up approach. The welfare gains of this study will be reported by the household's mean WTP for irrigation water improvements at Infulene Valley.

4.4.1 *Environmental quality change to be valued*

Our previous analysis showed that respondents agree that the water from Infulene Valley is not suitable for vegetable irrigation, which justifies the presentation of the following environmental quality change scenario. Infulene Valley is considered the green belt of Maputo and Matola cities due to its importance for vegetable production. However, because of its proximity to the city, the valley is a receptacle for untreated sewage from different sources through the drainage channel, including untreated domestic sewage, thus placing human health and the environment in danger. After the plan has been approved, the wastewater would receive treatment, and the pollution would be reduced, resulting in clean water that is suitable for irrigating crops that are consumed by people.

To verify whether respondents consider this environmental quality credible, there were asked to confirm whether in their view it is possible to implement a project that improves the quality of water in the Infulene Valley from state A to state B, and over 90 % of respondents are in agreement that is possible. These results suggest that respondents found the environmental change scenario presented to be credible.

The respondents were then given the plan presented bellow which shows how the environmental quality change will be operationalised: the Municipality/Government of Mozambique will fund the construction of a modern wastewater treatment plant. Wastewater will be collected from the valley, it will be processed and then pumped back to the valley, where it can be used for various purposes including irrigation by farmers. The municipality will then levy a charge on farmers who might want to use safe and recycled wastewater for irrigation, and this payment is intended to provide the wastewater treatment services continuously. To verify whether respondents considered the plan to be credible, they were asked to confirm whether in their view the Government of Mozambique and the Municipalities of Maputo and Matola have the capacity to operationalise the plan, and over 75 % of respondents believe that the government has the capacity. This result suggests that the respondents found the operationalisation plan to be credible.

4.4.2 *Valuation scenario*

To motivate the valuation scenario, the respondents were presented with the following information to ensure that they understood the status quo of the Infulene Valley. As we may expect, the water from the Infulene Valley is subjected to different sources of pollutants because of the untreated sewage, including untreated domestic sewage, that it receives from the municipal districts through the drainage channel, thus placing human health and the environment in danger.

To ensure that respondents understood what they paying for, the following hypothetical improvement scenario was presented: suppose that the government and private agencies are planning to improve the quality of water flowing through the valley, thus making it safe for humans and the environment. Therefore, the Municipality comes up with a plan to collect water from the valley, process it in a modern wastewater treatment plant, and then pump it back to the valley, where it can be used for various purposes including irrigation by farmers. The municipality will then levy a charge on farmers who might want to use safe and recycled wastewater for irrigation.

To assess the extent to which respondents accepted the valuation scenario, they were asked to confirm whether they would vote for the programme, and the results suggest that respondents generally accepted the valuation scenario presented – about 85 % would vote for the programme. The few who did not accept the valuation scenario gave the following reasons for their choice: the majority of the dissenters say that they cannot afford it, while others said that is only going to protect one river, and other reason given is that the programme is not worth the amount.

4.4.3 *Payment vehicle*

The payment vehicle used in this study was a charge to be added on top of the regular price of a bunch of cabbage in the market. Following Carson and Groves (2007), the study applied the price increase since it is compulsory and is incentive compatible. Thus, a typical valuation question was presented to respondents as follows: "Suppose the final cost estimates showed that instead of bunch of cabbage costing 50Mts, they will cost 55Mts (i.e. an extra 5Mt per bunch). Would you vote FOR the project"?

4.4.4 *Determination of true and protest zeros*

To determine the sample size to be used in the econometric analysis, we need to identify the true zeros and protest zeros. In CVM studies, protest zeros are excluded from the analysis because they do not reflect the respondent's genuine preference for the specified change in the environmental good to be valued. The inclusion of protest zeros will bias the WTP estimates downward and the valuation function coefficients would also most likely be biased, and it is not possible to say a priori in which direction (Strazzera et al., 2003). The study targeted 244 respondents, and the respondents that stated a zero WTP were given four possible reasons in a closed question format (following Jones et al., 2008; Meyerhoff et al., 2008; and Baral et al., 2008) in order to identify protest responses. The alternatives presented are (1) It is not worth the amount, (2) I cannot afford it, (3) It will only protect one river channel, and (4) Other reasons. Following Strazzera et al., (2003), the first and second reasons were considered true zeros, with the other two as protest responses, because they do not attach the value to the environmental good to be valued. Table 4.10 below presents the reasons for voting against the programme.

Table 4.10: Respondents' reasons for not being WTP for irrigation water quality improvements

Reason	Frequency	Per cent
It is not worth the amount	23	38.98
I cannot afford it	33	55.93
It will only protect one river channel	2	3.39
Other	1	1.69
Total	59	100

Source: Author's elaboration

Based on the given reasons, 56 (22.9 %) of the respondents had true zero WTP responses, while 3 (1.2 %) had protest responses. Following Brouwer (2009), Whittington (2004), and Mitchell and Carson (1989), the protest responses were excluded from the analysis.

4.4.5 *Sensitivity of WTP estimates to internal scope effects*

The objective is to determine whether the WTP estimates are sensitive to scope effects, that is, whether the WTP increases or decreases with the quality of environmental good to be valued (Hausman, 1993; Svedsater, 2000). Therefore, the internal test of scope analysed the within respondents' bottom-up and top-down mean WTP for irrigation water improvement.

4.4.5.1 *Analysis of top-down responses*

Respondents were first asked to value 100 % of wastewater improvement, followed by a question on how much they WTP for a 50 % improvement.

4.4.5.1.1 *Analysis of the first bid*

The purpose of this section is to check whether the contingent valuation data reveal that the respondents are sensible to the bid amount, which would be shown by a lower proportion of 'yes' responses as the bid amount increases. The analysis in Table 4.11 below shows the first bid mount distribution and Table 4.12 below displays the proportions of respondents that said 'yes' to the first bid as the amount.

Table 4.11: Proportional responses to the amount of bid 1

Response 1	TD (100 %)	TD (50 %)
Yes	93 (86.92 %)	57 (66.28 %)
No	14 (13.08 %)	29 (33.72 %)

Source: Author's elaboration

The distribution of bid 1 responses was analysed to determine the proportion of respondents who gave positive response to the first WTP question. The results show that about 87 % of respondents gave a positive response 'Yes' to the first bid amount question for a 100 % improvement programme, and 66 % for a 50 % improvement programme, and this shows that respondents were sensible to the level of wastewater treatment programme, since the rate of positive responses decreases drastically from 87 % TD (100 %) to 66 % TD (50 %).

Following Lopez-Feldman (2012), the study analysed the proportional response to the amount of fist bid. In CV data analysis, it is important to check whether the respondents are sensitive to the bid amount presented to them and whether the given responses are in line with the theory. Table 4.12 below displays the rate of respondents' responses as the bid amount goes up.

Table 4.12: Proportional responses to the amount of bid 1

Bid 1						
	55		60		65	
Response 1	TD (100 %)	TD (50 %)	TD (100 %)	TD (50 %)	TD (100 %)	TD (50 %)
Yes	34 (94.44 %)	21 (72.41 %)	33 (94.29 %)	24 (77.42 %)	26 (72.22 %)	12 (46.15 %)
No	2 (5.56 %)	8 (27.59 %)	2 (5.71 %)	7 (22.58 %)	10 (27.78 %)	14 (53.85 %)

Source: Author's elaboration

The amount of the first bid was randomly presented to each respondent and the results show that the proportion of the respondents who said 'yes' to the first bid, when the programme would improve wastewater by 100 %, was 94.44 %, and 72.41 % for a 50 % wastewater improvement. The rate of the 'yes' response appears to decrease as the bid amount increases, and this is in line with an a priori expectation that the response would decrease with the amount of the bid increment, which shows that respondents were sensible to the bid amount, as expected. Furthermore, the results in Table 4.14 below show that for TD (50 %), 46 % of respondents answered 'yes', while about 54 % said 'no' to the highest bid. This response rate is attributed to the respondents' price sensitivity and also to the level of wastewater improvement. Respondents that said 'no' for the bid amounts for the programme that would improve water partially TD (50 %) gave as their reason that it was not worth the amount.

4.4.5.1.2 *Analysis of the second bid*

Before we proceed to the econometric estimation of WTP, and since the study used a double-bound CV approach, the next step is to present the distribution of the second bid amount. The second bid was given following the respondents' response to the first bid amount. If the respondents answered 'yes' to the first bid, they were then asked a WTP for the higher bid amount, and if they answered 'no' to the first bid, they were asked to answer a WTP question for the lowest bid amount. The results are presented in table 4.13 below.

Table 4.13: Proportional responses to the amount of bid 2

Response 2	TD (100 %)	TD (50 %)
Yes	93 (86.92 %)	20 (23.26 %)
No	14 (13.08 %)	66 (76.74 %)

Source: Author's elaboration

The above results show that about 87 % answered 'yes' to the second bid amount for TD (100 %) and 23 % answered 'yes' for TD (50 %). It can be noted from the results that about 77 % of respondents answered 'no' to the second bid amount for the programme that would improve wastewater by 50 %, and therefore the number of respondents who said 'no' to the second bid are not those who voted against the programme – those are the respondents who gave negative responses to the highest bid amount following the positive response to the first bid. Based on a follow-up closed-ended question, respondents were then asked to give reasons for 'no' answers to the bid. The study found that the main reason was that the programme is not worth the amount for TD (50 %) and for TD (100 %), with the main reason being the affordability of the bid amount.

4.4.5.1.3 *Econometric estimation of double-bounded model without control variables*

The doubled command displays the estimation of the WTP without control variables, and with control variables. For the model without control variables, the doubled command directly estimates $\hat{\beta}$, and then the WTP formula is $Z\hat{\beta}$. Therefore, the WTP with no control variables is the beta constant. However, following Lopez, Feldman (2012) the estimation allows checking whether the WTP value with no control variables changes too much when including control variables evaluated at their mean values. Table 4.14 in appendix 1.1 presents the WTP without control variables for TD (100 %) and TD (50 %), respectively.

The results on table 4.14 show that the average WTP with no control variables is approximately 68 Meticais and is statistically significant at 1 % level. The WTP at the lower bound was approximately 66 MTs, and at the upper bound it was approximately 70 MTs for TD (100 %) and for TD (50 %). The average WTP is approximately 60 MTs, which is significant at 1 % level. The WTP at the lower bound is about 59 MTs, and about 61 MTs at the upper bound. The next step is the estimation of WTP with control variables, and the results are presented in Table 4.15 below.

4.4.5.1.4 *Econometric estimation of double-bonded model with control variables*

The regression results will support the relationship between the explanatory variables and the WTP for irrigation water improvement. The likelihood ratio test of model fit produced a statistically significant probability chi-square of (P< 0.0056) for TD (100 %) and (p<0.0000) for TD (50 %), which implies that the models fits the data. The likelihood ratio statistics were statistically significant at 1 % level (x^2=47.89, p = 0.0056) for TD (100 %) and (x^2=53.51, p = 0.0000), which means that the models have robust explanatory power. The ML results for TD (100 % improvement) and TD (50 % improvement) are presented in Table 4.15 below.

Table 4.14: Maximum likelihood results of factors explaining households' WTP

	TD (100 %) model_1			**TD (50 %) model_2**		
Variable	**Coefficient**	**Std. Err.**	**z-stats**	**Coefficient**	**Std. Err.**	**z-stats**
Constant	70.88625***	10.65133	6.66	54.3902***	4.204488	12.94
Gender	-2.258907	1.68755	-1.34	-1.89779**	0.9424841	-2.01
Age	-0.1332656**	0.0601956	-2.21	0.0736462**	0.0355037	-2.07
HHsize (Household size)	-0.2768902	0.2361051	-1.17	–	–	–
NEWEduc2 (University degree)	-0.2505495	2.395606	-0.10	-1.974217	1.222072	-1.62
NEWEduc4 (Secondary school)	-0.367766	1.986393	-0.19	-1.386553	1.123286	-1.23
NEWEduc5 (High school)	-0.6550674	3.596024	-0.18	-3.255716***	0.9883253	-3.29
NEWINCO1(income bellow 5.000)	-7.294495 **	3.266913	-2.23	-	-	-
NEWINCO2 (Income btw 5000-15000)	-6.065794 **	2.642031	-2.30	0.9559522	2.483349	0.38
NEWINCO3	-3.201567	2.809652	-1.14	-	-	-
NEWINCO5	0.0527614	2.686459	0.02	-	-	-
NEWINCO6	0.8773431	4.066314	0.22	-	-	-
NEWQ15_11	1.147908	1.776797	0.65	3.561707	1.929243	1.85
NEWQ15_12	4.180177**	1.660304	2.52	5.078191***	1.918005	2.65
NEWQ16_52	-6.994017***	2.543106	-2.75	-	-	-
NEWQ16_53	-2.869813	3.586957	-0.80	-	-	-
NEWQ16_54	-9.710316 ***	3.257611	-2.98	-2.456129	1.563699	-1.57
NEWQ16_62	3.683665**	1.475372	2.50	1.711047**	0.8162521	2.10
NEWQ16_63	2.16918	4.381308	0.50	-	-	-

Q23_IMPORTSUPPLY	6.617352	3.500651	1.89	-	-	-
Q22_INADWSUPLY	6.899464	3.783042	1.82	5.554689**	2.151759	2.58
NEWQ26_1WNOSUITATALL1	-2.027809	2.880666	-0.70	0.5914083	0.9236844	0.64
NEWQ26_1WNOSUITATALL2	2.3487	2.401883	0.98	-	-	-
NEWQ26_1WNOSUITATALL3	4.760867	2.644765	1.80	3.491844**	1.622478	2.15
NEWQ26_2WSUITABLE1	-11.14613**	5.243202	-2.13	-	-	-
NEWQ26_2WSUITABLE2	-8.047304 **	3.654873	-2.20	-	-	-
NEWQ26_2WSUITABLE3	-5.127402	3.026474	-1.69	-	-	-
sec3_Q17	-	-	-	2.883071**	1.124063	2.56
NEWs4_Q21_12	-	-	-	-3.408753**	1.461617	-2.33
NEWs4_Q21_13	-	-	-	-3.115803	1.933293	-1.61
NEWs4_Q21_14	-	-	-	-3.211897**	1.634465	-1.97
NEWs4_Q21_15	-	-	-	-6.03525**	2.681786	-2.25
Sigma _Constant	2.907488 ***	0.4480583	6.49	3.166951	0.2869845	11.04
Number of observations	107			86		
Wald chi2(26)		47.89			-	
Wald chi2(19)		-		53.51		
Log likelihood		-50.511139		-123.53053		
Prob > chi^2		0.0056		0.0000		

Source: Author's elaboration.

*Note: *, **, and *** denote statistical level of significance at 10 %, 5 % and 1 %, respectively*

As observed from above results, the variables of Age, Average monthly income (bellow 5 000) and (between 5 000 and 15 000), and NEWQ15_12 dummy variable, refer to respondents who agreed that water is a scarce resource. The NEWQ16_52 dummy variable refers to respondents who agreed that farmers should use irrigation practices that conserve water, and the NEWQ16_54 dummy variable refers to respondents who disagreed that farmers should use irrigation practices that conserve water. The NEWQ16_62 dummy variable refers to respondents who agreed that the water distribution infrastructure should be improved to reduce water that is lost through leakages. The NEWQ26_2WSUITABLE1 dummy variable refers to respondents who strongly agreed that the water from the Infulene valley is suitable for vegetable irrigation, and the NEWQ26_2WSUITABLE2 dummy variable refers to respondents who agreed that the water from the Infulene valley is suitable for vegetable irrigation. These are the variables that significantly influenced the WTP for (100 %) wastewater improvements at Infulene valley. Therefore, for model 1, the coefficient of age has a negative sign and is statistically significant at 5 %, which is in line with expectation, since older people are less likely WTP for improvement in irrigation water than younger people are. This is in line with the findings by Fujita et al. (2005) and Jurado et al. (2012) which show that as the more people grow older, the more they fear investing in long-term programmes, thus reflecting in more WTP for younger people than older people.

The WTP of households with incomes ranging from 5 000 to 15 000 gave lower WTP bids ($\beta = -6.065794$) than those with other household income levels did, while households with incomes less than 5 000 per month were WTP, on average, much lower (β= -7.294495), as compared with households with higher income levels, which is consistent with the economic theory. Moffat et al. (2011) and Khan et al. (2010) have shown that the more income a household has, the more the household is WTP for improved water quality services.

However, the households who recognise water scarcity as an important issue (variable NEWQ15_12) are WTP positive amounts, which is expected since the water supply shortage is a problem in Maputo and Matola cities for drinking and irrigation purposes. Furthermore, respondents who agreed that farmers should use irrigation practices that conserve water (variable NEWQ16_52) were less likely WTP for irrigation water improvements, which is contrary to our expectations, since the irrigation practices that conserve water would improve the availability of water.

Moreover, for the model 2 TD (50 % improvement), the variables of gender and age are statistically significant at 5 % and these variables appear to have negative coefficients, so we can conclude that females are less likely WTP for vegetables irrigated with recycled wastewater. The same is true for older people, and these results are in line with findings by Menegaki et al. (2007) and Bakopoulou et al. (2009) which reveal that younger people are more WTP for products irrigated with recycled water, and that the probability of females being WTP for and use products irrigated with recycled water is less than that of males.

The NEWEduc5 dummy variable refers to respondents who had attained high school level education, and appears to have a negative coefficient, statistically significant at 1 %, so we can conclude that the respondent's education level decreases the probability of him/her being WTP, as one could expect that a higher level of education would imply a higher respondent WTP. This result is not surprising and we can say that this is a proof of sensitivity to scope effects because respondents were not indifferent to the level of water improvement, which in this case was partial TD (50 % improvement). These results are in line with findings of Menegaki et al. (2007) which show that educated people (those who had attained secondary school level) see recycled water as a lower quality by-product of fresh water, and hence they bid less. From another perspective, this result can be interpreted to the effect that respondents with low levels of education are most likely to give higher bids than secondary school and graduate respondents are.

The NEWQ15_12 dummy variable refers to those households who recognise the water scarcity as an important issue in both models TD (100 % improvement) and TD (50 % improvement), and this variable appears to be an important variable. The coefficients are positive for the two models and are statistically significant. These results show that if water is scarce in Maputo and Matola cities, the households are more likely to be WTP for irrigation water improvement.

The NEWQ16_62 dummy variable refers to households who agreed that the water distribution infrastructure should be improved to reduce water that is lost through leakages. This variable appears to be statistically significant at 5 % level and the coefficient is positive for the two models. This result shows that households recognise the loss of water through leakages as being an important issue and they are WTP positive amounts for irrigation water improvements.
The Q22_INADWSUPLY dummy variable refers to a household's awareness of the inadequate water supply in Maputo and Matola cities. The significance of this variable, and the positive

coefficient, means that respondents who recognise the inadequate water supply as a serious problem are WTP more for irrigation water improvements. Furthermore, the awareness of households, that it is possible for the government to collect wastewater, process it and make it available to households for reuse, is reflected by variable sec3_Q17, which has a positive coefficient and is statistically significant at 5 % level. This result points to a higher conscience of environmental matters and this will definitely determine the willingness of households to pay for vegetables irrigated with recycled wastewater in order to see that the irrigation water is ultimately improved.

The NEWs4_Q21_12 dummy variable refers to the households who agreed, the NEWs4_Q21_14 dummy variable to those who disagreed, and the NEWs4_Q21_15 dummy variable to those households that strongly disagreed, that wastewater reuse irrigation has potential health risks. These three variables appear to be statistically significant, at 5 % level, in influencing households' WTP and they have negative coefficients. We expected that the respondents who agreed that wastewater reuse has potential health risk to be WTP more for irrigation water improvement than their counterparts who either disagreed or strongly disagreed were. The sign of the health awareness variable NEWs4_Q21_12 is not in line with our prior expectation. This result is surprising, as Khan et al (2010) have indicated that a higher awareness about health problems implies that people would wish to pay more to avoid the health risks. Moreover, Ndunda et al. (2013), in their study on farmers' awareness of health risks in urban and peri-urban wastewater irrigation in Nairobi, Kenya, show that education has a high impact on risk awareness for indirect users since education helps indirect users to be open-minded and knowledgeable on the health risks of wastewater reuse for irrigation.

4.4.5.1.5 *The mean WTP at the mean values of variables*

To further analyse WTP for improved irrigation water at Infulene Valley by Maputo and Matola residents, the explanatory variables used in the double-bounded model were evaluated at their mean values. The purpose was to find their effect on mean WTP and to estimate the welfare change for Maputo and Matola residents attributable to a wastewater improvement programme. The results are presented below in Table 4.16 below.

Table 4.15: Mean WTP with mean values of explanatory variables

	TD (100 %)			TD (50 %)		
	Coefficient	Std. Err.	z-stats	Coefficient	Std. Err.	z-stats
WTP	67.8554***	0.8684554	78.13	59.76448***	0.3899668	153.26

Source: Author's elaboration.
*Note: *** denotes statistical level of significance at 1 %.*

The above results show that the mean WTP for irrigation water improvements from the double-bounded model was estimated to be 67.86 Meticais for TD (100 %) and 59.76 Meticais for TD (50 %), while the WTP without explanatory variables was estimated to be 67.85 Meticais for TD (100 %) and 59.74 Meticais for TD (50 %). This shows that when including explanatory variables evaluated at their mean values, the WTP value does not change too much. These results are consistent with prior expectations. The differences in WTP for the two models show that respondents were sensitive to scope effects, since they were WTP higher amounts for a 100 % improving programme than for the programme that would reduce emissions partially (50 % improvement). Moreover, the explanatory variables at their means have a positive and statistically significant influence on the mean WTP, at 1 % level of significance.

4.4.5.2 *Analysis of bottom-up responses*

Respondents were first asked to value 50 % in wastewater improvement, followed by a question on how much they would be WTP for a 100 % improvement.

4.4.5.2.1 *Analysis of the first bid*

The purpose of this section is to check whether the contingent valuation data used shows whether respondents are sensible to the bid amount, which will be shown by a lower proportion of 'yes' responses, as the bid amount increases. We expect that as the bid amount increases, the proportions of respondents that answer 'yes' will decrease. The analysis in Table 4.17 below shows the proportion of respondents that said 'yes' to the first bid amount.

Table 4.16: Proportional responses to the amount of bid 1

Response 1	BU (50 %)	BU (100 %)
Yes	60 (59.4 %)	97 (91.5 %)
No	41 (40.6 %)	9 (8.50 %)

Source: Author's elaboration

The distribution of bid 1 responses was analysed to determine the proportion of respondents that answered 'yes' to the first WTP question. The results show that about 59 % of respondents gave a positive response 'yes' to the first bid amount question for a 50 % improvement programme, and about 92 % for a 100 % improvement programme. About 41 % of respondents answered 'no' to the first valuation for BU (50 %), with the main reason given being that the programme that would improve wastewater partially was not worth the amount. However, the same respondents, when presented with the programme that would improve wastewater at a 100 % level, gave positive response to the WTP question. This implies that respondents were sensible to scope effects, since the majority gave a positive answer to the first WTP question for the programme that would improve the quality of irrigation water by 100 %.

Following Lopez-Feldman (2012), the study analysed the proportional response to the amount of the first bid. In CV data analysis, it is important to check whether the respondents are sensitive to the bid amount presented to them and whether the given responses are in line with the theory. Table 4.18 below displays the rate of respondents' responses as the bid amount goes up.

Table 4.17: Proportional responses to the amount of bid 1

Bid 1						
	55		60		65	
Response 1	BU (50 %)	BU (100 %)	BU (50 %)	BU (100 %)	BU (50 %)	BU (100 %)
Yes	32 (94.1 %)	36 (94.7 %)	17 (50 %)	32(91.4 %)	11 (33.3 %)	29 (87.9 %)
No	2 (5.9 %)	2 (5.3 %)	17 (50 %)	3 (8.6)	22 (66.7 %)	4 (12.1 %)

Source: Author's elaboration

The above results for both BU (50 %) and BU (100 %) show that as the bid amount increases, the probability of receiving positive responses decreases, which is in line with the theory. From the analysis, about 95 % of respondents answered 'yes' to the first bid for BU (100 %) and the proportion of 'yes' responses appears to decrease as the bid amount increases, for example when the bid was 65, the proportion of 'yes' responses decreased to 67 %.

For BU (50 %), the proportion of respondents who said 'yes' to the first bid amount was 94 %, and as the bid amount increases, the proportion of 'yes' responses appears to decrease. These results are consistent with the economic theory of a negative relationship between price and demand. This implies that as the amount of the initial bid increases, the likelihood that a respondent would say 'yes' as the bid value decreases and vice versa, implying that the respondents are sensible to increments in the bid amount.

4.4.5.2.2 *Analysis of the second bid*

Before we proceed to the econometric estimation of WTP, and since the study used a double-bound CV approach, the next step is to present the distribution of the second bid amount. The second bid was given following the respondents' response to the first bid amount. If the respondent answered 'yes' to the first bid, respondents were then asked a WTP the higher bid amount, and if they answered 'no' to the first bid, they were asked to answer a WTP question for the lowest bid amount. The results are presented in Table 4.19 below.

Table 4.18: Proportional responses to the amount of bid 2

Response 2	BU (50 %)	BU (100 %)
Yes	43 (42.6 %)	86 (81.1 %)
No	58 (57.4 %)	20 (18.9 %)

Source: Author's elaboration

The above results show that about 81 % of respondents answered 'yes' to the second bid amount for BU (100 %), while 43 % answered 'yes' for BU (50 %). It can be noted from the results that 57 % of respondents answered 'no' to the second bid amount for the programme that would improve wastewater at 50 %. However, the number of respondents who said 'no' to the second bid are not those who voted against the programme; those are the respondents who gave negative responses to the highest bid amount following the positive response to the first bid. Based on follow-up closed-ended question, respondents were then asked to give reasons for a 'no' answer to the bid. The study found that the main reason was that the programme is not considered to be worth the amount for BU (50 %), while for BU (100 %), the main reason was the affordability of the bid amount.

4.4.5.2.3 *Econometric estimation of double-bounded model without control variables*

The doubled command displays the estimation of the WTP without control variables, and with control variables. For the model without control variables, the doubled command directly estimates $\hat{\beta}$, and then the WTP formula is $Z\hat{\beta}$. Therefore, the WTP with no control variables is the beta constant. Table 4.20 in appendix 1.2 presents the WTP without control variables for BU (50 %) and BU (100 %), respectively.
The results show that the average WTP with no control variables is approximately 61 Meticais and is statistically significant at 1 % level. The WTP at the lower bound is approximately 60 MTs, and at the upper bound, it is approximately 61 MTs for BU (50 %) and for BU (100 %). The average WTP is approximately 69 MTs, which is significant at the 1 % level. The WTP at the lower bound is about 66 MTs, and about 71 MTs at the upper bound. The next step is the estimation of WTP with control variables, and the results are presented in Table 4.21 below.

4.4.5.2.4 *Econometric estimation of double-bonded model with control variables*

The regression results will support the relationship between the explanatory variables and the WTP for irrigation water improvements. The likelihood ratio test of model fit produced a statistically significant probability chi-square of ($P< 0.0032$) for BU (50 %) and ($p<0.0000$) for BU (100 %), which implies that the models fits the data. The likelihood ratio statistics were statistically significant at 1 % level (x^2=37.20, p = 0.0032) for TD (100 %) and (x^2=66.31, p = 0.0000), which means that the models have robust explanatory power. Some of the variables considered in modelling the factors that affect households' WTP for irrigation water improvements at Infulene Valley were: household size, age, gender, education, income, household future income certainty, the suitability of irrigation water at Infulene valley, risk awareness of wastewater reuse, the awareness of possibility that government can collect wastewater process it, and make it available to the households for reuse, the awareness that the Infulene Valley is an important supplier of fresh vegetables, and the awareness that water is a scarce resource. The ML results for BU (50 % improvement) and BU (100 % improvement) are presented in Table 4.21 below.

Table 4.19: Maximum likelihood results of factors explaining households' WTP

	BU (50 %) model_1			BU (100 %) model_2		
Variable	**Coefficient**	**Std. Err.**	**z-stats**	**Coefficient**	**Std. Err.**	**z-stats**
Constant	34.08765***	804.7106	0.04	101.8573	6.91518	14.73
Gender	-	-	-	5.50787***	1.343186	-4.10
Age	0.0752567 **	0.035375	2.13	-0.2117573***	.053934	-3.93
Q43_3HHSIZE5	1.059865**	0.425386	2.49	2.33888**	1.057869	2.21
Q43_1HHSIZE18	-	-	-	-1.573788***	0.475888	-3.31
NEWEduc2	4.994222***	1.734896	2.88	-1.549385	1.724776	-0.90
NEWEduc3	1.364434	1.812593	0.75	-	-	-
NEWEduc4	3.866138**	1.791781	2.16	-	-	-
NEWEduc5	-	-	-	-6.640966***	2.354823	-2.82
NEWINCOME2	-0.5680164	.995377	-0.57	-4.938375***	1.810414	-2.73
NEWINCOME3	-	-	-	-4.784549**	1.858581	-2.57
NEWINCOME4	-0.6256556	1.031088	-0.61	-	-	-
NEWINCOME5	-1.263661	1.318829	-0.96	-	-	-
Q48_HHFINCOME	-	-	-	-11.54196***	2.077747	-5.56
NEWQ26_1WNOSUITATALL1	1.589534	.8623917	1.84	2.038418	1.739719	1.17
NEWQ26_1WNOSUITATALL2	-	-	-	3.936793**	1.588134	2.48

NEWQ26_1WNOSUITATALL4	2.616081**	1.297149	2.02	-	-	-
NEWs4_Q21_12	-	-	-	-5.010868***	1.767498	-2.84
NEWs4_Q21_13	-	-	-	-9.631866***	2.727381	-3.53
NEWs4_Q21_23	-1.921174	1.13984	-1.69	-	-	-
NEWs4_Q21_25	-7.369775**	3.744381	-1.97	3.561707	1.929243	1.85
NEWs4_Q21_24	-1.742729**	0.8259146	-2.11	5.078191***	1.918005	2.65
NEWs4_Q21_42	-	-	-	4.558157**	2.28614	1.99
NEWs4_Q21_43	-	-	-	2.901306	1.769694	1.64
NEWs4_Q21_44	-	-	-	3.314907	1.712942	1.94
Q23_IMPORTSUPPLY	3.996217**	1.808219	2.21	-	-	-
NEWQ13_WSDserious4	1.60114	1.523832	1.05	-	-	-
Q22_INADWSUPLY	18.01084	804.6986	0.02	-	-	-
sec3_Q17	-2.282099**	1.077612	-2.12	-	-	-
Sigma _Constant	3.003388	0.2856608	10.51	2.971458	0.5104598	5.82
Number of observations	101			106		
Wald chi2(17)		37.20			-	
Wald chi2(18)		-		66.31		
Log likelihood		-114.11825		-49.550402		
Prob > chi^2		0.0032		0.0000		

Source: Author's elaboration.

*Note: *, **, and *** denote statistical level of significance at 10 %, 5 % and 1 %, respectively*

The results from the model 1 BU(50 %) show that, out of seventeen explanatory variables included in the model, nine were statistically significant, and these included Age, households with children below 5 years old, NEWEduc2 (university degree), NEWEduc4 (high school level), NEWQ26_1WNOSUITATALL4 (refers to households who disagree that water from Infulene Valley is not suitable at all for vegetable irrigation), and Q23_IMPORTSUPPLY (refers to awareness that Infulene Valley is an important supplier of fresh vegetables to Maputo and Matola cities). These last-named variables have positive and statistically significant effects on a households' willingness to pay for irrigation water improvements at Infulene Valley.

Three of the explanatory variables had a negative and statistically significant effect on WTP for irrigation water improvements, namely the NEWs4_Q21_25 dummy variable (refers to households who strongly disagreed that wastewater reuse irrigation leads to food contamination), the NEWs4_Q21_24 dummy variable (refers to households who disagreed that wastewater reuse irrigation leads to food contamination), and sec3_Q17 (refers to the households who are aware that it is possible for governments to collect waste water, process it and avail it to households for reuse). On the other hand, the rest of the explanatory variables included in the model were not statistically significant. The variable age of the respondent was found to be positively related with WTP for vegetables irrigated with recycled wastewater, which implies that older people were willing to pay more than younger people are, and this result is surprising. However, this can be explained by the fact that older people are more concerned about the current status of the irrigation water in the Infulene Valley, thus offering positive bids to see that the water used to irrigate vegetables is improved. Although the positive influence of age on WTP is considered peculiar, but it can be attributed to the households' concerns for their household members' health (Moffat et al., 2011).

Moreover, the households with children below 5 years old variable is statistically significant at 5 % and has a positive coefficient, which implies that those households who have children aged below 5 years old are more likely to be WTP than their counterparts are. However, this result was expected because households with young children are more careful about the health and other risks involved in contaminated improved irrigation products than their counterparts are. Menegaki et al. (2007) shows, in connection with willingness to visit a park irrigated with recycled water, that parents in households with children were more worried about the safety of food that the children eat, than the space they play in.

The NEWEduc2 dummy variable refers to the respondents who had attained university degree and NEWEduc4 to those who attained secondary school level, which appear to have positive coefficients and are statistically significant at 1 % and 5 % levels, respectively. This is in accordance with prior expectation that a higher level of education implies a higher WTP. These results are in line with findings of Bakopoulou et al. (2007) and Khan et al. (2010) which state that a higher education level implies higher WTP for improved services.

The NEWs4_Q21_25 dummy variable (refers to households who strongly disagreed that wastewater reuse irrigation leads to food contamination) and the NEWs4_Q21_24 dummy variable (refers to households who disagreed that wastewater reuse irrigation leads to food contamination) appear to be statistically significant at 5 % level and to have a negative effect on households' WTP. This implies that people who do not realise that wastewater irrigation has negative impacts are WTP less than their counterparts who agreed that irrigation with wastewater leads to food contamination are.

The results show that the dummy variable Q23_IMPORTSUPPLY (refers to respondents awareness that Infulene valley is an important supplier of fresh vegetables to Maputo and Matola cities) The significance of this variable, together with the positive coefficient, means that those who recognise the Infulene Valley as an important supplier of fresh vegetables to cities of Maputo and Matola are WTP more for products irrigated with recycled wastewater, in order to see that the Infulene Valley irrigation water is improved.

Moreover, the results for the model 2 BU (100 %) show that out of eighteen variables included in the model, thirteen were statistically significant and these included: Gender, age, households with children below 5 years old, households with people aged above eighteen, NEWEduc5 (High school level), household future income certainty, NEWINCO2 (Households with income ranging from 5 000 to 15 000), NEWINCO3 (Households with income ranging from 15 000 to 25 000), NEWs4_Q21_42 dummy variable (refers to households who agreed that wastewater reuse irrigation leads to soil degradation), NEWQ15_12 dummy variable (refers to the households who agreed that water scarcity as an important issue), NEWQ26_1WNOSUITATALL2 dummy variable (refers to the households who agree that the water from the Infulene Valley is not suitable at all for vegetable irrigation), NEWs4_Q21_12 dummy variable (refers to households who agreed that wastewater reuse irrigation has potential health risk), and NEWs4_Q21_13 dummy variable (refers to households who are neutral that wastewater reuse irrigation has potential health risk). The last-named variables have statistically significant effects on the households' WTP for irrigation water improvements at Infulene Valley.

The variable of gender was found to be negative and statistically significant at 1 % level. A significant difference was noted among the households of Maputo and Matola cities between males and females in their WTP. Female respondents were willing to pay less than their male counterparts were. These results are similar to the findings of Bayru (2004), Menegaki et al. (2007) and Bakopoulou et al. (2009) who in their studies also observed differences between male- and female-headed households' mean WTP.

The coefficient of the variable age has a negative sign and is statistically significant at 1 %, which is in line with prior expectation since older people are less likely to be WTP than younger people are. This is also in line with the findings of Fujita et al. (2005), Jurado et al. (2012) and Ndunda et al. (2013) which show that the older people grow, the more they fear investing in long-term programmes, thus reflecting in higher WTP by younger people in environmental improvements programmes, than for older people. An earlier study by Menegaki et al. (2007) also found that the variable of age is significant and concluded that younger people are more WTP and consume products irrigated with recycled water. These authors also asserted that younger people are more environmentally conscientious and consequently found that age was the factor that mainly determined the WTP in their study on the social acceptability and valuation of recycled water in Crete.

The variable for households with children below 5 years old is statistically significant at 5 %, with positive coefficient, which implies that those households who have children aged below 5 years old are more likely to be WTP than their counter parts are. However, this result was expected because households with young children are more careful about the health and other risks involved in contaminated improved irrigation products than their counterparts are. Menegaki et al. (2007) shows, in connection with willingness to visit a park irrigated with recycled water, that parents in households with children were more worried about the safety of food that the children eat, than the space they play in. This result is confirmed by the coefficient of the variable households with people aged above eighteen, which is negatively correlated with WTP for irrigation water improvement and is statistically significant at 1 % level.

The variables NEWINCO2 (Households with income ranging from 5 000 to 15 000) and NEWINCO3 (Households with income ranging from 15 000 to 25 000) were found to have negative signs and are statistically significant, meaning that poor households were WTP less than their wealthier counterparts were. This is in line with earlier studies by Fujita et al. (2005), Menegaki et al. (2007), Bakopoulou et al. (2009), Weldesilassie et al. (2009), and Kanayo et al. (2013) which concluded that a higher income would increase the probability for stating a higher WTP for improved services than a lower income will.

The NEWEduc5 dummy variable refers to respondents who had attained high school level education, and appears to have an unexpected negative coefficient and is statistically significant at 1 %. From this, we can conclude that respondents' education level decreases the probability their being WTP, notwithstanding that one would expect that a higher level of education implies a higher WTP. These results are in line with findings of Menegaki et al. (2007) who found in their study that EDUC3 people with secondary school level education had a negative coefficient and that EDU1 illiterate people had a positive coefficient. They concluded that farmers who had attained secondary school level education see recycled water as being a lower quality by-product of fresh water, and hence would bid less. Another perspective is that respondents with a low level of education are more likely to give higher bids than high school graduate respondents would.

The NEWQ26_1WNOSUITATALL2 dummy variable refers to the households who agree that the water from the Infulene Valley is not suitable at all for vegetable irrigation, and this variable was found to have a positive effect on WTP. This implies that there was a greater WTP for households who recognised that the water used at Infulene Valley is not proper for irrigation, thus biding more than their counterparts who are indifferent or disagreed. The significance of this variable indicates that the level of households' awareness of the current water used for irrigation is the most important determinant of WTP the amount for the proposed programme.

The NEWs4_Q21_42 dummy variable refers to households who agreed that wastewater reuse irrigation leads to soil degradation, and this variable appears to be significant at 5 % level, with positive sign. This means that people that recognise the reuse of wastewater as being a threat are more WTP for improved irrigation water.

4.4.5.2.5 *The mean WTP at the mean values of variables*

To further analyse WTP for improved irrigation water at Infulene Valley by Maputo and Matola residents, nonlinear combinations of parameters were run on all the independent variables used in the double-bounded model at their mean values. The purpose was to find the their effect on mean willingness to pay. The results are presented in Table 4.22 below.

Table 4.20: Mean WTP with mean values of explanatory variables

	BU (50 %)			**BU (100 %)**		
	Coefficient	**Std. Err.**	**z-stats**	**Coefficient**	**Std. Err.**	**z-stats**
WTP	60.56291***	6.55205	9.24	68.08536***	0.895359	76.04

Source: Author's elaboration.
*Note: *** denote statistical level of significance at 1 %.*

The above results show that the mean WTP for irrigation water improvement derived from the double-bounded model was estimated to be 60.56 MTs for BU (50 %) and 68.09 MTs for BU (100 %), while the WTP without explanatory variables was estimated to be 60.60 Meticais for BU (50 %) and 68.59 Meticais for BU (100 %). This show that when including explanatory variables evaluated at their mean values, the WTP value does not change too much. These results are consistent with prior expectations. The differences in WTP for the two models show that respondents were WTP higher amounts for a 100 % improvement programme than the programme that would reduce emissions partially (50 % improvement), which is proof of scope effects. Moreover, the explanatory variables at their means have positive influence and are statistically significant on mean WTP at 1 % level.

4.4.5.3 *Hypothesis test for internal sensitivity to scope*

The objective was to test whether the WTP within 244 surveyed respondents is influenced by the level of wastewater improvement. The study formulated the following hypothesis to determine the internal test of scope for top-down and bottom-up approaches. In order to determine the internal test of scope, two paired t-tests were performed on a sample of 121 households for a top-down approach, and on a sample of 123 households for a bottom-up approach. Test results are presented below in Tables 4.23 and 4.24, respectively.

4.4.5.3.1 *Top-down test*

H0: WTP TD (100 %) = WTP TD (50 %):
The mean WTP for 100 % wastewater improvement is equal to mean WTP for 50 % wastewater improvement.

Table 4.21: Paired t-test for top-down mean WTP

Variables	Observations	Mean	Std. Err.	Std. Dev.	95 % Conf. Interval	
WTP TD (100 %)	121	67.61778	0.4720889	5.192977	66.68308	68.55249
WTP TD (50 %)	121	60.80992	0.244515	2.689665	60.32579	61.29404
difference		6.807867	.4839109	5.32302	5.849757	7.765977

mean(diff) = mean(WTP1Td100 – WTP3Td50)
Ho: mean(diff) = 0
Ha: mean(diff) < 0 Ha: mean(diff) != 0 Ha: mean(diff) > 0
Pr(T < t) = 1.0000 Pr(|T| > |t|) = 0.0000 Pr(T > t) = 0.0000
t value = 14.0684
Degree of freedom = 120

Source: Author's elaboration

The households' mean WTP when respondents evaluated the programme that would improve wastewater totally TD (100 %), followed by the valuation of the programme that would partially improve TD (50 %) were: 67.86 MTs and 59.76 MTs, and are statistically significant at 1 % level. The paired t-test results show that the null hypothesis of no significant differences in the mean WTP for a top-down approach in the level of wastewater improvements was rejected, at 1 % level of significance. Therefore, the mean WTP TD (100 %) and mean WTP TD (50 %) are statistically significantly different, which result implies that respondents were WTP larger amounts for high quality of irrigation water, as opposed to lower quality. We can conclude, then, that respondents passed the top-down internal test of scope. Similar findings were reported by Bateman et al. (2004) and Czajkowski and Hanley (2009), who found that respondents passed the internal test of scope and that they were consistent with their responses.

4.4.5.3.2 *Bottom-up test*

H0: WTP BU (50 %) = WTP BU (100 %)

The mean WTP for a 50 % wastewater improvement is equal to mean WTP for 100 % wastewater improvement.

Table 4.22: Paired t-test for bottom-up mean WTP

Variables	Observations	Mean	Std. Err.	Std. Dev.	95 % Conf.	Interval
WTP BU (100 %)	123	71.71891	0.7348154	8.149498	70.26427	73.17355
WTP BU (50 %)	123	60.54165	0.2399434	2.661101	60.06665	61.01664
difference		11.17726	0.731674	8.114657	12.62568	9.72884

mean(diff) = mean(WTP4Bu100 – WTP2Bu50)

Ho: mean(diff) = 0

Ha: mean(diff) < 0 Ha: mean(diff) != 0 Ha: mean(diff) > 0

Pr(T < t) = 1.0000 Pr(|T| > |t|) = 0.0000 Pr(T > t) = 0.0000

t value = 15.2763
Degree of freedom = 122

Source: Author's elaboration

For the bottom-up approach, the survey found that the mean WTP BU (50 %) is 60.56 MTs and 68.09 MTs for BU (100 %) and that both are statistically significant at 1 % level. The null hypothesis of the equality of the mean WTP for the bottom-up approach was also rejected, at 1 % level of significance. Thus, the difference between mean WTP BU (50 %) and mean WTP BU (100 %) is not equal to zero. Based on this result, we can conclude that respondents' WTP is influenced by the level of wastewater improvement, since they were WTP larger amounts for the programme that would improve wastewater irrigation totally (100 %), than for partial improvements (50 %). These results imply that respondents were sensitive to scope effects, which leads this study to conclude that respondents passed the bottom-up internal test of scope. These findings are in line with the study done by Ndambire et al. (2016) which shows that the within respondent mean WTP for 25 % emission reduction first, followed by 50 % reduction, were sensitive to scope effects, since respondents were WTP larger amounts for larger emissions reductions.

4.4.6 *Sensitivity of WTP estimates to external scope effects*

The objective is to determine whether the WTP estimates are sensitive to scope effects, that is, whether WTP increases or decreases with the quality of the environmental good being valued (Hausman 1993; Svedsater 2000). Therefore, the external scope test analysed the between respondents bottom-up and top-down mean WTP for irrigation water improvement.

4.4.6.1 *Hypothesis test for external sensitivity to scope*

The objective was to test whether the WTP between surveyed respondents is influenced by the level of wastewater improvement. Therefore, the mean WTP for 121 respondents who were asked to value 100 % wastewater improvement first, and the mean WTP for 123 respondents who were first asked to value 50 %, were then estimated and compared. The following hypothesis was formulated. In order to determine the internal scope test, two unpaired t-test were performed on a sample of 121 households for the top-down approach, and on a sample of 123 households for the bottom-up approach.

(A) H0: WTP TD (100 %) = WTP BU (50 %)
(B) WTP BU (100 %) = WTP TD (50 %)

The mean WTP for 50 % wastewater improvement is equal to mean WTP for 100 % wastewater improvement between respondents. The test results are presented below in Tables 4.25 and 4.26, respectively.

Table 4.23: unpaired t-test on external test (A)

Variables	Observations	Mean	Std. Err.	Std. Dev.	95 % Conf.	Interval
WTP TD (100 %)	121	67.61778	0.4720889	5.192977	66.68308	68.55249
WTP BU (50 %)	123	60.54165	0.2399434	2.661101	60.06665	61.01664
Combined	244	64.05071	0.3473609	5.425951	63.36649	64.73494
diff		7.076137	0.527027	-	6.037991	8.114283
diff = mean(WTP1Td100) – mean(WTP2Bu50)						
Ho: diff = 0						
Ha: diff < 0		Ha: diff = 0		Ha: diff > 0		
Pr(T < t) = 1.0000		Pr(|T| > |t|) = 0.0000		Pr(T > t) = 0.0000		
t value = 13.4265						
degrees of freedom = 242						

Source: Author's elaboration

According to the results presented in Table 4.16 for the top-down valuation, and in Table 4.23 for the bottom-up valuation, respondents were, on average, WTP 67.86 MTs for TD (100 %) and 59.76 MTs for TD (50 %); 68.09 MTs for a 100 % wastewater improvement BU (100) and 60.56 MTs for a wastewater improvement of 50 % BU (50 %). The results show that WTP for a 100 % improvement is higher than for partial improvement of 50 %. For the equality of mean WTP of in between respondents, the null hypothesis was rejected at 1 % level of significance (t=13.43, p=0.0000)

Table 4.24: unpaired t-test on external test (B)

Variables	Observations	Mean	Std. Err.	Std. Dev.	95 % Conf.	Interval
WTP BU (100 %)	123	71.71891	0.7348154	8.149498	70.26427	73.17355
WTP TD (50 %)	121	60.80992	0.244515	2.689665	60.32579	61.29404
Combined	244	66.30912	0.5231848	8.172408	65.27856	67.33968
diff		10.90899	0.7795684		9.373386	12.4446
diff = mean(WTP4Bu100) – mean(WTP3Td50)						
Ho: diff = 0						
Ha: diff < 0		Ha: diff = 0		Ha: diff > 0		
Pr(T < t) = 1.0000		Pr(|T| > |t|) = 0.0000		Pr(T > t) = 0.0000		
t value = 13.9936						
degrees of freedom = 242						

Source: Author's elaboration

The results presented show that WTP for a 100 % improvement is higher than for partial improvements of 50 %. Regarding the equality of mean WTP for in between respondents, the null hypothesis was also rejected at 1 % level of significance (t=13.99, p=0.0000). This implies that the mean WTP estimates for irrigation water improvements for between respondents were sensitive to scope effects, and accordingly the respondents passed the external scope test. These results are in line with findings reported by Mitchell and Carson (1993), Whitehead et al. (1998), and Ndambire et al. (2016). Figure 4.1 below shows the WTP for improved irrigation water at the Infulene Valley.

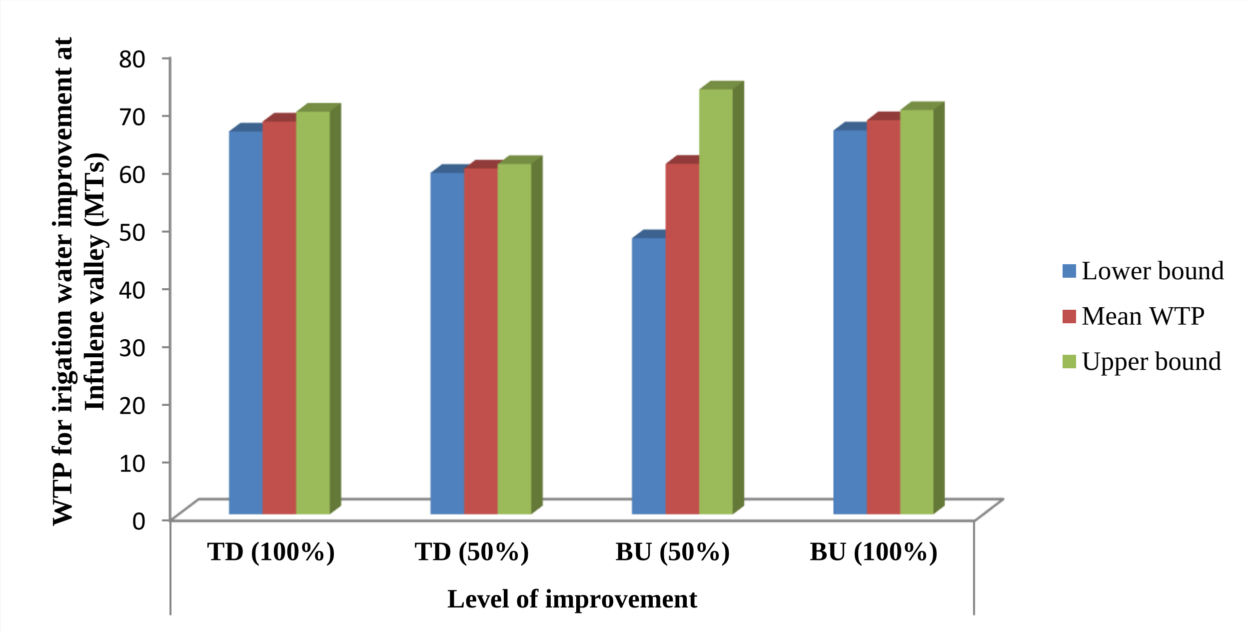

Figure 4.1: WTP for wastewater improvements at Infulene Valley

Source: Authors elaboration

From the above figure, it can be concluded that respondents' mean WTP was the highest when the level of improvement was BU (100 %), at 68.09 MTs, followed by TD (100 %) at 67.9 MTs. The lowest mean WTP was recorded when the level of improvement was partial, at about 59.8 MTs for TD (50 %). Thus, we can conclude that the mean WTP is influenced by the level of wastewater treatment, since respondents were WTP larger amount for a total improvement programme. The two paired tests for mean WTP statistical comparison within respondents and the unpaired test for mean WTP statistical comparison between respondents confirmed that respondents passed the internal and external scope effects test, thus the non-significant differences in the mean WTP null hypothesis was rejected at the 1 % significance level.

4.4.7 *Assessing quality of the survey*

In order to ensure that the study is reliable for policy implementation purposes, the interviewer, at the end of the survey questionnaire, answered debriefing questions to evaluate the level of understanding and the reliability of the responses given by the interviewee. The purpose of this was to evaluate the overall performance of the questionnaire. The results for this analysis are presented in Table 4.27 in appendix 1.

The levels of understanding of the interviewee were presented in the following order: very well understood, well understood, understood, not understood, and not at all understood. To evaluate the reliability of the interviewee responses, the options presented are: very reliable, quite reliable, reliable, not quite reliable, not reliable, and not at all reliable. We also asked the interviewee to scale responses using a Likert scale with the following choices: strongly agree, agree, neutral, disagree, and strongly disagree of the statement whether the results of the study would influence policies relating to the management of wastewater at the Infulene Valley.

The above evaluation results suggest that, generally, the respondents understood the questionnaire, including the valuation scenario, since the statistical analysis shows that 67 % of respondents understood the questions, while 30 % of respondents fell into the category that they understood the questions well, and very few respondents fell in the category of not understood (2 %).

Furthermore, we assessed the reliability of the given responses and the results show that 88.52 % of the given responses were reliable, while 7.34 % were quite reliable, and 2.87 % were not quite reliable. From these results, we can conclude that the questionnaire reached the desired outcome, as the final assessment shows that over 80 % of respondents either agreed or strongly agreed that this study would influence wastewater management policies.

4.4.8 *Concluding summary*

The analysis presented in this study provides evidence that households in Maputo and Matola have high levels of knowledge of the problem of water supply shortages that affect urban and peri-urban households. The variables of education, gender and income were found to be statistically important in influencing a respondent’s knowledge of the management of the water supply shortage problem in Maputo and Matola cities. The results suggest that this knowledge is stimulated by education, which indicates that educated people are more likely to have higher levels of knowledge on the management of the water supply shortage. The households also seem to have high levels of awareness and knowledge that potential policy measures should be implemented by the city to mitigate the water supply shortage problems that the people of Maputo and Matola cities currently suffer. However, there were relatively low positive responses to the policy measures regarding water restrictions for consumption and irrigation uses, even though the respondents have clear knowledge about the water supply shortages problems. They seem to be not aware that the excessive use of water for both domestic and productive uses can worsen the water supply status. Again, the variable of education was important in increasing the likelihood of knowing about policy measures to manage water supply shortages.

The study showed that the respondents factually know about the threats affecting water supply, and the problem of management of water supply shortages. Therefore, the study asked questions to explore the respondents' attitudes towards the reuse of recycled wastewater because of the fact that wastewater reuse is a possible policy option for mitigating the above-mentioned problem. It can be confidently reported, based on the results, that respondents are familiar with, and have positive attitudes towards, recycled wastewater reuse. This brings this study to conclude that wastewater reuse is a possible policy option for mitigating the consequences of increased water demand. The variables of education and income appear to have influence on the respondents' attitudes and perceptions towards recycled wastewater reuse for irrigation. This is not surprising since the reuse of wastewater for irrigation is widely adopted for irrigation in urban and peri-urban areas, and this is also common in Maputo and Matola cities, and it is essential for the livelihoods of low-income households.

Regarding the potential treats related to wastewater irrigation, the study found that the awareness of challenges regarding recycled water reuse for irrigation is independent of education and age. The majority of respondents recognise that the Infulene Valley is an important supplier of fresh vegetables, and they are aware of the production system used by farmers. However, the irrigation water from the valley is generally not suitable for vegetable irrigation without policy intervention, and the current irrigation water from the Infulene Valley should be improved before being reused. Regarding the improvement programme presented, the study found that 85 % of respondents voted for the programme, which shows that residents of Maputo and Matola find the proposed scenario credible, along with the proposed payment vehicle.

The survey found that the mean WTP TD (100 %) was 67.86 MTs, and 59.76 MTs for TD (50 %), while for the bottom-up approach, the survey found that the mean WTP BU (50 %) was 60.56 MTs, and 68.09 MTs for BU (100 %). The paired t-tests show that the null hypothesis of no significant differences in the mean WTP for top-down and bottom-up approaches in the level of wastewater improvements was rejected, at 1 % level of significance. Based on these results, this study has concluded that respondents were WTP larger amounts for the programme that would improve wastewater irrigation totally, as opposed to partial improvements. These results imply that the respondents were sensitive to scope effects. Hence, the respondents passed the top-down and bottom-up internal tests of scope. Moreover, for the external test of scope, the unpaired t-test also rejected the null hypothesis of equality of mean WTP between respondents, therefore respondents passed the external test of scope.

The analysis of the financial and debriefing questions also gives high confidence that the households do support the proposed programme for improving the irrigation water so as to be suitable for vegetable irrigation. This conclusion is supported by the high rate of positive responses of support and the level of understanding of the programme, which is reflected in the WTP for it, implying that the respondents seek to have the problems that they actually face solved.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This study was designed to ascertain whether WTP estimates are sensitive to variations in the quality of irrigation water improvements in the Infulene Valley. The study also established the respondents’ levels of knowledge, attitudes and perceptions concerning the water supply shortages problems. The attitudes, opinions and perceptions of the respondents towards recycled wastewater reuse were also captured in the analysis.

Various statistical analyses were performed in this study. The robustness of the statistical results on the respondents’ knowledge, perceptions and attitudes was investigated through the use of Chi-square tests and the one-way Analysis of Variance (ANOVA) to verify the potential influence of socio-economic characteristics, namely gender, age, education and income, on the above-mentioned constructs of knowledge, perceptions and attitudes. To estimate the mean WTP for irrigation water improvement, the study employed a double-bounded bid elicitation format. The data was collected from a random sample of 244 households, split into two according to the level of irrigation water improvement (top-down and bottom-up samples). Further statistical tests were performed using t-tests to assess the statistical difference within and between respondents mean WTP estimates (internal and external test). This chapter summarises the overall key conclusions, recommendations, policy implications, limitations, and suggested future research.

5.2 CONCLUSION

The study results have shown that households in Maputo and Matola cities have high levels of knowledge of the water supply shortages problems and of the policy instruments that the municipality should implement to mitigate the problems. The households also demonstrated high levels of knowledge and positive attitudes toward recycled wastewater reuse. The households of Maputo and Matola cities have attitudes and perceptions that are receptive to a police that improves the status quo of the Infulene Valley.

Socio-economic factors, namely education level, gender and income, have a significant positive influence on households' knowledge, perceptions and attitudes towards recycled wastewater reuse for irrigation. The results show that Maputo and Matola residents were willing to pay positive amounts towards irrigation water improvements.

A number of socio-demographic characteristic were found to significantly influence households' mean WTP for irrigation water improvements. The mean WTP for irrigation water improvement, when households valued a 100 % improvement and a 50 % improvement (top-down and bottom-up), was positive and statistically significant.

Therefore, the mean WTP was the highest when respondents valued a 50 % improvement, followed by how much they WTP for 100 %, BU100 % (68.09 MTs per household), followed by the mean WTP when respondents valued 100 % improvement, followed by how much they WTP for 50 % improvement, TD100 % (67.86 MTs per household), and WTP BU50 % (60.56 MTs) when respondents valued 50 %, followed by 100 % improvements, and the lowest was when respondents valued 50 % improvement, followed by 100 % TD 50 % (59.76 MTs per household). The study results showed that respondents were WTP larger amounts for the programme that would improve wastewater totally, as opposed to partial improvements. Thus, respondents were sensitive to scope effects, and they passed top-down and bottom-up internal tests, as well as an external test of scope, which results are consistent with economic theory that states that welfare estimates should be sensitive to the levels of changes of the valued environmental good.

The basic conclusion emerging from this study is that households indicate an acceptance of the usage of recycled wastewater; therefore, farmers will agree to use it and consumers will purchase products related to it. The results also make a novel contribution to the CV literature regarding scope effect tests and ultimately support the studies that passed internal and external test of scope. The study found the use of CV approach to be suitable in the socio-economic setting of urban and peri-urban households. In this survey, very little protesting behaviour was found, and this is because the respondents were given policy option choices.

5.3 RECOMMENDATIONS AND POLICY IMPLICATIONS

Recently, the economic developments that have occurred in Maputo and Matola cities, as well as increasing urbanisation and high population growth, have led to an unbalanced demand and supply for water and pollution problems. Therefore, the need for recycled water to be used in irrigation and for other uses stems from water supply shortages problems, and this requires that recycled wastewater should be made safe for use in irrigation.

This study has shown that households place a substantial value on water quality from the Infulene Valley and are WTP for, and participate in a programme that provides, improvements to the status quo. On the basis of the above-mentioned findings, the study makes the following recommendations:

- The Maputo and Matola City Council should establish a legal framework to require recycled water usage. If the price for providing recycled water were to be incorporated into fresh water pricing, this would ultimately drive more people to use it as a replacement for fresh water for agriculture irrigation, and for other uses. This is because the provision of safe recycled water has monetary implications for treatment and maintenance.

- The municipal authorities should use the estimated mean WTP as a benchmark for the budget and water policy proposals for wastewater treatment, and this should also be adjusted to the households' socio-economic characteristics that the study found to be important in determining the WTP decision. This is because, in addition to economic efficiency, any charge should be based on households' socio-economic characteristics, namely gender, ability to pay, poverty status and location, amongst others,

- The study has shown that households ranked highest the programme that would improve irrigation water totally (100 %), therefore the effort of providing safe irrigation water could be achieved through programmes aimed to improve sanitation infrastructure by government and other stakeholders. Moreover, the government should involve urban and peri-urban farmers in wastewater management, as well as investing in programmes (education and information) that aim to increase farmers' awareness of health risks associated with untreated wastewater reuse.

5.4 LIMITATIONS OF THE STUDY AND SUGGESTED FUTURE RESEARCH

The contingent valuation method has been proven to provide reliable estimates for non-market values, but faces several limitations, namely:

- The data used to estimate the mean WTP of the two subsamples does not represent the total urban and peri-urban residents of Maputo and Matola. It only reflects 82 urban and 162 peri-urban residents.

- The survey only includes Maputo and Matola residents and does not incorporate the residents of nearby cities who might also see value in the Infulene Valley. It is highly likely that residents of surrounding districts, such as Boane, Moamba and Maracuene, also value the resource.

Therefore, continued research on other possible causes for the problems of excessive contamination in the Infulene Valley should also be explored. An interesting area for future socio-economic studies would be to calculate the cost and benefit of the provided pollution reduction. This could allow different attributes of the good to be valued, as well as provide incremental values for improved water quality in the Infulene valley. Using another method, such as Choice Experiment method (CE), to compare with the results from this study would also be informative. More studies with a sample that covers almost the majority of residents are required to further our understanding of the welfare benefits of reducing health and environmental risks that arise from polluted water, and such studies may produce true total welfare values.

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APPENDICES

Appendix1.1: Table 7.1: The double-bounded model without control variables

	BU (50 %)						**BU (100 %)**					
	Coefficient	**Std. Error**	**z**	**P>z**	**95 % Conf. interval**		**Coefficient**	**Std. Error**	**z**	**P>z**	**95 % Conf. interval**	
Beta _ Constant	60.60174	0.423784	143.0	0.000	59.77114	61.43234	68.58518	1.252345	54.77	0.000	66.13063	71.03973
Sigma_Constant	3.754602	0.3475352	10.80	0.000	3.073445	4.435758	6.36934	1.025317	6.21	0.000	4.359756	8.378925
Number of observations	=	101	**Log likelihood** -130.21562				**Number of observations** = 106		**Log likelihood** = -76.745872			

Source: Author's elaboration

Appendix1.2: Table 7.2: The double-bounded model without control variables

	BU (50 %)						**BU (100 %)**					
	Coefficient	**Std. Error**	**z**	**P>z**	**95 % Conf. interval**		**Coefficient**	**Std. Error**	**z**	**P>z**	**95 % Conf. interval**	
Beta _ Constant	60.60174	0.423784	143.0	0.000	59.77114	61.43234	68.58518	1.252345	54.77	0.000	66.13063	71.03973
Sigma_Constant	3.754602	0.3475352	10.80	0.000	3.073445	4.435758	6.36934	1.025317	6.21	0.000	4.359756	8.378925
Number of observations	=	101	**Log likelihood** -130.21562				**Number of observations** = 106		**Log likelihood** = -76.745872			

Source: Author's elaboration

Appendix1.3: Table 0.1: The analysis of survey instrument

Statements/Questions	Options	Top down	Bottom up	Total
How well do the interviewee understood the questions	Very well understood	1 (0.83)	3 (2.44)	4 (1.64)
	Well understood	36 (29.75)	36 (29.27)	72 (29.51)
	Understood	81 (66.94)	82 (66.67)	163 (66.80)
	Not understood	3 (2.48)	2 (1.63)	5 (2.05)
	Not at all understood	0 (0)	0 (0)	0 (0)
What was the rate of reliability of the responses given by this interviewee	Very reliable	0 (0)	2 (1.63)	2 (0.82)
	Quite reliable	11 (9.09)	7 (5.69)	18 (7.34)
	Reliable	106 (87.60)	110 (89.43)	216 (88.52)
	Not quite reliable	3 (2.48)	4 (3.25)	7 (2.87)
	Not reliable	1 (0.83)	0 (0)	1 (0.41)
	Not at all reliable	0 (0)	0 (0)	0 (0)
The results of this study will influence policies related to wastewater management in the Infulene valley	Strongly agree	19 (15.70)	28 (22.76)	47 (19.26)
	Agree	81 (66.94)	80 (65.04)	161 (65.98)
	Neutral	19 (15.70)	13 (10.57)	32 (13.11)
	Disagree	2 (1.65)	2 (1.63)	2 (1.64)
	Strongly disagree	0 (0)	0 (0)	0 (0)

Source: Author's elaboration

Appendix 2: Letter of consent

Informed consent for participation in an academic research study

Department of Agricultural Economics, Extension and rural development

Scope effects in contingent valuation: an application to the valuation of irrigation water quality improvements in Infulene Valley, Mozambique

Research conducted by: Graca Manjate (13367499)

Cell: (Moz) +258 827052750/ (SA)+27 (0) 73 9817144

Email: gracamanjate@gmail.com

Dear respondent

You are invited to participate in an academic research study conducted by Graca Manjate, Master student in the Department of Agricultural Economics, Extension and Rural Development at the University of Pretoria. The purpose of the study is to estimate the willingness to pay of residents of Maputo and Matola municipality for irrigation water improvements in Infulene valley as basis for policy recommendations on suitable wastewater management.

Please note the following:

This is an academic research and information will be used primarily for that purpose. Answers you give will be treated as strictly confidential. Your name will not appear in the questionnaire. Therefore the respondent will not be identified in person based on the information provided.

1. Your participation in this study is very important to us. You may, however, choose not to participate or stop participating any time without any negative consequences.
2. Your selection as one of the respondents is through a random sampling process.
3. Please answer the questions in the questionnaire as completely and honestly as possible.
4. The result of the study will be used for policy formulation and academic purposes only, and may be published in an academic journal. We will provide you with a summary of our findings on request.
5. Please contact our study leader, Prof Eric Mungatana on tel. +27 124 203253 (email: eric.mungatana@up.ac.za) if you have any questions or comments regarding the study.

Please sign the form to indicate that:

1. You have read and understood the information above.
2. You choose to participate on the study voluntarily.

Respondent's signature………………………………. Date ……………………………..

Appendix 3: Questionnaire

Scope effects in contingent valuation: an application to the valuation of irrigation water quality improvements in Infulene Valley, Mozambique

Questionnaire Number		hhID
Place of interview		Loc
Date of interview		intdate
Demographic dimension:	Urban [1]	Peri-urban [2]
Time	Start:	End:

SECTION 1: RESPONDENT INFORMATION

1. **Gender**		2. **Age**	3. **Role in the household**		4. **Education level**	
Male	[0]		Head of household	[1]	No formal education	[1]
Female	[1]	……..	Spouse of the head	[2]	University	[2]
			Child of the head	[3]	Primary	[3]
			Parent of the head	[4]	Secondary	[4]
			Other (specify) ………… ………..	[5]	Other (*specify*)…………..	[5]

HOUSEHOLD HEAD INFORMATION

Instructions to interviewer: If respondent is the household head, skip this section.

5. **Gender**	6. **Age**	7. **Education level**
Male [0] Female [1]	……...	No formal education [1] University [2] Primary [3] Secondary [4] Other [5] (*specify*)…………..........

SECTION 2: CONSUMERS KNOWLEDGE AND PERCEPTIONS TOWARDS MANAGEMENT OF WATER SUPPLY SHORTAGES IN MAPUTO/MATOLA CITIES

The purpose of this section is to collect general information about your personal knowledge, attitudes and perceptions towards water supply shortages in cities of Maputo and Matola.

8. **Household's main source of water**: Which of the following are the main sources of water for your household? The **main source** is where you draw your water regularly.
   - In-house water supply from tap [ ]
   - Well [ ]
   - Borehole [ ]
   - Neighbours tap [ ]
   - Water tanker/bowser [ ]
   - Rain water [ ]
   - Others (specify) …………………………………………

9. In the past 12 months, did your household experience water supply shortages from the main source of supply? Yes [ ] No [ ]

10. If YES, when did your household last experience a water supply shortage? Specify month…………

11. The last time your household experienced a water supply shortage, how many days did it last? ....days

12. How did your household cope with the water supply shortage?
    1. We accessed water from a tanker/bowser
    2. We restricted water use to only domestic uses
    3. We used rain water
    4. We used water drawn from a well
    5. Others (specify) ……………………………………

13. What degree of seriousness would you place on the problem of water supply shortages in Maputo/Matola cities?

1. Very serious 2. Serious 3. Neutral 4. Less serious 5. Not serious

14. Do you expect the problem of water supply shortages to persist in future?

Yes [ ] No [ ] Not sure [ ]

15. Please rate on a scale of 1 (strongly agree) to 5 (strongly disagree) the extent to which you agree or disagree with the following statements regarding water supply shortages in Maputo and Matola cities.

Statement	**Strongly agree (1)**	**Agree (2)**	**Neutral (3)**	**Disagree(4)**	**Strongly disagree (5)**
1. Water is a scarce resource.					
2. Maputo/Matola cities should enact policies to address **CURRENT** water supply shortages					
3. My household can use the same amount of water even if the price of water was to double					
4. We are all responsible to use water carefully.					
5. My household will reduce water use if the price of water was to double.					
6. I would like to stay informed about Maputo/Matola cities water supply shortage issues.					
7. My household is willing to use less water to help other households in my community to have access to water.					
8. Farmers should learn to reduce the amount of water they use for irrigation					
9. Maputo/Matola cities should enact policies to address **FUTURE** water supply shortages					

16. The following statements describe potential policy measures the cities of Maputo/Matola could use to manage water supply shortages. Please rate on a scale of 1 (strongly agree) to 5 (strongly disagree) the extent to which you agree or disagree with the following statements designed to address the problem.

Statement	**Strongly agree (1)**	**Agree (2)**	**Neutral (3)**	**Disagree(4)**	**Strongly disagree (5)**
1. The City should implement communication and education campaigns to raise household awareness of strategies to reduce amount of water consumed per day.					
2. The City Council should **pass laws** that require households to conserve water for example a law that requires households to **install water-saving shower heads.**					
3. The City Council must install technologies that collect effluent water from households, cleanse the effluent water to a level that is safe for human re-use, and return it to households for reuse.					
4. The City Council should appropriately price water to avoid water wastage by households who think water is cheap.					
5. Farmers should use irrigation practices that conserve water (e.g. drip irrigation)					
6. The water distribution infrastructure should be improved to reduce the water that is wasted through leakages.					
7. The city should restrict water supply to households to **six** days a week					
8. The city should restrict water supply to households from **seven** to **five** days a week					
9. Farmers should be prohibited from use water for irrigation					

SECTION 3: CONSUMERS KNOWLEDGE, ATTITUDES AND PERCEPTIONS TOWARDS RECYCLED WASTEWATER REUSE

The purpose of this section is to reveal whether the respondent is familiar with wastewater reuse.

17. Are you aware that it is possible for governments to collect waste water, process it to a level that is safe for human use, and avail it to households for reuse? Yes [ ] No [ ] **(If YES go to Q18 and if NO, go Q20 in Section 4)**

18. If YES, where did you learn that waste water can be collected, processed and reused by humans?
    1. Newspapers/magazines
    2. School
    3. Television
    4. Government agencies
    5. Others (specify) ……………………………………

19. Please rate on a scale of 1 (strongly agree) to 5 (strongly disagree) the extent to which you agree or disagree with the following statements regarding wastewater reuse.

	Strongly agree (1)	**Agree (2)**	**Neutral (3)**	**Disagree (4)**	**Strongly disagree (5)**
1. Recycled water should be used for industrial processes. E.g. cooling water for power plants and oil refineries					
2. Recycled water should be used for agricultural irrigation of food crops. E.g. vegetables					
3. Recycled water should be used to irrigate areas that humans use for recreation including parks, lawns and sport fields and school fields					
4. Recycled water should be used for domestic uses E.g. car wash, and garden/lawn irrigation					
5. Recycled water should be used for groundwater recharge					
6. Recycled water should be used for construction activities. E.g. concrete mixing					
7. Recycled water should be used to create or enhance wetlands					
8. Reusing wastewater reduces the pollutants discharged in the environment E.g. oceans, rivers, and other water					
9. Reusing wastewater has potential health hazards for human beings					

SECTION 4: WASTEWATER REUSE FOR IRRIGATION

You may not be aware that countries exist that have been known to collect waste water, process it to a level that is safe for some human uses and supply it back to households for re-use. In the European Union, United States of America, Australia, India and Middle East, water reuse for irrigation purposes is growing practice. In Israel more than 65% of the total municipal sewage production is reused for irrigation purposes. In France is considered a traditional practice which is used to irrigate golf course and landscape areas in addition to agricultural irrigation purposes. Recent technological advances have reduced the technical and economic barriers to reusing wastewater. Example of the country that the utilization is for direct potable reuse is Namibia, which the rivers are over 700 kilometres from Windhoek.

20. Following from the above examples, suppose the city government in Maputo and Matola collected waste water, processed it to a level that is safe for irrigation and offered it for reuse. Rate on a scale of 1-5 the extent to which you agree with the following statements.

Statement	**Strongly agree (1)**	**Agree (2)**	**Neutral (3)**	**Disagree (4)**	**Strongly disagree (5)**
1. I will be happy buying vegetables irrigated by recycled wastewater.					
2. I will be happy washing my car with recycled wastewater.					
3. I will be happy using recycled wastewater in my toilet, if that would be possible					
4. I will be happy using recycled wastewater in my garden and filling ornamental ponds					
5. I will be happy using recycled wastewater for fish and farming					

Specify any other use: …………………………..

21. Please indicate the extent to which you agree with the following challenges regarding treated wastewater reuse in irrigation.

Statement	Strongly agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly disagree (5)	I don't Know (6)
1. Wastewater reuse irrigation has potential health risk E.g. dysentery, diarrhoea						
2. Wastewater reuse irrigation leads to food contamination						
3. Wastewater reuse irrigation leads to groundwater contamination						
4. Wastewater reuse irrigation leads to soil degradation E.g. land salinity and land sealing						

SECTION 5: IMPROVED WASTEWATER IRRIGATION IN THE INFULENE VALLEY

Interviewer: Maputo is relatively dry, with a short rainy season and due to its location on the Indian Ocean coast, it is vulnerable to climate shocks. The main source of water supply to Maputo/ Matola residents is FIPAG (from the Umbeluzi river) while other residents obtain their water supplies from digging wells and boreholes. According to (USAID, 2008), more than half of the urban residents in Maputo do not have access to adequate water supply (i.e. enough water is not available whenever residents would like to use it)

Question (22): Are you aware that more than half of the urban population in Maputo and Matola do not have access to adequate water supply?

1=YES [ ] 2=NO [ ]

Interviewer: In addition to commercial activities in Maputo/Matola, agricultural activities are well developed in the Infulene Valley (i.e. the Maputo green belt)

<u>Question (23)</u>: Are you aware that Infulene Valley is an important supplier of fresh vegetables to Maputo/ Matola residents?

1=YES [ ] 2=NO [ ]

<u>Question (24)</u>: In your view, **<u>do the majority of vegetable farmers</u>** in the Infulene Valley exclusively use **<u>rain</u>** for growing their vegetables or they **<u>irrigate</u>**? *(encircle an appropriate option)*

If the answer is **<u>IRRIGATE</u>**, go to Q26. Otherwise continue with Q25.

<u>Interviewer</u>: even when farmers use rain water to grow their vegetables, during seasons of extreme drought, they may decide to use available water from Infulene valley for irrigation rather than abandon farming.

<u>Question (25)</u>: Do you agree that during seasons of extreme drought, farmers may decide to use available water from Infulene valley for irrigation rather than abandon farming? 1=YES [ ] 2=NO [ ]

<u>Question (26)</u>: Please indicate the extent to which you agree or disagree with the following statements on scale of 1 to 5 that best describes current suitability of the water from the Influene valley for vegetable irrigation.

Statement	**Strongly agree (1)**	**Agree (2)**	**Neutral (3)**	**Disagree (4)**	**Strongly disagree (5)**
1. The water from the Infulene valley is **<u>not suitable</u>** at all for vegetable irrigation					
2. The water from the Infulene valley is **<u>suitable</u>** for vegetable irrigation					
3. It does not matter to me whether the water from the Infulene valley is suitable for vegetable irrigation or not					
4. The water from the Infulene valley is **<u>not suitable</u>** for vegetable irrigation					
5. The water from the Infulene valley is **<u>very suitable</u>** at all for vegetable irrigation					

<u>Interviewer:</u> As you may expect, the water from the Infulene valley might be subjected to different sources of pollutants because of untreated sewage it receives from the municipality districts through the drainage channel as well as untreated domestic sewage, thus placing human health and environment in danger. In this research, I would like to describe a plan that will enhance the quality of water flowing through the river thus making it safe for humans and the environment. If this plan is approved, the Municipality will collect water from the valley, process it in a modern wastewater treatment plant and then pump it back to the valley, where it can be used for various purposes including irrigation by farmers.

Picture (A) shows how Infulene valley looks like before implementation of the plan (at the moment).

From the picture you can see that the Infulene valley is receptacle of untreated sewage from different sources this lead to water pollution and ultimately the negative impacts associated with it.

Picture (B) shows how the water in Infulene valley is going to look like in the future (after implementation of the plan).

As you can see in the picture, after the plan has been approved the wastewater will receive treatment, the pollution will be reduced, resulting in clean and healthy water.

This water is suitable to irrigate crops that are consumed by people.

Question (27): In your view, is it possible to implement a project that improves the quality of water in the valley from State A to State B?

1=YES [ ] 2=NO [ ]

Interviewer: This is how the proposed plan will be operationalized:

- The government of Mozambique will fund construction of the proposed treatment plant.
- To ensure the proposed treatment plant provides waste water treatment services continuously, the Municipality will levy a charge on farmers who will might want to use safe and recycled water from the Infulene Valley for irrigation.
- The purpose of this charge would be general maintenance and management of the water treatment plant once it is in use.
- A regular audit will be conducted by Ministry of Finance to ensure the funds collected are only used in the waste water treatment plant.

Question (28): Do you believe the Government of Mozambique and the Municipality have the capacity to implement such a plan?

1=YES [ ] 2=NO [ ]

Interviewer: However, imposing the charge on treated irrigation water on **farmers** would imply that the cost vegetable **consumers** will pay will also increase. In this research, we are interested in knowing whether you would be willing to accept higher prices for vegetable in support of the proposed project.

So far we have found that some vegetable consumers are willing to accept higher prices in support of the project, others are not willing to accept higher prices in support of the project, while others are undecided. Those who accept higher prices state that the project is worth the money to guarantee human health and environmental safety. Those who reject it state that the project is not worth the money. The proposed project will only be implemented if the number of vegetable consumers voting for it is greater than the number voting against it). Remember that upon the implementation of this project, your household income and expenditure will be affected.

Question (29): Would you vote for the program? 1=YES 2= NO

Interviewer: If NO go to Q35, if YES continue with Q30.

Question (30): Suppose the final cost estimates showed that instead of vegetable costing 50Mt for a bunch, they will cost 55Mt (i.e. an extra 5Mt per bunch). Would you vote FOR the project? 1. Yes [go to 31] 2. No [go to 33]

Question (31): Suppose it turned out that the true total cost is 57.5Mt extra per bunch of vegetables (i.e. an extra 7.5Mt per bunch). Would you vote FOR the project? *(encircle an appropriate option)*

1. Yes [go to 32], 2. No [go to 32]

Question (32): What encouraged you to vote for the proposed program? *(encircle an appropriate option)*

1. It will reduce health problems
2. It will reduce water pollution
3. It will improve irrigation water
3. Others (specify)

Question (33): Suppose that the final cost estimates to improve the quality of recycled wastewater from A to B showed that the vegetables will cost 52.5 Mt per bunch (i.e. an extra 2.5Mt per bunch). Would you vote FOR the project? *(encircle an appropriate option)*

1. Yes [go to 34]. 2. No [go to 35]

Question (34): What encouraged you to vote for the proposed project? *(encircle an appropriate option)*

1. It will reduce health problems
2. It will reduce water pollution
3. It will improve irrigation water
3. Others (specify) …………………………………………

<u>Question (35)</u>: Why did you vote against the proposed project? *(encircle an appropriate option)*

1. It is not worth the amount
2. I cannot afford it
3. It will only protect one river channel
4. Others (specify) ………………………………………………

<u>Interviewer:</u> Suppose it turns out that the proposed plan can only improve the quality of the water as shown below:

Picture (A) shows how Infulene valley looks before implementation of the plan (at the moment).


Picture (B): If we put this plan into place, this is how infulene valley would look like.

<u>Question (36)</u>: Would you vote for the program? 1=YES 2= NO

<u>Interviewer:</u> If NO go to Q42, if YES continue with Q37

<u>Question (37)</u>: Suppose the final cost estimates showed that instead of vegetable costing 50Mt for a bunch, they will cost 55Mt (i.e. an extra 5Mt per bunch). Would you vote FOR the project? *(encircle an appropriate option)*

1. Yes [go to 38], 2. No [go to 40],

<u>Question (38)</u>: Suppose it turned out that the true total cost is 57.5Mt extra per bunch of vegetables (i.e. an extra 7.5Mt per bunch). Would you vote FOR the project? *(encircle an appropriate option)*

1. Yes [go to 39], 2. No [go to 39]

<u>Question (39)</u>: What encouraged you to vote for the proposed program? *(encircle an appropriate option)*

1. It will reduce health problems
2. It will reduce water pollution
3. It will improve irrigation water
3. Others (specify)

<u>Question (40)</u>: Suppose that the final cost estimates to improve the quality of recycled wastewater from A to B showed that the vegetables will cost 52.5 Mt per bunch (i.e. an extra 2.5Mt per bunch). Would you vote FOR the project? *(encircle an appropriate option)*

1. Yes [go to 41]. 2. No [go to 42]

<u>Question (41)</u>: What encouraged you to vote for the proposed program? *(encircle an appropriate option)*

1. It will reduce health problems
2. It will reduce water pollution
3. It will improve irrigation water
3. Others (specify) ……………………………………

<u>Question (42)</u>: Why did you vote against the proposed program? *(encircle an appropriate option)*

1. It is not worth the amount
2. I cannot afford it
3. It will only protect one river channel
4. Others (specify) __________________________

SECTION 6: SOCIOECONOMIC AND FINANCIAL STATUS OF THE HOUSEHOLD

43. Number of people in this household
    1. > 18 years ....
    2. 6 - 18 years ....
    3. < 5 years ....

44. Do you think that your household can afford basic needs for food and water?

Yes, always	[1]
It is sometimes difficult	[2]
No	[3]

45. Which of the following statements would best describe your family's financial situation?
    1. We have no money even for food
    2. We have money for food but we cannot pay for public utilities (e.g. water and electricity)
    3. We can afford food and public utilities but it is difficult for us to buy clothes

4. We have money for food, clothes, footwear and public utilities but cannot afford buying durable goods
5. We can also afford buying durable goods (e.g. fridge or a TV-set)

46. You consider yourself as:
    1. Rich
    2. With middle level of income
    3. Poor
47. Household monthly average income level?

1= below 5.000 Mt 2= 5.000-15.000 Mt

3= 15.000-25.000 Mt 4= 25.000- 35000 Mt

5= 35.000-50.000 Mt 6= above 50.000 Mt

48. Is the household head certain about her/his future income? 1=Yes 2= No

SECTION 7: DEBRIEFING QUESTIONS

The following analysis will help pinpoint specific problems in the questionnaire; as well confirm whether the questionnaire performed well in most cases.

49. How well do you think the interviewee understood the questions? Rank in order of comprehension, (1– the interviewee clearly understood 5– the interviewee did not understand at all)

Level of understanding	**Rank**
Very well understood	
Well understood	
Understood	
Not understood	
Not at all understood	

50. How do you rate the reliability of the responses given by this interviewee? Please rank in order of reliability in the following table.

Level of understanding	**Rank**
Very reliable	
Quite reliable	
Reliable	
Not quite reliable	
Not reliable	
Not at all reliable	

51. Give reasons for your responses to question (49) and (50) above

……………………………………………………………………………………………………

…………………………………………………………………..

52. To what extent do you agree with the following statement with (1 – strongly agree to 5 – strongly disagree)?

“The results of this study will influence policies related to wastewater management in the Infulene valley.”

- Strongly agree [1]
- Agree [2]
- Neutral [3]
- Disagree [4]
- Strongly disagree [5]

End of interview, thank you very much for your time and for participating in this survey!