INVESTIGATING CONSUMER WILLINGNESS TO PAY FOR IMPROVEMENTS IN WATER SERVICE ATTRIBUTES IN AND AROUND VUWANI TOWN, SOUTH AFRICA

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DECLARATION

I, Rasimphi Mokgadi Grace, do hereby declare that the dissertation "Investigating Consumer Willingness to pay for improvement of water service attributes in and Vuwani Town, South Africa" for a Master of Commerce degree in Economics at the University of Venda has not been previously submitted in part or in full, for a degree at this or any other institution except where due acknowledgement has been made. It is a product of my own investigation, and all reference material contained therein have been fully acknowledged and a list of references is given.

Signature Rasimphi M.G **Date 06/March/2023**

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ABSTRACT

Water scarcity is a major problem in South Africa given the country's classification as "water stressed" and the thirtieth driest country in the world. Moreover, and like many other developing countries, the country faces severe challenges with the reliability of water supplies. These challenges includes but are not limited to, the frequency of water supply, low water pressure and poor water quality among other challenges. Although these challenges impose difficulties in the country in general, they impose a severe burden in rural settings and outlying towns such as Vuwani town and the surrounding villages in Limpopo. To this end, this study investigates the willingness to pay (WTP) by households of the Vuwani town and surrounding villages in respect of potential improvements of attributes of a water service. The study also sought to uncover potential heterogeneity in the preferences for improvements of attributes of a water service. Using the Conditional and Mixed Logit models, and a sample of 230 households, the study's findings indicated evidence of respondents expressing willingness to pay for improvements in the attributes of a water service in Vuwani. The results also demonstrated strong evidence of preference heterogeneity among the respondents as well. Since the findings of the study makes it possible to estimate the potential benefits of an improved water service in Vuwani, the results of the study should provide local policy makers with evidence based information of one component of a potential cost – benefit analysis study necessary to inform the potential level of investments required to improve water services in rural settings.

Key words: **Willingness to pay, attributes of a water service, choice modeling**, **discrete choice experiments.**

LIST OF ABBREVIATIONS

ABSCM	Attribute Based Stated Choice Methods
CLM	Conditional Logit Model
CM	Choice Modeling
CVM	Contingent Valuation Method
DCE	Discrete Choice Experiments
DWAF	Department of water and forestry
DWS	Department of Water and Sanitation
EV1	Extreme Value Type 1 Distribution
GHS	General Household Survey
HEV	Heteroscedastic Extreme Value
IDP	Integrated Development Plan
IIA	Independence of Irrelevant Alternatives
IID	Independent and Identically Distributed
MLM	Multinomial Logit Model
MWTP	Marginal Willingness to Pay
MXL	Mixed Logit Model
NGOs	Non-Governmental Organizations
NWA	National Water Act
NWL	National Water Law
NWSA	National Water Service Act
RP	Revealed Preferences Method
RPL	Random Parameter Logit Model
RUM	Random Utility Model
RUT	Random Utility Theory
RWS	Rural Water Supply

SAG	South African Government
SP	Stated Preferences Method
TEV	Total economic value
WRM	Water Resource Management
WSA	Water Service Authority
WSP	Water Service Provider
WTP	Willingness to Pay

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CHAPTER 1.

1.1 INTRODUCTION

The provision of quality water to all communities is essential for human health and well-being. However, according to Mahirah, Kuna & Azlina (2018) almost 1 billion people in the developing countries still do not have access to water, and 4 billion people in the world still live without reliable access to safe water supply. The World health Organisation (2017) further asserts that around 1 in 10 or 630 million people all over the globe do not have access to safe and clean water.

From a South African perspective, the provision of quality water is also important for economic development and the realisation of the constitutional rights of all South Africans. In spite of this however, distinct inequalities characterise domestic access to readily available and safe water in South Africa's private dwellings, off site or nearby in terms of provincial and national spread (Statistics South Africa, 2022). For example, the proportion of households that have water in their dwellings (nearby, on-site or off-site) in 2021 was highest among households in the provinces of the Western Cape, Gauteng and Free State at respectively 99.4%, 98.4% and 93.6%. The Eastern Cape and Limpopo provinces had the lowest proportion of households having water similarly defined at 71% and 69.4% respectively. At a national level, the proportion of households having access to water over the same period was 88.7% (Statistics South Africa, 2022).

These notable improvements however, masks the fact that while access to water actually improved between 2002[1] and 2010/12, it started to decline thereafter (2010/12 to 2021) at a national level and in all the provinces but the provinces of the Western Cape and Gauteng (Statistics South Africa, 2022). While these two provinces recorded percentage point increases of 0.6, and 1.2 respectively, there was a -1.3 percentage point decline at a national level in terms of access to water period (Statistics South Africa, 2022). While the other seven provinces experienced decreases in proportions of households having access to water from 2010/12 to 2021, the provinces of the Eastern Cape and Limpopo recorded the most pronounced decreases. For example, while access to water peaked at 84% in the Limpopo province in 2010 and at 79.2% in the Eastern Cape in 2012, the percentage of

[1] The year 2002 onward represents the period in which Statistics South Africa (StatsSA) started recording household access to water consistently.

household having access to water had declined in both provinces to 69.4% and 71% respectively by 2021. These declines respectively represented percentage point declines of 14.6 and 8.2 from the peak access levels of 2010 (Statistics South Africa, 2022).

Limpopo province's decline in access to water is the most pronounced of all provinces and this development takes on disturbing proportions when one takes into account that 73.8% of Limpopo's households had access to water in 2002. The fact that 69.4% of the Limpopo province's households had access to water in 2021 means that over the reporting period, the Limpopo province has recorded a 4.2 percentage point (or 6%) decline in access to water between 2002 and 2021 (Statistics South Africa, 2021). It is noteworthy however that the number of households (the basic unit of service delivery) in the Limpopo province have increased over the same period from 1.121 million in 2002 to 1.684 million in 2021 (Statistics South Africa, 2022). Nevertheless, the 6% decline in access to water between 2002 and 2021 is disturbing since it suggests a reversal of sorts as far as the gains of democracy are concerned when it comes to a resource so crucial to human health.

The decline in the proportion of Limpopo households that had access to tap or pipe water in their yards or dwellings from 2002 to date also finds resonance in its various categories of municipalities and towns, including the Vuwani town. For example, and using the latest household data from the 2011[2] census conducted when the Vuwani town still fell under the Makhado local municipality, out of an estimated population of 516 031 and 143 889 households in the Makhado local municipality, only 16 % of households had access to piped water in their dwellings (or yards). However, Vuwani town, with a population of 2 800 and 710 households fared much better since 48.2% of its households had access to tap water in their yards (Statistics South Africa, 2021).

Vuwani Town's access to piped water then, although lower in terms of national and provincial water access levels (that is at 88.2% and 82.9% respectively), was however much better than that of its surrounding villages. For example, Ha-Ṋesengani which is the most populated village located immediately to the north, northwest and west of the Vuwani town with an estimated population of 13 951 people and 3 603 households, had 19% of its households connected to piped water in their yards. On the other hand,

[2] StatsSA, the country's premier statistical agency conducts a census every ten years with the latest one conducted in 2021. However, StatsSA have yet to release the results of the 2021 census.

Nngwekhulu, a village located immediately to the south of Vuwani town only had 0,8% of its 126 households connected to piped water while Ha-Davhana, located even further south of the Vuwani town with a population of 6 686 and 1 713 households had 11,3% of its households connected to piped water (Statistics South Africa, 2011).

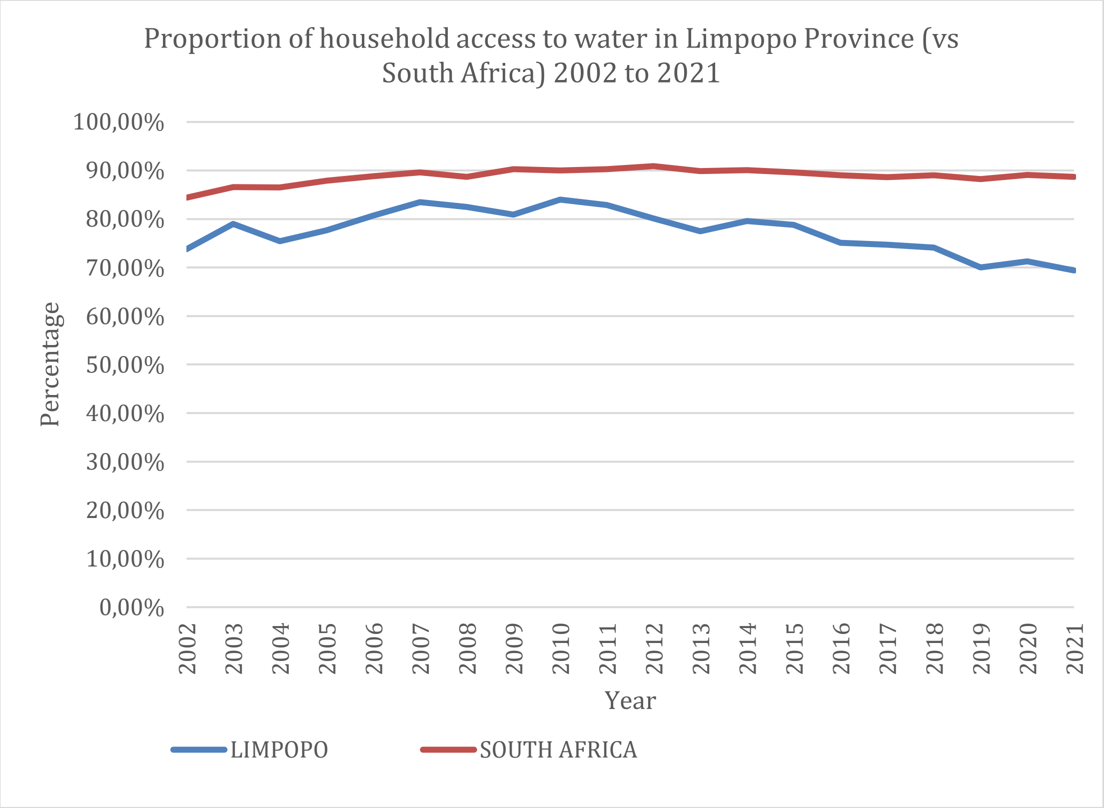

Figure 1.1: Household access to water in limpopo and South Africa – 2002 to 2021

Given the foregone discussion, it comes as little surprise that Vuwani town's residents including those from immediate surrounding villages (hereafter, Vuwani) have consistently experienced challenges (or difficulties) with the level of their water service[3]. As a result, Vuwani residents have frequently engaged in service delivery protests, which at times have also turned violent, to express their displeasure to this state of affairs.

Water supply, refuse removal, sewerage treatment and other services that local residents receive is the competence of the local government. However, many local governments have not always lived up to the expectations of residents when it comes to service delivery and this includes the Collins Chabane Local Municipality[4], which

[3] This refers to satisfaction with the frequency, quality and quantity of water supply among other dimensions.
[4] There currently are still issues around the status of Vuwani in terms of which local authority it falls under (i.e. is it the Makhado Local Municipality, the Collins Chabane Local Municipality or the Vhembe District Municipality?) because of other political

serves Vuwani. The result has been that residents have often experienced water supply interruptions. These interruptions often occur over extended periods of time, if not for days with obvious negative consequences for residents and ironically, the local authority (municipality) as well. This is because lack of service delivery generally translates into residents not paying for services. This is not sustainable in the long term for municipalities iven that municipalities on average derive 42% of their revenues from service charges[5], the payments of which local municipalities relies upon for their operations.

It is important to note however, that interruptions to water service delivery may occur due to several other reasons. This include but are not limited to (a) unanticipated emergencies, (b) planned maintenance or, (c) inadequate capital investments. If however, the frequency, timing and duration of the interruptions resulted from inadequate investments, increases in the level of investments in the associated infrastructure may mitigate, if not completely eliminate the associated service delivery interruptions. However, residents may face higher costs and potentially, higher service charges, if the local authorities increase investment levels to improve the service delivery infrastructure.

If water service boards and municipalities understand the residents' perceptions and preferences of water services, it would enable them to address the needs and concerns of residents more accurately, thus potentially leading to overall improvement in water services. Therefore, in order to determine the appropriate levels of investment that are required to improve service delivery infrastructure, information on the residents' willingness to pay (WTP) for the attributes of service delivery improvements is required. The study therefore investigates the potential WTP for improvements in water attributes of water service by Vuwani town residents including residents from surrounding villages (and hereafter, Vuwani). Over and above providing information on household WTP for improvements in water service attributes, researchers use the estimated WTP coefficients of the water service attributes to quantify the benefits likely to accrue to the residents of Vuwani because of the resulting improvements in water service attributes. Policy makers can then use the information on the benefits of an

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developments, a state of affairs that may be resolved in due course. Until that happens, the Collins Chabane Local Municipality will be the default local municipality for Vuwani.

[5] According to Statistics South Africa (2018), the major source of income for all municipalities in the country is service charges (which account for 42% of all revenue). This is followed by grants and subsidies (28%), property rates (18%), and other income (12%).

improved water service when conducting a cost-benefit analysis to improve water services in Vuwani.

1.2 PROBLEM STATEMENT

According to Hall, Van Koppen & Van Houweling (2014), the right to safe and clean drinking water and sanitation is a human right that is essential for the full enjoyment of life and all human rights. However, many developing countries, including South Africa continue to rely on unimproved water services, which are often characterised by erratic water supplies, poor quality of water and low water pressure among others (Snowball, Willis, & Jeurissen (2007), Kanyoka, Farolfi, & Moradet (2008) & Dikgang, Mahabir, & Murwirapachena (2017)).

Section 27 of the South African constitution, adopted in 1996, provides for the desired level and quality of a minimum standard of a water service. In this regard, section 27(1)(b) of the constitution accords every citizen; the right of access to sufficient water. Furthermore, section 27(2) of the same constitution requires the State to take reasonable legislative and other measures, within its available resources, to achieve the progressive realisation of the right. According to the then Department of Water Affairs and Forestry (1994), sufficient water relates to the quality and quantity of water required to satisfy basic domestic needs. Furthermore, the quantity of water relates to the minimum amount of water that is required to meet basic needs. On the other hand, the quality of water relates to the minimum standards acceptable to consumers in terms of health related characteristics. Thus, water quality implies that drinking water should be free from adverse substances such as toxins, bacteria and other harmful substances. This qualification is necessary because drinking water, which is safe, is an essential part of the human diet and is necessary for survival, and should therefore, be within acceptable standards concerning portability (i.e. taste, appearance and odour). Finally, such water should also be safe enough for food preparation, bathing, and for washing laundry (Department of Water Affairs and Forestry, 1994).

According to the Water Services Act (1997), a basic water service must ensure the supply of potable water to a formal water connection point at the boundary of a yard/ stand, or a public institution (school, clinic, hospital, etc.) with the lowest volume available per household. The Minister responsible for the water portfolio determines the ideal level of water services deemed sufficient to meet the basic daily domestic need for potable water, which is metered, tariffed and guarantees constant quality. To this end and pursuant to the passage of the 1997 Water services Act, the Minister responsible for the water portfolio, determined that every South African household shall be entitled to a minimum volume of 6000 liters (or 25 liters per person per day) of portable water household per month. Additionally, the water shall be available for a period of at least 350 days per year without interruption, and for longer than 48 consecutive hours.

However, and in spite of the constitutionally guaranteed right to access to water the constitution guarantees to the South African citizens, the reality on the ground has been very different for most of them, particularly those in rural settings like Vuwani. This is because residents of Vuwani already expreince access levels to water that are far much lower than those at the national and provincial level as the foregone discusion has already demonstrated. Poor access to water as per the nationally defined standard may lead to citizens exploring alternative options which may include the use of contaminated water, or water that is of a poor quality. Contaminated and/or poor quality water has the potential to expose citizens to preventable health rinks including the potential transmission of diseases such as cholera, diarrhoea, dysentery, hepatitis A, typhoid and polio (World Health organisation, 2017). When state institutions intervene, as they should, this has the potential of putting a strain on already stretched financial resources.

Despite the fact that residents may go for lengthy periods without access to their constitutionally guaranteed water service standard, they do not resign themselves to their fate, but instead make alternative arrangements to obtain water. Some of these alternatives includes but are not limited to buying water from water vendors or buying water from neighbours that have borehole water, etc. Household attempts to not only pursue alternative arrangements, but also implement them to source water is an expression of willingness to pay for this resource. It is this expression among other things, which provides the motive for this study to seek to determine the potential willingness of Vuwani residents to pay for improvements in the water service attributes.

1.3 AIMS OF THE STUDY

1.3.1 General aim of the study

The aim of this study is primarily to investigate Vuwani residents' WTP for improvements in the attributes of a water service, and use the study findings to make relevant policy recommendations.

1.3.2 Specific aims.

The specific aims of this study are to:

(a) estimate the Vuwani households' WTP for improvements of water service attributes,

(b) quantify the benefits of an improved water service in Vuwani; and

(c) propose appropriate policy recommendations.

1.4 STUDY HYPOTHESES

Initial focus group discussions with selected residents within the study area have established the following as far as water services are concerned.

(a) On many occasions, water is not readily available in Vuwani. When water is available, its frequency of availability is hard to predict. At other times, water may be available once every two weeks while at other times, water may not be available for up to a month, if not longer.

(b) During the times when the water is available, it comes out very slowly from the taps. This is usually a sign of low or inadequate water pressure.

(c) Even when the water is available, it is often has colour and tends to blemish garments when directly applied, particularly those garments that have lighter colours. At times, the water would also have unpleasant odour, all of which potentially talks to poor water quality.

The study therefore will test the following hypotheses:

a) An increase in the *frequency of water availability* will be positively related to the WTP for improvement in the attributes of water services in Vuwani.

b) An increase in the *water pressure* will be positively related to the WTP for improvement in the attributes of water service in Vuwani.

c) An increase in the *quantity of water* will be positively related to the WTP for improvement in the attributes of water service in Vuwani.

d) An Increase in the *water quality* will be positively related to the WTP for improvement in the attributes of water service in Vuwani.
e) An Increase in the availability of *water for productive* purposes will be positively related to the WTP for improvement in the attributes of water services in Vuwani; and finally
f) An increase in the *monthly cost of water* will be negatively related to the WTP for improvement in the attribute of water services.

1.5 SIGNIFICANCE OF THE STUDY

South Africa is among the 30th most water-stressed countries in the world (Ngam, 2020) and as a result, water is generally a scarce commodity, which has economic, sociocultural,[6] and in some instances, political dimensions[7] as well. Furthermore, access to water in South Africa used to be rooted along racial lines. For example, at the dawn of democracy in 1994, not only was 98% of available water already fully allocated (WWF, 2017), but also, access to water was rooted on the riparian principle, which granted water rights to those having title to land (Tewari, 2009). Effectively this meant that whenever a river was flowing through someone's property, it belonged to that person until it exited his/her property only to belong to the next and subsequent legal landowners downstream. In view of the many discriminatory laws governing land ownership in the country, this meant that those who faced the brunt of the country's racist policies (i.e. the majority in South Africa) were already on the back foot when it came to access to water. The passage of the National Water act, 36 of 1998, which removed the privatisation of water, a hallmark of Apartheid South Africa, finally put in place measures to address this skewed situation.

Before the 1980s, policy makers approached household water provision primarily from the supply side resulting in the International Water Supply and Sanitation Decade

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[6] Some communities in Limpopo make offerings (to ancestors) in water bodies such as Lake Fundudzi (e.g. The Vhangoṋa and Vhaṭavhatsindi of Tshiavha) and other pools such as the Phiphidi waterfalls (The Ramunangi clan) and Tshiswavhathu pool (The Mamphwe clan) in terms of their sociocultural beliefs, thus rendering water very important to them beyond its basic uses.
[7] As an example, there are currently some serious disagreements between Egypt and Sudan (downstream states) and Ethiopia (an upstream state) which some commentators believe may lead to an all-out warover Ethiopia's construction of the Grand Ethiopian Renaissance Dam (GERD) (since completed) on the Blue Nile (one of the major tributaries of the Nile River). In South Africa, the Heligoland-Zanzibar treaty of 1890, which settled boundaries among other things between the German and British empires in Africa, resulted in the border between South Africa and Namibia not being the centre of the then Orange (now Xhariep) River as is the case with other river-based boundaries. The border is actually the high water mark on the north bank (i.e. the Namibian side). This effectively means that Namibia only has rights to the waters of the Xhariep River when it is in full flood, something that is a very infrequent if not a rare occurrence. To date, the South African government has ignored all attempts to renegotiate this river border.

placing a greater focus on the demand side of water provision (Webster, 1999 and Nam & Son, 2005). Despite this, it is only lately that studies devoted to the improvement of various water service attributes such as water quality, frequency of water supplies and water pressure among other attributes, have started to attract the interests of researchers. As such, evidence based research in this area is important since improvements in the attributes of a water service can be directly linked to the consumers' WTP and hence, to price and welfare changes (Snowball et al, 2008 and Dikgang et al, 2017).

The results of this study will achieve among other things, the following outcomes: (a) Reveal the preferences of Vuwani residents and the surrounding villages as far as improvements of water service attributes are concerned. (b) Provide policy relevant information on the willingness to pay for improvements of attributes of a water service; and (c) Provide evidence based information to local government policy makers, the evidence of which would contribute to ensuring optimal levels of investments in water service infrastructure. Such investments will go a long way in minimising water service challenges as well as ensuring that residents are able to have their constitutionally guaranteed rights of access to safe and clean water. Knowing the preferences of Vuwani residents for water service attributes is important because it guides policymakers and water service providers in understanding which attributes they should consider and focus on when planning for future improvements of water services (Kamaludin, Shaari & Ibrahim, 2019).

1.6 STUDY DELIMITATION

Water service challenges are widespread across South Africa and they are not limited to Vuwani. Frustrations with the challenges often lead to service delivery protests with the frequency of such protests increasing. For example, the year 2019 saw two hundred and thirty seven (237) service delivery protests related to the households' dissatisfaction with local government's poor record of delivery versus two hundred and eighteen (218) in 2018 (Media24, 2020). Although the focus of this study is on WTP for improvements of attributes of water services in Vuwani as opposed to the same across the whole country, with some adjustments, the rural character of the study makes it possible for the results to be generalisable across other rural settings in South Africa. Furthermore, the study utilises primary data (survey data). Because of financial constraints, convenience sampling is used. Finally, although a water service may have many attributes, this study only confines itself to the attributes that a pre-test found relevant to Vuwani residents and for which primary data collection is possible.

1.7 OPERATIONAL DEFINITIONS

This study uses a number of terms, with some but not all, defined hereunder.

Willingness to pay (**WTP**). As an economic concept, willingness to pay made its first appearance in the literature more than a century ago (Davenport, 1902). WTP represents the highest amount of money at which a consumer will definitely purchase a unit of a good or a service (Varian, 1992 and Breidert, Hahsler, & Reutterer, 2006). As a concept, WTP suggests that while consumers generally pay market prices for various goods and services that they consume; their WTP for the same goods or services may be higher or lower than what they actually pay. The difference between how much a consumer is willing to pay and how much she actually pays constitutes the "consumers surplus" (Willig, 1976). Consumer surplus is a very useful measure used in economic literature to estimate consumer or social welfare. In this regard, the higher the amount of money a consumer is willing to pay versus the amount of money she actual pays to acquire a good or service, the higher will be her consumer surplus and vice versa, hence the associated welfare.

Choice modeling (or Choice Experiments (CE)). Choice modelling is a non-market economic valuation method that attempts to model the decision process of individual or segment via stated preferences made in a particular context or contexts (Louviere & Hensher, 1982 & Louviere & Woodworth, 1983). It uses discrete choice (i.e. choice A over choice B; choice B over choice A, etc.) in order to infer position of the items (A, B and C) on some relevant latent scale. This method uses a sample of respondents, who experience the benefits /costs where researchers ask them a series of questions about their preferences for alternative resource management strategies. Each question, called a 'choice set' presents to respondents the outcome of usually three or four alternative strategies described in terms of a common set of attributes, and differentiated by different attribute levels.

Discrete Choice Experiments (DCEs) or Choice Experiments (CEs). According to Ben Akiva & Lerman, DCEs/CEs, describe, explain, and predict choices between two or more discrete alternatives. The choices may involve issues such as whether to enter the job market or not to enter the job market, studying at university A or university B, whether to use a bus or a taxi to get to a particular destination, etc. Such choices contrast with standard consumption models in economics where economic theory assumes that the quantity of each good or service consumed is a continuous variable. Unlike contingent valuation (another example of SP valuation methods), CEs do not ask respondents to make a choice between some base case scenario and specific alternative scenario and state their maximum WTP to pay for some non-market goods or service. However, CEs present respondents with a series of hypothetical alternatives (or options) contained within some choice set (with the options described by differentiated attributes and varying levels) and then ask respondents to choose their most preferred option(s) (Adamowicz, Hanley, & Wright, 1998, Mangham, Hudson, & McPake, 2009, and Hanley, Mourato, & Wright, 2001).

Marginal Willingness to pay (MWTP) or marginal implicit price. MWTP is the shadow price (or estimated coefficient) of an attribute or characteristic of a good or service (Rosen, 1974) while all the other characteristics or attributes are held constant, and the shadow price is implicit in the overall price of the good or service.

Conditional Logit Model (CLM). McFadden (1973) was the first to introduce the CLM in the economics literature. For this contribution, he received a joint Nobel Prize in economics (with James Heckman) in 2000. CL is rooted within a random-utility framework where researchers assume that the expected utility from a respondent's choice depends on the characteristics or attributes (Rodriguez, 2020). It further assumes that respondents have similar preferences or tastes. This study utilises a conditional logit model as a base model.

Independence of irrelevant alternatives (IIA). The economics Nobel laureate, Kenneth Arrow first applied this concept in 1951. It is however, widely attributed to Luce (1959) (e.g. Allison (2014) and Breitmoser (2019)) and often called Luce's Axiom of Choice when positivity holds. This is an axiom in decision theory which suggests that if respondent Y was choosing between alternatives A and B within some choice set {A,B} and preferred choice A, the introduction of a third and irrelevant choice, X through expanding the choice set to {A,B,X} should not make choice B preferable to A. In other words, if an individual has expressed a clear choice between two options, the introduction of the third and irrelevant option should not cause the individual to alter her preferences (Bhat, 1995).

Mixed (random parameters) Logit Model (MLM). It is regarded as the most promising state of art discrete choice model at the moment (Hensher & Greene, 2002). MLM is a very flexible model that can resemble an y random utility model (McFadden & Train, 2000). It avoid the three standard logit limits by allowing for random variation of taste, unrestricted substitution patterns, and correlation in unobserved factors overtime. Unlike probit it is not confined to the normal distribution. Its direct derivations, and simulating its choice probabilities is computationally simple (Train, 2012). The first applications of the Mixed Logit model were apparently the automobile demand models created jointly by Boyd, Mellman, Cardell & Dunbar (1980). MLM is a generalisation of the conditional logit model where researchers relax the assumption that the respondents are homogenous (i.e. the estimated coefficients are the same across all individuals). It is a model that overcomes the limitations of the conditional logit model by allowing the coefficients of the model to vary across decision makers. Allowing coefficients to change implies that the different policy makers may have different preferences. In this regard the Independence of Irrelevant Alternatives (IIA) and homogeneous preferences property is no longer valid (Train, 2002).

Hedonic pricing (or property value) method: It is a revealed preference method for estimating the monetary value of property characteristics where the property does not have markets. It decomposes the good or property under consideration into its characteristics and obtains estimates of the monetary contribution of each of the characteristics (Rosen, 1974, Nelson, 1978 and Freeman, 1979). Unlike SP methods, the hedonic pricing method infers monetary values from observed consumer behaviour and enables the estimation of the monetary values of the characteristics or attributes of a good/service when the price of the good/service changes (My-Linh, 2020).

Basic water service. In this study, it refers the ministerial determined water service standard which prescribes that every South African households must be entitled to a minimum volume of 6000 liters (or 25 liters per person per day) of portable water per month[8]. Furthermore, the water needs to be available for at least 350 days a year without interruption, for longer than 48 consecutive hours (Government gazette no. 18522, 1997)

[8] This volume assumes a household with eight members.

1.8 ORGANIZATION OF THE STUDY

The study is presenteted in six chapters:

Chapter 2, which is the next chapter, reviews the existing literature on willingness to pay for water in general but willingness to pay for improvements in attributes of water services specifically.

Chapter *3* focuses on the research methodology underpinning the study. It will also describe in detail, among other things, the research method used, the mechanisms behind the DCE study as well as issues around evaluating the reliability and validity of such studies.

Chapter 4 Describe the construction of efficient designs, survey development, data collection and formulation of testable hypotheses.

Chapter 5 looks at the empirical results of the study, while chapter 6 concludes with a summary and proposal about potential directions for future research.

1.9 SUMMARY

This chapter sketched the general issues motivating the study, including the problem statement, the general and the specific objectives of the study, testable hypotheses of the study, significance and delimitation of the study, operational definitions and concluded with a highlight of the organisation of the study.

CHAPTER 2. LITERATURE REVIEW

This chapter gives an overview of the theoretical foundations and approach to the study. Furthermore, it also provides a brief review of the theoretical and empirical literature review underpinning the study.

2.1 THEORETICAL LITERATURE REVIEW

2.1.1 Attribute Based Stated Choice Methods

This study is underpinned by the attribute based stated choice methods (ABSCM) or Stated Choice Methods (SCM) (Adamowicz, Louviere and Swait, 1998). This method refers to a flexible approach to collecting data on preferences from respondents in a hypothetical situation with the goal of putting the decision maker in a realistic state of mind to compare a number of alternatives (or options), that are described in terms of attributes. The context of the decision and the description of the product are the *stimuli* and the individual's decision (which may be a choice, a ranking, matching, rating or a quantity task) is the *response achieved*.

Some researchers suggest that SCMs evolved from a conjoint analytic paradigm long associated with marketing research (Adamowicz, Louviere and Swait, 1998. However, Louviere, and Hensher (1982) and Louviere, and Woodworth (1983) developed the initial applications of SCMs as a natural analogue to the already well-established revealed preference choice modeling theory and methods. While it is true that conjoint analysis is a very popular approach for understanding and predicting trade-offs and consumer choices, conjoint analysis is not a theory of choice behavior because it is not based on a sound theoretical behavioural foundation consistent with economics.

The behavioral foundations of SCMs that distinguishes them from conjoint analysis are rooted in the following:

i. Lancastrian consumer theory (Lancaster, 1966) which suggested that utilities of goods can be broken down into utilities separable from their characteristics or attributes,

ii. the handling of information processing in psychological judgement and decision making (Hammond, 1955; Slovic and Lichtenstein, 1971; Anderson, 1962 &1970, van Raaij, 1988 and De Dreu & Nijstad and van Knippenberg, 2008).

iii. The theory of random utility, which illuminates the basis of many models and theories of consumer judgement and decision-making in psychology and economics (Thurstone, 1927; McFadden, 1974; Ben Akiva, & Lerman, 1985, Cascetta, 2009); and

iv. Market solutions in relation to goods having multi-dimensional attributes (Rosen, 1974).

The historical foundations of SCM however, must be found (or are rooted) in the writings of the first classical economists like as Adam Smith (1776) and David Ricardo (1817) in their explanations of the issues that were topical during their time. These issues included, differences in wages, rent and so forth. In this regard, Adam Smith explained the career wage gaps for a given job in terms of *(a)* the challenges associated with the job, *(b)* the struggle to learn the job, *(c)* the stability in employment levels, *(d)* the responsibility attached to the job and *(e)* the opportunity to succeed or fail in the job.

On the other hand, Ricardo (1817) in his economic rent theory, explained the rent differentials across the productivity differences of similar pieces of land that produce the same products but where the other piece of land is of a poorer quality. Thus, according to Ricardo, market clearing wages and market compensation rent can be explained respectively by the differentiated attributes of the job and a piece of land in the same manner as the market value of a water service may be explained by its different attributes. In this respect, a good or a service is considered to be the sum of its attributes (*i.e*. the individually selected attributes add up to the demand for the final good) which essentially implies that the whole must be considered to be equal to the sum of its constituent parts.

The notion that a good is just a sum of its attributes was formalised by Lancaster's consumer theory (1966) and Rosen's work on the Hedonic Price theory (1974).

2.1.2 Lancaster's Consumer Theory

In what was termed a modification of the standard microeconomic demand theory at the time, Lancaster (1966 and 1990), put forward a proposal for a "new theory of consumer demand". The theory posited that what consumers seek to acquire is not goods themselves such as cars, but the characteristics the goods contain such as transport from one point to another. Thus, from Lancaster's view, all goods possess characteristics or attributes that consumer demand, and not necessarily the goods themselves. In this regard, Lancaster's theory would posit that consumers do not demand food per se, but rather they demand the nutrients and flavors associated with the food for example. A number of authors (e.g., Hendler, 1975, Wierenga, 1984, and Fernandez-Castro and Smith, 2002) have not only extended Lancaster's model, but have also subjected it to empirical scrutiny and found robust results in support thereof.

With conventional (classical) economic theory, the introduction of a new option meant that researchers could not reliably predict how this slot in the consumer's preference map. However, by carefully studying the characteristics or attributes of the good, rather than the goods or services themselves, researchers are in a position to predict how changes in the associated characteristics (or attributes) of the good will affect a consumer's behavior in respect of the good or service. This approach allows researchers to calculate dummy prices (or in this case, MWTP) for various attributes of the good, even without having a price for the good itself by associating utility to the charecteristics that contitute that good rather than the good itself (Lancaster, 1966, Hendler, 1975, and Fernández Castro and Smith, 2002).

2.1.3 Rosen's Hedonic Price Theory

In what researchers still regard as a seminal contribution, Rosen in a journal article published[9] in the Journal of Political Economy in 1974, showed that virtually all heterogeneous goods are essentially a vector of their utility supporting attributes or characteristics. Moreover, he suggested that while researchers can observe the total price of such a goods, this is not enough to shed much light on the demand for and supply of their characteristics. The main contribution of the paper was to provide a model of how consumers and suppliers optimize behaviour governs data production process that delivers the potentially observable equilibrium relationship between characteristics (attributes) and their prices (Rosen, 1974, Freeman, 1979, Chin and Chau, 2003 and My-Linh, 2020).

In Rosen's formulation, a vector of its characteristics describes a differentiated good C or service such that $C = C(c_1, c_2, \ldots, c_n)$. In the case of a house, these characteristics may include (a) structural attributes such as the number of bedrooms in the house, the stand (lot) size and floor area among other structural attributes). (b)

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[9] As of December 2017, Rosen's paper was the sixth most cited paper in the history of the Journal of Political Economy (JPE), the JPE of which was first published in 1892).

neighborhood attributes such as the quality of the local schools, proximity to a bus/ taxi/ train station), etc., and (c) attributes of the local environmental amenities such as air quality, water quality) among other house attributes. Thus, researchers can present the market price of the i^{th} house as $P_i = P\left(c_{i1}, c_{i2}, \ldots, c_{ij}\right)$. The partial derivative of $P(.)$ (or the rate of change of P with respect to the j^{th} characteristic (attribute) of the house), i.e. $\frac{\partial P}{\partial c_j}$ is referred to as the marginal implicit price (or MWTP). Essentially, $\frac{\partial P}{\partial c_j}$ in this formulation represents the marginal price of the house's j^{th} characteristic (attribute), holding constant all other characteristics, and is implicit in the overall price of the house (Rosen, 1974).

It is important to note that the hedonic pricing method, which is an example of a revealed preference (RP) economic valuation method, is rooted on the fact that attributes (characteristics) affect the prices of goods in a market. As such, the method enables the estimation of a good (or a service)'s price based on people's WTP for the good, as and when the good's attributes change. Unlike SCMs, which primarily uses primary (survey) data, the hedonic price method uses secondary data or surrogate markets in order to uncover the value of attributes that ordinarily do not get traded in in formal markets. The fact that it relies on secondary data makes it one of the preferred non-market valuation methods economists rely upon to estimate the value of goods (and services) that have no formal markets.

A practical example of the hedonic pricing method in the housing market could be supposed where the value of two different properties that are otherwise comparable, will differ depending on the various environmental amenities present in the areas surrounding these properties. If there is a measurable price drop of properties located near an environmental bad such as a landfill as compared with other locations, the difference in the prices of the properties located around a landfill and those located where there is no landfill would point towards the external cost of the landfill. The difference in the residential property price (value) would then be the MWTP (in higher housing prices) for the given difference in cleanliness, odourless and serenity of the locality surrounding the two properties (Rosen, 1974).

Therefore, according to Lancaster and Rosen's approaches, researchers can assess attributes values based on the relationship between the observed prices for differentiated products (such as houses) and the attributes associated with these products.

2.2 EMPIRICAL LITERATURE REVIEW

This section present a review and summary of studies that provide empirical evidence whith repect to SCM as far as the attributes of water services or the WTP for the associated improvement(s) is (are) concerned. Unfortunately, there are very few published studies that this study could locate, the focuses specifically on the willingness to pay for improvements of water service attributes at a local level (i.e. South Africa), and in particular, those applying DCE. However, the literature is replete with studies that concern themselves with WTP for improvements in the attributes of waters services in developed countries using various non-market valuation methods, with the majority being those that applies the contingent valuation method.

Since this study is concerned with estimating WTP for improvements in water service attributes using DCE, the empirical literature review start off by considering and summarising the relevant literature in respect of WTP for improvements in water services in developed countries, including those from developing countries (where possible) that applies CE. It closes off by summarising the few studies that specifically concern themselves with WTP for improvements in water service attributes in South Africa that also applies CE.

2.2.1 Willingness to pay for improvements in water service attributes using DCE.

Upfront, and as indicated in Chapter 1, this study defines a water service is a service provided to consumers that includes things like water quality (i.e. is the water drinkable, does it have odours, sediments, particles, discolourations, etc.), frequency of water supplies (or water interruptions), the quantity of water supplied, and water pressure among other factors. For example, if water pressure is low or insufficient, then it will be difficult for consumers to receive water. Water interruptions will also inconvenience users since they can go for hours, days or even months without water supplies. Finally, if water has discolouration, bad odour or indeed, foreign particles in it, it may prove to be a disutility to consumers who may reject it or reluctantly use it.

2.2.2 Willingness to pay for improvements in water service attributes using DCE: International evidence.

At the international level in general and developed countries in particular, water service attributes that appear to be most problematic, are water interruptions (for example, Hensher, Shore and Train (2005), Macdonald, Barnes, Bennett, Morrison, and Young (2005) and Willis, Scarpa, and Accut (2005)). This could be because a proper and well-functioning infrastructure, be it transport, communication or water, is a common feature in developed countries. Moreover, developed countries have universal coverage of water service infrastructure. Even though the application of DCE studies to value WTP for improvements of water service attributes is at its nascent stages, this study found two studies from Australia, and one from the UK and Greece respectively, as far as WTP for improvements of a water service through the application of a DCE in developed countries is concerned. The water service attribute that was common in all the studies, was water interruptions and the studies are summarised hereunder.

Hensher, Shore, and Train, (2005) conducted a DCE study to assess household willingness to pay for improvements of drinking and wastewater service attributes in Canberra, Australia through the application of a Mixed Logit model. They considered water service attributes of two categories of water, namely drinking water and wastewater. Regarding drinking water, they considered the attributes related to drinking water service interruption (such as, frequency of interruptions, duration of interruptions, time of day of the interruptions, notification of interruptions, information provided during an interruption) and the price of water. The attributes of the wastewater services considered for investigation were, (a) the frequency of wastewater service interruptions is expressed as the 'number of times a respondent experiences an excessive flow of wastewater' with four levels varying from '2 times per year' to 'once in 10 years'. (b) the interference coverage expressed as an 'overflow source '. The associated attribute levels were 'inside your house', 'just outside your home'; and 'to the nearest sewer hole in the street'. (c) the mean length of the water overflow, expressed as the ' time before the overflow is contained', (d) overflow information service provided in response to telephone inquiriesin the event of a wastewater overflow and lastly (e) price, as the total of the water and sewer bill for the year.

The results from the study indicate that respondents were willing to pay for reductions in the number and frequency of interruptions, and they highly prefer to have interruptions on weekdays and later in the day and the notice of interruptions is much appreciated as in-person information services. For wastewater services, the results indicate that as the number of outages increased, households were willing to pay less to avoid them. The study also found that households' willingness to pay to avoid a sewage overflow depends on the frequency of overflows, demonstating adaptability to frequent overflows. The longer the expected duration of the overflow, the lesser the amount customers were willing to pay to reduce its length by an hour. They also noticed that an overflow within the home is four times worse than an overflow outside of the streets.

In a study that almost mirrored Hensher et al (2005) in terms of attributes considered, Macdonald, Barnes, Bennett, Morrison, and Young, (2005) conducted a study in Adelaide, Australia where the issue of water supply interruptions and the duration thereof were among the attributes investigated. Furthermore, they also investigated the impact of notification options of the interruptions (such as letter, phone call or in-person visit) and alternative water supply during the water supply interruption (such as whether there was none, from a central location or through the delivery of bottled water). They found that unlike the Hensher et al (2005)'s study, the only statistically significant attributes in all models they took into account were the frequency of interruptions and the price.

In the UK and in a study focusing on the water utility, Yorkshire Water, Willis, Scarpa, and Accut (2005) applied a choice experiment to conduct a cost-benefit study regarding drinking and wastewater disposal. The purpose of the study was to estimate the benefit to Yorkshire Water customers of marginally changing the level of service provided relative to a variety of service factors. The study's overall thrust of investigation was also similar to the overall thrust of the two Australian studies. The study included 14 water service factors. In order to make the number of choices manageable, the authors have split the water service factors into three sets. These were: supply and quality of household water (which included, security of supply, interruptions to supply, the biological quality of drinking water and water discoloration); external disbenefits of wastewater disposal (which included sewage flooding and odor from sewage works); and environmental factors related to waste water disposal (which included the ecological quality of rivers and bathing beach water quality). Similar to the Australian research, the results indicate that customers are willing to pay to reduce the number and frequency of supply disruptions, with an important distinction that the willingness to pay is highly influenced by the number of interruptions. Unsurprisingly, the respondents also valued security of supply during drought conditions including improvements in water quality (in particular, biological and chemical) as well as a reduction in the number of households complaining about water discoloration.

In what appears to be an interesting if not confounding finding for a developed country, Latinopoulos (2014) used CE[10] to estimate the social benefits from improved water supply services in Greece's Propontida municipality. The attributes of interest were water quality, frequency of water supply interruptions and water availability for agriculture and annual cost for service improvement. The study used a structured questionnaire to collect primary data from 302 residents through face-to-face interviews and used a CL regression analysis to analyze the results. The results showed that the respondents were willing to pay higher amounts for improvements in the quality of water than to avoid interruptions in the water service. The fact that the focus of the study was on agricultural rather than drinking water, may explain the reasons behind a WTP for water interruptions lower than that reported in the studies from other developed countries (i.e. Australia and the UK). Furthermore, the findings could also be indicative of the fact that WTP may very well depend on the context under consideration.

The foregoing discussion focused on international evidence, but from a developing country's point of view (albeit international), Nam and Son (2005) conducted a study in Vietnam, where they focused on the WTP for domestic water quality and pressure in Ho Chi Minh City through a comparison of the results of both a CVM and CE methods. They found that water quality was by far the most important attribute relative to water pressure, particularly among households that were not yet connected to piped water. Furthermore, they also found that the amount that households were willing to pay for improved water service attributes was significantly higher than the households' current water bill, including the costs of a variety of adaptation strategies (such as

[10] For the purposes of clarity, this study uses DCE and CE interchangeably and they mean the same thing

water collection, boiling and filtering treatment, storage in the home tanks, or buying it from vendors).

In a study that focused on water service attributes slightly different from those in Nam and Son (2005), Anand (2001) used CE to examine consumer preferences for the attributes of alternative sources of water supply at Chennai City (formally known as Madras) and Chennai metropolitan areas, India. The attributes of interest were (a) monthly household charge for water, (b) quantity and quality of water supplied, (c) whether the household accessed water through a yard tap or a shared tap, and finally, (d) the household's source of water supply (i.e. whether supplied by private or public sector). With a sample of about 148 respondents, the results showed that access to tap water was a more important attribute than water quantity and water quality. Furthermore, households in Chennai city were willing to pay more for having a yard tap while households living in the suburban areas were not willing to pay to improve the water supply. While these results may seem a bit out of step with results from other developing countries, domestic issues in India such as equity politics and a general feeling of entitlement to subsidized water by peri-urban residents may lie at the root of explaining the seeming anomaly as compared with other developing cities.

In one of the few published studies on the African continent in respect of households' WTP for improved drinking water quality, Radam, Dauda, and Samdin (2013) applied a CE to assess household's WTP for improved drinking water quality in Damaturu, Nigeria. They identified four attributes of water quality, namely; tap water quality (TWQ), tap water supply (TWS), tap water pressure (TWP) and Price. The results showed that Damaturu households were willing to pay more than they have been paying to have an improved drinking water quality.

In a study that investigated water service attributes that are slightly different from those most common in studies in the developing world, Yilikal, Zeleke, and Gebre (2019) applied the CE method to value improvements in water supply as well as an ecosystem based water supply management intervention in the Legedadie-Dire catchment, Ethiopia. The study considered an ecosystem based water supply management programme because it could supply high quality drinking water with little or no interruptions at an appropriate flow pressure. The study examined household's willingness to pay (WTP) for improved of water services by identifying their water choice decisions and method of water supply that they prefer the water authority to use among several alternative water supply options.

They found that 75 percent of the households were prepared to pay each month for an ecosystem-based water supply management intervention program (EB WSM). Most of the respondents chose a bundle of water supply options that provided risk-free and high-quality water with no months of shortages than moderate water quality that is safe to drink and portable, but with one-month shortage annually implying that households prefer to be supplied with risk-free, high-quality water without interruption at an appropriate flow pressure.

Although attributes of water services appear to be similar across developing and developed countries, the issues of concern in respect of WTP for improvements in water service attributes appear miles apart. While the attribute that appears to be universally of interest in the developed countries is the frequency of water supply interruptions, the attribute(s) that appear to be universally of interest in the developing countries is (are) water quality and water pressure.

A number of factors may explain these observations. Most developing countries, including South Africa experience poor coverage as far as water infrastructure is concerned, albeit in varying degrees. Since most services are concentrated in urban areas, high levels of urbanization may imply that many people end up competing for a water service meant for a limited number of people. This would tend to affect water service attributes such as water pressure and water quality negatively, which may explain why these two attributes appear to resonate across developing countries.

2.2.3 Willingness to pay for improvements in water service attributes using DCE: South African experience

As already indicated in the foregoing, the literature is very sketchy regarding published studies utilising CE to value improvements in water service attributes in South Africa. To date, only three published studies that used CE to value WTP for improvements in water services in South Africa could be located and are summarised hereunder. Albeit limited, these studies are from three different settings, namely (a) a metro municipality, (b) a small town and (c) a rural area.

In what appears to be the earliest published study that attempted to elicit households' WTP for improvements in water service attributes in South Africa, Snowball, Willis, and Jeurissen, (2008) used CE to elicit the WTP for water service improvements in the then Eastern Cape province town of Grahamstown (now Makhanda). For the longest period, Makhanda has experienced water challenges that includes erratic water supply, failing sewerage infrastructure, water toxicity in the region and the increase of water-borne diseases[11]. Unsurprisingly, the water service attributes analysed in the study were bacteria count, water discolouration, water pressure, water supply interruption, water meter problems and price. The results indicated that estimates of bacteria count, water discolouration, water supply interruptions and price were statistically different from zero.

Snowball et al's (2008) study was followed immediately thereafter by Kanyoka, Farolfi, and Moradet (2008), who applied CE study to elicit household WTP for multiple-use water services (i.e. domestic and productive uses) at Sekororo-Letsoalo village, Limpopo province. The study segmented the sample into two strata, namely, households not connected to a water tap and households connected to a water tap. The authors considered the following attributes, namely (a) quantity of water, (b) quality of water, (c) frequency of water supply, (d) productive uses of water, and (e) source of water. Their results showed that the households were willing to pay for improvements in water services. However, due to the current poor level of water services in the area, households were willing to pay more for improvements in basic domestic water uses than for improvements in productive water uses. Furthermore, households already well served with water services were interested in engaging in multiple water uses.

Finally, and in a first of its kind at a metropolitan municipal level, Dikgang et al (2017) applied a CE study to elicit WTP for improvement in water services in the eThekwini Metro municipality, South Africa. Like the Kanyoka et al., (2008) study, the study divided the households into two strata (i.e. Township and Suburbs) for analysis and considered five water service attributes; namely (a) access to pipe water, (b) reliability of water supply, (c) water pressure, (d) water quality; and (e) monthly water cost. Their results showed that for both Suburb and Township households, access to water via a pipe inside their dwelling, monthly cost and water quality were statistically different

[11] The Makana local municipality (i.e. the municipality under which Makhanda falls)'s poor or non-existent service delivery history finally led to a high court sanctioned dissolution of the municipality. The supreme court of appeals (SCA) has however granted the municipality leave to appeal the high court ruling and at the time of writing, the SCA had yet to rule on the matter.

from zero (statistically significant) while water reliability and water pressure were statistically not different from zero (i.e. not statistically significant).

Although this study could only find three published studies in South Africa that applies CE to elicit WTP for improvements, the studies are a good start since they span different settings and backgrounds in South Africa.

2.3 SUMMARY

This chapter commenced by presenting the theoretical foundations of SCMs and noted that they are rooted in the ideas of classical economists such as Adam Smith and David Ricardo. Lancaster (1966) and Rosen (1974) refined these foundations when they posited that a good (or service) is but a sum total of its constituent parts and through a careful analysis, the implicit prices of the good's constituent attributes or characteristics (for which formal markets are absent) can be recovered. Since the study focuses on eliciting households WTP for improvements in water service attributes using DCE, in addition, a review of the relevant literature was provided. The chapter also noted that WTP studies for improvements in water service attributes have mostly applied CVM at both the local and international level. Unsurprisingly, very few studies currently exist at both the international and local level that applies DCE.

CHAPTER 3: RESEARCH METHODOLOGY

This chapter describes the research methodology employed in this study. It also provides an overview of the research paradigm and research design including a discussion on non-market valuation methods, deriving a good's total economic value, and the basics of conducting a DCE study. It rounds off with a discussion on the statistical analysis of DCE, demonstrating how researchers determine the WTP of and the quantification of the benefits of an improved water service, including a discussion on issues around the validity of DCE studies.

3.1 RESEARCH PARADIGM.

The world of research is made up of different disciplines such as the social and natural sciences. As such, different disciplines approach research problems from different angles depending on the nature of the discipline. For some disciplines such as the natural sciences where relationships are established in some specific manner, there may be a general or unanimous approach to addressing research problems. On the other hand, in disciplines such as the social sciences in general and economics in particular, a research problem (for example inflation) would generally be approached from many different angles. This may be motivated by a number of things, including the general school of thought the economist in question is more at home with (for example, is the economist a Keynesian, Monetarist, institutionalist, etc.).

Given the differences in disciplines and the inherent differences regarding how practitioners may approach research problems, it is important from the outset for researchers to have some foundation, a view as it were, or overarching idea that informs how they would approach a research problem. This reality then calls for some foundation if not underpinning or overarching idea that informs how researchers from different disciplines approach research problem. This overaching research foundation or underpinning idea from which researchers from different disciplines organise their reasech problem around, is called a research paradigm. The word paradigm originates from the Greek word "paradeigma" which means patterns (Kivunja & Kuyini, 2017 as cited by Kamal, 2019). Different authors have proposed different versions of a research paradigm. For example, Hughes (2010) conceives a research paradigm as a way of looking at the world that frames the research subject. On the other hand, Bryman (2006) defines a research paradigm as a set of beliefs and precepts that, for scientists in a particular discipline, influence what needs to be investigated including, how the research should be conducted and how findings should be interpreted. Finally, Kuhn (1962), sees a research paradigm is a philosophical way of thinking.

From the above, it would appear that there is no unanimity or common definition of a research paradigm. The multiplicity and complexities of the different disciplines and views would explain the apparent lack of unanimity on what a research paradigm actually is. In this regard, the Merriam-Webster Dictionary (2023) would appear to provide some clarity in its definition of a research paradigm. It defines a research paradigm as "a philosophical and theoretical framework of a scientific school or discipline within which theories, laws, and generalizations and the experiments performed in support of them are formulated." Within the context of research, a research paradigm would then be a worldview or philosophical framework, including ideas, beliefs, and biases, that guides the research process and the research paradigm in which a study is situated and it helps determine the manner in which the research will be conducted.

Thus a research paradigm could be viewed as a framework into which the theories and practices of the social sciences discipline, fit to create the research plan. The research plan then acts as a foundation that guides all areas of the research, such as (a) the aim of the study, (b) the research question; and (c) the research methods and the associated ways in which the results are analysed (Ulz, 2023).

For most disciplines, research paradigms are generally split into two model types which guides the theories and methodologies used in the research project. These model types are positivism and interpretivism. Positivist research paradigms tend to lean more towards quantitative research or studies with interpretivist research paradigms leaning more towards qualitative tend studies. Since research studies are not discrete (i.e. they are neither strictly quantitative nor strictly qualitative), it is possible to have variations within one study potentially leading to mixed method which incorporates elements of both positivism and interpretivis. This study uses DCEs, a quantitative method and would therefore be an example of a positivist research approach.

Taking into account the reality of economics where there are different schools of thought which different economists find appealing and thus latch onto, it becomes clear that their research paradigms will be informed by a number of things including inherent biases. This necessitates the question, "what then informs the research research paradigms"?

Ulz, (2023) suggests that the research paradigm framework is supported by three pillars, namely; ontology, epistemology, and methodology. She defines ***Ontology*** as the study of the nature of reality. Ontology therefore is sezed with establishing whether there a single reality, multiple realities, or no reality at all? Additionally, she defines ***Epistemology*** as the study of knowledge and how researchers can know reality. Epistemology incorporates the extent and ways to gain knowledge and how to validate that knowledge. Finally, she defines ***Methodology*** as the study of how one investigates the environment and validates the knowledge gained. In this regard, methodology is concerned with how to go about discovering the answer/reality and addressing this pillar leads to specific data collection and analysis plans.

In relation to this study, we are seized with the question of quantifying the non-market values of attributes of a water service. There are two non-market valuation methods that the study can apply to achieve the task, namely stated preference and revealed preference. This study applies stated preference methods in general and DCEs in particular to provide estimates of WTP for attributes of a water service. The underlying research paradigm underpinning this study is the ABSCM and the next section outlines the associated research design and plan.

3.2 RESEARCH DESIGN

Research design is a framework of research methods and techniques chosen by a researcher. It constitutes the outline of collection, measurement and analysis of data (Akhtar, 2016). It is a blueprint, procedure or plan of action. The design of a research topic explains the type of research (experimental, survey, correlational, semi-experimental, and review) and its sub-type experimental design, research problem, descriptive case study. There are three main types of research design: Data collecting, measurement, and analysis. An impactful research design usually creates minimum bias in data and increases trust in the accuracy of data collected (Sileyew, 2019). Given the foregone discussion, this study will adopt an experimental (or survey) research design for investigating the WTP for improvements in attributes of water service in Vuwani. Experimental design can explain the relation between the dependent variable and its independent (or explanatory) variables. In the current study, the dependent variable (Choice) and the explanatory or independent variables (i.e. the attributes of water service) which consist (among other attributes) of frequency of water availability, water pressure, water quality and water pressure inter alia are all measured quantitatively (Sileyew, 2019).

3.3 SAMPLE, SAMPLING TECHNIQUE AND SAMPLING FRAME

The sample design strategy entails four distinct steps: selecting the target population (sample), determining who to sample (the sample frame), determining the appropriate sample size and choosing the method of respondent selection and elicitation of response technique (Lee, Hosking, and du Preez, 2014).

3.3.1 Population of the Study

In this research, the study population can be explained as a comprehensive group of individuals, institutions or objects, which have common characteristics that are the interest of a researcher. The common characteristics of the groups distinguish them from other individuals, institutions and objects (Rafeedie, 2017). In this study, the study population pertaining are respondents (representing households) of Vuwani who receive (or are supposed to receive) piped water from the local municipality.

3.3.2 Target Population

The target population is the whole population, or group, that a researcher wishes to investigate. It defines (variable characteristics) the overall sets of all items (or people in the case of market research) who will qualify for the study (David, 2020). The target population for the study will be members of randomly sampled Vuwani households receiving (or are expected to receive) water from the local municipality.

3.3.3 Sampling Strategy

A sample is a subsection of the population, and researchers call the process of selecting a sample, sampling (Singh, 2018). It is the process of selecting the sample for estimating the population characteristics. In other words, it is the process of obtaining information about an entire population by examining only a part of it. As reported by Singh (2018) researchers, sampling strategies are divided into two categories: probabilistic sampling and non-probability sampling.

Probability sampling is based on likelihood that events such as random numbers, the drawing of a coin, and is often used in quantitative investigation. Probability sampling represents a group of sampling techniques that help researchers to select units from a population that they are interested in studying. A core characteristic of probability sampling techniques is that researchers select research units from the population at random using probabilistic methods. This enables researchers to make statistical inferences (i.e. generalisations) from the sample that they are studying/investigating over the population of interest (Singh, 2018).

Non-probability sampling on the other hand is based on a researcher's choice and concentrates largely on the target population that is accessible and available. Some of non-probability sampling methods are purposive sampling, convenient sampling (Setia, 2016). This study applies non-probability sampling techniques since it will collect data through convenience sampling. Convenience sampling is defined as "a type of non-probability sampling that involves the sample being drawn from that part of the population that is close to hand" (Lund, 2012). It is not only a common sampling method in DCE studies, but it also offers practical advantages over the other sampling methods. Like any sampling method, convenience sampling has advantages and disadvantages. The key advantages of convenience sampling are that it is cheap, efficient, and simple to implement, (something that appeals to this study given the present realities) while the key disadvantage of convenience sampling is that, the sample may lack clear generalisability.

3.3.4 Sample Size

The determination of the sample as part of a quantitative study is difficult. There are both probabilistic and non-probabilistic ways to determine a sample size. With a probabilistic design, each unit of population has a fixed probability of inclusion in the sample. With a non-probability design, the discretion of the researcher is key (Lee et al, 2014). There are factors to take into account as each experience is different, with varying degrees of certainty and expectation. Generally, in a given study, a researcher must be aware of three factors, or variables with a certain numeric value. These are the magnitude of the significance level, power and size of the effects. When researchers know these values, they can use the relevant statistical table or an online calculator to determine sample size (Scruggs, 2017). Kothari and Gau rav (2015) outline a method of determining a sample size (SS) through the application of the formula in equations (3.1) and (3.2) as follows:

$$SS = \frac{(z-score)^2+\rho(1-\rho)}{(margin\ of\ error)^2} \quad \text{...(3.1)}$$

In (3.1) above, SS is the sample size, $z - score$ =1.96 (representing 95% of the target population, ρ is the probability of selecting a given respondent in the target population (and is set equal to 0.5 which suggests that every respondent has a fair chance to be selected), and;

$$SS_{adjusted} = \left(\frac{SS}{1+\frac{SS-1}{Population}}\right) \quad \text{...(3.2)}$$

In (3.2) above, everything is defined as in (3.1) while population refers to the number of households in the study area. Noting that a sample is primarily an attempt to represent the larger population with a larger sample increasing the precision of the estimated population characteristics, DCE often fulfills these criteria easily. This is because each respondent generates multiple observations. As such and because of reliance on convenient sampling as in most DCE studies, the state of the art in DCE suggests a sample size of at least 50 respondents (Lee, Hosking, and du Preez, 2014). In this study, the sample consists of 230 respondents with each respondent generating twenty-four (24) observations thus giving us a total of 5 520 observations.

3.5 DATA COLLECTION PROCEDURES

There are different methods researchers use to collect data from a sample of respondents (Maree, 2010). They include face to face, mail surveys and lately, internet based surveys among other data collection methods. This study collects data through a DCE questionnaire and via face-to-face (personal) interviews. However, because DCE studies primarily involve respondents making a choice between various alternatives, the study may also collect data via online surveys.

3.6 Data Analysis

According to LeCompte and Schensul (1999), research data analysis is a process used by researchers for reducing data to a story and interpreting it to derive insights. The data analysis process helps in reducing a chunk of data into smaller fragments, which makes sense. Marshall and Rossman (as cited by Silva, 2008) on the other hand, describe data analysis as a messy, ambiguous, and time consuming, but creative and fascinating process through which a mass of collected data is brought to order, structure and meaning.

There are many different data analysis methods, depending on the type of research conducted (Bhatia, 2018). The first step of analysing quantitative data is data preparation where the aim is to convert raw data into something meaningful and readable (Bhatia, 2018). Data analysis summarises collected data. Quantitative data analysis uses numerical representation and manipulation of observation for the purpose of describing and explaining the phenomena that those observations reflect (Humble, 2020).Thereafter, the researcher may use a statistical package for estimation purposes particularly where multiple variables are involved. This study uses the STATA software to analyse the data and provide the relevant interpretation.

3.7 Research Ethics

Researchers define research ethics as norms for conduct that distinguish between acceptable and unacceptable behaviour (David, and Resnik, 2020). They also explain ethics as a method, procedure, or perspective for deciding how to act and for analysing complex problems and issues. Research ethics is not a one size fits all approach. The research strategy chosen to guide dissertation determines the approach a researcher should take towards research ethics. Even though all dissertations should adhere to the basic ethical principles of doing well (i.e., beneficence) but also avoid doing any harm (i.e., non-malfeasance), the approach to research ethics adopted in any dissertation should be consistent with the research strategy (Lund, 2012).

3.7.1 The principles of research ethics

When performing dissertation research, there are several ethical principles that a student must take into consideration. These ethical principles requires that a researcher (student) must: (a) obtain informed consent from participants. (b) Protect the anonymity and confidentiality of participants. (c) Avoid deceptive practices when designing the research; and (d) Give participants the right to withdraw from the research at any time (Lund, 2012).

3.8 Steps in conducting a DCE study

The integrity and use of the method in the determination of values is highly dependent on the design of the DCE as it affects the amount of information that researchers can elicit from a given respondent's choices. To this end, Bateman, Carson, Day, Hanemann, Hett, Jones-Lee, Loomes, Muaurato, Aezdemiroglu, Pearce, Sugden and Swanson, (2002) recommend five stages for conducting DCE studies, namely: (a) identification and selection of attributes, (b) determining attribute levels, (c) choosing the experimental design, (d) construction of choice sets; and (e) measuring preferences.

3.8.1 Identification of attributes and attribute levels.

Since the stated preference techniques (under which DCE falls) are intended to simulate real market behavior, the first step in a CE is to identify the attributes that best describe the situation or scenario the researchers seek to describe as well as to assign credible attribute ranges and levels for these attributes. Variation across the range of the attributes allows econometric estimation. Researchers combined attribute and related levels to analyse the respondent's response. The attributes are used as explanatory variables in the estimated regression model. Researchers may derive attributes and their levels from observation of stature, the underlying economic theory, focus group discussions, or literature (Tinelli, 2016). Constructing attributes and their levels is important to this process in that it forces the respondent to compromise and make a decision (Kjær, 2005). In this way, biases that are inherent in survey-based methods such as the free rider problem, starting point bias and yeah saying are minimized/ mitigated.

In a CE, it is important to always include cost (or a monetary measure) as one of the attributes as it is more likely to assume that the economic agents making trade-offs, the associated cost is an significant determinant. After all, economic agents almost never buy goods and services for free. and it is therefore more plausible to include the cost to ensure that the trade-offs are realistic. More importantly , the inclusion of the cost attribute is crucial because it allows for the derivation WTP estimates for each attribute as well as to quantify and express the benefits of improvements in those attributes in monetary terms. The cost attribute can be included in a CE in many different forms, such as through a price, a salary/income, a fee, a user charge or any such attribute that denotes a payment to be made or income payable for the respondent to choose either (but not all) of the alternatives in any paired comparison.

By its very nature, a CE compels respondents to choice between two or more alternatives where the attributes (characteristics), attribute levels and their ranges characterise each alternative or option that a respondent chooses in every choice occasion. Thus, once researchers have identified the attributes, their levels and ranges, they organise them into paired comparison called a choice set of choices that they present to the respondent to choose the alternative that best represents that respondent's preferences or provides the respondent with the highest utility.

As an example, consider a hypothetical improvement of a water service proposed for implementation to a community. As already indicated, a number of attributes (including their levels and ranges) describes this hypothetical water service. The attributes may include (a) piped water, reliability of water supply, water pressure, water quality, and most importantly, its cost.

Table 3.1 below outlines an example of attributes, attribute levels and the range (or coding) of a hypothetical water service.

Attribute	Description	Level	Range
Piped water	**How pipe water is delivered to the household**	**Inside the dwelling In the yard <200m from dwelling >200m from dwelling No access to pipe water**	**1 2 3 4 5**
Reliability of water supply	**Whether the household experienced any interruptions in piped water in the last month.**	**No Yes**	**1 2**
Water pressure	**Pressure is the force that pushes water through pipes and determines the rate of water flow from pipes**	**Low water pressure High water pressure**	**1 2**
Water quality	**A measure of suitability of water for a particular use based on elected physical, chemical and biological characteristics**	**Safe to drink Has color Has bad taste Has bad odour**	**1 2 3 4**
Cost (or price)	**Cost of the service per month**	**R120.00 R220.00 R 500.00 R 600.00 R1000.00**	**120 220 500 600 1000**

Table 3.1: Example of attributes, attribute levels and range of a hypothetical water service (Source: Adapted from Dikgang et al, 2017)

3.8.2 Experimental design

After identifying the attributes, attribute levels and their ranges, the next step is to combine them in a sequence to generate a hypothetical alternatives used in a choice set. Practitioners divide experimental design in DCE studies into two categories, a full factorial design (where they present all potential choice sets to a respondent) and fractional factorial design (where the present only some of the choice sets to a respondent, more often than not, because there are too many choice sets) (Sanko, 2001; and Kjær, 2005). The number of possible alternatives increases exponentially as the number of attr ibutes and attribute levels increases. For example, four attributes each having three levels would yield sixty-four (64) possible choice profiles and a maximum of 2 016 unique choice sets[12]. This represents a full factorial design. As it is not practical to present all 2 016 choice sets to a respondent during the interview, DCE practitioners employ a fractional factorial design to minimise the number of choice sets in a manageable number.

3.8.3 Full factorial design.

Researchers use a full factorial design when there are a small number of attributes and levels of attributes such that the respondent answer to all possible choice alternatives in an interview. While there is no rule about the number of attributes and attribute levels that can be included in a CE study, the state of the art in CE studies is to have at least of three (excluding the cost attribute) with a minimum of two levels (Morrison, 2009).

3.8.4 Fractional factorial design.

A fractional factorial design occurs when there are many attributes and levels of attribute so that the total number of choice sets becomes too large to be presented to a respondent during an interview. In this case, researchers construct a subset of alternatives comprising all the main effects and present them to the respondents. The question then becomes how to go about constructing the sub-set of alternatives or constructing a fractional design without losing too much information. This becomes possible through constructing an efficient experimental design (Morrison, 2009).

3.8.4.1 Constructing an efficient experimental design

The next and most crucial task towards the implementation of a (discrete) choice experiment is the construction of an efficient experimental design. Because it is not possible to work with a f ull fractional design researchers construct the fractional design. This ensures that the choice tasks (i.e. where a respondent either choses alternative 1 (or option A), alternative 2 (or option B) or neither option (or option N) in this study) are not only meaningful, but also enable respondents to tradeoff between the options without experiencing respondent fatigue. Meaningful choice tasks means that among other things, respondents must not choose among dominated alternatives.

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[12] Researchers determine the maximum number of unique choice sets via this formula

$$Maximum\ choice\ sets = \frac{(Total\ number\ of\ choice\ profiles\ \times\ (Total\ number\ of\ chice\ profiles - 1))}{Number\ of\ options\ in\ choice\ set}$$

To this end, an efficient experimental design must meet the following desirable criteria: (a) Orthogonality (i.e. the levels of each attribute vary independently of one another). (b) Level balance (i.e. the levels of each attribute appear with eq ual frequency in a choice set; and (c) Minimum overlap (i.e. the alternatives within each choice set have non-overlapping attribute levels (or a choice task must not repeat within the same choice set). Finally, (d) Utility balance (i.e. the utilities of alternatives within choice sets are the same).

The construction of an efficient design can make or break a CE study and as such, this is a crucial step in the design of choice experiments. Although it is possible to construct efficient experimental designs manually, these days, researchers use various statistical software such as R, Stata, Sawtooth, Ngene, etc., to construct them.

3.8.5 Survey instrument development, pretesting and data collection

Once researchers have settled upon the preferred efficient experimental design, they generate the resulting choice sets with their alternatives for inclusion in the survey instrument (or questionnaire). In CE, the survey instrument usually starts with an introduction which provides survey information as well as providing information about the attribute and their associated levels, the background and goal of the study, etc. Prior delivery to the target sample, the survey instrument should be tested to ensure that potential respondents understand and fully comprehend the scenario that has been established. Pre-screening also ensures that relevant changes to the survey instrument can also be made. This ensures that respondents provide at least answer that are not only coherent, but also significant. Prior to the actual data collection or completion of the survey instrument, the enumerator is requied to have respondents participate in warm up questions in order to ensure respondents' familiarity with the survey instrument and process.

The survey instrument can also collect information on the respondents' characteristics (such as gender, race, etc.) in case the researcher is interested in how such factors may affect consumer preferences (Bateman et al*,* 2002). Researchers use a number of ways to collect CE data. These include face-to-face interviews, telephone interviews or mailed questionnaires. In this regard, enumerators presents respondents with a series of choice sets containing at least two alternatives, the respondents of which are asked to choose within a choice set, one choice (or alternative) which can either be A, B, C…) that best represent their preferences (or a choice alternative which the respondent prefers the most). For illustrative purposes, table 3.2 hereunder presents an example of a choice set with two alternatives (A and B) of a hypothetical water service.

Choice set 1		
ATTRIBUTE	**OPTION A**	**OPTION B**
Piped water	**No piped water**	**Inside dwelling**
Reliability of water supply	**Yes**	**Yes**
Water pressure	**Low**	**High**
Water quality	**Safe to drink**	**Has bad odour**
Cost	**R 600.00**	**R 120.00**
I would choose (TICK ONE BOX ONLY)	☐	☐
Taking into account my situation, I would Choose		
OPTION A ☐	**OPTION B** ☐	**NEITHER OPTION** ☐

Table 3.2. An example of a choice set with two options. Source: adapted from (Dikgang, et al., 2017)

3.8.6 Methodological approach

In the social sciences, particularly economics, WTP is a concept which seeks to determine the maximum amount of money a consumer (or household) is willing to pay for a good or service. The concept of willingness to pay first made its appearance in economic literature more than a century ago (Davenport, 1902). This concept suggests that while consumers in general pay market prices for various goods and services that they consume what they are **willing to pay** for the same good or service may be higher or lower than what they actually pay. The difference between these two (i.e. how much a consumer is willing to pay and how much she actually pays to acquire a good or service) constitutes the ‘consumers surplus’ (Willis, 1976) and it a very useful measure used in the economic literature to estimate consumer (or social) welfare. Thus, the higher the amount a consumer is willing to pay versus the amount she actually pays to acquire a good or service, the higher the consumer surplus and vice versa, hence, the associated welfare. Microeconomic theory usually assumes that rational consumers always aim to maximize their welfare. Therefore, we can view this study as an attempt to evaluate the welfare of Vuwani residents resulting from improvements in water supply attributes.

This study seeks to estimate the WTP for improvements in the attributes of a water service and the associated benefits thereof for the residents of Vuwani. Because there are no markets where Vuwani residents trade (buy or sell) attributes of water services, the study applies non-market valuation techniques to achieve this objective. While it is easier and more convenient to estimate the value of goods and services through formal markets, formal markets do not enable the determination of the good or service's total economic value i.e. use and non-use (or passive use) value, something which non-market valuation methods are quite capable of achieving (Alpizar, Carlsson and Martinsson, 2001).

As already indicated above, a good (or a service)'s total value is made up of use value (which is further subdivided into direct use, indirect use and optional use values) on the one hand and non-use (or passive use) values (which is further subdivided into bequest, altruistic and existence values) on the other hand. We provide a brief explanation of each category of value hereunder.

Direct use values relate to values which are derived directly (be they consumptive or non-consumptive) from the use of a good. **Indirect use values** relate to values that derives from the services related to the good. One example of indirect use values would be the noise and air pollution reduction services that trees in a neighborhood park provides to residents living nearby, the water quality improvement associated with a wetland or indeed, the avoidance of waterborne diseases as a result of residents receiving improved water supply in their community. **Option values** relates to the importance that people place on the future availability of a good or service for personal benefit. **Bequest value,** which is an example of passive (non-use) value, refers to the value that individuals attach to the fact that future generations will also have access to the benefits from that good or service. This is the so-called inter-generational equity concept, where those living today place a value or express the need to preserve a good (or species such as the so-called big five) for the enjoyment by generations yet to be born. **Altruistic values** are values individuals attach to the fact that other people of the present generation have access to the benefits provided by a good or service. For example, some people may contribute financially to the preservation of wild fauna and flora because they want others to enjoy its benefits without themselves actually benefitting from their financial contributions. Finally, **existence value** relates to the satisfaction that individuals derive from a mere knowledge that a particular good or service continues to exist. For example, some individuals may be willing to place a positive value on a Rhinoceros because they want Rhinos to exist into perpetuity, and irrespective of whether they will ever get to experience them or not (Braden, et al., 2010). Figure 3.1 illustrates a taxonomy of a good's total value which non-market value methods enable estimation.

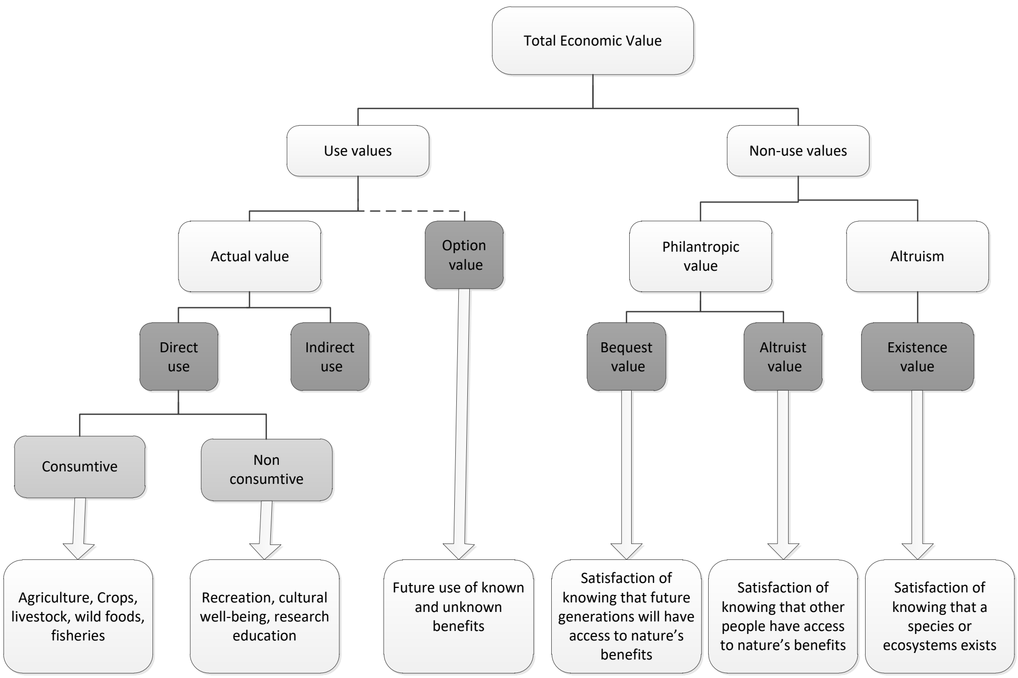

Figure 3.1. A taxonomy of a good's total economic value (adapted from Pascual et al.(2010))

Non-market valuation methods include revealed, stated preference and benefit transfer methods. Revealed preference methods such as the travel cost and the hedonic property value infers the value of a good through observed behaviour or data. For example, researcher can use changes in the property values around Hartebeespoort dam after the removal of water hyacinth infestation to infer the value of water quality improvement. With stated preference methods (which include contingent valuation and DCE), researchers presents respondents with one or more hypothetical scenarios, and ask them to indicate their economic value (willingness to pay or accept) for the non-market good in question through some sort of ranking, rating or matching task. Finally, researchers define benefit transfer as a method to estimate welfare measures such as WTP from an existing research study and apply the estimates to a new context or policy. For example, researchers can infer values of water service attributes in a particular area through values obtained from an existing study conducted in another area. Researchers apply benefit transfer when the resources to conduct an economic valuation study are limited or constrained (Rahim, 2008).

Although these non-market valuation methods are useful and researchers have applied them to estimate values in many countries[13], they have advantages and disadvantages. The major criticism leveled at stated preference methods is that the behaviour they depict is hypothetical, and not observed (for example, Cummings et al., 1986, Mitchell and Carson, 1989 and Hausman, 1993). As a result, stated preference methods may fail to take into account certain types of real market constraints (e.g. Louviere et al., 2000). Notwithstanding this criticism however, researchers can apply stated preference valuation methods to cover a wide range of attribute levels in instances where revealed data may not be available or applicable, such as with public goods. Moreover, stated preference valuation methods provide the only means for estimating the values for public goods that have no related or surrogate markets. This means stated preference methods can be applied to consider a range of choices that are different from existing ones as well as exploiting information about potential attribute trade-offs (for example, Swait et al. 1994).

The criticism level against revealed preference methods is that since the attributes and attribute levels of non-market goods generally may not vary over time in a single cross section, the value of changes in the quantities and qualities provided of public goods may be difficult to estimate without panel data. On the plus side, revealed preference methods are considered ‘more palatable’ by many because the data they utilise reflect real choices that take into account various constraints

[13] After the environmental disaster resulting from the Exon Valdez oil spill in the USA in 1989, American courts endorsed the use of stated preference methods to value environmental damages (see the state of Ohio v The department of interior, 1991). In addition, given the widespread use of the methods, the National Oceanic and Atmospheric Administration (NOAA), an American scientific agency within the United States Department of Commerce that focuses on the conditions of the oceans, major waterways, and the atmosphere, appointed a blue ribbon panel led by two economics Nobel laureates to develop guidelines for conducting CV studies.

on individual choices, such as budget and time constraints and are thus considered to have high 'face validity'.

Finally, while benefits can be transferred much quicker (Vuletić *et al.*, 2009) with results generated quickly and less costly, benefit transfer may provide inaccurate measures unless the study or policy site share the same characteristics with the site where benefits are transferred. Other limitations include: 1) difficulty in finding the appropriate studies for the good or service in question; 2) difficulty in assessing the existing research study and to ensure appropriateness; and 3) benefit transfer estimates can only be as precise as the initial research study (Rahim, 2008). Figure 3.2 provides an example of methods researchers use to estimate non-market values.

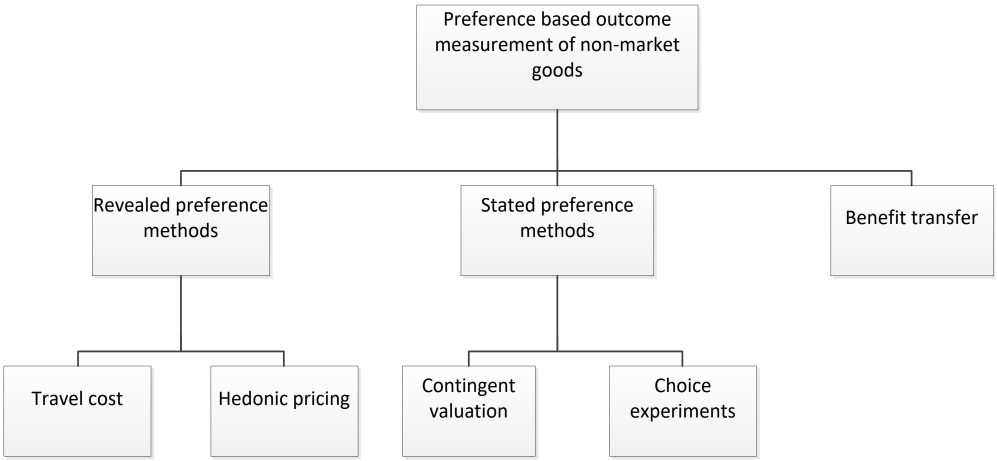

Figure 3.2: Examples of various economic valuations methods utilised in non-market valuation (adapted from (Kjær, 2005)

3.8.7 Motivation for the research method applied in the study

This study as already indicated, applies the DCE to estimate the WTP for improvements of various attributes of water services in Vuwani. Although contingent valuation (CV) is the most commonly applied SP method in non-market valuation, it requires significant resources, which are not available for this study. Moreover, various biases accompany CV studies and among the suggested methods to minimise them include the use of close-ended questions when interviewing respondents (Arrow, et al., 1983). Apart from being less expensive, DCE use close-ended elicitation methods, thereby minimising most of the biases inherent in CV studies. These reasons, including the fact that the elicitation method in DCE mimic how consumers would normally go about making a purchase (choosing a product based on the attributes it possesses) strongly motivated for this study using DCE.

3.9 MODEL ESTIMATION

Choice experiment models are primarily about respondents making a choice where researchers ask a respondent to choose from a number of potential choices, the option/alternative she (or the respondent) prefers the most. As such, DCE are an example of limited (or dummy) dependent variable models so exhaustively described by Madalla, (1986). In such models, the respondent's choice (or dependent variable) is a discrete response where a respondent either choose yes or no. The choice depends on a number of explanatory factors that includes attributes of the good/service in question as well as the respondent's socioeconomic characteristics. To this end, researchers estimate the following model:

$$V = \boldsymbol{X}'\boldsymbol{\beta} + \boldsymbol{\varepsilon} \quad (3.3)$$

In equation (3.3) above, V is the indirect utility that respondents receives from their preferred choice, $\boldsymbol{X}$ is a vector of the factors that influences the respondent's choice of a water service the factors of which in this case includes the water service attributes as well as the respondent's characteristics. $\boldsymbol{\beta}$ is a vector of their associated coefficients and $\boldsymbol{\varepsilon}$ is a vector of the errors**.** While the explanatory (independent) variables represented by vector $\boldsymbol{X}$ includes the respondents socioeconomic characteristics, the attributes and any other factors that may influence the respondents choice of a water service, this study takes the view that it is only the attributes of a water service that influences respondents choice and the associated WTP thereof, of Vuwani residents. These attributes include among others:

Water Quality: The water quality in question is such that it complies with the standard drinking water quality as per the relevant domestic (and international) water quality standard. At the minimum, the water is of a good drinking quality and safe for direct human consumption and it is tasteless, odourless, has no foreign objects or sediments and is colourless. This implies that it should be free from adverse substances such as toxins, bacteria and other harmful substances. More obvious are the polluting activities such as damaged or leaking pipes, the discharge of domestic, industrial urban and other wastewater into the watercourse. At a practical level, the consumer may judge water quality by its clarity, palatability and freedom from taste and odour (Lin, 1977).

Water pressure: This refers to the force that pushes water through the pipes and determines the rate of flow of water from the tap. Water may have low or high pressure. Low pressure can have a number of causes. For example, when demand for water is high (such as in the morning or early evenings) pressure can be lower than during the rest of the day (Webster, 2020).

Frequency of water availability: This refers to the frequency at which households receive pipe water. According to the South African water service standard, frequency of water supply is the provision of a basic water supply facility, sustainable operation of the facility (available for at least 350 days per year and not interrupted for more than 48 consecutive hours per incident) and the communication of good water-use, hygiene and related practices (Government gazette no. 982, 2017).

Water quantity. On average, households prefer to use more water than less water if additional water were available. This is because water has many uses including bathing, washing, cooking, cleaning, etc.

Water for productive uses. The average household can use water for productive and consumptive purposes. Water for productive purposes would include water used to irrigate back-yard vegetable gardens, water used for activities such as washing cars, doing laundry for a fee, or using water to brew sorghum beer for sale, etc.

Monthly Water cost (or price): In this study, the monthly water cost is a monetary attribute reflecting the amount of money households are prepared (or willing) to pay for water per month. The price of water is included as one of the attributes for two primary reasons. These are (a) to enable the estimation of the marginal utility that can be converted into a willingness to pay value for changes in the attributes levels and welfare estimates obtained for the combination of attribute changes (Hanley et al, 2006); and (b) because it is realistic if not reasonable to expect consumers to pay something towards an improved water service. Above all, in DCE, the price or cost attribute is required since the presence of cost makes it possible for respondents to make trade-offs between various choices.

3.9.1 A-PRIORI EXPECTATIONS

Given that the dependent variable in this study is the household's **choice** of the preferred water service, we expect the following relationships to hold between the dependent variable and independent variables (in this study, the attributes of a water service outlined above). Therefore holding the other attributes (variables) constant, we expect a positive relationship between the choice and water quality, water pressure, frequency of water availability, water for productive uses, water quantity and a negative relationship between choice and monthly water cost.

3.9.2 SOURCES OF DATA

The study focuses on the willingness to pay for improvement of water service attributes in Vuwani (as already defined in chapter 1). The study will primarily collect data through an in-person (or face-to-face) interview using a structured survey instrument (or questionnaire) as recommended by Arrow, (2003). Other economic valuation studies that applied CE to estimate WTP for improvements in water service attributes such as Kanyoka et al (2008), Mohd Rusli et al (2011), Latinopoulos (2014), and Mahirah et al (2016) have applied this procedure. Furthermore Carson and Gilmore (2000), indicated that face-to-face interviews are better than mail surveys because they don't exclude people who may have reading difficulties and that they make the hypothetical scenario more understandable as the use of drawings and maps can be presented to the respondents. In some instances, however, I may also supplement primary data collection using online surveys.

3.10 STATISTICAL ANALYSIS OF DCE MODELS

Choice modeling assumes that an individual (or household) derives utility (satisfaction) from choosing the most desirable water service alternative (or option) from a potential choice of options. In economics, utility is an abstract concept that seeks to measure the degree of satisfaction a consumer derives from utilising a product or a service. While it is not possible to measure directly how much utility an individual derives from utilising a product or a service, inferences can however be drawn on the basis of an individual's observed behaviour. Researchers analyse DCE within the Random Utility Theory (RUT) and utility maximisation as a conceptual framework. Within this framework, the individual (respondent) or household indexed as i, is assumed to choose among J options of water service attributes and opts for the option associated with (or that provides her with) the highest utility. Thus, individual i will choose water service option j over water service option k within some choice set C_n if and only if the utility she drives from choosing water service option j is higher than the utility she obtains from choosing a water service option k. An alternative (mathematical) way to represent the same statement is

$U_{ij} > U_{ik}$, $\forall_{j \neq k}, j \in J$, where $U_{ij}$the total utility is which respondent i obtains from choosing a unique option j out of all possible choices within a given choice set. RUT assumes that researcher can decompose the utility associated with a particular water service option into a systematic component along with some degree of randomness (random component) and is formally presented as follows:

$$U_{ij} = V_{ij}\left(Z_{ij}, S_i\right) + e_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.4)$$

In equation (3.4) above, U_{ij} is the total utility that a respondent (i) receives from choosing a water service option j. Noting that from (3.3) above, the indirect utility (V) is influenced by a vector ***X,*** the systematic component V_i of an individual respondent's choice is furthermore decomposed into a function (Z_i, S_i) of the respondent's responses to the water service attributes, Z_i and the respondent's (socio-economic) characteristics S*i.* These characteristics may include gender, race, marital status, household income, etc. and e_i is the random component associated with the respondent making the most desired choice and made up of unobserved but equally important factors that affect the respondent's choice(s).

Since Z_i is assumed to represent the attributes of a water service that an individual respondent choses, and that it is only the attributes of a water service that influences the respondent's choice, the systematic component of (3.3) can be further expressed as a linear function of the explanatory variables (excluding the respondent's characteristics) as follows:

$$V = X'\beta + \varepsilon_i \Rightarrow V_i = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \cdots + \beta_m Z_m + e_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots. \quad (3.5)$$

In equation (3.5), the β_{is} (i.e. $\beta_1\ to\ \beta_m$) are coefficients associated with the water service attributes $Z_i\ (i.e. Z_1\ to\ Z_m$, where the betas (i.e. $\beta_1\ to\ \beta_m$) provide quantitative information on the strength of preferences for each explanatory variable, trade-offs, monetary values as well predicted preferences for water service attributes, while e_i represents error terms (Train, 2003 & WHO, 2012).

When researchers assume (as is the case in this study) that it is only the attributes of a water service (excluding the characteristics of the respondent) that influences the respondent's choice for a water service option, they apply the conditional logit model (CLM) to provide estimates for the β_i $(i.e.\ \hat{\beta}_i)$ or to model the respondent's choice of a preferred water service[14]. A property that the CLM must adhere to is the independence of irrelevant alternatives, which states that the relative probabilities of two options being selected are unaffected by the introduction or removal of other alternatives.

The utility of any given water service is not directly observable such that the coefficients in equation (3.5) cannot be estimated directly. DCE data is therefore modeled within a probabilistic framework such that when individual i is presented with a pair of water service options j and k, the probability (P) that individual i chooses a unique water service option j over water service option k given (or conditioned upon) some choice set that the i^{th} respondent chooses from, C_n can be estimated as:

$$P_{ij}|C_n = Pr[U_{ij} > U_{ik}] \qquad \forall_{j \neq k}, j \in C_n \text{...(3.6)}$$

Using equation (3.4), but excluding the respondent's characteristics, equation (3.6) becomes:

$$P_{ij}|C_n = Pr\ [e_{ij} \ - e_{ik} > V_{ik} - V_{ij}] \text{..(3.7)}$$

In CE models, researchers typically assume (amongst other assumptions) that the error term e_i to be independently and identically distributed (IID) with an extreme-value, type 1 distribution (EV1) represented as:

$$Pr\ (e_{ij} \leq t = \ exp^{-exp^{(-t)}} \text{...(3.8)}$$

Estimating equation (3.8) requires that appropriate assumptions must be made about the distribution of the error term, e_{ij}. Some authors (e.g. Chomitz et al, 1998, Mangham and Hanson, 2008 & Hanson and Jack, 2010) prefer a Probit approach that assumes a normally distributed error term, while others (e.g. Kolstad, 2011) prefer a logistic approach, which assumes a logistic distribution for the error term. Because

[14] If researchers however assume that both the attributes and the respondent's sociodemographic characteristics jointly explain the respondent's choice, they apply a Multinomial Logit Model (MNL).

researchers consider the logit approach flexible, they generally assume the associated error term is to have a logistic distribution in CE literature (de Bekker-Grob et al., 2012). To this end and using the logit approach, researchers define the probability of a respondent choosing water service option j over water service option k as:

$$P_{ij}|C_n = \frac{exp^{(V_{ij})}}{\sum_{k \in C_n} exp^{(V_{ik})}} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \quad (3.9)$$

Each respondent (or household)'s response as obtained from the survey instrument (questionnaire) can be interpreted as the result of the choice for the respondent (or household) that maximizes its utility. To obtain the estimated coefficients, researchers estimate the CLM via the maximum likelihood method. This implies the maximisation of a probabilistic function with respect to the parameters (e.g. Do & Bennett, 2007; Hensher et al, 2005 & Louviere et al., 2000). Because the choice results for option j for the i^{th} respondent (or household) will be "yes" or "no", the associated log-likelihood function is presented as:

$$\mathcal{L} = \sum_{i=1}^{i=I} \sum_{j=1}^{j=N} (y_{ij} \ log[P_{ij}|C_n)]) \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . \quad (3.10)$$

In equation (3.10) above,

$$y_{ij} = \begin{cases} 1 \ if \ individual \ i \ chooses \ water \ option \ \ j \ within \ choice \ set \ C_n; and \\ 0 \ otherwise, \end{cases}$$

where y_{ij} also acts as the dependent variable (Choice).

The CLM has a number of assumptions including. These includes, (a) the scale parameters have a constant variance (θ) which is assumed to be 1 (Greene, 2003), (b) random components do not exhibit serial correlation (i.e. the Independence of Irrelevant Alternatives assumption (IIA))[15], (c) respondents have homogenous (or similar) preferences. Finally, (d) the random components of the utilities of the different alternatives are Independent and Identically Distributed (IID) (or utility parameters are set). When (a) is violated or relaxed, the CLM can be adapted to allow for the variance of the scale parameter by dividing the respective representative utilities defining the probability of choice by the scale parameter as follows:

[15] The IIA assumption suggests that if a respondent prefers choice A over choice B out of choice set $\{A, B\}$, introducing a third choice X and expanding the choice set to $\{A, B, X\}$ must not make choice B preferable to choice A. In other words, consumer preferences for *A* or *B* should not be changed by the inclusion of *X*, i.e., *X* is irrelevant to the choice between *A* and *B.*

$$P_{ij}|C_n = \frac{exp^{\left(\frac{v_{ij}}{\theta_{ij}}\right)}}{\sum_{k \in C_i} exp^{\left(\frac{v_{ik}}{\theta_{ik}}\right)}} \ldots\ldots(3.11)$$

In that event, a problem of bias occurs because the IIA assumption is now violated since the observed $\left(\frac{v_{ij}}{\theta}\right)$ and unobserved $\left(\frac{e_{ij}}{\theta}\right)$ components of utility are now dependent on each other and the error terms exhibit serial correlation (Do & Bennett, 2007). As a result, the IID property also no longer holds.

A model that may overcome the violation of the IIA property (i.e. assumption (b) and by extension, the IID property (i.e. assumption (d)) is the Heteroscedastic Extreme Value (HEV) model first proposed by Bhat (1995). Relaxing the IID involves three ways namely, (i) by permitting the random components to be non-identical and non-independent; (ii) by enabling the random components to be correlated while maintaining the assumption that they are identical; and (iii) enabling the random components to be non-identically distributed (different variances), but then again sustaining the independence assumption.

The HEV model assumes a RUM with independent but non-identically error terms distributed with a type 1 extreme value distribution as well as allowing for different variances on the random components across alternatives. The HEV model is specified as follows:

$$\begin{aligned} P_{ij}|C_n) &= \Pr\,[U_{ij} > U_{ik}], \forall_{j \neq k}, j \in C_n \\ &= \Pr\big(V_{ij} + e_{ij} > V_{ik} + e_{ik}\big), \forall\, j \neq k, j \in C_n \\ &= Pr\ (V_{ij} - V_{ik} > e_{ik} - e_{ij}), \forall\, j \neq k, j \in C_n \\ &= Pr\big(\varepsilon_{ik} \leq V_{ij} - V_{ik} + \varepsilon_{ij}\big), \forall\, j \neq k, j \in C_n \ \ldots\ldots\ldots\ldots\ldots (3.12) \end{aligned}$$

The HEV model then models the probability that an individual i will choose the j^{th} water service option within choice set C_n and may be specified as follows:

$$\mathrm{P_{ij}}|\mathrm{C_n} = \int_{\frac{\varepsilon_{ij}}{\theta_{ij}}=-\infty}^{\frac{\varepsilon_{ij}}{\theta_{ij}}=+\infty} \prod_{j \in C_n, j \neq k} \Lambda\left[\frac{V_{ij} - V_{ik} + \varepsilon_{ij}}{\theta_{ik}}\right] \frac{1}{\theta_{ij}} \lambda\left(\frac{\varepsilon_{ij}}{\theta_{ij}}\right) d\,\frac{\varepsilon_{ij}}{\theta_{ij}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.13)$$

In equation (3.13), $\Lambda[.]$ and $\lambda(.)$ respectively represents the cumulative distribution function (F) and the probability density function (*f*) of the standard type 1 extreme value distribution (Johnson and Kotz, 1970) such that:

$$\lambda(t) = e^{-t}e^{-e^{-t}} \text{ and } \Lambda(t)e^{-e^{-t}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.14)$$

If we substitute $\omega = \frac{\varepsilon_{ij}}{\theta_{ij}}$ in (3.13), equation (3.13) can be re-expressed as:

$$\mathrm{P_{ij}}|\mathrm{C_n} = \int_{\omega=-\infty}^{\omega=+\infty} \prod_{j\in C_i, j\neq k} \Lambda\left[\frac{V_{ij} - V_{ik} + \theta_{ij}\omega}{\theta_{ik}}\right]\lambda(\omega)d\omega \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.15)$$

The coefficients to be estimated from equation (3.15) are the parameter vector $\boldsymbol{\beta}$**,** and the scale parameters for each of the scale parameters of the random component of each of the options. The related log likelihood function in respect of the HEV to be estimated is the given by:

$$\mathcal{L} = \sum_{i=1}^{i=I}\sum_{j=1}^{j=N}(y_{ij}\ log\left\{\int_{\omega=-\infty}^{\omega=+\infty} \prod_{j\in C_n, j\neq k} \Lambda\left[\frac{V_{ij} - V_{ik} + \theta_{ij}\omega}{\theta_{ik}}\right]\lambda(\omega)d\omega\right\} \ldots\ldots\ldots\ldots\ldots (3.16)$$

The log likelihood function in (3.16) has no closed form expression[16] but can be estimated or solved for, through the use of numerical methods (or numerical analysis) most of which are based on the Gaussian quadrature[17]. To estimate (3.16) through numerical analysis and following Bhat (1995), start by defining a variable $u = e^{-w}$, then

$\lambda(\omega)d\omega = -e^{-u}du$, and $\omega = -lnu$. Finally, define a function G_{ij} as:

$$G_{ij} = \prod_{j\epsilon C_n, j\neq k} \Lambda\left[\frac{V_{ij} - V_{ik} + \theta_{ij}lnu}{\theta_{ik}}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.17)$$

Given (3.17), equation (3.16) can now be rewritten as:

$$\mathcal{L} = \sum_{i=1}^{i=I}\sum_{j=1, j\epsilon C_n}^{j=N} y_{ij}\ log\left\{\int_{u=0}^{u=\infty} G_{ij}(u)e^{-u}du\right\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.18)$$

[16] A closed-form expression is a mathematical process that can be completed in a finite number of operations.
[17] Gausian quadrature is a rule for the approximation of the definite integral of a function usually stated as a weighted sum of function values at specified points within the domain of integration.

Equation (3.18) above then becomes an ideal candidate for estimation through numerical analysis based on the Gaussian quadrature methods (Bhat, 2002).

A major drawback for both the CLM and the HEV models is that both models assume that the Vuwani household's preferences for water service attributes included in the model are the same for all respondents. This is to say, both the CLM and the HEV assumes homogeneity in preferences among all households and that they have similar values for water service attributes (Green, 2003). This assumption may not necessarily hold since in practice; people have different preferences and do not necessarily have similar* tastes. A model that accommodates preference heterogeneity or relaxes the assumption of preference homogeneity is the random parameters logit (RPL) model or mixed logit model (MXL).

The MXL model is a generalisation of the standard MNL logit model. The MXL model has since become the most popular method of choice for uncovering preference heterogeneity in choice modelling. Its advantages include; (1) the model does not rely on the IIA assumptions and therefore the alternatives need not be independent, and (2) it allows for investigation of the existence of potential unobserved heterogeneity of preferences (Carlsson et al., 2003; and Train, 2003). These advantages generally make the MXL model to be superior over both the CLM and HEV in terms of fit and overall performance (McFadden & Train, 2000 and Carlsson et al., 2003). A generalised version of the MXL model can be expressed as follows:

$$\mathrm{P_{ij}|C_n} = \frac{exp^{(\alpha_{ij}+\theta_i S_i+\delta_i f_{ij}+\beta_{ij}X_{ij})}}{\sum_{j=1}^{J} exp^{(\alpha_{ij}+\theta_j S_i+\delta_j f_{ij}+\beta_{ij}X_{ij})}} \dots\dots\dots\dots\dots\dots\dots\dots\dots (3.19)$$

In equation (3.19) above, the various .

are defined as follows:

α_{ij} is a fixed or random alternate specific constant, with *j* = 1,2, 3……, *J* alternatives and *i* = 1, 2, 3……, *I* individuals. Also, α_{ij} = 0

$\boldsymbol{\theta}_i$ is a vector of individual specific parameters.

$\boldsymbol{\delta}_i$ is vector of non-random parameters.

$\boldsymbol{\beta}_{ij}$ is a parameter vector that is randomly distributed across individuals.

μ_i is the individual specific random disturbance of unobserved heterogeneity and is a component of $\boldsymbol{\beta}_{ij}$ parameter vector.

$\boldsymbol{S}_i$ is a vector of individual tastes (or individual specific characteristics).

$\boldsymbol{f}_{ij}$ is a vector of individual specific and alternate specific non-randomised attributes.

$\boldsymbol{x}_{ij}$ is a vector of individual specific and alternate specific randomised attributes.

The MXL model can take on a number of different functional forms and incorporate a number of underlying distribution assumptions. The most common assumptions are the normal, triangular, uniform and log-normal distributions (Bhat, 2002). The log-normal distribution is applied if the response parameter (or the parameter for the explanatory or independent variable) needs to have a specific sign (Alpizar & Martinsson, 2001 and Louviere et al., 2000). For example, the law of demand suggests an inverse relationship between the price and quantity of the attribute and as such, it may be necessary to restrict the price to a negative sign, which may then call for the price (or cost) attribute to have a log-normal distribution. A uniform distribution with a (0,1) bound is appropriate where dummy variables are utilized. It not easy to determine which variables must be randomly distributed. Some applications only randomize the cost variable, while others choose to randomize all non-price variables and leave cost as non-random (Layton, 2000).

Ideally, all three models should be implemented in order to ensure robust results. However, lack of resources forced this study to only implement the CLM and the RPL (MXL) models.

3.11 Estimating the WTP for attributes of water supply.

Once we have estimated the models (CLM, HEV and RPL), the WTP for each attribute must be determined. To determine the WTP for the attributes, we go about it as follows: We start by expressing the deterministic component of the indirect utility function V_{ij} as a linear combination of the water service attributes (Z_{ij}) as follows:

$$V_{ij} = \beta_1 Z_1 + \beta_2 Z_2 + \cdots + \beta_k Z_k + \beta_p Z_p \quad (3.20)$$

In equation (3.20) above, Z_1 to Z_k represents each attribute of water supply, while Z_p represents the price (or cost) attribute, β_1 to β_k denotes parameters that are estimated (i.e. the WTP) for each attribute 1,2,….,k, while β_p denotes the estimated parameter for the price (or cost) attribute. To determine/calculate the WTP value for each attribute, we take the total derivative of equation (3.22) (and dropping the indexing on the dependent variable) such that:

$$dV = \frac{\partial V}{\partial Z_1}.dZ_1 + \frac{\partial V}{\partial Z_2}.dZ_2 + \cdots + \frac{\partial V}{\partial Z_k}.dZ_k + \frac{\partial V}{\partial Z_p}.dZ_p$$

$$0 = \frac{\partial V}{\partial Z_1}.dZ_1 + \frac{\partial V}{\partial Z_2}.dZ_2 + \cdots + \frac{\partial V}{\partial Z_k}.dZ_k + \frac{\partial V}{\partial Z_p}.dZ_p$$

$$0 = \beta_1.dZ_1 + \beta_2.dZ_2 + \cdots + \beta_k.dZ_k + \beta_p.dZ_p \ldots\ldots\ldots\ldots\ldots\ldots \quad (3.21)$$

To determine the WTP for each attribute such as Z_1 (while holding the other attributes constant) for example, we manipulate equation (3.21) to have:

$$-\beta_1.dZ_1 = \beta_p.dZ_p$$

$$-\frac{\beta_1}{\beta_p} = \frac{dZ_p}{dZ_1}$$

Define $WTPZ_i = \frac{dZ_p}{dZ_i}$; therefore

$$WTPZ_1 = -\frac{\beta_1}{\beta_p} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.22)$$

And by the same analogy,

$$WTPZ_2 = -\frac{\beta_2}{\beta_p}, WTPZ_3 = -\frac{\beta_3}{\beta_p}, \ldots\ldots, \text{and } WTPZ_k = -\frac{\beta_k}{\beta_p} \ldots\ldots\ldots (3.23)$$

3.12 Determining the benefits of improvements in the attributes of a water service.

Once the WTP for each of the attributes of a water service has been derived, the next step is to sum the WTP of all attributes and take the resulting total WTP value and aggregate it over the sample (to obtain sample benefits) or the target population (to obtain overall benefits). In our case, we would aggregate the WTP of the attributes of water service over the population of Vuwani in order to have an estimate of the potential benefits of improvements of water service attributes in Vuwani. Once the benefits have been estimated, we could also quantify the discounted sum of benefits and compare them with the discounted sum of the associated costs (if they have been (or could be) quantified). Comparison of the discounted benefits and costs would enable policy makers to justify potential investment in the water service infrastructure in Vuwani. Therefore, the benefits of water service improvements are determined as follows:

$$Benefits_{ws} = \left(\sum_{i=1}^{N} WTP_{all\ water\ service\ attributes}\right) \times NH \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ldots (3.24)$$

In (3.24) above, *N* represents the total number of respondents, while *NH* is the number of all households in the study area.

3.13 Validity and Reliability of the study and study results

Since this study is quantitative thus lending itself to empirical findings, there is a need for researchers to validate their findings, if not ensure that their empirical results are robust. Researchers achieve this through evaluating their empirical results against validity and reliability. This is important because while empirical results may be valid, they may not necessarily be reliable and vice versa. In this regard, the degree to which the empirical results and underlying theoretical rationale support the sufficiency and relevance of the empirical results clarifications and the subsequent conclusions, reflect validity. To this end, validity refers to the degree to which researchers measure and find comfort with the outcomes of a research.

Researchers consider three major categories of validity, namely, (a) content validity; (b) construct validity; and (c) criterion validity. Content validity will be concerned with whether the research instrument (in this study, a DCE questionnaire) sufficiently covers all the content that it should cover to address the study's objectives. In addition, because the study focuses on determining the WTP for attributes of water services, content validity will be concerned with whether the DCE questionnaire asks respondents questions that are clear enough to elicit the desired response.

Construct validity refers to the degree to which inferences can be drawn for the empirical results of a study. Construct validity would therefore be interested on the degree to which empirical results for example, accords with a-priori hypotheses while construct reliability concerns itself with the degree to which the study results relate with other similar studies.

Reliability on the other hand relates to the consistency of the different measures researchers use to arrive at the conclusions of research findings. In other words, the reliability of research finding depends to a large degree on their potential replicability by other researchers. Because reliability and validity are crucial in ensuring robust research outcomes, they mutually reinforce each other. For this reason, validity and reliability are implicitly involved in almost every stage of a quantitative research since research methods invariably stick to strict protocols

3.14 Summary

This chapter provided and discussed an overview of the research methodology applied in this study as well as discussing issues related to research paradigm and research design including a discussion on the best practice in designing a DCE study. The chapter rounds off with a discussion and an illustration of the estimation of CE models, how WTP is determined including the evaluation of the benefits of improvements in water service attributes including issues around how researchers validate their research findings.

Chapter 4 Data and Methods

This chapter kicks off with the identification, selection of attributes and attribute levels, experimental research design and construction of choice sets, properties of a choice model, and a statement of testable hypotheses. The chapter rounds off with a discussion of issues around the estimation and evaluation of a DCE model.

4.1 Identification of attributes and attribute levels

Researchers use a number ways to identify the attributes used in a choice model including their associated attribute levels. The most common method is through literature review and focus group discussions in cases where previous studies do not exist. Through literature review, researchers are able to establish the nature and type of attributes applied in different studies and under different circumstances. As already pointed out in Chapter 2, very few published studies in South Africa have considered WTP for attributes of an improved water service. Therefore, identification attribute and attribute levels in this study used a combination of literature review and focus group discussion.

Focus group discussions conducted with residents within the study area identified the following issues regarding the water service currently available:

(a) Residents are not satisfied with the quality of water received. More often than not, the water smells of fish or mud and has colour that tends to blemish clothing with bright colours.

(b) Residents do not have a reliable water supply. In this regard, water is not always available in the Vuwani town for weeks, and is at times not available for periods exceeding months particularly in the villages surrounding the Vuwani town. This results in residents having to make alternative arrangements to source water, which includes among other things, turning to alternative water sources such as springs, boreholes including purchasing water from water vendors. When residents have to purchase water from water vendors, they pay R5/25ℓ container and R2/25ℓ container in the town and surrounding villages respectively.

(c) When water is available, more often than not, it has low pressure and it takes long to fill a water container.

(d) Residents would also prefer to have higher volumes of water that will enable them to use water for other household chores as well.

Literature review within a South African setting (Snowball et al., 2008 and Dikgang et al., 2017) assisted in identifying attributes of a water service, in particular, productive uses of water (Kanyoka et al., 2008) which resonated in the study area as well. This is because some residents within the study area operate businesses such as a car wash including keeping backyard vegetable gardens for domestic consumption or selling all of which talks to the productive nature of water use. The focus group also allowed study allowed identifying water service attributes and levels used to design the options submitted to interviewed respondents in the form of choice sets. The combination of literature review and focus group discussions yielded the following attributes:

(a) Water quality
(b) Water quantity
(c) Water pressure
(d) Frequency of water availability
(e) Water for productive purposes; and
(f) Monthly cost of water

The inclusion of a cost attribute is important in choice modelling since it enables the quantification of WTP estimates. The number of attributes to include in the DCE is important. This is because when respondents respond to the choices, researchers assume that respondents are considering all the attributes, and making trade-offs among them. The trade-offs that respondents make when confronted with competing choices are an important feature in DCE since they allow the estimation of such trade-offs and monetary values. Of concern though, is the fact that if there are too many attributes and attribute levels, respondents may not consider all the attributes due to respondent fatigue. In this case, the estimated trade-offs and monetary values will be invalid. This then raises a question as to how many attributes are too many. Although there is no general rule of thumb as to how many attributes to include in a DCE, some authors consider eight attributes as a maximum (World Bank, 2012). Table 4.1 summarises their description and levels.

ATTRIBUTE	ATTRIBUTE DESCRIPTION	ATTRIBUTE LEVELS
Water quality 	Water is of a high quality if it is safe to drink directly and has no odour, colour, is tasteless and above all, complies with the standard of drinking water quality.	Water has bad taste
		Water has bad smell
		Water has discoloration
		Water is of a good quality and is safe to drink
Water quantity 	Households use water for many things and would prefer to use more water per day if it were available.	100ℓ per day (or 4 x 25ℓ) containers per day
		200ℓ per day (or 8 x 25ℓ) containers per day
		300ℓ per day (or 12 x 25ℓ) containers per day
		More than 300ℓ per day
Frequency of water supply 	Households generally experience water supply disruptions for long periods that often exceed two weeks or more.	Water is unavailable most of the time
		Water is available for a limited time/week
		Water is available all the time
Water pressure 	Water pressure is the force that pushes water through the water pipes. High water pressure ensures water is delivered at a faster rate while low water pressure ensures water is delivered slowly	Low water pressure
		High water pressure
Productive uses of water 	When water is readily available, households would want to use it for productive purposes such as irrigating backyard gardens, the produce of which may be a dietary and income supplement.	Unavailable
		Readily available
Monthly cost of water 	Potable water which is of a good quality and safe to drink is not provided free of charge and residents are expected to pay for the water on a monthly basis.	R100.00
		R250.00
		R400.00
		R600.00
		R1000.00

Table 4.1. Attributes Attribute descriptions and Attribute levels

To enable econometric analysis, we coded the attribute levels as per table 4.2 below.

ATTRIBUTE	ATTRIBUTE LEVELS	CODING
Water quality 	Water has bad taste	1
	Water has bad smell	2
	Water has discoloration	3
	Water is of a good quality and is safe to drink	4
Water quantity 	100ℓ per day (or 4 x 25ℓ) containers per day	1
	200ℓ per day (or 8 x 25ℓ) containers per day	2
	300ℓ per day (or 12 x 25ℓ) containers per day	3
	More than 300ℓ per day	4
Frequency of water supply 	Water is unavailable most of the time	1
	Water is available for a limited time/week	2
	Water is available all the time	3
Water pressure 	Low water pressure	1
	High water pressure	2
Productive uses of water 	Unavailable	1
	Readily available	2
Monthly cost of water 	R100.00	1
	R250.00	250
	R400.00	400
	R600.00	600
	R1000.00	1000

Table 4.2 Coding of attribute levels

Note that coding and the range of attribute levels referred to in chapter 3, denote the same thing

4.2. Experimental design

This study detailed the issues around experimental design in full in the preceding chapter. This chapter thus outlines how the study implemented the experimental design, implemented specifically in respect of this study. Having selected the attributes and their levels, the next step is to construct hypothetical water service options (i.e. option A, B, Neither, etc.) characterised by different attributes and attribute levels, which we present to the respondents. From table 4.1, there are two attributes with 4 levels each, two attributes with two levels each as well as one attribute with 3 levels and one attribute with five levels. This means that we can generate a maximum number of 64 choice profiles $(i.e.\ 4^2 \times 2^2 \times 1^3 \times 1^5 = 64)$. Because there are three options per choice occasion, in this study, the maximum number of unique choice sets will be 1 344 $\left(i.e.\ \frac{(64\times63)}{3} = 1\,344\right)$. One thousand three hundred and forty four is clearly too many choice sets for a respondent to consider. This is an example of a full factorial design.

To ensure that researchers present respondents with manageable choice sets, there is a need to reduce them (fractional factorial design). When using experimental design methods to reduce the full set of scenarios (full factorial design) down to a manageable level (fractional factorial design), DCE practitioners often use orthogonal designs based on orthogonal arrays. Orthogonal arrays have the following properties (a) orthogonality (meaning attributes are statistically independent of one another), (b) level balance (the levels of attributes appear an equal number of times), and (c) there is minimum overlap (i.e. an attribute level is not repeated across options or alternatives). Some authors (e.g. Willis et al., 2005 and Snowball et al., 2007) considers the use of main effects sufficient since main effects usually account for between 80% to 90% of the total variation of the data in DCE. To ensure the efficiency of the orthogonal design and accuracy of the estimators, the design must be efficient the efficiency of which is evaluated via D-efficiency in this study[18]. The efficient design of a DCE requires prior information in the form of "prior coefficients" of the model researchers want to estimate to perform an optimisation procedure. This procedure consists of creating a design matrix (experimental design) that reduces the variance of the coefficients that we are going to calculate. One of the most common ways to

[18] Researchers implement efficient designs through different designs such as the A-efficient designs (see Huber and Zwerina, 1996) or C-efficient designs (see Scarpa and Rose, 2008). Despite these alternative efficient design options, the D-error remains the most widely used efficient design (Bliemer and Rose, 2014). Model estimation in this study utilised the STATA software, which implements design efficiency through D-Efficiency via the dcreate command. Dcreate uses an algorithm that maximises the D-efficiency (or minimises the d-error) using the modified Fedorov algorithm (Cook and Nachtsheim, 1980, Zwerina et al., 1996 and Carlsson and Martinsson, 2003).

estimate this variance is $d - error = \left|\Omega^{\frac{1}{k}}\right|$ where Ω is the covariance matrix of the model coefficients and K is the number of parameters in the model.

The STATA software employs an algorithm to iterate random designs matrices until it finds the experimental design with a lower d-error. Before we design a final questionnaire with choice sets, we first generated a questionnaire for a pilot study, which consisted of creating an efficient design based on a set of prior coefficients set equal to zero. This designed enabled the generation of a pilot questionnaire that we presented to a limited number of respondents (30). We used the results from the pilot study as a source of actual prior coefficients (instead of zeros) to enable the efficient design of the final questionnaire. With actual coefficients obtained from the pilot study, the orthogonal design allowed the generation of 16 water service alternatives, which we further subdivided into two questionnaires of eight choice sets each. We did this in order to reduce the cognitive burden or potential respondent fatigue on the respondent. Thereafter, we administered the questionnaires during face-to-face interviews with respondents in the study area.

The total number of households in the study area (based on the results of the 2011 census) is 6 026. We used a sample of 230 respondents representing about 3.8% of the households (and considered representative) in the study area. Each choice set (or paired comparison) had three alternatives, the third being an opt-out (or status quo) alternative that we included to avoid presenting respondents with forced[19] choices. There are advantages and disadvantages to presenting respondents with a forced choice or an opt-out choice. The inappropriate application of a forced choice may result in biases in parameter estimates because it forces respondents to make choices they may not want to make. On the other hand, an opt-out option may cause respondents to choose such an alternative not because it provides the highest benefit (utility) among the alternatives but because they wanted to avoid making a difficult decision (World Bank, 2012). However, authors have found significant differences in the results of choice experiments with and without the presence of and opt-out (status quo alternatives) within the literature (Dhar, 1997), with some authors recommending that in general, an opt-out option should be considered (Adamowicz and Boxall, 2001; Bennett and Blamey, 2001; Bateman et al., 2003) whenever a DCE is conducted.

[19] A forced choice involves a situation where a respondent can only chose between two alternatives with no opportunity to opt out if neither of the options are appealing.

In this study, we asked respondents to choose between three options (alternatives) within a given choice set (i.e. option (alternative) A, option B or Neither option) with the options described by their attributes. Table 4.3 presents an example of a choice set presented to respondents.

4.2.1 Checking the properties of experimental design efficiency.

The foregoing discussion outlined the steps required to generate a perfect experimental design satisfying the properties of D-efficiency, we test the validity of the design we generated which, albeit not perfect, we expect it to be a good design. Whether we have a perfect or good design, we still need to check it to verify its validity. As already indicated, an efficient design must satisfy three properties, namely (a) orthogonality, (b) level balance and, (c) minimum overlap; the properties of which we test.

CHOICE SET X

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water is of a good quality and is safe to drink	Water has bad smell
Water Quantity	More than 300ℓ per day	100ℓ (or 4 x 25ℓ) containers per day
Water Frequency	Water is available all the time	Water is available for a limited time/week
Water Pressure	Low water pressure	High water pressure
Productive Uses	Unavailable	Readily available
Monthly Water cost	R600.00	R100.00

I would Choose (TICK ONE BOX ONLY)	OPTION A	☐	OPTION B	☐	NEITHER OPTION	☐

Table 4.3. An example of a hypothetical choice set presented to respondents

4.2.1.1. Orthogonality

Orthogonality requires that the attributes must be independent of each other. Table 4.4 shows the correlations of the attributes in the design including their level of significance below each correlation coefficient. Overall, the correlations among attributes are very low (less than 0.5) except for the attributes Water quantity and

Productive uses of water and we can conclude the satisfaction of the orthogonality property

	choice	watqul	watqnt	frequncy	pressure	prodctv	cost
choice	1.0000						
watqul	0.0796	1.0000					
	0.0000						
watqnt	-0.0898	0.3141	1.0000				
	0.0000	0.0000					
frequncy	-0.0692	0.3067	0.2939	1.0000			
	0.0000	0.0000	0.0000				
pressure	-0.0515	-0.0669	0.1262	0.2270	1.0000		
	0.0001	0.0000	0.0000	0.0000			
prodctv	-0.0008	0.3904	0.5266	0.3782	0.1297	1.0000	
	0.9509	0.0000	0.0000	0.0000	0.0000		
cost	-0.2207	0.3843	0.3881	0.4154	0.1865	0.3278	1.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	

Table 4.4 Pairwise correlation between attributes

4.2.1.2 Level balance

Level balance requires all levels of each attribute to appear with equal frequency across profiles. Thus for a 2-level attribute, each level should appear in 50% of the profiles, and for a 4-level attribute each level should appear in 25% of the profiles. In this study however, there is a need to note that the attribute level 1 relates to the opt-out option. In this study, there are three choices per each choice set and16 choice sets. This gives us 48 choice occasions. If we ignore the opt-out level (level 1) and consider the next four levels in a five level attribute (such as the Monthly cost of water) or the next three levels in a four level attribute (such as Water Quality and Water Quantity), we find that the levels appear in almost similar proportions. We conclude that the design therefore has a good level balance albeit not perfect. Table 4.5 shows the distribution of levels across the attributes.

4.2.1.3 Minimum overlap

This property requires the minimisation if not elimination of a repeated attribute level within a choice set. This ensures that the experiment provides maximum information when respondents trade-off one choice over the other. The final questionnaires (booklets 1 and 2) in the appendix clearly demonstrate evidence of limited or no attribute level overlap in this study.

Attribute	Value	Number of appearances	Percentage of appearance
Monthly cost of water	1	16	33,33%
	100	5	10,42%
	250	6	12,50%
	400	6	12,50%
	600	8	16,67%
	1000	7	14,53%
Water Quality	1	31	64,58%
	2	6	12,50%
	3	5	10,42%
	4	6	12,50%
Water Quantity	1	22	45,33%
	2	9	19,26%
	3	8	16,67%
	4	9	18,75%
Frequency of water supplies	1	25	52,08%
	2	13	27,08%
	3	10	20,83%
Water Pressure	1	36	75,00%
	2	12	25,00%
Water for productive purposes	1	33	68,75%
	2	15	31,25%

Table 4.5 Level distribution across attributes

4.3 Data and variables definition

Since the study utilises primary data, we outline the dataset's organisation for estimation purposes. The attributes in a DCE are also the variables and table 4.2 provides their description under attribute description. Ryan et al. (2010), highlights the importance of ordering the data in a reasonable manner, which includes the presentation of all the variables used in the study.

4.3.1 Data organisation

The first thing to note is that the study collected data from 230 respondents. Given that each respondent was faced with three options per choice occasion, this provided 5 520 observations. Moving from left to right, we organized the data as follows:

(a) **Obs.** This is a mnemonic for observation number. Because each choice task is comprised of three options, there will be three entries per observation. This gives observations per respondent of 1 840 and a total number of observations at 5 520. For estimation purposes in STATA, the variable Obs also represents the group identification of each respondent.

(b) **PID**. This variable is a unique identifier for every respondent. Since we present every respondent with eight choice sets with three choice occasions, it will be the same for the first twenty four (24) rows, then a subsequent and sequential number for the next 24, etc. For estimation purposes in STATA, PID is also important when estimating the RPL model since it enables the uncovering of potential preference heterogeneity.

(c) **Cno.** This variable depicts the choice set number in the DCE questionnaire. There are sixteen choice sets in the study (albeit split in half to reduce respondent fatigue).

(d) **Booklet.** The splitting of the 16 choice sets into two halves of 8 choice sets each means the DCE questionnaire was split into two booklets. Therefore, Booklet indicates whether the choice sets belong to the first half (Booklet 1) or the second half (booklet 2) of the sixteen choice sets.

(e) **Option.** This depicts the options (alternatives) that the respondent chooses from in every choice occasion within a choice set. The respondent can choose either Option A (A), Option B (B) or Neither Option (N).

(f) **Alt**. This represents the alternative within each choice set that the respondent chooses. We can also interpret it as numerical coding of the variable, Option. Therefore, Alt = 1 when the respondent chooses option A, Alt = 2 when the respondent chooses option B, and Alt = 3 when the respondent choses Neither option.

(g) **Constant.** This is a variable that researchers must include when using conditional logit in the data matrix. It indicates whether a row of data represents Option A, B, or Neither. It is a dummy variable that takes on values of 1 and 0. Researchers include it to soak up the preference for the base comparator (opt-out). In this study, we code it 1 when the option = N (or Alt = 3).

(h) **Choice.** For the purposes of this study, this is the dependent variable. It is a dichotomous (binary) variable where Choice = 1 when the respondent choose a given option (alternative) within a given choice set and Choice = 0 otherwise (or Choice = 0 for every option not chosen within that choice occasion).

(i) **Watqul**. This is a mnemonic for Water Quality as described in table 4.1

(j) **Watqnt.** This is a mnemonic for the variable Water quantity as described in table 4.1

(k) **Frequncy.** This is a mnemonic for the variable, Frequency of water supply as described in table 4.1.

(l) **Pressure.** This is a mnemonic for the variable, Water pressure as described in table 4.1

(m) **Prodctv.** This is a mnemonic for the variable, Water for productive purposes as described in table 4.1; and finally

(n) **Cost.** This is also a mnemonic for the variable, Monthly cost of water as described in table 4.1

As already indicated, a conditional logit model assumes that only the attributes of a good or service explains the WTP to the exclusion of sociodemographic data. In this regard, we do not describe the sociodemographic data even though we collected it.

4.4 Testable hypotheses

A-priori, we expect a positive relationship to obtain between the dependent variable (Choice) and all the explanatory variables (i.e. Water Quality, Water Quantity, Frequency of water supplies, Water Pressure, and Water for productive purposes) except for the Monthly cost of water where we expect a negative relationship. Briefly, we will expect respondents to positively value improvements/increases in Water Quality, Water Quality, Water Pressure, Frequency of water supplies and Water for productive purposes. In addition, and in keeping with the law of demand, we would not expect respondents to prefer increases in the monthly cost of water.

4.5 Methodology and empirical estimation issues

Discrete Choice Experiments involve a number of models within the logistic regression milieu and the estimated coefficients from these models leads to the estimation of WTP for the underlying attributes if the models satisfies certain properties. These properties include parsimony, plausibility and informative content (Feldstein, 1982). In this regard, researchers deem a model parsimonious when it comprises the minimum number of parameters that describes the key concepts. Researchers regard a model plausible when its variables, concepts, and the specified relations among them are reasonable in terms of a larger body of coherent knowledge. Finally, researchers consider a model informative if it provides situational guidance that is suitable for the application at hand (Bowen et al., 2009).

The nature of attributes used in choice models is prone to introduce collinearity. While the estimated coefficients are still unbiased in the presence of collinearity, they will however have larger variances of the standard errors. Larger variances of the standard errors may induce incorrect signs in the estimated coefficients including reducing the values of the t-statistic (and the z-scores) of the affected coefficients. This has the effect of causing researchers to commit type II[20] error when variables are involved in a collinear relationship (Studenmund, 2014). Moreover, if Multicollinearity is pronounced, the software will simply return no results

There are a number of ways to address the problem of collinearity, which includes among others[21], dropping the variables involved in a collinear relationship. However, dropping variables risks introducing the problem of omitted variable bias. Studenmund (2014) suggests that rather than drop variables per se, researchers must consider dropping redundant[22] variables instead. It is important therefore, to explicitly test for potential collinearity when working with DCE.

[20] In (statistical) hypothesis testing, researchers commit a type I error when they reject a true null hypothesis, and commit a type II by failing to reject a false null hypothesis.
[21] Other potential remedies include increasing the sample size,
[22] Researchers deem a variable redundant if it measures the same thing as the other area. For example. In hedonic property value studies, one of the variables often used is the area of the house. However, other studies also use the roof area as one of the explanatory variables. If a researcher use both variables simultaneously, it is clear that both will be measuring the same thing in which case, one of them is a good candidate for dropping.

4.5.1 Testing for (multi) collinearity[23]

In this study, we detect (multi)collinearity through the pairwise correlation among attributes and via the method of Variance Inflation Factors (VIF). We would suspect Multicollinearity when the pairwise correlation between attributes is 0.8 and above and cannot rule out collinearity when the pairwise correlation between attributes is 0.5 and above. On the other hand, we cannot rule out Multicollinearity when VIF > 5. As we have already seen from table 4.4, the pairwise correlation among attributes is very low except for the pairwise correlation between Water Quantity and Water for productive purposes, which is 0.5266. While we can rule out Multicollinearity since the pairwise correlation < 0.8 and there are only two attributes involved, we cannot rule out some collinearity between these two attributes. Since both appear to be measuring the same thing, one of them is redundant and is an ideal candidate fro dropping when we estimate the final model.

The construction of the VIF calls for the estimation of auxiliary regressions where the attributes are regressed against each other. After obtaining the R-squared of each attribute, we compute the VIF thus: $VIF_i = \frac{1}{1-R_i^2}$, where *i* indexes the attributes and *i* = 1,2,3,4,5,6 with R^2 representing the R-squared value of the attribute acting as the dependent variable. If the VIF > 5 for the attributes, we are unable to rule out the possibility of attributes involved in a collinear relationship. Table 4.6 shows the VIFs of the six attributes and since none of them have a VIF > 5; we conclude that (multi) collinearity is not a problem in the model.

Attribute	**Variance Inflation Factor**	**R-Squared**
Cost	1,4413	0,3062
Water Quality	1,3669	0,2684
Water Quantity	1,5006	0,3336
Frequency	1,3680	0,269
Pressure	1,1140	0,1023
Productive	1,5860	0,3695

Table 4.6 Variance Inflation Factors for the attributes

[23]Collinearity is a linear association between two explanatory variables. When that linear association is more pronounced, Multicollinearity in a multiple regression model are highly linearly related associations between two or more explanatory variables.

4.6 Evaluating the results of a DCE

After estimating a DCE model, the regression output reports a number of things. For each attribute, the regression output reports: (a) the estimated coefficient $(\hat{\beta}_i)$ and its associated standard errors and, (b) the probability (ρ) value for each estimated coefficient. With the appropriate decision rule, the ρ value enables researchers to reject or fail to reject the Null hypothesis. Since we are interested in whether the attributes explain the hypothesised relationship or not, we set the Null and its associated Alternative hypothesis as follows:

$$Null\ hypothesis\ \ H_0: \hat{\beta}_i = 0 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (4.1)$$

$$Alternate\ hypothesis\ H_A: \hat{\beta}_i \neq 0 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (4.2)$$

In this study, as in most DCE studies, we set the decision rule as follows:

$$\alpha = 0.05 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (4.3)$$

Given the decision rule, we reject the Null hypothesis when $\rho \leq 0.05$, and we fail to reject the Null hypothesis when $\rho > 0.05$. With the estimated coefficient, we can take its antilog $\left(10^{\hat{\beta}_i}\right)$ as well as calculate the implicit price (or WTP) for an attribute $\left(that\ is, Implicit\ price\ (WTP) = \frac{\hat{\beta}_i}{\hat{\beta}_{Cost}}\right)$. The RPL model, which enables the uncovering of potential preference heterogeneity, reports the means and standard deviations of the attributes. Researchers achieve this through performing this calculation: $\frac{\hat{\beta}_{Mean\ i}}{\hat{\beta}_{Standard\ Deviation\ i}}$, where $i = 1,2,3,4$. To test for preference heterogeneity, we set up the relevant Null and Alternative hypotheses respectively as follows:

$$H_0: Respondents\ have\ heterogeneous\ preferences\ for\ water\ service\ attributes \ldots\ldots\ldots\ldots\ldots\ldots\ldots. (4.4)$$

$$H_A: Respondents\ do\ not\ have\ heterogeneous\ preferences\ for\ water\ service\ attributes \ldots\ldots\ldots\ldots. (4.5)$$

Concentrating on the standard deviations in the RPL model, we reject the Null hypothesis when $\rho > 0.05$, (concluding there is evidence of preference homogeneity thus concluding there exist a possibility of preference homogeneity among respondents) and fail to reject the Null hypothesis when $\rho \leq 0.05$ thus concluding there is evidence of preference heterogeneity among respondents).

For each attribute (variable), the estimated coefficient $\hat{\beta}_i$ of the attribute (variable) shows the relationship between the respondent's choice and that specific attribute. A positive coefficient shows that the respondent prefers a quantitative increase or a qualitative improvement of the attribute and *vice versa*. The sign of the coefficient tests or indicates whether the relationship between variables is consistent with the underlying (micro) economic theory. The associated standard error is an indicator of how precise an estimate of the "true" population parameter the estimated coefficient is. It seeks to measure the accuracy of prediction.

The estimates coefficients can also be used for two main purposes, namely (a) To determine whether the attributes are important (i.e. statistically different from zero or not) as shown by the ρ – value, and (b) the relative importance (size) of the estimated parameter.

The antilog or the log odds ratio interpretation indicates how an increase (decrease) in an attribute's level (or a change from one attribute level to the next) would result in a percentage change in the probability of choosing an option (A, B or Neither) from the choice set, which includes the increase (decrease), Lee, Hosking & du Preez (2016).

The implicit price (or WTP) shows the amount that the respondents are willing to pay for improvements in the attributes of a water service.

We measure the statistical significance of each of the attributes in the model through the probability (ρ value). The ρ value is the lowest level at which the Null hypothesis can be rejected. To this end, the ρ value should be lower than or equal to the fixed level of 1%, 5% and 10% for the attribute's coefficient for us to say that the coefficient is statistically different from zero (Gujarati, 2003). In this study, an estimated coefficient is statistically different from zero when $\rho \leq$ 0.05).

The study assess the overall performance of the estimated model by looking at the so-called McFadden's pseudo R^2 value. This is determined by comparing the proportion of the likelihood ratio of the estimated full model with that of the constant only model (i.e. a model where there are no explanatory variables) and it ranges between 0 and 1. The McFadden pseudo R^2 is analogous to the R^2 in the Ordinary Least Squares (OLS) model and it refers to the proportion of the variance of the dependent variable that is explained by the variance in the independent variables in the model.

A model whose McFadden[24] pseudo R^2ranges between 0.2 and 0.4 is considered to have a better fit (Louviere et al., 2000). In addition, just like the adjusted R^2in an OLS model, which adjust the R^2 for inclusion of additional explanatory variables, we also make use of the Adjusted[25] McFadden pseudo R^2 in Choice Models. The adjusted McFadden pseudo R^2 is analogous to the adjusted R^2 in OLS models in that it penalises the pseudo R^2 for the inclusion of additional explanatory variables by adjusting the pseudo $R^2$with the inclusion of *K* number of explanatory variables.

Since choice modelling is implemented through Maximum Likelihood estimation techniques, the values of the LL_0 and LL_m suggests that the parameter values from both models are such that they maximise the likelihood that the process described by the model produced the data that were actually observed. We consider the model that has the highest LL value to have a better fit.

Furthermore, we test for rationality among the respondents by determining the extent to which respondents choose water service options at various monthly water cost levels. We will deem respondents' behaviour as rational or consistent with economic theory if a smaller percentage of respondents choose an option when the monthly water cost is high and vice versa. Figure 4.1 presents a non-parametric test (a graph in this instance) which shows the number of respondents making the choice against the various levels of monthly water cost.

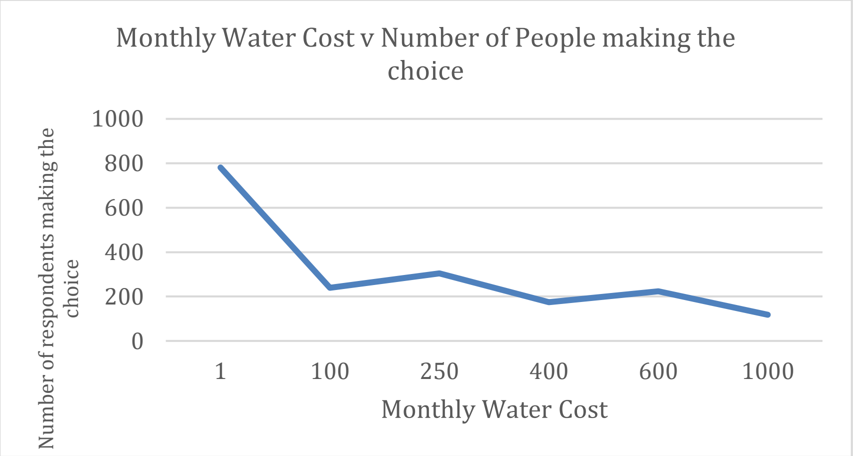

Figure 4.1 Monthly water cost and number of people making the choice

[24] The McFadden pseudo $R^2$is determined as follows: $McFadden\ R^2 = 1 - \frac{LL_m}{LL_0}$, where LL_m is the Log likelihood of the estimated model and LL_0 is the Log Likelihood of the constant model.

[25] The Adjusted McFadden pseudo R^2 is determined as follows: $Adjusted\ McFadden\ R^2 = 1 - \left[\left(\frac{LL_m - K}{LL_0}\right)\right]$, where K is the number of variables in the model

Figure 4.1 shows that the largest number of respondents of respondents (781) choose an option with the lowest monthly water cost (i.e. R1.00) while the lowest number of respondents (118) choose an option with the highest monthly water cost (i.e. R 1000.00). Figure 4.1 in a way mimics a typical individual demand function where consumers demand smaller quantities at higher prices and vice versa. While economics textbooks typically depict an individual demand function characterised by smoothness and continuity and would look nothing as the graph in figure 4.1, the "true" nature of an individual demand function paints a different[26] picture[27].

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[26] As proof, consider the dual of a utility maximisation problem where a consumer has a choice between goods X and Y. We set the constrained minimization problem as: $_{\min}\mathcal{L} = P_x X + P_y Y + \lambda(\bar{U} - U(X, Y))$, where P_x, P_y, and $\bar{U}$ are respectively, the prices of X and Y, and the fixed level of utility. Solving the constrained minimization problem, and noting that at an initial utility maximisation point where utility is a given level $\bar{U}$, we know that the following condition always holds $X^c(P_x, P_y, \bar{U}) \equiv X^O(P_x, P_y, M)$................(1). This condition simply states that at that point, the compensated demand function $X^c(.)$ Is always **identically** equal to the ordinary demand function $X^O(.)$. Letting M (Income) = E (Expenditure) and noting that $E = E(P_x, P_y, \bar{U})$, then $X^c(P_x, P_y, \bar{U}) = X^O\left(P_x, P_y, E(P_x, P_y, \bar{U})\right)$ ....(2). Noting that a small change in price along the ordinary demand function $\frac{\partial X}{\partial P_x}$ can be decomposed into the substitution and income effect, then $The\ total\ effect\ of\ a\ price\ change = Substitution\ effect + Income\ effect$. Solving for $\frac{\partial X^O}{\partial P_x}, or\ \frac{\partial X}{\partial P_x}$, and noting that equation (1) is a composite function and applying the composite function (chain) rule of differentiation, equation (2) becomes $\frac{\partial X^c}{\partial P_x} = \frac{\partial X^O}{\partial P_x} + \frac{\partial X^O}{\partial E}.\frac{\partial E}{\partial P_x}$...................(3). Collecting terms and dropping the superscript O on the ordinary demand function in order to solve for $\frac{\partial X}{\partial P_x}$ and noting that $\frac{\partial E}{\partial P_x} = X$, while recalling that M = E, equation (3) gives us the famous Slutzky equation $\frac{\partial X}{\partial P_x} = \frac{\partial X^c}{\partial P_x}|_{U=\bar{U}} - \frac{\partial X}{\partial M}.X$.......................(4). The Slutzky equation simply restates the condition that at some initial utility maximisation point, $X^c(P_x, P_y, \bar{U}) \equiv X^O(P_x, P_y, M)$. For any small change in the price of X, microeconomic theory tells us the substitution effect, $\frac{\partial X^c}{\partial P_x}|_{U=\bar{U}} < 0$ (i.e., the substitution effect (when the level of utility is constant) is always negative). Assuming X is a good (and not a bad), then X > 0 always. Noting that $\frac{\partial X}{\partial M}$ is the income effect, microeconomic theory tells us that $\frac{\partial X}{\partial M} > 0$ for normal goods and $\frac{\partial X}{\partial M} < 0$ for inferior goods. Recalling that the $The\ total\ effect\ of\ a\ price\ change = Substitution\ effect + Income\ effect$, and noting the foregoing, the total effect of a price change would be (a) negative for normal goods implying a downward sloping demand function, (b) negative for inferior goods if the substitution effect dominates the income effect, still implying a downward sloping demand function; and (c) positive for inferior goods if the income effect dominates the substitution effect and implying an upward sloping demand function. Noting that a good can only be locally inferior but not globally inferior, we therefore cannot rule out some section(s) of the ordinary demand function sloping upwards, but only over some section thereof. Therefore, if figure 4.1 were an ordinary demand function, then its shape would be consistent with what microeconomic theory postulates about the potential shape of the demand function.

[27] Alternatively, consider an inverse demand function given by $p = p(q)$. The total revenue function (TR (q)) would be given by $p(q) \times q \Rightarrow TR(q) = p(q)q$. This results in the marginal revenue $MR(q) = \frac{dTR(q)}{dq} = p(q)\frac{dq}{dq} + q\frac{dp}{dq} \Rightarrow MR(q) = p(q) + q\frac{dp}{dq}$. Even though microeconomic theory tells us that while an individual demand function slopes downward and to the right, just like the MR curve, an evaluation of the slope of the MR curve is revealing. Noting that $MR(q) = p(q) + q\frac{dp}{dq}$ then the slope of the marginal revenue function is given by $\frac{dMR(q)}{dq} = \frac{dP(q)}{dq} + q\frac{d^2p}{dq^2} + \frac{dp(q)}{dq}\frac{dq}{dq} \Rightarrow MR(q) = 2\frac{dp}{dq} + q\frac{d^2p}{dq^2}$. The first term of the slope of the Marginal Revenue curve shows that the intercept of the $MR(q)$ function will not only have a negative slope, but it will be twice the slope of the demand function. Because the quantity demanded, $q > 0$ in the second term of the slope of the $MR(q)$ is always positive, the term $\frac{d^2p}{dq^2}$ can be locally positive or negative. If it is locally negative, the entire $MR(q)$ function will have a negative slope. However, if the $\frac{d^2p}{dq^2}$ term is locally positive, then we are unable to rule out segments of the $MR(q)$ function that could be upward sloping. Needless to say, this can only be possible when there are also segments of the underlying demand function p(q) that are locally positive. Assuming that figure 4.1 was analogous to an individual demand function; then figure 4.1 would depict a valid demand function that globally adheres to the law of demand.

4.7 Summary

This chapter considered a number of issues specifically related to the implementation of a DCE. These issues included the selection of attribute of a water service, their associated attribute levels including attribute description. It also touched upon a key element in DCE, that of experimental design. It considered issues around the administration of the questionnaire and rounded of by providing an explanation of how researcher evaluate a DCE once they have estimated the model.

CHAPTER 5: Empirical Results and Discusion

This chapter presents and discusses the results of the model estimation as well as the willingness to pay for the attributes of improvements of a water service improvement. Owing to inability to have access to a software that enables the estimation of the HEV model, this chapter only presents the empirical results for both the Conditional Logit and Mixed Logit models. Finally, the chapter concludes by proffering the potential policy implications of the empirical results.

5.1 Results of Conditional Logit and Mixed Logit models

Table 5.1 and table 5.2 respectively provides a summary of the empirical results of the Conditional Logit and the Random Parameters (or mixed) Logit Models (RPL or MXL). To reiterate, the CLM's point of departure is that the consumers WTP for attributes of an improved water service solely depends upon the attributes of the water service including the fact that respondents have homogenous (similar) preferences in respect of those attributes. The RPL relaxes homogeneity of preferences, which characterises the CLM and instead assumes that respondents have heterogeneous preferences regarding their preferences for attributes of an improved water service. As already indicated previously, the study does not provide results for the HEV model. This is because of limitations of the software used (STATA version 14) which does not handle estimation of the HEV model.

Tables 5.1 and 5.2 reports from left to right, the following results. (a) The estimated coefficients (or the estimates $(\hat{\beta}_{Attribute})$ of the i^{th} attribute of a water service, (b) the antilog (or log odds) of the estimated coefficient, (c) the implicit price (or WTP for the i^{th} water service attribute[28], (d) the probability (ρ) value for each estimated coefficient; and (e) WTP estimates obtained from STATA's inbuilt Delta method. The RPL model (table 5.2) goes a step further by including (f) the means, (g) standard deviations; and (h) the degree of heterogeneity (or the lack thereof) among respondents within the study area.

[28] In this case, the implicit price (or WTP) is simply the estimated coefficient $\hat{\beta}$ of the i^{th} attribute divided by the estimated coefficient of the cost attribute.

Attribute	Coefficient	Log odds	Implicit Price $\left(or\ WTP = \frac{\hat{\beta}_{Attribute}}{\hat{\beta}_{Cost}}\right)$	ρ	WTP in Stata (Delta method)
Water Quality	0,643440***	4,3999	R828,43	0,00000	R828,40
Frequency of water availability	0,451494***	2,8281	R581,30	0,00000	R581,26
Water Pressure	0,734186***	5,4223	R945,26	0,00000	R945,21
Productive uses of water	0,328406***	2,1301	R422,82	0,00000	R422,80
Water cost	-0,000777***	1,0017		0,00000	

MODEL CHARACTERISTICS

LL_c	-816,6400
LL_m	-500,9238
McFadden Pseudo R^2	0,3866
Adjusted McFadden Pseudo R2	0,3817
LR $chi^2(5)$	2425,4200
Prob > chi^2	0,0000

Note:

***, $\rho \leq 0.001$

**, $\rho \leq 0.01$

*, $\rho \leq 0.05$

Table 5.1: Conditional Logit Model Results

	Attribute	Coefficient	Log odds	Implicit Price $\left(or\ WTP = \frac{\hat{\beta}_{Attribute}}{\hat{\beta}_{Cost}}\right)$	ρ	WTP (Delta method)	Heterogeneity
Mean	Water Quality	0,523982***	3,3418	R251,14	0,000	R251,14	
	Frequency of water availability	-0,071479	0,8482		0,316		
	Water Pressure	0,262981***	1,8322	R126,05	0,006	R126,10	
	Productive uses of water	0,192653**	1,5583	R97,34	0,033	R97,34	
	Water cost	-0,002209***	1,0051		0,000		
SD	Water Quality	0,221720			0,000		99,91%
	Frequency of water availability	0,658057			0,000		57,14%
	Water Pressure	0,434671			0,014		74,22%
	Productive uses of water	0,566691			0,000		63,31%

MODEL CHARACTERISTICS

LL_c	-1773,5802
LL_m	-1137,7962
McFadden Pseudo R^2	0,3585
Adjusted McFadden Pseudo R^2	0,3562
LR $chi^2(4)$	142,7900
Prob > chi^2	0,0000

Note:
***, $\rho \leq 0.001$
**, $\rho \leq 0.01$
*, $\rho \leq 0.05$

Table 5.2. Mixed (Random Parameters) Logit results

5.2 Evaluation, interpretation and discussion of the model results

As indicated on table 4.4, in the previous chapter, the pairwise correlating among the attributes suggests that the attributes are not only independent, but orthogonal too. Above all, they indicate very little if not the absence of collinearity, except for the attributes Water quantity and Productive uses of water whose pairwise correlation is 0.53 hence suggesting they are involved in a collinear relationship. For estimation purposes, the attributes Water quantity and Productive uses of water measures the same thing, hence leading to the dropping of the attribute, Water quantity in both the CLM and RPL models.

Having dispensed with the foregone discussion above, tables 5.1 and 5.2 presents the empirical results for both the CLM and RPL models. All the estimated coefficients of the attributes of a water service accords with the a-priori hypotheses, and have the hypothesised signs thus conforming with the underlying economic theory. In the CLM, all the estimated coefficients are statistically different from zero and are highly significant (at least at the 99% level of confidence). This means that the respondents in the study area prefer qualitative (and or) quantitative increases of all the attributes of a water service except the attribute, Monthly cost of water where they prefer a quantitative decrease in the attribute. Despite preferring a quantitative decrease in the Monthly cost of water, the fact that the estimated coefficient of Cost is not only negative, but is statistically different from zero accords with the law of demand where higher prices are accompanied by lower quantities demanded and vice versa.

These findings also applies to the RPL model with the exception of the attribute, Frequency of water availability, which is statistically not different from zero. Because $\rho > 0.05$ for the attribute, Frequency of water availability in the RPL (i.e. ρ = 0.316), this leads to failure to reject the Null hypothesis and the conclusion that for this attribute, $\beta_i = 0$, This simply means that the attribute, Frequency of water availability does not explain the respondents' WTP for improvements in water service attributes. And because $\rho < 0.05$ for the rest of the attributes across both models, this leads to the rejection of the Null hypothesis and the conclusion that $\beta_i \neq 0$, or the conclusion that but for the attribute Frequency of water availability, all the other attributes explain the respondents WTP for improvements in water service attributes.

The antilog or the log odds ratio interpretation indicates how an increase (decrease) in an attribute's level (or a change from one attribute level to the next) would result in a percentage change in the probability of choosing an option (A, B or Neither) from the choice set, which includes the increase (decrease). In this regard and focussing on the CLM, an improvement in the quality of water from one level to the next will result in in an increase in the probability of the respondent choosing that option in the choice set by 4.4%. An improvement in the Frequency of water supplies from one level to the next will result in the probability of the respondent choosing that option in the choice set by around 3%. An improvement in the Water pressure from one level to the next increases the probability of a respondent choosing that option in a choice set by 5.4%. Finally, an improvement in the Water for productive purposes from one level to the next increases the probability of a respondent choosing that option by 2.1%. By the same analogy, an increase in the monthly cost of water from one level to the next will result in decrease in the probability of the respondent choosing that option in the choice set by 1%. The log odds interpretation applies *mutatis mutandis* to the rest of attributes in the RPL models that are statistically different from zero.

There are two ways of estimating the WTP (or implicit prices) of the attributes. The first is to divide the estimated coefficient of the i^{th} attribute by the estimated coefficient of the cost attribute and the second is to derive them through the software package, which estimates WTP via the delta method (Hole, 2007). The results would be identically similar except for small differences in the decimals points, if any differences at all.

With respect to the CLM, the monthly WTP for improvements in the attributes of a water service range from a low of R 422.82c in respect the attribute, Productive uses of water to a high of R 924.26c in respect of the attribute, Water pressure. When one considers that residents within the study area are already paying R 5/25ℓ container per day within the Vuwani town and R 2/25ℓ container per day to water vendors, these WTP values appear to accord with the residents lived reality if not very credible. With respect to the RPL model and only focusing on attributes that are statistically different from zero, the WTP values for improvements in water service attributes ranges from a low of R 97.34 for Productive uses of water to a high of R 251.14 with respect to water quality. It is important to note that the primary aim of the RPL model is to uncover potential heterogeneity among respondents in the study area.

Estimation of the RPL model assumes that the estimated coefficients of the attributes (i.e. $\hat{\beta}_i$) are either normally, triangularly, uniformly or log-normally distributed over the population of individuals (Bhat et al., 2000; Bhat, 2001). Normally distributed parameters, means and standard deviations of coefficients can determine to what extent respondents place positive or negative values on a change in an environmental attribute (Train, 2003). From table 5.2, all the $\rho -$ values for the standard deviations in respect of the RPL model indicate significant preference heterogeneity across all attributes (since $\rho < 0.05$ for all attributes). From the magnitudes of the standard deviations relative to the mean coefficients, practically all respondents prefer water of a higher quality (i.e. 99%)[29], 74% prefer water with a high pressure (implying that 26% of the respondents are indifferent to water pressure (or prefer low water pressure), 63% prefer quantities of water that enables productive uses while 57% prefer water to be available more frequently[30]. Unfortunately, the RPL model does not make it possible to uncover the reasons for respondents hetrogenous preferences and researchers at best, can all ut speculate.

The values of the McFadden pseudo R^2 and the adjusted McFadden pseudo R^2 provides an indication as to the overall performance (or goodness of fit) of both models. The statistic, just like the R^2 in the Ordinary Least Squares Model (OLS), provides an indication of the proportion of the variance in the dependent variable (i.e. choice) explained by the variation in the explanatory variables (i.e. attributes of a water service). Both the McFadden pseudo R^2 and the adjusted McFadden pseudo R^2 are a scalar that ranges between one and zero. A choice model has a good fit if the associated pseudo R^2 value ranges between 0.2 and 0.4 (Koutsoyanis, 1996 and Louviere et al., 2000). Therefore, with the McFadden Pseudo R^2 values respectively at 0.39 and 0.36, and adjusted McFadden pseudo R^2 values of 0.37 and 0.36 respectively, both models have a good fit.

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[29] From a practical point of view, 99% of the respondents expressing preference for an improved water quality (and 1% preferring otherwise) is tantamount to all the respondents in the study area having homogenous preference for improved water quality. This would appear rational since it would be difficult to imagine a respondent who would be contented with water of a poor quality. Indeed, water of a high quality (or uncontaminated water) is not only a standard that policy makers aim for and consumers desire, but it is also a good (as opposed to a bad). Moreover, having access to water of a high quality would also enable respondents to avoid the transmission of diseases such as typhoid, cholera, polio and other diseases that arise as a consequences of using water of a poor quality.

[30] Within the RPL model, researchers test for potential heterogeneity of respondents through the following formulation: $100 \times \Phi\left(\frac{b_i}{s_i}\right)$, where Φ is the cumulative standard normal distribution while $b_i and\ s_i$ are respectively, the mean and the standard deviation if the i^{th} attribute.

Finally, both models (i.e. the CLM and RPL) reports a likelihood-ratio test for the joint significance of the attributes as well as the standard deviations. At 0.000, the associated ρ –values are small, implying rejection of the null hypothesis that all the estimated coefficients and the standard deviations are equal to zero.

5.3 Determining the potential benefits of an improved water service in the study area.

Having estimated the respondents' WTP for the various attributes of a water service, the next important step is to quantify the benefits of an improved water service. Recalling chapter 3, we use the following formulation to quantify the benefits

$$Benefits = n \times \sum_{1}^{4} (WTP_{water\ service\ attributes}) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (5.1)$$

In (5.1), n represents the number of respondents (230) in the sample used in this study. There are four attributes that are statistically different from zero in this study, namely, Water Quality, Frequency of water availability, Water pressure, and Productive uses of water. Their respective WTP estimates are R828.43, R581.30, R945.26, and R422.82. Using these four estimates of WTP, the monthly sample benefits of an improved water service in Vuwani are:

$$Sample\ benefits_{Monthly} = 230 \times 2777.81 = R\ 638\ 896.30 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (5.2)$$

From this monthly sample benefit of an improved water service, the undiscounted[31] annual value of the sample benefits of an improved water service would be:

$$Sample\ Benefits_{Annual} = 230 \times 2777.81 \times 12 = R\ 7\ 666\ 755.60\ \text{year}) \ldots \ldots \ldots \ldots\ (5.3)$$

To have an appreciation of the potential benefits of an improved water service in the study area, we would multiply the R 7.7m sample benefits by the number of households in the study area. Currently, the latest data on the number of households in the study area come from the results of the 2011 census[32]. Recalling that the study

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[31] To ensure intertemporal balance, researchers apply the process of discounting. Given that a water service project is a public project, the appropriate discount rate is the social discount rate defined as the rate at which society is willing to trade present versus future consumption. By applying the appropriate social discount rate, this ensures that the value of a unit of currency (say R1.00) at the beginning of a period (say at the start of the year) is similar to the value of that unit of currency at the end of another period (say at the end of the year).

[32] Statistics South Africa conducts a population census every ten years in South Africa with the latest one conducted in 2021. However, the results are still outstanding at the time of writing.

area comprised of the Vuwani town and surrounding villages, namely HaṊesengani and HaDavhana, the number of households in 2011 were respectively, 710, 3 603 and 1 713, giving a total of 6 026 households[33]. Based on the foregoing, the monthly benefits of an improved water service in the study area are:

$$Overall\ Benefits_{Monthly} = 6026\ \times 2777.81 = R16\ 739\ 083.06 \dots \dots \dots .. \dots \dots .. \dots \quad (5.4)$$

The associated potential undiscounted annual benefits of an improved water service in the study area will therefore be:

$$Overall\ Benefits_{Annual} = 16\ 739\ 083.06 \times 12\ = R\ 200\ 868\ 996.72 \dots \dots \dots \dots \dots (5.5)$$

For the longest period, South Africa has applied a social discount rate of 8% on social infrastructural projects such as roads, water, etc., (Central Economic Advisory Services, 1989). Conningarth Economists (2014) define a social discount rate as the rate of return to balance the social opportunity cost of undertaking a project in the public sector versus the next best alternative in the private sector where rates are observable. Therefore, following Conningarth Economist (2014) and Pienaar (2021), this study applies a social discount rate of 8% to obtain the discounted monthly and annual benefits of an improved water service in the study area. Accordingly, applying a social discount rate of 8% yields the discounted monthly and annual benefits of an improved water service in the study area of R 209 238 538.25 and R 2 510 862 459 (or R 209.24m and R 2.51bn) respectively.

The discounted monthly and annual values provide and indication of the monetary benefits that could potentially be realised in Vuwani if the water service were to be improved (or conversely, they provide an indication of how much the Vuwani households are willing to pay monthly and annually for an improved water service). This information is important since it provides an indication of the potential benefit (or welfare gain) that Vuwani residents would derive from an improved water service.

5.4 Summary

This chapter presented and provided an analysis of the estimated results of bot the CLM and RPL model. Above all, it demonstrated the significant benefits in the study

[33] The number of households in the study area has since perceptibly increased since the last census. However, until the StatsSA releases the latest census data (2021), this study will use the household data from the 2011 census to quantify the benefits of an improved water service in the study area.

area likely to arise out of an improved water service. It rounded off by offering tentative implications of the study’s findings to policy makers.

CHAPTER 6: SUMMARY AND DIRECTIONS FOR FUTURE RESEARCH

This chapter presents the overall summary of the study. It rounds off the discussion by proposing potential directions for further research

6.1 Summary

The first observation to make is that residents within the study area are willing to pay for improvements in the attributes of a water service across all the models since all the estimated coefficients are statistically different from zero, except for the attribute, Frequency of water availability in the RPL model. In both models, the results also show that as is consistent with economic theory, respondents do not prefer increases in the monthly cost of water.

Furthermore, and with respect to the CLM, the respondents' maximum monthly WTP for improvements in the attributes of a water service is R 2 777.81 while it is R474.53 for the RPL model. If we assume a household of eight people that that receives a basic water service per day (i.e. 25ℓ per person per day), the monthly water costs will be R480/month and R1 200/month if that household reside within the surrounding villages or Vuwani town respectively[34]. However, and based on the proposed 2021/22 Vhembe District Municipality's water tariffs, if the households were receiving the basic water service from the local municipality, they would have paid R35.00/m and R9.00/m respectively if connected to a conventional meter or having a prepaid meter. Noting that the estimated monthly payments for improvements in water services reported from the CLM and RPL model represents the maximum amount a household is willing to pay, then the estimated monthly WTP values appear credible since they very close to what respondents are paying currently.

The study results also indicates that the monthly undiscounted sample benefits resulting from improvements of water service attributes amount to R 638 896 and R 7 666 756 per year, with the overall undiscounted monthly and annual benefits amounting to

[34] Note that the basis of these figures is that the residents of Vuwani town currently pay R5/25ℓ container while those in the surrounding villages pay R2/25ℓ container.

R 16 739 083 and R 200 869 997 respectively. Finally, the overall discounted benefits from improvements of water service attributes within the study area yields monthly and annual benefits amounting to R 209 238 538.25 and R 2 510 862 459 respectively.

The study also demonstrated that residents in the study demonstrate strong heterogeneity in their preferences for water service attributes although the model is not able to indicate specifically, who those respondents are. In this regard, the study demonstrated that almost all the respondents (i.e. 99%) in the study area prefer water of a higher quality, while 74% prefer water with a high pressure, with 63% prefering quantities of water that enables productive uses and finally, 57% preferring more frequent availability of water per month.

These results leads to important observations and policy implications. First, the findings of the study suggests that the discounted benefits from improvement of water services in Vuwani amount to some R2.51bn per annum. The study arrives at this value using the results of the 2011 census since the results of the 2021 census are still pending. When the 2021 census results are finally released, the annual benefits will be much higher since the number of households in Vuwani has increased. The resulting benefit will be a more realistic estimate to work with that the current R 2.51bn estimated in this study. Notwithstanding the unavailability of Vuwani household data from the latest census results, what is important from a policy perspective is that the study has provided policy makers with one of the values required in conducting a cost-benefit analysis exercise of improving water services within their local jurisdictions.

Secondly, water plays an important role in people's daily lives, whether as an economic, cultural or indeed a good that ensures a healthy life. Indeed, at a residential level, some communicable and life threatening diseases such as those that are water borne like cholera, dysentery, etc., can only be prevented through a consistent supply of good quality water. The fact that almost all the residents in Vuwani are unanimous in their preference for water of a high quality is something that cannot escape the attention of local, and indeed, national policy makers. Therefore, the findings of this study clearly provides policy makers with evidence based information on the need to improve the various attributes of a water service made available to citizens.

6.2 Directions for future research

Like all studies, this study does not pretend to have uncovered all there is to know about the willingness to pay for improvements of water service attributes. Furthermore, the fact that this study applied non-probability sampling methods means its results have relevance only within the study area. As such, generalisation of the study's findings to other areas, albeit possible through the use of benefit transfer, can only be done under strong assumptions regarding the conditions within the study area and their potential applicability to another area. As a result, this study makes no such assumptions that its results can be generalised over rural South Africa.

Therefore, one potential suggestion for future research would be the need to consider the use of probability sampling methods when drawing a sample of prospective respondents in rural Limpopo or in similar rural settings. This is because every citizen within that rural setting stand an equal chance of selection as a potential respondent making the study results potentialy generalisable over other areas in rural Limpopo specifically, and potentially, across rural South Africa in general.

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APPENDIX I : ETHICAL CLEARENCE

APPENDIX II: QUESTIONNAIRE/SURVEY INSTRUMENT – BOOKLET 1 (ENGLISH)

WILLINGNESS TO PAY FOR IMPROVEMENT OF WATER SERVICE ATTRIBUTES

Water scarcity is a major problem in South Africa given the country's classification as "water stressed" and the thirtieth driest country in the world. Like many developing countries, South Africa faces severe challenges with the reliability of water supply. These challenges include but are not limited to intermittence (frequency of water supply), low pressure, poor water quality and quantity of water supply. Although these challenges impose difficulties in the country in general, they impose a severe burden in rural settings and outlying towns.

We designed this survey to gather information about your preferences for various attributes of water services in your residential area (village/town). As such, I would appreciate very much if you could take a few minutes of your time to complete this questionnaire. The information would assist a great deal in helping us in having some ideas regarding preferences people may have for water services attributes in your village/town

PART A: DETAILS (To be completed by the enumerator)

Study ID		
Date of Survey		
Enumerator		
Town/Village		
Gender	☐ Male	☐ Female
Does the respondent have a water tap in the yard?	☐ Yes	☐ No
If no, does the respondent have a borehole in the yard	☐ Yes	☐ No
Has the respondent consented to the interview? No ☐ Yes ☐ **If no, do not proceed with the questionnaire/survey.**		

ATTRIBUTE	ATTRIBUTE DESCRIPTION	ATTRIBUTE LEVELS
Water quality 	Water is of a high quality if it is safe to drink directly and has no odour, colour, is tasteless and above all, complies with the standard of drinking water quality.	Water has bad taste
		Water has bad smell
		Water has discoloration
		Water is of a good quality and is safe to drink
Water quantity 	Households use water for many things and would prefer to use more water per day if it were available.	100ℓ per day (4 x 25ℓ) containers per day
		200ℓ per day (8 x25ℓ) containers per day
		300ℓ per day (12 x 25ℓ) containers per day
		More than 300ℓ per day
Frequency of water supply 	Households generally experience water supply disruptions for long periods that often exceed two weeks or more.	Water is unavailable most of the time
		Water is available for a limited time/week
		Water is available all the time
Water pressure 	Water pressure is the force that pushes water through the water pipes. High water pressure ensures water is delivered at a faster rate while low water pressure ensures water is delivered slowly	Low water pressure
		High water pressure
Productive uses of water 	When water is readily available, households would want to use it for productive purposes such as irrigating backyard gardens, the produce of which may be a dietary and income supplement.	Unavailable
		Readily available
Monthly cost of water 	Potable water which is of a good quality and safe to drink is not provided free of charge and residents are expected to pay for the water on a monthly basis.	R100.00
		R250.00
		R400.00
		R600.00
		R1000.00

PART B: Introduction to the choice question

Section 1

In this part of the questionnaire, I would like to understand the factors that may affect your preferences with regard to an improved water service in your Town/Village. While many factors/characteristics/attributes may contribute to an improved water service, I would like you to focus on the six listed below:

- Water quality
- Water pressure
- Frequency of water supply/water interruptions
- Water quantity
- Productive uses for water
- Cost of water per month

I will present you with paired choices of a water service (i.e. Option A, Option B and Neither Option) where we describe a water service by its attributes/factors/characteristics and ask you to select the water service choice you prefer the most. Each choice of a water service you make has advantages and disadvantages. You will need to trade-off the advantages and disadvantages in making your choice in response to the following question:

Note: The question below will remain the same throughout the questionnaire/survey.

1. ***Suppose you needed to make your choice of a water service right now from a choice set (i.e. where you are selecting from choice set 1 up to choice set 8), which one (i.e. Option A, Option B or Neither Option) would you choose? Please select your choice (Option A, Option B or Neither Option) by making a mark on the relevant box.***

Do you understand the questions above?

Note: Both choices will change and there is no wrong or right choice.

Before we begin, I present you with an example of a paired choice (**choice set X**). Look at the two choices presented here, identify the differences between them and then answer the questions when you are ready.

Choice set X

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water is of a good quality and is safe to drink	Water has bad smell
Water Quantity	More than 300ℓ per day	100ℓ (or 4 x 25ℓ) containers per day
Water Frequency	Water is available all the time	Water is available for a limited time/week
Water Pressure	Low pressure	High water pressure
Productive Uses	Unavailable	Readily available
Monthly Water cost	R600.00	R100.00

I would Choose (TICK ONE BOX ONLY)	OPTION A	☐	OPTION B	☐	NEITHER OPTION	☐

Choice set 1

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water has discoloration	Water has bad smell
Water Quantity	300ℓ (or 12 x 25ℓ containers) per day	200ℓ (or 8 x 25ℓ containers) per day
Water Frequency	Water is available for a limited time/week	Water is unavailable most of the time
Water Pressure	High water pressure	Low water pressure
Productive Uses	Readily available	Unavailable
Monthly Water cost	R 250.00	R 400.00

I would Choose (TICK ONE BOX ONLY)	OPTION A ☐	OPTION B ☐	NEITHER OPTION ☐

Choice set 2

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water has discolouration	Water bad taste
Water Quantity	300ℓ (or 12 x 25ℓ containers) per day	200ℓ (or 8 x 25ℓ containers) per day
Water Frequency	Water is available all time	Water is available for a limited time/week
Water Pressure	High water pressure	Low water pressure
Productive Uses	Unavailable	Readily available
Monthly Water cost	R100.00	R600.00

I would Choose (TICK ONE BOX ONLY)	OPTION A	☐	OPTION B	☐	NEITHER OPTION	☐

Choice set 3

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water is of a good quality and is safe to drink	Water has bad smell
Water Quantity	More than 300ℓ per day	300ℓ (or 12 x 25ℓ containers) per day
Water Frequency	Water is available all the time	Water is available for a limited time/week
Water Pressure	High water pressure	Low water pressure
Productive Uses	Unavailable	Readily available
Monthly Water cost	R400.00	R 1000.00

I would Choose (TICK ONE BOX ONLY) OPTION A ☐ OPTION B ☐ NEITHER OPTION ☐

Choice set 4

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water has bad taste	Water is of a good quality and is safe to drink
Water Quantity	100ℓ (or 4 x 25ℓ containers) per day	More than 300ℓ per day
Water Frequency	Water is available all the time	Water is unavailable most of the time
Water Pressure	High water pressure	Low water pressure
Productive Uses	Unavailable	Readily available
Monthly Water cost	R250.00	R 1000.00

I would Choose (TICK ONE BOX ONLY)	OPTION A ☐		OPTION B ☐		NEITHER OPTION ☐

Choice set 5

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water has bad smell	Water has discolouration
Water Quantity	200ℓ (or 8 x 25ℓ containers) per day	More than 300ℓ per day
Water Frequency	Water is available all the time	Water is available for a limited time/week
Water Pressure	High water Pressure	Low water pressure
Productive Uses	Readily available	Unavailable
Monthly Water cost	R 1000.00	R 600.00

I would Choose OPTION A (TICK ONE BOX ONLY) ☐ OPTION B ☐ NEITHER OPTION ☐

Choice set 6

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water is of a good quality and safe to drink	Water has bad taste
Water Quantity	200ℓ (or 8 x 25ℓ containers) per day	100ℓ (or 4 x 25ℓ containers) per day
Water Frequency	Water is unavailable most of the time	Water is available all the time
Water Pressure	High water pressure	Low water pressure
Productive Uses	Readily available	Unavailable
Monthly Water cost	R 250.00	R 400.00

I would Choose (TICK ONE BOX ONLY) OPTION A ☐ OPTION B ☐ NEITHER OPTION ☐

Choice set 7

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water has bad taste	Water has bad smell
Water Quantity	300ℓ (or 12 x 25ℓ) containers per day	More than 300ℓ per day
Water Frequency	Water is unavailable most of the time	Water is available for a limited time/week
Water Pressure	Low water pressure	High water pressure
Productive Uses	Unavailable	Readily available
Monthly Water cost	R 250.00	R 600.00

I would Choose (TICK ONE BOX ONLY) OPTION A ☐ OPTION B ☐ NEITHER OPTION ☐

Choice set 8

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water is of good quality and is safe to drink	Water has bad taste
Water Quantity	100ℓ (or 4 x 25ℓ containers) per day	300ℓ (or 12 x 25ℓ containers) per day
Water Frequency	Water is available all the time	Water is available for a limited time/week
Water Pressure	Low water pressure	High water pressure
Productive Uses	Readily available	Unavailable
Monthly Water cost	R 1000.00	R 100.00

I would Choose (TICK ONE BOX ONLY) OPTION A ☐ OPTION B ☐ NEITHER OPTION ☐

PART C: Socio - demographic details

Please answer the following questions:

1. How old are you? ______ Years

2. What is your highest educational qualification?

- ☐ Tertiary (e.g. University / College)
- ☐ Technical/vocational training
- ☐ High school
- ☐ Primary school
- ☐ No schooling

3. What is your marital status?

☐ Married ☐ Not married

4. What is your employment status?

☐ Employed ☐ Unemployed ☐ Self employed

5. How many people do you have in your household? ☐ People

6. Which income tax bracket does your household fall in?

1	**R 1 – R 226 000**	
2	**R 226 001 – R 353 100**	
3	**R 353 101 – R 488 700**	
4	**R 488 701 – R 641 400**	
5	**R 641 401 – R 817 600**	
6	**R 817 601 – R 1 731 600**	
7	**R 1 731 601 and above**	

APPENDIX III: QUESTIONNAIRE/SURVEY INSTRUMENT – BOOKLET 2 (ENGLISH)

WILLINGNESS TO PAY FOR IMPROVEMENT OF WATER SERVICE ATTRIBUTES

Water scarcity is a major problem in South Africa given the country's classification as "water stressed" and the thirtieth driest country in the world. Like many developing countries, South Africa faces severe challenges with the reliability of water supply. These challenges include but are not limited to intermittence (frequency of water supply), low pressure, poor water quality and quantity of water supply. Although these challenges impose difficulties in the country in general, they impose a severe burden in rural settings and outlying towns.

We designed this survey to gather information about your preferences for various attributes of water services in your residential area (village/town). As such, I would appreciate very much if you could take a few minutes of your time to complete this questionnaire. The information would assist a great deal in helping us in having some ideas regarding preferences people may have for water services attributes in your village/town

PART A: DETAILS (To be completed by the enumerator)

Study ID		
Date of Survey		
Enumerator		
Town/Village		
Gender	☐ Male	☐ Female
Does the respondent have a water tap in the yard?	☐ Yes	☐ No
If no, does the respondent have a borehole in the yard	☐ Yes	☐ No
Has the respondent consented to the interview? No ☐ Yes ☐ **If no, do not proceed with the questionnaire/survey.**		

ATTRIBUTE	ATTRIBUTE DESCRIPTION	ATTRIBUTE LEVELS
Water quality 	Water is of a high quality if it is safe to drink directly and has no odour, colour, is tasteless and above all, complies with the standard of drinking water quality.	Water has bad taste Water has bad smell Water has discoloration Water is of a good quality and is safe to drink
Water quantity 	Households use water for many things and would prefer to use more water per day if it were available.	100ℓ per day (4 x 25ℓ) containers per day 200ℓ per day (8 x25ℓ) containers per day 300ℓ per day (12 x 25ℓ) containers per day More than 300ℓ per day
Frequency of water supply 	Households generally experience water supply disruptions for long periods that often exceed two weeks or more.	Water is unavailable most of the time Water is available for a limited time/week Water is available all the time
Water pressure 	Water pressure is the force that pushes water through the water pipes. High water pressure ensures water is delivered at a faster rate while low water pressure ensures water is delivered slowly	Low water pressure High water pressure
Productive uses of water 	When water is readily available, households would want to use it for productive purposes such as irrigating backyard gardens, the produce of which may be a dietary and income supplement.	Unavailable Readily available
Monthly cost of water 	Potable water which is of a good quality and safe to drink is not provided free of charge and residents are expected to pay for the water on a monthly basis.	R100.00 R250.00 R400.00 R600.00 R1000.00

PART B: Introduction to the choice question

Section 1

In this part of the questionnaire, I would like to understand the factors that may affect your preferences with regard to an improved water service in your Town/Village. While many factors/characteristics/attributes may contribute to an improved water service, I would like you to focus on the six listed below:

- Water quality
- Water pressure
- Frequency of water supply/water interruptions
- Water quantity
- Productive uses for water
- Cost of water per month

I will present you with paired choices of a water service (i.e. Option A, Option B and Neither Option) where we describe a water service by its attributes/factors/characteristics and ask you to select the water service choice you prefer the most. Each choice of a water service you make has advantages and disadvantages. You will need to trade-off the advantages and disadvantages in making your choice in response to the following question:

Note: The question below will remain the same throughout the questionnaire/survey.***1. Suppose you needed to make your choice of a water service right now from a choice set (i.e. where you are selecting from choice set 1 up to choice set 8), which one (i.e. Option A, Option B or Neither Option) would you choose? Please select your choice (Option A, Option B or Neither Option) by making a mark on the relevant box.***

Do you understand the questions above?

Note: Both choices will change and there is no wrong or right choice.

Before we begin, I present you with an example of a paired choice (**choice set X**). Look at the two choices presented here, identify the differences between them and then answer the questions when you are ready.

Choice set X

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water is of a good quality and is safe to drink	Water has bad smell
Water Quantity	More than 300ℓ per day	100ℓ (or 4 x 25ℓ) containers per day
Water Frequency	Water is available all the time	Water is available for a limited time/week
Water Pressure	Low pressure	High water pressure
Productive Uses	Unavailable	Readily available
Monthly Water cost	R600.00	R100.00

I would Choose (TICK ONE BOX ONLY)	OPTION A	☐	OPTION B	☐	NEITHER OPTION	☐

Choice set 9

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water is of good quality and safe to drink	Water has discoloration
Water Quantity	300ℓ (or 12 x 25ℓ containers) per day	200ℓ (or 8 x 25ℓ containers) per day
Water Frequency	Water is available all the time	Water is available for a limited time/week
Water Pressure	Low water pressure	High water pressure
Productive Uses	Readily available	Unavailable
Monthly Water cost	R 1000.00	R 600.00

I would Choose (TICK ONE BOX ONLY)	OPTION A	☐	OPTION B	☐	NEITHER OPTION	☐

Choice set 10

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water is of a good quality and safe to drink	Water has bad smell
Water Quantity	200ℓ (or 8 x 25ℓ containers) per day	300ℓ (or 12 x 25ℓ containers) per day
Water Frequency	Water is available for a limited time/week	Water is unavailable most of the time
Water Pressure	High water pressure	Low water pressure
Productive Uses	Unavailable	Readily available
Monthly Water cost	R 600.00	R 400.00

I would Choose (TICK ONE BOX ONLY)	OPTION A	☐	OPTION B	☐	NEITHER OPTION	☐

Choice set 11

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water is of a good quality and is safe to drink	Water has discolouration
Water Quantity	100ℓ (or 4 x 25ℓ containers) per day	More than 300ℓ per day
Water Frequency	Water is available for a limited time/week	Water is unavailable most of the time
Water Pressure	High pressure	Low pressure
Productive Uses	Readily available	Unavailable
Monthly Water cost	R 100.00	R 600.00

I would Choose (TICK ONE BOX ONLY)	OPTION A	☐	OPTION B	☐	NEITHER OPTION ☐

Choice set 12

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water has bad smell	Water has bad taste
Water Quantity	100ℓ (or 4 x 25ℓ containers) per day	More than 300ℓ per day
Water Frequency	Water is available for a limited time/week	Water is unavailable most of the time
Water Pressure	Low water pressure	High water pressure
Productive Uses	Not available	Readily available
Monthly Water cost	R 1000.00	R 250.00

I would Choose OPTION A (TICK ONE BOX ONLY) ☐ OPTION B ☐ NEITHER OPTION ☐

Choice set 13

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water has discolouration	Waters has bad smell
Water Quantity	200ℓ (or 8 x 25ℓ container) per day	100ℓ (or 4 x 25ℓ containers) per day
Water Frequency	Water is available all the time	Water is unavailable most of the time
Water Pressure	Low water pressure	High water pressure
Productive Uses	Unavailable	Readily available
Monthly Water cost	R 600.00	R 400.00

I would Choose (TICK ONE BOX ONLY)	OPTION A	☐	OPTION B	☐	NEITHER OPTION	☐

Choice set 14

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water is of a good quality and is safe to drink	Water has bad taste
Water Quantity	300ℓ (or 12 x 25ℓ containers) per day	100ℓ (or 4 x 25ℓ containers) per day
Water Frequency	Water is available for a limited time/week	Water is unavailable most of the time
Water Pressure	Low water pressure	High water pressure
Productive Uses	Unavailable	Readily available
Monthly Water cost	R 600.00	R 250.00

I would Choose (TICK ONE BOX ONLY)	OPTION A	☐	OPTION B	☐	NEITHER OPTION	☐

Choice set 15

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water has discolouration	Water has bad taste
Water Quantity	100ℓ (or 4 x 25ℓ containers) per day	More than 300ℓ per day
Water Frequency	Water is unavailable most of the time	Water is available for a limited time/week
Water Pressure	High water pressure	Low water pressure
Productive Uses	Unavailable	Readily available
Monthly Water cost	R 400.00	R 100.00

I would Choose (TICK ONE BOX ONLY) OPTION A ☐ OPTION B ☐ NEITHER OPTION ☐

Choice set 16

ATTRIBUTE	OPTION A	OPTION B
Water Quality	Water has discolouration	Waters has bad smell
Water Quantity	100ℓ (or 4 x 25ℓ containers) per day	More than 300ℓ per day
Water Frequency	Water is unavailable most of the time	Water is available all the time
Water Pressure	Low water pressure	High water pressure
Productive Uses	Readily available	Unavailable
Monthly Water cost	R 100.00	R 1000.00

I would Choose (TICK ONE BOX ONLY)	OPTION A	☐	OPTION B	☐	NEITHER OPTION	☐

PART C: Socio - demographic details

Please answer the following questions:

1. How old are you? ______ Years

2. What is your highest educational qualification?

☐ Tertiary (e.g. University / College)

☐ Technical/vocational training

☐ High school

☐ Primary school

☐ No schooling

3. What is your marital status?

☐ Married ☐ Not married

4. What is your employment status?

☐ Employed ☐ Unemployed ☐ Self employed

5. How many people do you have in your household? ☐ People

6. Which income tax bracket does your household fall in?

1	**R 1 – R 226 000**	
2	**R 226 001 – R 353 100**	
3	**R 353 101 – R 488 700**	
4	**R 488 701 – R 641 400**	
5	**R 641 401 – R 817 600**	
6	**R 817 601 – R 1 731 600**	
7	**R 1 731 601 and above**	

APPENDIX IV: MBUDZISAVHATHU – KUBUGWANA KHA U THOMA (LUVENḒA)

DZANGALELO ḼA U BADELELA KHWINIFHADZO YA ZWIGAṰALUSI ZWA TSHUMELO YA MAḒI VHUPONI HA VUWANI

Ṱhahelelo ya maḓi ndi thaidzo khulwane Afurika Tshipembe musi ri tshi dzhiela nṱha zwauri ḽashu hupfi ndi shango ḽa vhufuraru (30th) ḽo omesaho ḽifhasini. Sa mashango maṅwe ngaḽo ane a kha ḓi bvelela, Afurika Tshipembe na ḽone ḽi na thaidzo maelana na nḓisedzo ya tshumelo ya maḓi. Thaidzo hedzi ndi dzi fanaho na zwigaṱalusi zwa tshumelo ya maḓi zwi fanaho na hezwi, kuwanalele (kana kubvele) kwa maḓi bommbini, mutsiko wa maḓi (aya ṱavhanya u ḓadza kana aya lenga u ḓadza naa), vhuḓi ha Maḓi, na vhunzhi ha maḓi. Naho thaidzo hedzi dzi tshi ḓisela vhathu vhukonḓi shangoni ḽashu nga u angaredza, thaidzo hedzi dzo ṋaṋesa vhuponi na dziḓoroboni dza mahayani dzi fanaho na Vuwani fhano Vunḓuni ḽa Limpopo. Hezwi zwi ṋaniswa nga ḓivhazwakale maelana na thaidzo ya nḓisedzo ya tshumelo vhathuni ine madzuloni a u khwinifhadzea, ya vha i tshi to u ṋaṋa u tshinyala tshoṱhe.

Ro lugisa mbudzisavhathu heyi ri tshi itela u wanulusa uri ndi zwiṱalusi zwifhio zwine vha zwi takalela malugana na tshumelo ya maḓi muvhunduni wavho. Zwo ralo, ndi kho u humbela u tswa tshifhinga tshavho lwa kufhinganyana uri vha ḓadze mbudzisavhathu heyi. Phindulo dzavho dzi ḓo thusa vhukuma khauri ri kone u ḓivha uri ndi zwiṱalusi zwifhio zwine vhadzulapo vha zwi takalela maelana na u khwinifhadzea ha tshumelo ya maḓi.

TSHIPIḒA TSHA U THOMA: : Zwidodombedzwa (zwi ḓadziwa nga muvhudzisi)

Study ID				
Date of Survey				
Enumerator				
Town/Village				
Mbeu	☐	Munna	☐	Mufumakadzi
Mudzulapo uyu una phaiphi ya Maḓi dzharaṱani yawe?	☐	**Ee**	☐	Hai
Arali phindulo i hai, u na gwedzo la Maḓi dzharaṱani?	☐	Ee	☐	Hai

Mudzulapo o tenda u vhudziswa kana u shela mulenzhe?

☐ Ee ☐ Hai

Arali o hana/lamba/landula/usa tenda, vha so ngo isa nae phanḓa

TSHIGAṰALUSI	ṰHALUTSHEDZO YA TSHIGAṰALUSI	ZWIṰALUSI
Vhuḓi ha maḓi 	Maḓi a vha a vhuḓi vhukuma arali a tshi nwea thwii, ubva phaiphini, nahone a sa nukhe, a sa vhe na muvhala wa mashika kana muḓifho u si wavhuḓi. Zwihulwanesa, a tea u vha kha tshiimo tshi no tshimbilelana na zwine mulayo wari maḓi a unwa a tea uvha zwone.	Maḓi ana muḓifho u si wavhuḓi
		Maḓi ana munukho u si wavhuḓi
		Maḓi ana muvhala wa mashika
		Maḓi ndi a vhuḓi nahone a ya nwea
Vhunzhi ha maḓi 	Vhoṇemiḓi vha shumisa maḓi kha zwinzhi zwo fhambanaho mahayani, nahone vha nga takalela u shumisa maḓi manzhi nga ḓuvha, arali a tshi wanala	Zwigubu zwiṋa (4) nga ḓuvha
		Zwigubu zwa malo (8) nga ḓuvha
		Zwigubu zwa fuminazwivhili (12) nga ḓuvha
		A fhira (kana u paḓa) zwigubu zwa fuminazwivhili nga ḓuvha
Kuwanalele kwa maḓi (nga ṅwedzi) 	Vhoṇemiḓi kanzhi a vha koni u wana maḓi tshifhinga tshoṭhe. Misi miṅwe, a ya fhedza tshifhinga a sa wanali kana ubva kha dziphaiphi	Maḓi ha wanali tshifhinga tshinzhi
		Maḓi a wanala lwa tshifhinga nyana
		Maḓi a wanala tshifhinga tshoṭhe
Mutsiko wa (kana kubvele kwa) maḓi phaiphini 	Mutsiko wa maḓi ndi wone u no sukumedza maḓi phaiphini. Arali u nṱha, a bva e manzhi ngeno arali u fhasi, a bva nga zwiṱuku (kana nga u ongolowa)	Mutsiko wa maḓi u fhasi vhukuma (a ya lenga u ḓadza)
		Mutsiko wa maḓi u nṱha nga maanḓa ((ha lengi u ḓadza)
Maḓi a vhubindudzi 	Vhoṇemiḓi vha nga tama u shumisa maḓi lwa vhubindudzi arali a tshi bva e manzhi. Vhaṅwe vha nga a shumisa u sheledza miroho, u vula mabindu a u ṱanzwa mimoḓoro, u inga halwa, u vula bindu ḽa u kuvha zwiambaro, kana vhuṅwe vhubindudzi vho no ṱoḓa maḓi.	Ha tendi vhubindudzi
		A ya tenda vhubindudzi
Mbadelo ya maḓi nga ṅwedzi 	Vhadzulapo (khamusi ngannḓa ha vhane vha sa ḓi kone) vha lavhelelwa u badela maḓi ane vha a shumisa ṅwedzi nga ṅwedzi	R100.00
		R250.00
		R400.00
		R600.00
		R1000.00

Tshipida tsha B:: Thangelaphanḓa maelana na dzimbudziso

Tshitenwa tsha u thoma

Kha tshino tshipiḓa, ndi tama u pfesesa nga ha zwithu zwine zwa ṱuṱuwedza uri vha nga tama u vhona hu tshi khwinifhadziwa mini malugana na zwigaṱalusi zwa tshumelo ya Maḓi ine vha kho u i wana hafha muvhunduni wavho. Naho hu uri hu nga vha na zwigaṱalusi zwinzhi zwo fhambananaho zwa tshumelo ya Maḓi, ndi tama ri tshi sedza hezwi zwa rathi zwo dodombedziwaho hafha fhasi.

- Vhuḓi ha maḓi
- Vhunzhi ha maḓi
- Kuwanalele kwa maḓi (nga ṅwedzi)
- Mutsiko wa (kana kubvele kwa) maḓi phaiphini/bommbini
- Maḓi a vhubindudzi; na
- Mbadelo ya maḓi nga ṅwedzi

Ndi ḓo vha sumbedza kana u vha ṇekedza tsumbo ya tshumelo ya maḓi ine ya vha na minango ine vha tea nanga khayo (vha nga nanga MUNANGO WA A kana vha nanga MUNANGO WA B) hune tshumelo ya maḓi ya ṱalutshedzwa nga zwiṱalusi zwo fhambanaho. Ndiḓo humbela uri musi vho no sedza, nahone vha fhambanya minango heyo, mivhili, vha fhindule uri vha tama u nanga tshumelo ifhio ya maḓi ine vha i takalelesa. Vha ḓo tea u sedza vhuḓi (zwivhuya) na zwi si zwavhuḓi uya nga zwiṱalusi zwa tshumelo ya maḓi musi vha tshi kho u nanga vhukati ha minango heyo mivhili. Phelеledzoni yazwo, vha tea u nanga munango une vha pfa uri ndi wone une vha u takalelesa malugana na u khwinifhadzea ha tshumelo ya maḓi.

Khavha dzhiele hezwi nntha: Vhaḓovha vha tshi kho u fhindula mbudziso heyi ire hafha fhasi, ine ya sa ḓo shanduka u swikela vha tshi fhedza minangelo ire kha mbudzisavhathu heyi.

1. Khariri vho ṇewa tshikhala tsha u nanga tshumelo ya Maḓi zwino, (hune vha kho u nanga ubva kha munangelo wa vhuṱahe u swikela kha munangelo wa vhufuminavhurathi). Ndi ufhio munango (MUNANGO WA A, MUNANGO WA B, kana Athi nangi tshithu) une vha u takalelesa? Kha vha sumbedzise nga u vheya luswayo (X) kha kubogisi kwo teaho. Hone mbudziso iyi vha kho u i pfesesa?

Khavha dzhiele hezwi nnṱha: Minango ine vha kho u khetha khayo, i ḓo vha i tshi kho u shanduka kha munangelo muṅwenamuṅwe, fhedziha, ahuna phindulo ine ya vha yone, nahone ahuna phindulo ine ya sa vhe yone. Hu to uvha na phindulo yavho fhedzi.

Vha sa athu u thoma u fhindula, Khavhari ndi thome nga u vha sumbedza tsumbo yauri munangelo wo ima nga tshivhumbeoḓe. Kha vha sedze minango heyo mivhili ine ya vha kha munangelo, vha sedze uri yo fhambanana hani, vha kone u fhindula mbudziso ire hafho nnṱha.

MUNANGELO WA TSUMBO/NDINGO

TSHIGAṰALUSI	MUNANGO WA A		MUNANGO WA B		
Vhuḓi ha maḓi	Maḓi ndi a vhuḓi nahone aya nwea		Maḓi ana munukho u si wavhuḓi		
Vhunzhi ha maḓi	A fhira (kana u paḓa) zwigubu zwa fuminazwivhili (12) nga ḓuvha		Zwigubu zwiṋa (4) nga ḓuvha		
Kuwanalele kwa maḓi (nga ṅwedzi)	Maḓi a wanala tshifhinga tshoṱhe		Maḓi a wanala lwa tshifhinga nyana nga vhege		
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	Mutsiko wa maḓi u fhasi vhukuma (a ya lenga u ḓadza)		Mutsiko wa maḓi u nṱha nga maanḓa (ha lengi u ḓadza)		
Maḓi a vhubindudzi	Ha tendi vhubindudzi		A ya tenda vhubindudzi		
Mbadelo ya maḓi nga ṅwedzi	R600.00		R100.00		
Ndi nanga MUNANGO WA A (vha nanga tshithihi fhedzi)	☐	TSHIGA TSHA B	☐	ATHI NANGI TSHITHU	☐

Munangelo wa u thoma

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	Maḓi a na muvhala	Maḓi a na munukho
Vhunzhi ha maḓi	Zwigubu zwa fuminazwivhili (12) nga ḓuvha	Zwigubu zwa malo nga ḓuvha
Kuwanalele kwa maḓi (nga ṅwedzi)	Maḓi a wanala lwa tshifhinganyana nga vhege	Maḓi ha wanali tshifhinga tshinzhi
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	Mutsiko wa maḓi u nnṱha vhukuma (he lengi u ḓadza	Mutsiko wa maḓi u fhasi vhukuma (aya lenga u ḓadza)
Maḓi a vhubindudzi	Aya tenda vhubindudzi	Ha tendi vhubindudzi
Mbadelo ya Maḓi nga nwedzi	R 250.00	R 400.00

NDI NANGA Tshiga tsha A ☐ MUNANGO WA B ☐ Athi nangi tshithu ☐
(Vha nanga tshithihi fhedzi)

Munangelo wavhuvhil

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	**Maḓi a na muvhala**	**Maḓi a na muḓifho usi wavhuḓi**
Vhunzhi ha maḓi	**Zwigubu zwa fuminazwivhili (12) nga ḓuvha**	**Zwigubu zwa malo nga ḓuvha**
Kuwanalele kwa maḓi (nga ṅwedzi)	**Maḓi a wanala tshifhinga tshoṱhe**	**Maḓi a wanala lwa tshifhinga nyana nga vhege**
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	**Mutsiko wa maḓi u nnṱha vhukuma (he lengi u ḓadza**	**Mutsiko wa maḓi u fhasi vhukuma (aya lenga u ḓadza)**
Maḓi a vhubindudzi	**Ha tendi vhubindudzi**	**Aya tenda vhubindudzi**
Mbadelo ya Maḓi nga nwedzi	**R100.00**	**R600.00**
NDI NANGA Tshiga tsha A (Vha nanga tshitshihi fhedzi)	☐ **Tshiga tsha B**	☐ **Athi nangi tshithu** ☐

Munangelo wavhuraru

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	**Maḓi ndi a vhuḓi nahone a ya nwea**	**Maḓi ana munukho u si wavhuḓi**
Vhunzhi ha maḓi	**A fhira (kana u paḓa) zwigubu zwa fuminazwivhili nga ḓuvha**	**Zwigubu zwa fuminazwivhili (12) nga ḓuvha**
Kuwanalele kwa maḓi (nga ṅwedzi)	**Maḓi a wanala tshifhinga tshoṱhe**	**Maḓi a wanala lwa tshifhinga nyana nga vhege**
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	**Mutsiko wa maḓi u nnṱha vhukuma (ha lengi u ḓadza**	**Mutsiko wa maḓi u fhasi vhukuma (aya lenga u ḓadza)**
Maḓi a vhubindudzi	**Ha tendi vhubindudzi**	**Aya tenda vhubindudzi**
Mbadelo ya Maḓi nga nwedzi	**R400.00**	**R 1000.00**
NDI NANGA Tshiga tsha A (Vha nanga tshithihi fhedzi)	☐ **Tshiga B**	☐ **Athi nangi tshithu** ☐

Munangelo wavhuṋa

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	**Maḓi ana muḓifho u si wavhuḓi**	**Maḓi ndi a vhuḓi nahone a ya nwea**
Vhunzhi ha maḓi	**Zwigubu zwiṋa (4) nga ḓuvha**	**A fhira (kana u paḓa) zwigubu zwa fuminazwivhili nga ḓuvha**
Kuwanalele kwa maḓi (nga ṅwedzi)	**Maḓi a wanala tshifhinga tshoṱhe**	**Maḓi ha wanali tshifhinga tshinzhi**
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	**Mutsiko wa maḓi u nnṱha vhukuma (he lengi u ḓadza**	**Mutsiko wa maḓi u fhasi vhukuma (aya lenga u ḓadza)**
Maḓi a vhubindudzi	**Ha tendi vhubindudzi**	**Aya tenda vhubindudzi**
Mbadelo ya Maḓi nga nwedzi	**R250.00**	**R 1000.00**

NDI NANGA Tshiga tsha A (Vha nanga tshithihi fhedzi)	☐	**MUNANGO WA B**	☐	**Athi ngangi tshithu**	☐

Munangelo wavhuṱanu

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	Maḓi ana munukho u si wavhuḓi	Maḓi ana muvhala wa mashika
Vhunzhi ha maḓi	Zwigubu zwa fuminazwivhili nga duvha	A fhira zwigubu zwa fuminazwivhili nga duvha
Kuwanalele kwa maḓi (nga ṅwedzi)	Maḓi a wanala tshifhinga tshoṱhe	Maḓi a wanala lwa tshifhinga nyana nga vhege
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	Mutsiko wa maḓi u nnṱha vhukuma (he lengi u ḓadza	Mutsiko wa maḓi u fhasi vhukuma (aya lenga u ḓadza)
Maḓi a vhubindudzi	Aya tenda vhubindudzi	Ha tendi vhubindudzi
Mbadelo ya Maḓi nga nwedzi	R 1000.00	R 600.00
NDI NANGA Tshiga tsha A (Vha nanga tshithihi fhedzi) ☐	Tshiga tsha B ☐	Athi nangi tshithu ☐

Munangelo wavhurathi

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	Maḓi ndi a vhuḓi nahone a ya nwea	Maḓi ana muḓifho u si wavhuḓi
Vhunzhi ha maḓi	Zwigubu zwa malo nga ḓuvha	Zwigubu zwiṋa nga ḓuvha
Kuwanalele kwa maḓi (nga ṅwedzi)	Maḓi ha wanali tshifhinga tshinzhi	Maḓi a wana tshifhinga tshoṱhe
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	Mutsiko wa maḓi u nnṱha vhukuma (he lengi u ḓadza	Mutsiko wa maḓi u fhasi vhukuma (aya lenga u ḓadza)
Maḓi a vhubindudzi	Aya tenda vhubindudzi	Ha tendi vhubindudzi
Mbadelo ya Maḓi nga nwedzi	R 250.00	R 400.00
NDI NANGA Tshiga tsha A (Vha nanga tshithihi fhedzi)	Tshiga B	Athi nangi tshithu

Munangelo wavhusumbe

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	**Maḓi ana muḓifho u si wavhuḓi**	**Maḓi ana munukho u si wavhuḓi**
Vhunzhi ha maḓi	**Zwigubu zwa fuminazwivhili nga ḓuvha**	**A fhira zwigubu zwa fuminazwivhili nga ḓuvha**
Kuwanalele kwa maḓi (nga ṅwedzi)	**Maḓi ha wanali tshifhinga tshinzhi**	**Maḓi a wanala lwa tshifhinga nyana nga vhege**
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	**Mutsiko wa maḓi u fhasi vhukuma (aya lenga u ḓadza)**	**Mutsiko wa maḓi u nnṱha vhukuma (he lengi u ḓadza**
Maḓi a vhubindudzi	**Ha tendi vhubindudzi**	**Aya tenda vhubindudzi**
Mbadelo ya Maḓi nga nwedzi	**R 250.00**	**R 600.00**
NDI NANGA Tshiga tsha A (Vha nanga tshithihi fhedzi)	☐ **MUNANGO WA B**	☐ **Athi nangi tshithu** ☐

Munangelo wavhumalo

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	**Maḓi ndi avhuḓi nahone aya nwea wavhuḓi**	**Maḓi ana muḓifho u si wavhuḓi**
Vhunzhi ha maḓi	**Zwigubu zwina nga duvha**	**Zwigubu zwa fuminazwivhili nga duvha**
Kuwanalele kwa maḓi (nga ṅwedzi)	**Maḓi a wanala tshifhinga tshoṱhe**	**Maḓi a wanala lwa tshifhinga nyana nga vhege**
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	**Mutsiko wa maḓi u fhasi vhukuma (aya lenga u ḓadza)**	**Mutsiko wa maḓi u nnṱha vhukuma (he lengi u ḓadza**
Maḓi a vhubindudzi	**Aya tenda vhubindudzi**	**Ha tendi vhubindudzi**
Mbadelo ya Maḓi nga nwedzi	**R 1000.00**	**R 100.00**
NDI NANGA Tshiga tsha A (Vha nanga tshithihi fhedzi)	**MUNANGO WA B**	**Athi nangi tshithu**

Tshipiḓa tsha vhuraru: Zwiṱalusavhuṋe

Ndi kho u humbela uri vha fhindule mbudziso hedzi dzi tevhelaho:

1. Vha na miṅwaha mingana? ______

2. Ndalukano dza nṱhesa

- ☐ Ngudo dza nṱha (Yunivesithi kana Kholishi)
- ☐ Gudedzi ḽa vhutsila
- ☐ Sekondari
- ☐ Tshikolo tsha fhasi
- ☐ A thi ngo dzhena tshikolo

3. Tshiimo tsha vhudzekani?

☐ Ndo maliwa/ndo mala ☐ A thi ngo maliwa/mala

4. Mushumo?

☐ Ndo tholiwa ☐ A thi ngo tholiwa ☐ Ndi to u ḓi shuma

5. Tshivhalo tsha vhane vha dzula navho hayani? ☐

6. Muḓi wavho u wela ngafhi kha muthelo wa vhuṋe?

1	**R 1 – R 226 000**	
2	**R 226 001 – R 353 100**	
3	**R 353 101 – R 488 700**	
4	**R 488 701 – R 641 400**	
5	**R 641 401 – R 817 600**	
6	**R 817 601 – R 1 731 600**	
7	**R 1 731 601 and above**	

APPENDIX V: MBUDZISAVHATHU – KUBUGWANA KWA VHUVHILI (LUVENḒA)

DZANGALELO ḼA U BADELELA KHWINIFHADZO YA ZWIGAṰALUSI ZWA TSHUMELO YA MAḒI VHUPONI HA VUWANI

Ṱhahelelo ya maḓi ndi thaidzo khulwane Afurika Tshipembe musi ri tshi dzhiela nṱha zwauri ḽashu hupfi ndi shango ḽa vhufuraru ḽo omesaho ḽifhasini. Sa mashango maṅwe ngaḽo ane a kha ḓi bvelela, Afurika Tshipembe na ḽone ḽi na thaidzo maelana na nḓisedzo ya tshumelo ya maḓi. Thaidzo hedzi ndi dzi fanaho na zwigaṱalusi zwa tshumelo ya maḓi zwi fanaho na hezwi, kuwanalele (kana kubvele) kwa maḓi bommbini, mutsiko wa maḓi (aya ṱavhanya u ḓadza kana aya lenga u ḓadza naa), vhuḓi ha Maḓi, na vhunzhi ha maḓi. Naho thaidzo hedzi dzi tshi ḓisela vhathu vhukonḓi shangoni ḽashu nga u angaredza, thaidzo hedzi dzo ṋaṋesa vhuponi na dziḓoroboni dza mahayani dzi fanaho na Vuwani fhano Vunḓuni ḽa Limpopo. Hezwi zwi ṋaṋiswa nga ḓivhazwakale maelana na thaidzo ya nḓisedzo ya tshumelo vhathuni ine madzuloni a u khwinifhadzea, ya vha i tshi to u ṋaṋa u tshinyala tshoṱhe.

Ro lugisa mbudzisavhathu heyi ri tshi itela u wanulusa uri ndi zwiṱalusi zwifhio zwine vha zwi takalela malugana na tshumelo ya maḓi muvhunduni wavho. Zwo ralo, ndi kho u humbela u tswa tshifhinga tshavho lwa kufhinganyana uri vha ḓadze mbudzisavhathu heyi. Phindulo dzavho dzi ḓo thusa vhukuma khauri ri kone u ḓivha uri ndi zwiṱalusi zwifhio zwine vhadzulapo vha zwi takalela maelana na u khwinifhadzea ha tshumelo ya maḓi.

TSHIPIḒA TSHA U THOMA: : Zwidodombedzwa (zwi ḓadziwa nga muvhudzisi)

Study ID				
Date of Survey				
Enumerator				
Town/Village				
Mbeu	☐	Munna	☐	Mufumakadzi
Mudzulapo uyu una phaiphi ya Maḓi dzharaṱani yawe?	☐	**Ee**	☐	Hai
Arali phindulo i hai, u na gwedzo la Maḓi dzharaṱani?	☐	Ee	☐	Hai

Mudzulapo o tenda u vhudziswa kana u shela mulenzhe?

☐ Ee ☐ Hai

Arali o hana/lamba/landula/usa tenda, vha so ngo isa nae phanḓa

<table>
<tr><th>TSHIGAṰALUSI</th><th>ṰHALUTSHEDZO YA TSHIGAṰALUSI</th><th>ZWIṰALUSI</th></tr>
<tr><td rowspan="4">Vhuḓi ha maḓi
</td><td rowspan="4">Maḓi a vha a vhuḓi vhukuma arali a tshi nwea thwii, ubva phaiphini, nahone a sa nukhe, a sa vhe na muvhala wa mashika kana muḓifho u si wavhuḓi. Zwihulwanesa, a tea u vha kha tshiimo tshi no tshimbilelana na zwine mulayo wari maḓi a unwa a tea uvha zwone.</td><td>Maḓi ana muḓifho u si wavhuḓi</td></tr>
<tr><td>Maḓi ana munukho u si wavhuḓi</td></tr>
<tr><td>Maḓi ana muvhala wa mashika</td></tr>
<tr><td>Maḓi ndi a vhuḓi nahone a ya nwea</td></tr>
<tr><td rowspan="4">Vhunzhi ha maḓi
</td><td rowspan="4">Vhoṋemiḓi vha shumisa maḓi kha zwinzhi zwo fhambanaho mahayani, nahone vha nga takalela u shumisa maḓi manzhi nga ḓuvha, arali a tshi wanala</td><td>Zwigubu zwiṋa (4) nga ḓuvha</td></tr>
<tr><td>Zwigubu zwa malo (8) nga ḓuvha</td></tr>
<tr><td>Zwigubu zwa fuminazwivhili (12) nga ḓuvha</td></tr>
<tr><td>A fhira (kana u paḓa) zwigubu zwa fuminazwivhili nga ḓuvha</td></tr>
<tr><td rowspan="3">Kuwanalele kwa maḓi (nga ṅwedzi)
</td><td rowspan="3">Vhoṋemiḓi kanzhi a vha koni u wana maḓi tshifhinga tshoṱhe. Misi miṅwe, a ya fhedza tshifhinga a sa wanali kana ubva kha dziphaiphi</td><td>Maḓi ha wanali tshifhinga tshinzhi</td></tr>
<tr><td>Maḓi a wanala lwa tshifhinga nyana</td></tr>
<tr><td>Maḓi a wanala tshifhinga tshoṱhe</td></tr>
<tr><td rowspan="2">Mutsiko wa (kana kubvele kwa) maḓi phaiphini
</td><td rowspan="2">Mutsiko wa maḓi ndi wone u no sukumedza maḓi phaiphini. Arali u nṱha, a bva e manzhi ngeno arali u fhasi, a bva nga zwiṱuku (kana nga u ongolowa)</td><td>Mutsiko wa maḓi u fhasi vhukuma (a ya lenga u ḓadza)</td></tr>
<tr><td>Mutsiko wa maḓi u nṱha nga maanḓa ((ha lengi u ḓadza)</td></tr>
<tr><td rowspan="2">Maḓi a vhubindudzi
</td><td rowspan="2">Vhoṋemiḓi vha nga tama u shumisa maḓi lwa vhubindudzi arali a tshi bva e manzhi. Vhaṅwe vha nga a shumisa u sheledza miroho, u vula mabindu a u ṱanzwa mimoḓoro, u inga halwa, u vula bindu ḽa u kuvha zwiambaro, kana vhuṅwe vhubindudzi vho no ṱoḓa maḓi.</td><td>Ha tendi vhubindudzi</td></tr>
<tr><td>A ya tenda vhubindudzi</td></tr>
<tr><td rowspan="5">Mbadelo ya maḓi nga ṅwedzi
</td><td rowspan="5">Vhadzulapo (khamusi ngannḓa ha vhane vha sa ḓi kone) vha lavhelelwa u badela maḓi ane vha a shumisa ṅwedzi nga ṅwedzi</td><td>R100.00</td></tr>
<tr><td>R250.00</td></tr>
<tr><td>R400.00</td></tr>
<tr><td>R600.00</td></tr>
<tr><td>R1000.00</td></tr>
</table>

Tshipida tsha B:: Thangelaphanḓa maelana na dzimbudziso

Tshitenwa tsha u thoma

Kha tshino tshipiḓa, ndi tama u pfesesa nga ha zwithu zwine zwa ṱuṱuwedza uri vha nga tama u vhona hu tshi khwinifhadziwa mini malugana na zwigaṱalusi zwa tshumelo ya Maḓi ine vha kho u i wana hafha muvhunduni wavho. Naho hu uri hu nga vha na zwigaṱalusi zwinzhi zwo fhambananaho zwa tshumelo ya Maḓi, ndi tama ri tshi sedza hezwi zwa rathi zwo dodombedziwaho hafha fhasi.

- Vhuḓi ha maḓi
- Vhunzhi ha maḓi
- Kuwanalele kwa maḓi (nga ṅwedzi)
- Mutsiko wa (kana kubvele kwa) maḓi phaiphini/bommbini
- Maḓi a vhubindudzi; na
- Mbadelo ya maḓi na ṅwedzi

Ndi ḓo vha sumbedza kana u vha ṋekedza tsumbo ya tshumelo ya maḓi ine ya vha na minango ine vha tea nanga khayo (vha nga nanga MUNANGO WA A kana vha nanga MUNANGO WA B) hune tshumelo ya maḓi ya ṱalutshedzwa nga zwiṱalusi zwo fhambanaho. Ndiḓo humbela uri musi vho no sedza, nahone vha fhambanya minango heyo, mivhili, vha fhindule uri vha tama u nanga tshumelo ifhio ya maḓi ine vha i takalelesa. Vha ḓo tea u sedza vhuḓi (zwivhuya) na zwi si zwavhuḓi uya nga zwiṱalusi zwa tshumelo ya maḓi musi vha tshi kho u nanga vhukati ha minango heyo mivhili. Pheleledzoni yazwo, vha tea u nanga munango une vha pfa uri ndi wone une vha u takalelesa malugana na u khwinifhadzea ha tshumelo ya maḓi.

Khavha dzhiele hezwi nntha: Vhaḓovha vha tshi kho u fhindula mbudziso heyi ire hafha fhasi, ine ya sa ḓo shanduka u swikela vha tshi fhedza minangelo ire kha mbudzisavhathu heyi.

1. **Khariri vho ṋewa tshikhala tsha u nanga tshumelo ya Maḓi zwino, (hune vha kho u nanga ubva kha munangelo wa vhuṱahe u swikela kha munangelo wa vhufuminavhurathi). Ndi ufhio munango (MUNANGO WA A, MUNANGO WA B, kana Athi nangi tshithu) une vha u takalelesa? Kha vha sumbedzise nga u vheya luswayo (X) kha kubogisi kwo teaho.** Hone mbudziso iyi vha kho u i pfesesa?

Khavha dzhiele hezwi nnṱha: Minango ine vha kho u khetha khayo, i ḓo vha i tshi kho u shanduka kha munangelo muṅwenamuṅwe, fhedziha, ahuna phindulo ine ya vha yone, nahone ahuna phindulo ine ya sa vhe yone. Hu to uvha na phindulo yavho fhedzi.

Vha sa athu u thoma u fhindula, Khavhari ndi thome nga u vha sumbedza tsumbo yauri munangelo wo ima nga tshivhumbeoḓe. Kha vha sedze minango heyo mivhili ine ya vha kha munangelo, vha sedze uri yo fhambanana hani, vha kone u fhindula mbudziso ire hafho nnṱha.

MUNANGELO WA TSUMBO/NDINGO

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	Maḓi ndi a vhuḓi nahone aya nwea	Maḓi ana munukho u si wavhuḓi
Vhunzhi ha maḓi	A fhira (kana u paḓa) zwigubu zwa fuminazwivhili (12) nga ḓuvha	Zwigubu zwiṋa (4) nga ḓuvha
Kuwanalele kwa maḓi (nga ṅwedzi)	Maḓi a wanala tshifhinga tshoṱhe	Maḓi a wanala lwa tshifhinga nyana
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	Mutsiko wa maḓi u fhasi vhukuma (a ya lenga u ḓadza)	Mutsiko wa maḓi u nṱha nga maanḓa (ha lengi u ḓadza)
Maḓi a vhubindudzi	Ha tendi vhubindudzi	A ya tenda vhubindudzi
Mbadelo ya maḓi nga ṅwedzi	R600.00	R100.00
Ndi nanga MUNANGO WA A (vha nanga tshithihi fhedzi)	☐ MUNANGO WA B	☐ ATHI NANGI TSHITHU ☐

Munangelo wa vhuṱahe

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	Maḓi ana muvhala wa mashika	Maḓi ana munukho u si wavhuḓi
Vhunzhi ha maḓi	Zwigubu zwiṋa (4) nga ḓuvha	Zwigubu zwa fuminazwivhili (12) nga ḓuvha
Kuwanalele kwa maḓi (nga ṅwedzi)	Maḓi a wanala tshifhinga tshoṱhe	Maḓi a wanala lwa tshifhinga nyana nga vhege
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	Mutsiko wa maḓi u nṱha nga maanḓa ((ha lengi u ḓadza)	Mutsiko wa maḓi u fhasi vhukuma (a ya lenga u ḓadza)
Maḓi a vhubindudzi	Ha tendi vhubindudzi	Aya tenda vhubindudzi
Mbadelo ya maḓi nga ṅwedzi	R 1000.00	R600.00
Ndi nanga (vha nanga tshithihi fhedzi)	MUNANGO WA A ☐	MUNANGO WA B ☐ ATHI NANGI TSHITHU ☐

Munangelo wa vhufumi

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	Maḓi ana munukho u si wavhuḓi	Maḓi ana muvhala wa mashika
Vhunzhi ha maḓi	Zwigubu zwa fuminazwivhili (12) nga ḓuvha	Zwigubu zwa malo (8) nga ḓuvha
Kuwanalele kwa maḓi (nga ṅwedzi)	Maḓi a wanala tshifhinga tshoṱhe	Maḓi a wanala lwa tshifhinga nyana nga vhege
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	Mutsiko wa maḓi u nṱha nga maanḓa ((ha lengi u ḓadza)	Mutsiko wa maḓi u fhasi vhukuma (a ya lenga u ḓadza)
Maḓi a vhubindudzi	Ha tendi vhubindudzi	Aya tenda vhubindudzi
Mbadelo ya maḓi nga ṅwedzi	R100.00	R400.00
Ndi nanga (vha nanga tshithihi fhedzi) MUNANGO WA A ☐	MUNANGO WA B ☐	ATHI NANGI TSHITHU ☐

Munangelo wa vhuminavhuthihi

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B	
Vhuḓi ha maḓi	Maḓi ndi a vhuḓi nahone a ya nwea	Maḓi ana muvhala wa mashika	
Vhunzhi ha maḓi	Zwigubu zwa malo (8) nga ḓuvha	A fhira (kana a paḓa) zwigubu zwa fuminazwivhili nga ḓuvha	
Kuwanalele kwa maḓi (nga ṅwedzi)	Maḓi a wanala tshifhinga tshoṱhe	Maḓi ha wanali tshifhinga tshinzhi	
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	Mutsiko wa maḓi u nṱha nga maanḓa (ha lengi u ḓadza)	Mutsiko wa maḓi u fhasi vhukuma (a ya lenga u ḓadza)	
Maḓi a vhubindudzi	Aya tenda vhubindudzi	Ha tendi vhubindudzi	
Mbadelo ya maḓi nga ṅwedzi	R600.00	R250.00	
Ndi nanga MUNANGO WA A (vha nanga tshithihi fhedzi)	☐ MUNANGO WA B	☐ ATHI NANGI TSHITHU	☐

Munangelo wa vhufuminavhuvhili

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	Maḓi ana munukho u si wavhuḓi	Maḓi ana muḓifho u si wavhuḓi
Vhunzhi ha maḓi	Zwigubu zwiṋa (4) nga ḓuvha	Zwigubu zwa malo (8) nga ḓuvha
Kuwanalele kwa maḓi (nga ṅwedzi)	Maḓi ha wanali tshifhinga tshinzhi	Maḓi a wanala tshifhinga tshoṱhe
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	Mutsiko wa maḓi u nṱha nga maanḓa (ha lengi u ḓadza)	Mutsiko wa maḓi u fhasi vhukuma (a ya lenga u ḓadza)
Maḓi a vhubindudzi	A ya tenda vhubindudzi	Ha tendi vhubindudzi
Mbadelo ya maḓi nga ṅwedzi	R600.00	R100.00
Ndi nanga MUNANGO WA A (vha nanga tshithihi fhedzi)	☐ MUNANGO WA B	☐ ATHI NANGI TSHITHU ☐

Munangelo wa vhufuminavhuraru

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	Maḓi ndi a vhuḓi nahone a ya nwea	Maḓi ana muḓifho u si wavhuḓi
Vhunzhi ha maḓi	A fhira (kana a paḓa) zwigubu zwa fuminazwivhili nga ḓuvha	Zwigubu zwa malo (8) nga ḓuvha
Kuwanalele kwa maḓi (nga ṅwedzi)	Maḓi a wanala lwa tshifhinga nyana nga vhege	Water is Ha tendi vhubindudzi most of the time
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	Mutsiko wa maḓi u nṱha nga maanḓa (ha lengi u ḓadza)	Mutsiko wa maḓi u fhasi vhukuma (a ya lenga u ḓadza)
Maḓi a vhubindudzi	Ha tendi vhubindudzi	Aya tenda vhubindudzi
Mbadelo ya maḓi nga ṅwedzi	R400.00	R 1000.00
Ndi nanga (vha nanga tshithihi fhedzi)	MUNANGO WA A ☐	MUNANGO WA B ☐ ATHI NANGI TSHITHU ☐

Munagelo wa vhufuminavhuṋa

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	Maḓi ndi a vhuḓi nahone a ya nwea	Maḓi ana muvhala wa mashika
Vhunzhi ha maḓi	Zwigubu zwiṋa (4) nga ḓuvha	A fhira (kana a paḓa) zwigubu zwa fuminazwivhili nga ḓuvha
Kuwanalele kwa maḓi (nga ṅwedzi)	Maḓi a wanala lwa tshifhinga nyana nga vhege	Maḓi a wanala tshifhinga tshoṱhe
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	Mutsiko wa maḓi u fhasi vhukuma (a ya lenga u ḓadza)	Mutsiko wa maḓi u nṱha nga maanḓa (ha lengi u ḓadza)
Maḓi a vhubindudzi	Aya tenda vhubindudzi	Ha tendi vhubindudzi
Mbadelo ya maḓi nga ṅwedzi	R 1000.00	R600.00
Ndi nanga (vha nanga tshithihi fhedzi)	MUNANGO WA A ☐	MUNANGO WA B ☐ ATHI NANGI TSHITHU ☐

Munagelo wa vhufuminavhuṱanu

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	Maḓi ana munukho u si wavhuḓi	Maḓi ndi a vhuḓi nahone a ya nwea
Vhunzhi ha maḓi	Zwigubu zwiṋa (4) nga ḓuvha	Zwigubu zwa fuminazwivhili (12) nga ḓuvha
Kuwanalele kwa maḓi (nga ṅwedzi)	Maḓi a wanala tshifhinga tshoṱhe	Maḓi a wanala lwa tshifhinga nyana nga vhege
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	Mutsiko wa maḓi u fhasi vhukuma (a ya lenga u ḓadza)	Mutsiko wa maḓi u nṱha nga maanḓa (ha lengi u ḓadza)
Maḓi a vhubindudzi	Ha tendi vhubindudzi	Aya tenda vhubindudzi
Mbadelo ya maḓi nga ṅwedzi	R600.00	R250.00
Ndi nanga (vha nanga tshithihi fhedzi) MUNANGO WA A	☐ MUNANGO WA B	☐ ATHI NANGI TSHITHU ☐

Munangelo wa vhufuminavhurathi

TSHIGAṰALUSI	MUNANGO WA A	MUNANGO WA B
Vhuḓi ha maḓi	Maḓi a na muvhala wa mashika	Maḓi ana muḓifho u si wavhuḓi
Vhunzhi ha maḓi	Zwigubu zwa malo (8) nga ḓuvha	A fhira (kana a paḓa) zwigubu zwa fuminazwivhili nga ḓuvha
Kuwanalele kwa maḓi (nga ṅwedzi)	Maḓi a wanala tshifhinga tshoṱhe	Maḓi ha wanali tshifhinga tshinzhi
Mutsiko wa (kana kubvele kwa) maḓi phaiphini	Mutsiko wa maḓi u fhasi vhukuma (a ya lenga u ḓadza)	Mutsiko wa maḓi u nṱha nga maanḓa (ha lengi u ḓadza)
Maḓi a vhubindudzi	Aya tenda vhubindudzi	Ha tendi vhubindudzi
Mbadelo ya maḓi nga ṅwedzi	R250.00	R400.00
Ndi nanga (vha nanga tshithihi fhedzi) MUNANGO WA A	☐ MUNANGO WA B	☐ ATHI NANGI TSHITHU ☐

Tshipiḓa tsha vhuraru: Zwiṱalusavhuṋe

Ndi kho u humbela uri vha fhindule mbudziso hedzi dzi tevhelaho:

1. Vha na miṅwaha mingana? ______

2. Ndalukano dza nṱhesa

- ☐ Ngudo dza nṱha (Yunivesithi kana Kholishi)
- ☐ Gudedzi ḽa vhutsila
- ☐ Sekondari
- ☐ Tshikolo tsha fhasi
- ☐ A thi ngo dzhena tshikolo

3. Tshiimo tsha vhudzekani?

☐ Ndo maliwa/ndo mala ☐ A thi ngo maliwa/mala

4. Mushumo?

☐ Ndo tholiwa ☐ A thi ngo tholiwa ☐ Ndi to u ḓi shuma

5. Tshivhalo tsha vhane vha dzula navho hayani? ☐

6. Muḓi wavho u wela ngafhi kha muthelo wa vhuṋe?

1	**R 1 – R 226 000**	
2	**R 226 001 – R 353 100**	
3	**R 353 101 – R 488 700**	
4	**R 488 701 – R 641 400**	
5	**R 641 401 – R 817 600**	
6	**R 817 601 – R 1 731 600**	
7	**R 1 731 601 and above**	