A Choice Experiment Study of User Preferences for Levels of Water Service

Report to the
Water Research Commission

by

SG Hosking, JL Hosking, M du Preez and JG Hosking
Departments of Economics,
Nelson Mandela Metropolitan University

WRC Report No. 2087/3/14
ISBN 978-1-4312-0539-4

April 2014

Obtainable from

Water Research Commission
Private Bag X03
Gezina, 0031

orders@wrc.org.za or download from www.wrc.org.za

Two related reports emanating from this study were published previously. These reports are:

Trends in the growing South African municipal water service delivery problem (WRC Report 2087/1/P/13), and

Perspectives on the market processes followed in setting South African water services tariffs (WRC Report 2087/2/P/13)

Executive Summary

Discrete choice experimentation is one form of choice modelling. It utilises a stated preference survey technique to gather data for modelling choice. The aims of the study were to demonstrate that discrete choice experiment analysis and the survey instrument on which it is based could provide useful information about how consumer groups valued water service delivery and how they rated the water services that they were provided. The motivation for undertaking the study is that technical and cost considerations are inducing greater interest among South Africa's municipal providers of water services to adjust the levels of water services offered to various customer groups. Such adjustments have consumer welfare implications and potential impacts on the demand for water services and these implications and impacts need to be considered along with the technical and cost consequences (Chapter 1). The scientific credibility of the discrete choice experiment method of analysis and its appropriateness for application to assess the welfare merit of the levels of water services provided is well established. Background on the science of choice experiment analysis and the steps in applying the methodology are found not to be overly complicated (Chapter 2).

By incorporating some consumer satisfaction questions in the survey instrument it was possible to analyse customer ratings and perspectives on the water services that are provided at three selected municipalities, namely: Breede Valley and Knysna in the Western Cape and Msunduzi in KwaZulu-Natal. The choice experiment surveys were administered in 2012. The analysis of the customer satisfaction part of the survey yielded findings that were consistent with assessments reported in the form of Blue and Green Drop certification (Chapter 3). Three water service consumer groups were identified for the purpose of this analysis – high income, low income and business firms. The different water service consumer groups in the different municipalities did not share a common perspective on the way water services were managed. Majorities in all groups surveyed within the Breede Valley municipality felt the cost recovery tariff structure they faced was fair, whereas in the Msunduzi and Knysna local municipalities, the majority of the high income and business firm groups felt the cost recovery tariff they faced was unfair.

Almost 90 per cent of the total respondents surveyed in the Breede Valley were satisfied with the current level of water service provided to them. About two-thirds of the high income respondents in the Msunduzi were dissatisfied with the current level of water service provided to them, but the low income and business groups were mostly satisfied. Within the Knysna respondents, approximately two-thirds of all groups (business, high income and low income) were satisfied with the current level of water service provided to them.

The analysis of the choices in levels of water service made by the respondent groups in the three municipalities (Chapter 4) confirmed much that was expected, *a priori* – consumers prefer higher pressure, fewer interruptions on water service, higher quality water and lower costs of service. In most cases the conditional logit model yielded the best predictive fits of the choices of the different categories of respondent, but in a few the random parameters logit model was the preferred model. There were no cases where respondents found the choices to be overwhelmingly difficult and it was deduced that the results were valid.

The models estimated had the aim of predicting the choice of specifically identified groups of water service consumers – low Income, high Income and business firms. A number of the models yielded statistically significant estimates, so enabling relevant and valid marginal willingness's to pay to be calculated for the three water user groups across the three selected municipalities. These are shown in Tables 1, 2 and 3 (Chapter 5).

Table 1: A comparison of business firms MWTP across three municipalities

Attribute	**Msunduzi MWTP (R/kl)**	**Knysna MWTP (R/kl)**	**Breede MWTP (R/kl)**	**Marginal change in level**
Flow (pressure)	13.93	0.47	0.99	Weak to medium or medium to strong
Continuous supply	24.76	6.09	5.57	6hrs to 12hrs or 12hrs to 24hrs
Sanitation	2.59	10.91	14.54	Strong possibility of leaks to occasional leaks or occasional leaks to negligible leaks

Table 2: High income earners MWTP in the Msunduzi municipality

Attribute	**Msunduzi MWTP (R/kl)**	**Level change**
Flow (pressure)	0.44	Weak to medium or medium to strong
Continuous supply	1.40	6hrs to 12hrs or 12hrs to 24hrs
Sanitation	2.92	Strong possibility of leaks to occasional leaks or occasional leaks to negligible leaks

Table 3: Low income earners MWTP in the Msunduzi and Breede municipalities

Attribute	Msunduzi MWTP (R/kl)	Breede MWTP (R/kl)	Marginal change in level
Flow (pressure)	0.30	3.54	Weak to medium or medium to strong
Continuous supply	0.92	3.81	6hrs to 12hrs or 12hrs to 24hrs
Sanitation	2.42	1.39	Strong possibility of leaks to occasional leaks or occasional leaks to negligible leaks

Key features of these welfare calculations were that:

- Sanitation improvement was the **most highly valued** improvement among most classes of users within the three municipalities
- There is considerable **dispersion** in MWTP for attribute level improvements between the three municipalities selected for this study
- Business firms typically have **higher** marginal valuations for water services than either the high or low income groups
- The difference in marginal valuation between the high and low income groups is **not pronounced** in the three municipalities surveyed.

It was concluded that the discrete choice experiment analysis and survey on which this is based has the potential to yield useful insights into the levels of attributes preferred in the water service mix provided by South African municipalities. Thereby it can inform water service management thinking and policy decision making on potential implications for water service consumer welfare of technological and cost saving induced changes made to water service provision.

Acknowledgements

The financial support of the Water Research Commission is gratefully acknowledged, as is the guidance provided by a reference group assembled and managed by Mr Jay Bhagwan of the WRC, and the contributions to Chapter 2 of Dr Lee and Prof du Preez. Without the support and commitment of numerous municipalities, those members of the public who were prepared to serve on the focus groups and participate in the choice experiment surveys, the research would not have been possible. All are sincerely thanked.

The members of the WRC Reference Group that advised this study were:

Mr JN Bhagwan	WRC (Project Manager)
Prof H Kasan	Rand Water
Ms K Walsh	Palmer Development Group
Dr D Mullins	Conningarth Economists
Ms A Manus	City of Johannesburg

Capacity building through Project K5/2087

Student name	Employment	Degree (year awarded)	Title of thesis
Kevin Jacoby	Chief Financial Officer, City Of Cape Town, Cape Town	M Com (2013)	The growing South African Municipal Water Service Delivery Problem
Ryan Norden	Lecturer, Walter Sizulu University, East London	M Com (2013)	Perspectives on the market processes followed in setting South African water services tariffs
Jessica Hosking	Student, Nelson Mandela Metropolitan University	PhD (in Progress)	Applying choice modelling as a guide to the provision of water services in South Africa

Contents

List of Tables

List of Figures

List of Acronyms

ASC	Alternative specific constant
CDF	Cumulative distribution function
CL	Conditional logit
CM	Choice modelling
CVM	Contingent valuation methodology
DCE	Discrete choice experiment
HPM	Hedonic pricing method
IIA	Independence from irrelevant alternatives
IID	Independent and identically distributed
IV	Inclusive value
KL	Kilolitre
LL	Log-likelihood
LR	Likelihood ratio
MLE	Maximum likelihood estimation
MNL	Multinomial logit
MWTA	Marginal willingness to accept
MWTP	Marginal willingness to pay
NIMBY	Not in my backyard
NL	Nested logit
NMMM	Nelson Mandela Bay Municipality
OLS	Ordinary least squares
RPL	Random parameters logit
RUT	Random utility theory
TCM	Travel cost method
WTP	Willingness to pay
WTA	Willingness to accept
WRC	Water Research Commission

Chapter 1: Introduction

At the encouragement of the reference group for Water Research Commission (WRC) research project K5/1871/3, a study was commissioned to contribute further insight into water service provision and tariff setting in the challenging circumstances confronting South African municipal suppliers of water services. The follow up study recognized that the benchmarks for municipal water service provision in South Africa were set nationally and with reference to the level of income of the community in an urban settlement. A better service was provided to the well-off sections of communities than to the poor sections of communities. The municipal water service provision benchmark (standard) was set for the well-off and, historically, has been comparable with best international standards.

The well-off users are required to pay for the cost of providing the service. They are concentrated in relatively small urban areas. Historically, the tariff structure they faced was flat and determined with reference to a diverse range of accounting principles and practices. The burden of covering the cost of provision was averaged over the users, proportional to use.

During the last decade there have been several important changes, including a national government led initiative to increase the level of service provided to the poor (towards a uniform service for all) and a movement away from a flat tariff structure to an increasing block tariff structure. The latter was motivated partly by the objective of managing demand to the available supply and partly by the desire to redistribute the cost of providing a water service to the more well off users (rich households) of the service.

Along with all these changes, dual concerns emerged over the sustainability of the provision of municipal water services at the minimum quality levels set by government for itself, and over the possibility that water service consumer welfare were being neglected or sacrificed as a consequence of extending a uniform level of water service to all. The sustainability concern has been fueled partly by the limit of freshwater available in South Africa, partly by reduced hiring of personnel with the required competencies and partly by failures to collect sufficient revenue to cover the costs of providing and managing water services. Some of the concerns related to sustainability are addressed by WRC Research Report 2087/1/P/13 (Hosking and Jacoby, 2013) entitled 'Trends in the growing South African municipal water service delivery problem', and WRC Research Report 2087/2/P/13 (Hosking and Norden, 2013) entitled 'Perspectives on the market processes followed in setting South African water services tariffs'.

This report focused attention on the consumer welfare concern. The aims of the study were to demonstrate that a discrete choice experiment analysis and the survey instrument on which it is based could provide useful information about what specific consumer groups valued most about water service delivery and how they rated the water service they were provided. The motivation for undertaking the study is that technical and cost considerations are inducing greater interest amongst South Africa's municipal providers of water services in adjusting the levels of water services they offer various consumer groups. Such adjustments have consumer welfare implications and potential impacts on the demand for water services and these implications and impacts need to be considered along with the technical and cost consequences.

The application of choice experiment analysis to water services in South Africa is not novel, but the full benefit of this application has yet to be explored. It has been undertaken in WRC Project K5/1871/3 and by Snowball, Willis and Jeurissen (2007). The latter study related to Grahamstown West, Eastern Cape, while the former related to water service provision at the Amathole (district), Nelson Mandela Bay (metropolitan) and Kouga (local) municipalities (all in the Eastern Cape). Two models of choice estimated were found to be significant – one for the residents of the Kouga Local Municipality and another for business firms of the Nelson Mandela Bay Municipality (NMBM). Based on these models the following marginal willingness's to pay (MWTP) in Rand per month for improvements in the levels water service were calculated (see Table 1.1 below).

Table 1.1: Marginal willingness to pay for water service improvements in Rand per month – WRC Research Project K5/1871/3

Service attribute	Kouga residents	NMBM business owners
Sewerage disposal	R57.29	R35.93
Quality of water	R65.05	R62.26
Security	R21.90	R35.68
Interruptions	R9.83	R5.51
Rate of flow	-R2.77	R8.92

These findings (Table 1.1) indicated, *inter alia*, that in the Eastern Cape quality of water was particularly important, and cost saving through providing less continuous service and lower pressure would reduce consumer and producer welfare by less than sacrifices in sewerage disposal, quality of water and security of supply. The term willingness to pay (WTP) is used here to describe the amount the customer would voluntarily spend and presumes the customer has the required income needed (ability) to pay for the service. Bids (WTP) that are elicited from people (respondents) that do not have sufficient income to cover the bid, were deemed to be invalid.

This study (WRC Research Project K5/2087) extended the scope of the water tariff issues investigated in Project K5/1871/3, to cover three additional municipalities (outside of the Eastern Cape), and also to focus more attention on attributes of water service which were both sensitive to costs and for which there was scope to vary. The provision of a certain minimum quality of water is required by law, but there is more flexibility permitted with respect to delivery convenience attributes of the water service, such as water pressure, and municipalities may find the cost advantages of exploring this flexibility increasingly attractive.

Three local municipalities outside of the Eastern Cape agreed to cooperate with the research team. They were those of Knysna, Breede Valley and Msunduzi municipalities. The intention of selecting municipalities outside of the Eastern Cape was to broaden the relevance of the findings beyond the Eastern Cape (where most DCE analysis has been undertaken) to the Western Cape and KwaZulu-Natal.

The methodology of discrete choice experiments is well documented in economic and statistics literature – and is discussed in Chapter 2. It constitutes one of the variants of the choice modelling technique. The latter has evolved over a long period of time. In the year 2000 McFadden was awarded the Nobel Prize in Economics for his contributions in this field. The choice experiment method is a survey based method that generates probabilistic predictions of preferences for goods and services, and where these goods and services are represented in terms of different levels of attributes. Its conceptual roots track back to Lancaster's (1966) characteristics theory of value. The discrete choice experiment approach to valuation was first proposed by Hensher (1982).

It shares a theoretical framework with dichotomous choice valuation in random utility models (McFadden, 1973) and utilizes the empirical framework of limited dependent variable statistical models (Greene, 1997). The DCE approach suffers from many of the same problems that other revealed preference methods do, including hypothetical bias and sensitivity to design choice (Hanley, 2001). In this utility maximizing theory of choice, utility from consuming goods is decomposed into utilities from the attributes of the good rather than from the good as a whole. Applied to the modelling of choice, people within target populations are selected are presented with alternative packages of attributes and levels, and requested to reveal a preference. When the price of the composite good is included as one of the attributes, WTP (welfare) values can be determined for the component attributes (Hanemann, 1984). Two big advantages of the choice elicitation over rating and ranking elicitation are that it forces the respondent to trade off attributes against each other (so revealing opportunity cost) and that it is less prone to embedding bias.

For the purpose of determining marginal valuations of water service user preferences, a DCE approach is appropriate because the decision issues are typically multidimensional and inter-dependent. Management decisions relating to the water service supplied include: quality of the water delivered, water pressure, interrupted supply, investment in sanitation and disposal of used water – all relevant features in determining costs. The composite good that results determines the satisfaction of the water consumer.

Discrete choice experiment analysis of water services enables an assessment at the margin to be made of what water service consumers currently value most about the service they receive. Being a value derived through the analysis of a defined marginal change (such as of specific improved sanitation) it is not relevant to the question of the overall value of the service, that is the value that would be foregone in the absence of any service. It has the merit of providing indications of the kinds of changes in the mix of water service output (levels of attributes) that would most yield value to the water service receiving customer. For this reason, it is highly suited to complementing investigations into technical changes in water service provision that would have consequences for the mix of outputs provided.

Chapter 3 describes and analyses the survey information collected during 2012 about customer perceptions of the water services they were provided. Samples of between 0.5% and 2% of the water service consumer billed unit populations in the three local municipalities were surveyed. The respondents were drawn from three groups of water service customers – high income earners, low income earners and businesses. Chapter 4 analyses the choices the customers made between the alternative water service packages they were presented with and estimates models of the choices made for the level of service of selected identified important water service attributes. Chapter 5 draws conclusions.

Chapter 2: Applying the Choice Experiment Methodology

2.1 The Choice Experiment Method

If one chooses a technology to supply a service that leaves the consumers as happy as they were before, but the cost of provision is less, it is efficient to choose to apply that technology. Alternatively, if with the same total cost outlay on water services, but different technologies, consumers can be made happier by being supplied a different output mix linked to those different technologies, it is efficient to adopt those different technologies and the different service output mix. The scope for such improvements in efficiency may become increasingly attractive to municipalities in South Africa as they seek to meet the multiple development objectives they are tasked with.

The scope for efficiency improvement through the adoption of alternative technological combinations by municipalities to provide potable water services to their consumers may be demonstrated in a simplified utility maximising model. In this model there are only two utility generating attributes, two technologies for generating a potable water service and two rational water service purchasing residents (consumers). In the ideal world these two residents would make a choice between the combinations of the two elements available in order to maximise their utility. Let these two elements be Water Quality (E) and Delivery Convenience (D). For the purpose of this model (demonstration) the two residents are differentiated only in terms of the income they earn – one (the high income one) earning considerably more than the other (the low income one). The high income resident earns an income of I_{R1} and the low income (poor) resident an income of I_P. As both residents have the same preferences, their choices differ only due to the difference in income they earn. Being rational their preferences are complete and transitive.

Their utility function in the water service elements is:

$$U = f(E; D) \qquad (2.1)$$

More water delivery convenience increases utility, as would greater quality of water, but only up to a point (E_3 in Figure 2.1):

$$\frac{\partial U}{\partial D} \geq 0, \quad \frac{\partial^2 U}{\partial D^2} < 0;$$

$$\frac{\partial U}{\partial E} > 0, \ \frac{\partial^2 U}{\partial E^2} < 0, \ \frac{\partial^2 U}{\partial D \partial E} > 0, \quad E < E_3$$

$$\frac{\partial U}{\partial E} = 0, E \geq E_3$$

where E_3 is the water quality at which no further benefit is gained, and the marginal rates of substitution between the elements cease to diminish.

The two technologies whereby potable water can be produced are technology A and technology B. The attribute levels that can be realised with technology A are defined by a ray from the origin to A, and with technology B by a ray from the origin to B. Technology A is delivery convenience intensive (prioritising) and technology B is water quality intensive (prioritising). Using combinations of technologies A and B, other combinations of elements E and D, falling between rays A and B, can also be produced. Given the high income resident's income, of I_{R1}, any combination of elements/attributes can feasibly be purchased along the line labelled I_{R1} drawn between the production rays A and B. Similarly, given low income resident's income of I_P, any combination of elements/attributes can feasibly be purchased along the line labelled I_P drawn between the production rays A and B. If the relevant consumers were given the choice, their utility maximising choices (high and low income respectively) would be for E_3 and E_1 water quality purchases and D_2 and D_1 delivery convenience (see Figure 2.1). The poor consumer has less income than the rich consumer to allocate.

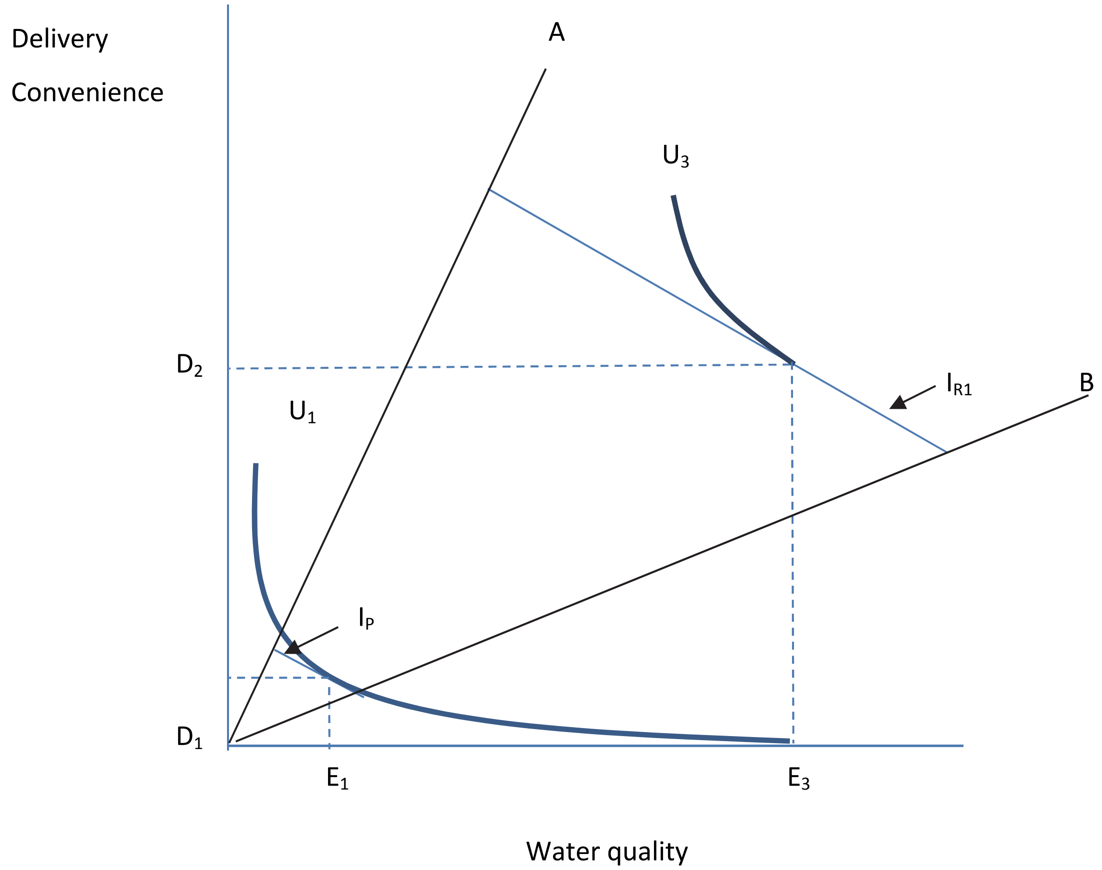


Figure 2.1: Choice of water quality and delivery convenience in water service delivery

What happens if a municipality decides they will only employ technology A (for non-efficiency related reasons) and also that a uniform level of water quality shall be provided to both income groups, at a level appropriate to the income of the high income group, viz. E_2? This level of water quality is lower than that which would have been demanded by the high income group (E_3E_2 less) but higher than that which would be demanded by the low income group (E_1E_2 higher, see Figure 2.2). The adoption of single technology A and commitment of uniform water quality service of E_2 for both income groups by the municipality, limits the delivery convenience option for both groups to level D_3., and introduces an income subsidisation requirement of the low income budget of I_{R1} - I_p

The resultant level of delivery convenience is greater than both the high income group would have demanded (D_2D_3 more, given their income of I_{R1}) and the low income group (D_1D_2 more, given their income of I_p). It follows that the imposition of technology (A) and minimum water quality constraints imposed on supply by the municipality have the dual impacts of improving the utility optimising choice of the low income resident (through the subsidisation of their budget) and preventing the utility optimising choice of the high income resident (and subsidised low income resident) from being realised.

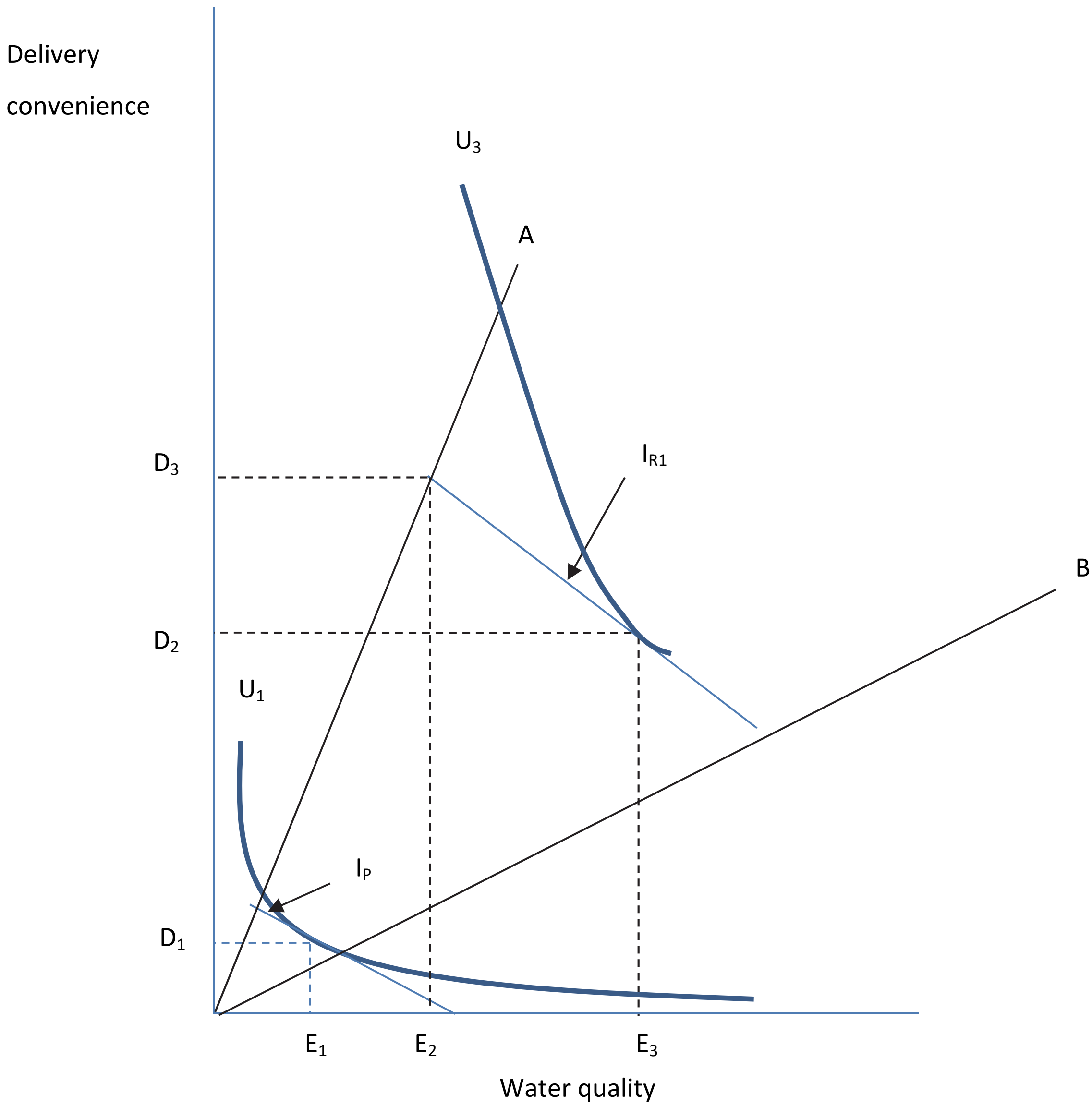


Figure 2.2: Choice of water quality and delivery convenience in water service delivery with the imposition of a minimum water quality constraint

As the preferences of both consumers of water service are the same (by assumption), the choice of D_3 delivery convenience and E_2 water quality is inferior to what could be achieved for both consumers. A combination of technologies A and B would enable the choice to be made of welfare superior option D_2 delivery convenience and E_3 (given the same budget, I_{R1}, see Figure 2.2). This welfare improving trade would only be technically feasible, if the municipality introduced technology B into production.

How can one determine whether welfare improving trades, such as less delivery convenience for greater water quality (Figure 2.2) exist, and make the changes to the technology balances employed in production (with no overall cost increase required)?

One way of finding out is to ask the respective consumers what trades they would be willing to make in the water service attribute/product mix. Their answer to this question would point the way to efficiency improving possibilities.

This report approaches this identification task by asking three groups of water service consumers to make choices between alternative combinations of composites of water services, high income residents, low income residents and business consumers. The approach is called the choice experiment statistical method and is based on the premise that people reveal their trade preferences through random choices made between alternative hypothetical composites of the attributes of goods/services.

2.2 Review of the choice modelling methodology

Discrete choice experimentation is one form of choice modelling (CM). The latter is a stated preference survey technique similar to that of the contingent valuation method (CVM). CM differs from CVM in that individual's preferences for a good or service are estimated by examining the trade-offs the respondents make between hypothetical levels of attributes making up a good or service, as opposed to direct willingness to pay (WTP) or willingness to accept (WTA) questions related to the good or service (Davies, Laing & Macmillan, 2000).

Three methods are grouped under the term 'choice modelling': discrete choice experiments (DCE), contingent ranking and contingent rating. All three techniques, under the right assumptions, are consistent with welfare economic theory and all share the same design of choice alternatives (Kjaer, 2005).

A DCE, known in marketing as conjoint-analysis, requires that the respondents choose one alternative out of a given set of alternatives (Kjaer, 2005). The data is said to be weakly ordered because only information on the chosen alternative is recorded (Kjaer, 2005).

Contingent ranking requires that the respondents rank the alternatives and therefore is preference ordered. This method results in more information than a discrete choice experiment. However, it is more cognitively demanding[1] on the respondents, which can lead to poor quality results.

Contingent rating is similar to contingent ranking, with the exception that the respondents are able to indicate ties (rank two or more alternatives as equal). Discrete choice experiment (DCE) methodology is the simplest method of the three and is the least cognitively burdensome for the respondents. From DCE analysis, four types of information can be inferred (Davies, Laing & Macmillan, 2000; Hanley *et al.*, 1998):

1. Which attributes significantly affect choice.
2. The order of importance of the attributes to the individuals.
3. The MWTP/A for the increase/decrease in a significant attribute.
4. The WTP/A for a package that simultaneously changes the levels of significant attributes.

There are five stages required to perform a DCE exercise. The first stage involves the selection of the attributes of the good to be valued. A monetary measure is usually included as one of the attributes. The second stage is the assignment of levels to the selected attributes. These levels are required to be feasible, realistic and non-linearly spaced (Hanley *et al.,* 2001). The levels should also include all options relevant to the respondent's preferences. Literature reviews, focus groups and pilot studies are used to determine the attributes and the levels (stages 1 and 2). The third stage is the experimental design stage. This stage uses statistical design theory to combine the levels of the attributes into a number of choice options or profiles that will be presented to the respondents. The fourth stage involves the construction of the choice sets. These choice sets can be presented individually or in groups. The last stage is the estimation procedure. OLS regression or Maximum likelihood procedure can be used to determine WTP or WTA compensation figures.

Due to its comparative advantages over the feasible alternatives, the discrete choice experiment methodology was selected for application in this study.

2.3 Theoretical framework

Choice experiment methodology is based on two fundamental theories, random utility theory and Lancaster's theory of value. The basic assumption of random utility theory (RUT) is that all decision makers are utility maximisers that will choose the alternative that maximizes their overall utility

[1] The complexity of the tasks and difficulty associated with indicating preferences.

(Shen, 2005). Lancaster's theory of value proposes that all goods be broken up into attributes and that the utility that a decision maker derives from the consumption of the good is not determined by the consumption of the good as a whole, but the attributes that make up the good (Lancaster, 1966). Because the utility of any decision maker cannot be observed by an analyst, it is assumed that a decision maker k's utility for alternative i has an observable, deterministic component and an unobservable or random error component:

$$U_{ki} = V_{ki} + \varepsilon_{ki} \tag{2. 2}$$

where U_{ki} represents the overall utility of decision maker k for a specific choice alternative i, V_{ki} represents the observable utility component and ε_{ki} represents the unobservable or stochastic utility component (Hensher, Rose & Greene, 2005).

The deterministic utility component is assumed to be linear:

$$V_{ki} = ASC_i + \beta_{1ki} f(X_{1ki}) + \beta_{2ki} f(X_{2ki}) + \beta_{3ki} f(X_{3ki}) + \cdots + \beta_{nki} f(X_{nki}) \tag{2. 3}$$

where β_{1ki} is the parameter associated with X_1 and alternative i and ASC_i is the alternative specific constant[2] associated with the i^{th} alternative. The ASC is a constant that takes up the unobserved variation not explained by the attributes or the socio-economic variables (a vector of zero's with the value one each time alternative i is chosen) (Hensher *et al.*, 2005).

From Equation 2.2 and Equation 2.3 the utility associated with alternative i as evaluated by decision maker k can be written in matrix notation:

$$U_{ki} = \boldsymbol{ASC}_i + \sum_n^N \boldsymbol{\beta}_{nki} \boldsymbol{X}_{nki} + \boldsymbol{\varepsilon}_{ki} \tag{2. 4}$$

In order to model individual choices with only the available or observed data, an analyst has to determine the probabilities associated with each alternative presented to the individual. If the individual faces a particular set of alternatives $i = 1, \ldots, j, \ldots, I$ then using the individual decision maker's rule, the individual will evaluate each alternative $U_1, U_2, \ldots, U_I$ and select the option that yields the greatest utility. From RUT, the analyst would assume that the probability of the individual selecting alternative i is equal to the probability that the utility of alternative i is greater than or

[2] Alternative specific constants (ASCs) are vectors of independent variables that take the value 1 for one alternative and zero for others (Tardiff, 1978). Including ASCs enables the analyst to control for correlations between observed and unobserved attributes (Klaiber & von Haefen, 2008). It is not necessary to include ASCs with models that have random coefficients, that is for unlabelled experiments (McFadden & Train, 2000).

equal to the utility of alternative j (given $i \neq j$) after comparing all alternatives in the choice set of $i = 1, \ldots, j, \ldots, I$ alternatives (Hensher *et al.*, 2005):

$$Prob_k(chooses\ i) = Prob\left(U_{ki} > U_{kj}\right) \forall\ i \neq j \quad (2.5)$$

which is the same as:

$$Prob_{ki} = Prob[(V_{ki} + \varepsilon_{ki}) \geq \left(V_{kj} + \varepsilon_{kj}\right)] \forall\ i \neq j \quad (2.6)$$

Equation 2.6 can be rearranged so that the unobserved components are separated from the observed components:

$$Prob_{ki} = Prob\left[\left(\varepsilon_{ki} - \varepsilon_{kj}\right) \leq \left(V_{ki} - V_{kj}\right)\right] \forall\ i \neq j \quad (2.7)$$

In order to estimate this probability with a conditional logit (CL) model[3] some assumptions are made about the distribution of the error component. The unobserved components are assumed to be independent and identically distributed (IID) with an extreme value (Gumbel) distribution. This assumption allows the analyst to estimate the probability of choosing alternative i over alternative j (Hanley *et al.*, 2001; McFadden, 1974; McFadden, 2001):

$$Prob\left(U_{ki} > U_{kj}\right) = \frac{e^{(\mu V_{ki})}}{\sum_{j=1}^{J} e^{(\mu V_{kj})}} \forall\ i \neq j \quad (2.8)$$

Equation 2.8 postulates that the probability of an individual selecting alternative i over alternative j is equal to the ratio of the exponent of the observed utility of i to the sum of the exponent of all the observed utilities of the other j alternatives (Bergmann, Hanley & Wright, 2006). As the deterministic component of utility is assumed to be linear in parameters, Equation 1.8 can be written as:

$$Prob\left(U_{ki} > U_{kj}\right) = \frac{e^{(\mu \beta_n X_{ki})}}{\sum_{n=1}^{N} e^{(\mu \beta_n X_{kj})}} \forall\ i \neq j \quad (2.9)$$

From Equation 2.9 above X_{ki} are the explanatory variables of V_{ki}, which would include the ASCs, the attributes associated with alternative i and the socio-economic aspects of decision maker k. The log-likelihood function of Equation 2.9 is as follows:

[3] The conditional logit (CL) is similar to the multinomial logit model (MNL) except that the CL model focuses on the set of alternatives as opposed to the individual and the explanatory variables are characteristics of those alternatives rather than characteristics of the individuals (Hoffman & Duncan, 1988).

$$LL = \sum_{n=1}^{N} \sum_{i=1}^{I} y_{ki} log \left[\frac{e^{(\mu \beta_n X_{ki})}}{\sum_{n=1}^{N} e^{(\mu \beta_n X_{kj})}} \right] \quad (2.10)$$

where y_{ki} is an indicator variable that equals one if decision maker *k* chooses alternative i and zero otherwise (Hanley *et al.*, 2001). The estimates for the coefficients ($\boldsymbol{\beta}_n$) of the model can be calculated by maximising the log-likelihood function.

The scale parameter μ in Equations 2.8 and 2.9 is inversely proportional to the standard deviation of the error distribution and confound the direct determination of the β_n parameters. It is typically normalised to 1 for the CL model (Hanley *et al.*, 2001; Shen, 2005). An implication of this specification is that the choice sets must conform to the restrictive assumption of independence from irrelevant alternatives (IIA) (Hanley *et al.*, 2001). This assumption requires that the ratio of choice probabilities must be independent of the introduction or the removal of other alternatives in the choice set (Hanley *et al.*, 2001). As a simple example, in a choice set containing three options for transportation: car, airplane and train, the IIA assumption postulates that the probability of choosing car over train is the same whether or not airplane is included in the choice set. One can test for the violation of this assumption using the test derived by Hausman and McFadden (1984)[4] – from here on referred to as the Hausman test.

One of the problems often encountered with CL models is that IIA assumption is often violated because these models do not account for heterogeneity in choice preference across respondents or correlation across observations (Glasgow, 2001; McFadden & Train, 2000; Hensher *et al.,* 2005). The nested logit (NL)[5] model was introduced to accommodate the violations of this assumption. The NL model allows the variation of the random components to differ across alternatives (relaxing the IID assumption[6]). This allows pairs of alternatives to be correlated. The NL model clusters the alternatives that are related into subgroups where the random components within the subgroup are correlated and the random components of alternatives that are not in the subgroup are

[4] The test is conducted by comparing the unrestricted model, synonymous with the null hypothesis, where all alternatives are included, with the alternative hypothesis using the restricted number of alternatives (Hensher *et al.*, 2005). The test statistic is defined below in Equation 2.16 below (Hensher *et al.*, 2005).

$Q = [p_u - p_r]'[VC_r - VC_u]^{-1}[p_u - p_r]$

Where p_u and p_r are the column vectors of parameter estimates for the unrestricted and restricted models and VC_u and VC_r are the variance-covariance matrix for the unrestricted and restricted models. The Q statistic is distributed Chi-squared with the number of parameters estimated in either model as the degrees of freedom (Hensher *et al.*, 2005).

[5] Also referred to as the hierarchical model or the tree extreme logit (Hensher *et al.*, 2005)

[6] The IID assumption has an equivalent behavioural association with the IIA assumption (Hensher *et al.*, 2005)

uncorrelated. As an illustration of this concept, the choice making decision for a NL model of a respondent is shown in **Error! Reference source not found.**.

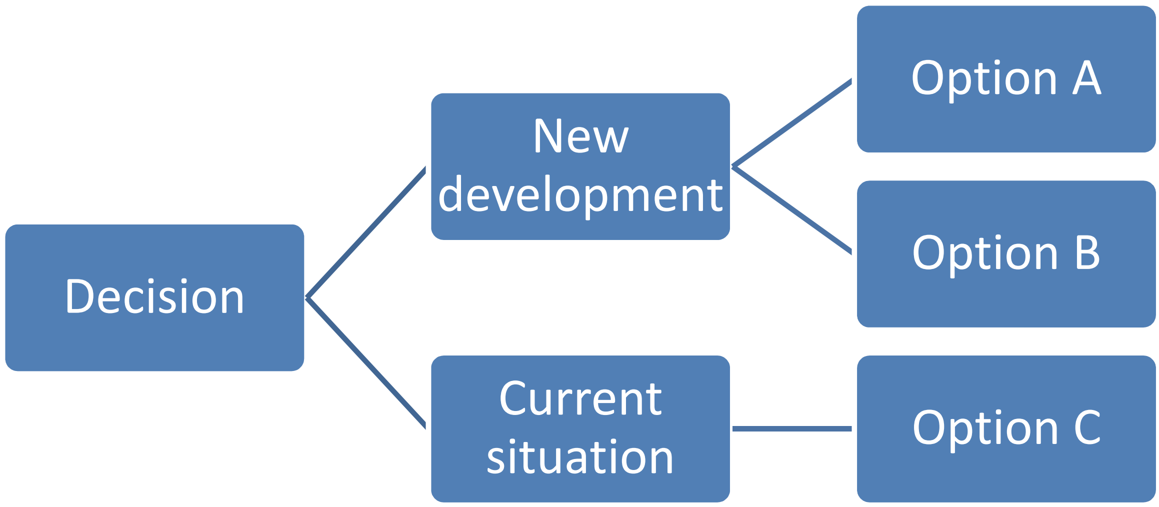


Figure 2.3: The choice scenario for a respondent for a NL model

Adapted from: Baskaran, Cullen & Wratten (2009)

In its simplest form, the ASC explains the utility associated with the first branch (the decision between a new development and the current situation). The choices for the second branch (alternatives A and B) are explained by the ASC_A (ASC for option A) and the levels if the attributes. The utility equations for the NL model illustrated in **Error! Reference source not found.** are as follows (Baskaran, Cullen & Wratten, 2009):

First Branch:

$$V_{ij}(New\ Development) = ASC \qquad (2.11)$$

Second branch:

$$V_{ki}(Option\ A) = ASC_A + \sum_k^N \boldsymbol{\beta}_j \mathbf{X}_{ijk} \qquad (2.12)$$

$$V_{ki}(Option\ B) = \sum_k^N \boldsymbol{\beta}_j \mathbf{X}_{kij} \qquad (2.13)$$

$$V_{ki}(Option\ C) = \sum_k^N \boldsymbol{\beta}_j \mathbf{X}_{kij} \equiv 0 \qquad (2.14)$$

In the two level NL model described above, the probability of a decision maker k choosing alternative i in the subgroup q $\left(Prob_{iq}\right)$, in the second branch,

$$Prob_{kiq} = Prob_k(i|q)Prob_k(q) \tag{2. 15}$$

where $Prob_k(i|q)$ is the probability of decision maker k choosing the i^{th} alternative, conditional on the qth subgroup being chosen, and $Prob_k(q)$ is the probability that the decision maker will choose the qth subgroup. These probabilities can be derived as follows (Baskaran, Cullen & Wratten, 2009; Kling & Thomson, 1996):

$$Prob_k(i|q) = \frac{e^{\frac{V_{kiq}}{\gamma_q}}}{e^{I_q}} \tag{2. 16}$$

$$Prob_k(q) = \frac{e^{\gamma_q I_q}}{\sum_{j=1}^{Q} e^{\gamma_j I_j}} \tag{2.17}$$

where $I_q = log\left[\sum_{r=1}^{R_q} e^{\frac{V_{krq}}{\gamma_q}}\right]$ is the inclusive value (IV) and γ_q is the coefficient of the IV parameter, which measures the degree of substitution between the various subgroups, Q is the number of subgroups and R is the number of alternatives in subgroup q (Baskaran, Cullen & Wratten, 2009).

A possible reason for the violation of the IIA assumption is that the preferences of respondents are heterogeneous, that is respondents with similar socio-economic characteristics have specific preferences. In order to incorporate taste variation among the respondents, a random parameters logit model (RPL)[7] can be used for estimation. This model assumes that the preferences of the respondents are distributed by some known statistical distribution $\eta_k \sim f\left(\eta_k \middle| \bar{\eta}, \sigma_\beta\right)$. The unobserved component of utility is $e_{ki} = \boldsymbol{\eta}_k \boldsymbol{z}_{ki} + \boldsymbol{\varepsilon}_{ki}$, where $\boldsymbol{\varepsilon}_{ki}$ is assumed to be IID Type I extreme value, $\boldsymbol{z}_{ki}$ is a vector of individual specific characteristics and $\boldsymbol{\eta}_k$ is a vector of random terms that varies across individuals k according to a known distribution $f(\eta_k|\bar{\eta}, \sigma_\eta)$ (Glasgow, 2001). Estimation of the variance σ_β provides an indication of heterogeneity in the model (Glasgow, 2001). With the new assumptions on the random component, the utility that individual k derives from choosing alternative i given in Equation 1.2 can be reformulated:

$$U_{ki} = \boldsymbol{\beta X}_{ki} + \boldsymbol{\eta}_k \boldsymbol{z}_{ki} + \boldsymbol{\varepsilon}_{ki} \tag{2.18}$$

[7] Also referred to as; a mixed logit model, a mixed multinomial logit model and a hybrid logit model.

If there is preference homogeneity $\boldsymbol{\eta}_k = 0$ and $\boldsymbol{\eta}_k \boldsymbol{z}_{ki} = 0$. The latter is a specific case – in fact, the CL model specification. The random component of utility is assumed to be IID extreme value Type 1. The unconditional choice probability that decision maker k will choose alternative i becomes:

$$Prob_{ki}(\eta) = \int L_{ki}(\eta) f\left(\eta | \bar{\eta}, \sigma_\eta\right) \partial(\eta) \tag{2. 19}$$

and the unconditional probability of respondent k choosing alternative i (Equation 2.18) can be reformulated as*:*

$$Prob(U_{ki}) = \int \left[\frac{e^{\boldsymbol{\beta X} + \boldsymbol{\eta X}}}{\sum_{n=1}^{N} e^{(\boldsymbol{\beta X} + \boldsymbol{\eta X})}}\right] f(\eta_k | \bar{\eta}, \sigma_\eta) \partial\eta \tag{2. 20}$$

where X contains all attributes and socio-economic characteristics of the individuals. Equation 2.20 cannot be estimated with standard maximum likelihood theory as the integral does not have a closed form. For this reason, a simulated maximum likelihood technique must be used (Glasgow, 1999). This technique involves drawing a value for η_k out of its distribution with given $\bar{\eta}$ and σ_η. The logit probability (the CL model in Equation 2.9) of each draw is calculated. This step is repeated several times, and the mean of the draws taken as the unbiased estimator of the unconditional choice probability of respondent k choosing alternative i. The simulated probability choice function is:

$$SimProb(U_{ki}) = \frac{1}{D} \sum_D log \left[\frac{e^{(\boldsymbol{\beta}_n \boldsymbol{X}_{ki} + \boldsymbol{\eta}_D \boldsymbol{X})}}{\sum_{n=1}^{N} e^{(\boldsymbol{\beta}_n \boldsymbol{X}_{kj} + \boldsymbol{\eta}_D \boldsymbol{X})}}\right] \tag{2. 21}$$

where D is the number of draws of D and η_D is the D^{th} draw of η. The resulting choice probabilities are those that maximise Equation 2.21. The underlying utility function of respondent k is:

$$U_{ki} = V_{ki} + \varepsilon_{ki} = ASC_i + \sum_n \boldsymbol{\beta}_{nki} \boldsymbol{X}_{nki} + \sum_n \boldsymbol{\eta}_{nk} \boldsymbol{X}_{nki} + \boldsymbol{\varepsilon}_{ki} \tag{2.22}$$

where the k is the respondent $k(1, \ldots., K)$ and i is the alternative option selected *(i = Option A, Option B, Option C…)*, n is the number of attributes $(1, \ldots, N)$ and $\boldsymbol{X}_{nki}$ is the vector of explanatory variables including the attributes of the alternatives, socio-economic characteristics of the respondents, decision context and choice task in choice set (Hensher *et al.*, 2005). The non-random component of utility V is assumed to be a function of n choice-specific attributes $\boldsymbol{X}_{nki}$ with parameters $\boldsymbol{\beta}_{nki}$. The coefficient vector $\boldsymbol{\eta}_{nk}$ varies across the population with density $f(\eta_k | \bar{\eta}, \sigma_\eta)$, where $\bar{\eta}$ is the vector of actual parameters of taste variation (Baskaran, Cullen & Wratten, 2009).

Using a RPL model is advantageous in that the model eliminates the bias due to heteroscedastic error terms (Glasgow, 1999). Additionally, the model allows for a statistical test of heterogeneity of respondent preferences for attributes by assessing the significance of the standard deviation of the η_{nk} estimates (Mazzanti, 2001). A significant standard deviation of the $\boldsymbol{\eta}_{nk}$ parameter would indicate heterogeneity in the preferences for an attribute (Mazzanti, 2001).

A RPL model estimates the amount of preference heterogeneity through the standard deviations of the parameters and the interaction between the mean parameter estimates and all the other attributes of alternatives and socio-economic descriptors (Hensher *et al.*, 2005). A further advantage of using RPL models is that these models are accommodating of correlation of alternatives and across choice sets (Hensher *et al.*, 2005).

In applying a RPL it is necessary to determine the appropriate set of random parameters. This application can be achieved using the Lagrange Multiplier, or by assuming all parameters are random, and testing the significance of the standard deviations of the parameters using an asymptotic *t*-test or the log-likelihood ratio test (Hensher *et al.*, 2005).

One of the main problems with RPL models is the determination of the distributions of the parameters. There are four popular distributions that are typically used as approximations to the real parameters distribution: log-normal, normal, uniform and triangular (Hensher *et al.*, 2005). The choice of distribution is essentially arbitrary, but can be approximated if the "empirical truth" lies within the chosen distributions domain (Hensher *et al.*, 2005). The normal distribution is often selected because it is symmetrical about the mean and allows for a change in sign in its range (Hensher *et al.*, 2005).

2.4 The application of discrete choice experiment methodology

There are several steps to follow in order to apply choice experiment methodology (Louviere *et al.*, 2000; Hanley *et al.,* 2001 and Shen 2005). These steps are summarised in Table 2.1.

Table 2.1: Summary of the choice experiment procedure

Steps			Components of each step
1.	Survey design	Choice set construction	Selection of attributes
			Assignment of levels
			Experimental Design
		Design considerations	Orthogonality
			Balanced and unbalanced designs
			Labelled and unlabelled experiments
			Dummy and effects coding
			Including a status quo option
		Survey development	Question framing
2.	Administration of surveys	Determination of sample size	Probabilistic sampling methods
			Non-probabilistic sampling methods
			Rule of thumb approaches
		Data collection	Survey mode
			Sampling strategy
			Survey technique
3.	Model Estimation		Choice model selection
			Interpretation of results
4.	Validity testing		Content Validity
			Construction and consistency
Source: Adapted from Hanley *et al.* (2001)			

2.4.1 Choice set construction

The first step in applying a choice experiment is to construct the vehicle through which to obtain decision makers preferences, a questionnaire to administer as part of a survey. The construction of this questionnaire is a critical part of the application of choice experiment methodology. The analytical results are dependent upon its relevance and accuracy. The design of the choice experiment questionnaire requires choice sets to be defined, which in turn involves the selection of appropriate attributes, the assignment of levels to each attribute and an experimental design to combine the attributes and levels into choice cards that will be presented to the respondents. The final phase of the survey construction is the presentation and decision on the choice of model to measure the preferences.

2.4.2 Selection of the choice attributes

The first step to creating choice sets involves the selection of the attributes to include in the choice experiment. These attributes must be important to the respondent group and should represent the characteristics of the relevant good appropriately (Shen, 2005). The number of attributes to include in the choice sets should be finite and as few as possible, without omitting important attributes that will affect the validity of the results. Literature reviews and focus groups are used to identify the attributes to include in the choice experiment (Hanley *et al.*, 2001).

There are two types of attributes, subjective and objective. Subjective attributes are usually qualitative attributes. These attributes can be assigned levels based on an ordinal scale. Proper descriptions of each level must be made to help the respondents understand. Subjective attributes are often difficult to define as the attributes do not have specified quantitative amounts. An example of a subjective attribute is conservation status. Objective attributes are objectively defined and are usually quantitative in nature. Distance and monetary measures are examples of objective attributes. A monetary attribute is usually incorporated into the choice experiment in order to allow for the estimation of WTP/A compensation.

2.4.3 Assignment of levels

Once the attributes are identified, levels expressing a range of potential variation in the attributes must be assigned (Louviere, Flynn & Carson, 2010). Literature reviews, focus groups and expert consultations are all processes that can be used to determine the levels for each attribute.

The range and the measurement of the attributes are important considerations when assigning the levels (Shen, 2005). The range of the levels can be determined by the range currently experienced by the respondents. One way in which the levels of the attributes can be assigned is by identifying the maximum and minimum values of the range. This way the respondents are more likely to agree on the magnitudes of the levels. The levels of the attributes must be realistic and acceptable to the respondents. Levels of qualitative attributes can be presented as an ordinal range (small, medium and large) or as levels representing realistic situations, such as whether or not there is a toll on the road (toll on the road, no toll on the road). These variables will need to be dummy or effects coded.

An important consideration for inclusion in the levels of the attributes is a status-quo or no-choice option. The inclusion of this level makes the choice scenarios realistic and improves the interpretation of the estimated welfare measures.

2.4.3.1 Experimental design

Once the attributes and levels have been specified, the next step is to create combinations of the levels and attributes in such a way that a variety of different hypothetical scenarios arise. The most common statistical designs employed are complete factorial designs and fractional factorial designs. The experimental design is analysed as a matrix with the columns as the attributes and levels and the rows as the treatment combinations.

2.4.3.2 Complete factorial designs

A complete factorial design is the combination of all attributes and levels. This design allows for the assessment of both the main effects and all interaction effects of the attributes on the choices. A main effect is a singular effect, such as the cost effect, or the effect of location (Kuhfeld, 2010). The interaction effects involve two or more factors, such as location by cost interaction (Kuhfeld, 2010). A main effects design only addresses the independent effects of each attribute on the response variable (choice) and does not include possible interaction effects between the attributes (Hensher *et al.*, 2005). A main effects only design explains 70-90% of the variation in choice (Louviere *et al.,* 2000). Interactions are included in the model when the preference for the level of one attribute in the model is dependent upon the level of another attribute (Hensher *et al.*, 2005).

Complete factorial designs are often unfeasible, as they can result in a large number of choice cards. For example, a complete factorial design of 5 attributes at 3 levels results in 3^5 = 243 choice cards. This large number of choice cards would require a large sample of respondents, and or a large number of choice sets to be presented to each respondent. The latter would be overly burdensome on the respondents and the former would increase the costs of the survey.

2.4.3.3 Fractional factorial design

A fractional factorial design limits the number of scenario combinations by fractioning the design. By using a factorisation factor of 3 the number of alternative combinations in the example above, can be reduced from 243 to 3^{5-3} = 9 alternative combinations. Fractioning the design reduces the estimation power of the experiment because it removes some or all of the interactions between the attributes. If some higher order interaction effects are also included in the fractional factorial design, the number of choice sets has to increase, increasing the difficulty of the choice tasks. In deciding which design to use the analyst needs to consider the trade-off between the cognitive burden placed on the respondents and the analytical sophistication of the design (Shen, 2005).

A fractional factorial experimental design can be generated in statistical software packages like SPSS, R and SAS. The rows of the experimental design are combinations of attribute levels. Each row represents a unique alternative and is referred to as a choice card. The choice cards are grouped into choice sets and presented to the decision makers in pairs or groups. Presentation of choice sets may be in any format, so long as the choice sets relay the relevant information and provide the means for respondents to make a choice. The complexity of the choice task increases as the number of choice sets presented to each respondent increases (Bateman *et al.*, 2002). The complexity of the choice task directly influences the results through respondent fatigue or disinterest. For this reason, it is important not to include too many choice sets.

The experimental design must be randomised before the design can be used. Randomising the design involves ordering and assigning the attribute levels. Research on the randomisation of the choice sets is still underway (Hensher *et al.*, 2005). Researchers have tried to randomise the choice sets by presenting two or more respondents with the same block of choice sets and randomising the order of the attributes and levels. Randomisation of the choice sets serves to improve the compliance of the model with the assumptions defined.

2.4.4 Design considerations

Some considerations need to be made when designing a choice experiment, such as design orthogonality, whether the design is balanced and whether to use an unlabelled or a labelled experiment.

2.4.4.1 Balanced and unbalanced designs

An important, but not an essential aspect of the experimental design, is whether the design is balanced or not. For each attribute, if all the levels of that attribute within the experimental design are represented equally the design is said to be balanced (Hensher *et al.*, 2005). For example, if an attribute has two levels (0 and 1) and the level 0 appears two times more than level 1, the design is unbalanced. It is desirable to have a balanced orthogonal design because unbalanced designs create false significance of the unbalanced attributes (Wittink & Nutter, 1982; Wittink, Krishnamurti & Reibstein, 1990; Hensher *et al.*, 2005).

2.4.4.2 *Orthogonality*

Orthogonality is a mathematical constraint requiring all attributes be statistically independent of one another (Hensher *et al.*, 2005). It implies that the attributes are uncorrelated. Although the respondents may perceive the attributes as correlated, it is important that the defined attributes be statistically independent (Hensher *et al.*, 2005). The rows included in the experiment determine the column orthogonality of the experiment, so the removal of any of the rows will affect the orthogonality (Hensher *et al.*, 2005). Non-orthogonal designs confound the determination of the contribution of each attribute and can result in incorrect parameter estimations (Hensher *et al.*, 2005). If the orthogonality of the design is compromised, the attributes of the design will be correlated. Once multicollinearity is detected, there is very little the analyst can do. For this reason, the test for multicollinearity should be conducted prior to model estimation.

The data can be tested for multicollinearity by the method of auxiliary regressions (Hensher *et al.*, 2005) and Klein's Rule (Hensher *et al.*, 2005; Klein, 1962). The auxiliary regression test is carried out by regressing each attribute in the design against the remaining attributes (including a constant term). The R^2 for each auxiliary regression is calculated using Equation 2.23.

$$R_i^2 = \frac{{R_{X_i}}^2/(k-2)}{(1-{R_{X_i}}^2)/(n-k+1)} \tag{2.23}$$

where ${R_{X_i}}^2$ is the R^2 of the regression of the attribute X_i on the remaining attributes, k is the number of parameters included in the regression and n is the sample size (Hensher *et al.,* 2005).

Each R_i^2 is compared to a critical F-statistic with degrees of freedom $k-2$ and $n-k+1$. If the R_i^2 value exceeds the critical value, the attribute under consideration is correlated with the remaining attributes (Hensher *et al.*, 2005).

Klein's rule compares the auxiliary ${R_{X_i}}^2$ values to the ${R_X}^2$ value of a regression of the dependent variable (choice) on the attributes of the model (Klein, 1962). If any of the auxiliary ${R_X}^2$ values exceeds the R^2 of the regression of choice, the design has significant multicollinearity (Hensher *et al.*, 2005).

Full factorial designs are inherently orthogonal, but only some fractional factorial designs are orthogonal. For this reason it is only necessary to test for orthogonality of the design if a fractional factorial design is utilised.

An orthogonal array is an array that is both balanced and orthogonal. An array that is orthogonal but not balanced is not necessarily an efficient design and may not be optimal. The efficiency of a $(N \times p)$ design can be quantified based on the information matrix[8] $(\boldsymbol{X}'\boldsymbol{X})$ (Kuhfeld, 2010). The diagonal elements of the inverse of the information matrix $(\boldsymbol{X}'\boldsymbol{X})^{-1}$ are the variances of the parameter estimates (Kuhfeld, 2010). The eigenvalues of $(\boldsymbol{X}'\boldsymbol{X})^{-1}$ determine the "size" of the efficiency of the design. Two methods are used to quantify the size of the efficiency: A-efficiency which determines the arithmetic mean of the eigenvalues $\left(trace\left(\boldsymbol{X}'\boldsymbol{X}\right)^{-1}\right)/p)$ and D-efficiency which determines the geometric mean $\left(det\left(\boldsymbol{X}'\boldsymbol{X}\right)^{-1}\right)^{1/p}$ of the eigenvalues[9] (Kuhfeld, 2010). These measures are scaled[10] to a range of 0 to 100. D-efficiency is preferred to A-efficiency because it is easier to compute and the ratio of two D-efficiencies is the same for different coding schemes (Kuhfeld, 2010). A D-efficiency value of 0 means that one or more parameters of the design are not estimatable (Kuhfeld, 2010). A D-efficiency of 100 implies that the design is perfectly balanced and orthogonal and values in between 0 and 100 mean that all parameters can be estimated but not with optimal precision (Kuhfeld, 2010).

2.4.4.3 Labelled and unlabelled experiment

There are two types of choice experiments: labelled and unlabelled experiments. An unlabelled experiment is an experiment where the alternatives presented are unlabelled and therefore uninformative to the decision maker (Hensher *et al.*, 2005). In an unlabelled experiment the choice sets are purely generic, in that the labels of the attributes do not provide any information beyond that which is provided by the attributes (Louviere *et al.*, 2000). With an unlabelled experiment the alternatives are differentiated by the comparison between the labels of the attributes and the attribute levels. A labelled experiment is alternative specific where a label conveys information about the alternatives to the decision maker (Louviere *et al.*, 2000, 2000). An example of an unlabelled experiment is given in Table 2.2 and an example of a labelled experiment in Table 2.3.

[8] In the context of discrete choice experiments, **X** represents the matrix of attributes and level combinations.
[9] The *trace* is the summation of the diagonal elements of a matrix and *det* is the determinant of the matrix.
[10] Scaling: $A - efficiency = 100 \times \frac{1}{N(trace(\boldsymbol{X}'\boldsymbol{X})^{-1})/p)}$ and $D - efficiency = 100 \times \frac{1}{N(det(\boldsymbol{X}'\boldsymbol{X})^{-1}))^{1/p}}$

Table 2.2: Unlabelled choice experiment for cell phone preferences

Attributes	Cell phone A	Cell phone B
Camera/ No camera	Camera	No Camera
Battery life	48 hours	72 hours
Cost	R400	R300

Table 2.3: Labelled choice experiment for cell phone preferences

Attributes	Smart phone	Ordinary cell phone
Camera/ No camera	Camera	No Camera
Battery life	48 hours	72 hours
Cost	R400	R300

Unlabelled experiments are more likely to produce attributes that satisfy the IID assumption because, in labelled experiments the label may be perceived as an attribute and/or be used to infer missing information and be correlated with the random component in the experiment (Louviere *et al.*, 2000). Labelled experiments also require an increase in the number of choice sets presented (Hensher *et al.,* 2005). Labelled experiments are best used when alternative specific parameters are required to be estimated.

It is possible to estimate utility functions for all alternatives with both labelled and unlabelled experiments. If the alternatives in the experiment are indefinable, the estimation of a utility function for each alternative is nonsensical.

2.4.5 Survey Development

The design of the survey to assess respondent preferences typically includes an introductory section, a choice experiment section, a follow-up section to the choice experiment and a socio-demographic question section (Lee, 2012; Hasler, Lundhese, Martinsen, Neye & Schou, 2005).

The introductory question section includes information about the study and the environmental issue addressed by the study. The questions in this section should provide sufficient information to the respondents about the study and encourage the respondent to think critically about the topic (Lee, 2012). The introductory questions should be concise and to the point so as not to irritate or bore the respondents. The questions should be neutrally worded and clearly understandable to all respondents. Ambiguities result in confusion and misleading results.

The introductory questions precede the choice experiment so as to prepare the respondents for the choice scenarios and provide information and allow the respondents to consider the different aspects of the choice scenarios (Lee, 2012).

The choice experiment section of the survey should include an information section explaining the choice experiment and outlining the way in which to respond to the questions. The respondents should be informed about each attribute in the choice experiment and be made to understand that choices require trade-offs to be made in the levels of the attributes.

The follow-up questions are used to validate the respondent's comprehension of the survey and choice experiment and to assess possible biases in the choice responses (Lee, 2012). The validity of the survey is assessed through questions about ease of the survey, the preferences for a specific attribute in the choice sets and questions regarding the choice of the *status quo* option.

Socio-demographic questions are necessary inclusions in the survey as these questions provide information about the characteristics of the sample of respondents. These questions are personal and can make the respondents uncomfortable. For this reason these questions are typically placed at the end of the survey.

2.4.6 Administration of survey

The administration of the survey involves the determination of the sample size and the data collection process. Data collection includes the survey mode, sample frame and sample strategy to be employed.

2.4.6.1 Sample size and selection

There are two dominant sampling methods that can be employed to select a sample: probabilistic and non-probabilistic. A probabilistic method assumes all individuals in the population have the same probability of being selected to participate in the study. Non-probabilistic methods are subjective. The individuals included in the sample are selected at the discretion of the researcher (Bateman *et al.*, 2002). Both probabilistic and non-probabilistic approaches as well as rule of thumb approaches are commonly used to determine sample size in choice modelling applications (Hensher *et al.*, 2005).

(a) Probabilistic sampling methods

Simple random sampling, systematic and stratified random samples are all probabilistic sampling techniques (Louviere *et al.*, 2000; Hensher *et al.*, 2005). The simplest method to determine sample size is with simple random sampling. The sample size can be determined using the formula given by Equation 2.24 (Louviere *et al.*, 2000; Hensher *et al.*, 2005):

$$n \geq \left[\Phi^{-1}\left(1-{}^{\alpha}\!/_{2}\right)\right]^{2} \frac{1-p}{pa^{2}} \qquad (2.24)$$

The sample size n is calculated by the level of accuracy of the estimated probabilities desired. The true percentage of the population is represented by p, α is the acceptable percentage of difference between the estimated probabilities and the true percentage of the population, q is the confidence interval of the estimation and Φ is the standard normal cumulative distribution function (CDF) (Shen, 2005). The formula for sample size is only applicable for simple random samples with independence between the choices (Shen, 2005).

(b) Non-Probabilistic sampling approaches

Convenience sampling, judgement sampling and quota sampling are all common non-probabilistic (and non-random) approaches to determine sample selection and size (Bateman *et al.*, 2002). These methods involve the researcher selecting the number of respondents for inclusion in the study by convenience or by judgement as to how many respondents to include, or by ensuring that certain proportions (quotas) of each respondent group appear in the study (Bateman *et al.*, 2002).

(c) Rule of thumb approaches

Theoretical specifications of sample size are often disregarded in practice in favour of simpler approaches because budgetary constraints often take precedence over the theoretical specifications (Hensher *et al.*, 2005). Rule of thumb approaches have been developed for discrete choice analysis and are commonly determined by the minimum number of respondents required to estimate a "robust model" (Hensher *et al.*, 2005). For an unlabelled discrete choice experiment, which only includes main effects, a sample size of at least 50 respondents with each respondent presented with 16 choice sets is acceptable (Hensher *et al., 2005*; Lee, 2012). There are two other rule of thumb approaches that can be employed. The first ascertains that each alternative appears at least 30 times in the sample and the second involves presenting every choice set to a minimum of 50 respondents (Bennett & Adamowicz, 2001).

2.4.6.2 Data collection

The inclusion of specific respondent groups and the method of administering the surveys are decided before the survey is administered. These decisions depend on the survey mode, sample frame and sampling strategy used. The survey mode determines how the respondents will answer the survey, the sample frame determines who the target population is and the sample strategy is the way in which the respondents are selected for inclusion in the survey.

(a) Survey mode

How the surveys are administered depends entirely on the type of respondents, the complexity of the survey, the objectives of the study and the budget constraints (Kragt & Bennett, 2008). In administering the survey the analyst should decide whether the surveys will be answered by the respondent (self-administration) or by an interviewer. Some self-administration survey modes include mail surveys, web-based surveys or computer-based surveys. Mail surveys and web-based surveys are easily administered, but suffer from low response rates and high error rates in the responses. Although web-based surveys have the advantage of being flexible, this type of survey suffers from targeting only a sub-group of the population (those who have access to computers and knowledge on how to use them). Two interviewer survey modes are telephonic and personal interviews. Choice experiment surveys are not ideally suited to telephonic survey methods as the choice sets are difficult to explain and can be confusing to the respondents. Personal interviews are the most advantageous form of response collection for a choice experiment survey. However, the costs of administering this type of survey are generally higher than for the other methods. Both methods of survey administration have benefits, but influence survey participation and reliability. For most choice experiment studies, personal interviews are recommended (Koponen, Maki-Opas & Tolonen, 2011).

(b) Sample Frame

The sample frame is defined as the target population from which a finite sample is selected and the survey tool administered (Oliver, 2010; Louviere *et al.*, 2000). The sample frame is determined principally from the objectives of a study. The objectives must be clearly defined so that a model may be developed from the sample. Incorrect specification of the sample frame can invalidate the data (Louviere *et al.*, 2000; Shen, 2005; Oliver, 2010).

(c) Sample strategy

The population from which the finite respondent sample will be drawn must be identified based on the objectives of the survey. Thereafter, a sampling strategy should be defined. There are many possible sampling strategies to employ, such as a simple random sampling, a stratified random sample or a choice-based sample (Shen, 2005). A specific sampling strategy may be more desirable if there is a sub-group that is of interest to the study or the accuracy of the estimates for a sub-group are to be improved (Shen, 2005). In practice, the sample size and sample strategy employed are determined mostly by budget constraints (Alpizar, Carlsson & Martinsson, 2003; Shen, 2005).

2.4.7 Model estimation

The response data can be analysed using a number of different statistical choice models. The most popular model to estimate the choice probabilities is the CL model, but the RPL model has a number of benefits over the CL model. The model estimation involves the analysis of the choice models, the estimation of welfare measures and validity testing.

2.4.7.1 Analysis of the choice models

Statistical models may be estimated using one of several statistical software packages, such as: SAS, Limdep NLogit, R and STATA. Once the parameters of the models have been estimated it is possible to compare the model effects of attribute interactions and socio-economic characteristics on choice probabilities. At this stage the WTP or WTA compensation welfare measures may also be calculated.

2.4.7.2 Marginal WTP or accept compensation

Marginal WTP (MWTP) or marginal WTA (MWTA) compensation is the ratio of the price attribute with all the other attributes in the choice experiment. The marginal values indicate the effect that a one unit change in the attribute levels will have on the price or subsidy accepted for a good or service. The formula to calculate MWTP or MWTA is given by Equation 2.25.

$$M = p^{-1} ln \left\{ \frac{\sum_i e^{V_i^1}}{\sum_i e^{V_i^0}} \right\} \qquad (2.25)$$

In this equation, M represents MWTP or MWTA, V^0 is the utility of the status quo, V^1 is the utility associated with the alternative and *p* is the coefficient of the cost attribute (Hanley *et al.*, 2001).

Equation 2.25 can be simplified into the ratio of the coefficients and is often referred to as the implicit price of the attributes. The implicit price represents the money trade-off that a respondent makes between the other attributes.

$$implicit\ price = -\left(\frac{\beta\ attribute}{\beta\ monetary\ attribute}\right) \quad (2.26)$$

The ratio of the two coefficients removes the confounding parameter in Equation 2.26 because the scale parameter μ is present in both the β coefficients of the attributes and the monetary attribute. A more complex matter is obtaining the standard errors for the implicit prices because the distribution of the maximum likelihood estimator for the welfare measure is a non-linear function parameter vector and unknown (Hanley *et al.*, 2001). The estimation of confidence intervals for the implicit prices can be derived by means of the delta method or the method proposed by Krinsky and Robb (1986).

The Krinsky and Robb (1986) method involves the simulation of an asymptotic distribution for the coefficient, by making repeated random draws for the multivariate normal distribution using the estimates of the coefficients and the associated covariance matrix (Hanley *et al.*, 2001). This method is also referred to as parametric bootstrapping (Hole, 2007). From the random draws, simulated values for WTA are calculated and these values used to determine the percentiles of the simulated distribution with the desired confidence level. The only assumption required is that the coefficients be joint normally distributed (Hole, 2007). Alternatively, the delta method can be used. This method involves estimating the asymptotic variance of the WTA or WTP measures, by taking the first order Taylor series expansion around the mean value of the variables, and calculating the variance for this expression.

$$var(W\hat{T}A_k) = [W\hat{T}A_{\beta_k} var(\hat{\beta}_k)] \times [W\hat{T}A_{\beta_c}\ var(\hat{\beta}_c)] = (\frac{-1}{\hat{\beta}_c})^2 W\hat{T}A_{\beta_k} W\hat{T}A_{\beta_c}\ covar(\hat{\beta}_k, \hat{\beta}_c) \quad (2.27)$$

$W\hat{T}A_{\beta_k}$ and $W\hat{T}A_{\beta_c}$ are the partial derivatives of $W\hat{T}A_k$ with respect to β_k and β_c (Hole, 2007). The confidence interval can be created using the standard formula:

$$W\hat{T}A \pm \Phi^{-1}[1-\alpha/2]\Phi^{-1}\sqrt{var(\,W\hat{T}A_k)} \quad (2.28)$$

where $\Phi^{-1}[1-\alpha/2]\Phi^{-1}$ is the inverse of the cumulative standard normal distribution and the confidence level is 100(1 - α) % (Hole, 2007). This method assumes that the WTA/WTP welfare measures are normally distributed.

2.5 Validity testing

Validity testing can be divided up into two sections, content validity and convergent validity. Content validity describes the extent the survey tool measures what it intends to. Construct validity describes the compliance or consistency of the results of the survey with the assumptions defined and as would be expected from standard economic theory and other similar local/international studies. The model's validity can be assessed through statistical goodness of fit tests.

2.5.1 Content validity

The survey is determined to have content validity if the survey tool is appropriate in measuring that which the study sets out to achieve and satisfies all objectives. Content validity requires that the right questions be asked in a clear, unbiased and easily understandable way (Oliver, 2010). Content validity can be achieved by ensuring that the survey tool has undergone a thorough examination by several external sources and has been tested and assessed in a pilot study.

2.5.2 Convergent validity

2.5.2.1 Compliance with assumptions defined

Assessing for compliance of the results with standard economic theory and the assumptions or expectations of the results can be done by assessing the sign and significance of the coefficients of the attributes. If the model is appropriately specified and estimated the model results should reflect expectations.

2.5.2.2 Compliance with international studies

The validity of the results can be determined by comparison with the results of other similar international studies and other similar stated preference studies. This type of validity should be interpreted with care as neither of the resulting estimations made by either study can be determined to be superior.

2.5.2.3 Compliance with survey findings

An important validity test for the choice experiment model estimations is the analysis of the answers to additional questions included in the survey specifically for this purpose. The most important section to consider when assessing the results validity is the follow-up questions to the choice experiment. Responses to the difficulty of the choice tasks, the understanding of the trade-offs and the preference for a specific alternative or attribute in the choice task to each respondent can be used to assess the validity of the choice experiment tool.

2.5.3 Model validity

Testing the significance and goodness of fit of the model to the data is a simple procedure for ordinary least squares (OLS) regression and it can be done with reference to the value of the adjusted R-squared and F-statistic (Hensher *et al.*, 2005). This same procedure cannot be applied to results of the choice experiment because maximum likelihood estimation (MLE) is used to estimate the choice models. For choice model estimation, the goodness of fit of the model can be determined by the log likelihood at convergence (Hensher *et al.*, 2005).

2.5.3.1 The Likelihood ratio (LR) test

The likelihood ratio test can be used to test the model significance and to compare two models to determine the superiority of one choice model over another for the same data set. The likelihood ratio test for model significance can be estimated by taking the difference in base model and the estimated model log-likelihoods and comparing the result to the chi-squared statistic with degrees of freedom equal to the difference in the degrees of freedom of the two models. The hypotheses tested are as follows:

Hypotheses:

$$H_0 = \beta_{Size} = \beta_{Cluster} = \beta_{Job} = \beta_{Distance} = \beta_{Income} = 0$$

$$H_1 = \beta_{Size} = \beta_{Cluster} = \beta_{Job} = \beta_{Distance} = \beta_{Income} \neq 0$$

and the likelihood ratio statistic is defined as:

$$\chi^2_{LL} = -2(L_0 - L_M) \tag{2.29}$$

where L_M is the maximum of the log-likelihood function and L_0 is the maximum of the log-likelihood function when all coefficients are zero (Koppelman & Bhat, 2006). The null hypothesis is rejected and the model is said to be significant if the test statistic is greater than the critical chi-squared value χ^2_{LL} at the 5% level of significance (Koppelman & Bhat, 2006).

The likelihood ratio index proposed by McFadden (1973) is used to test the goodness of fit of the model. The formula for this index is in Equation 2.30. The resulting pseudo-R^2 (namely R_{LL}^2) is similarly interpreted to an OLS regression model R^2.

$$R_{LL}^2 = 1 - \left[\frac{lnL_M}{lnL_0}\right] \qquad (2.\ 30)$$

In Equation 2.30 L_M is the maximum of the log-likelihood function and L_0 is the maximum of the log-likelihood function of all coefficients being equal to zero. The resulting pseudo-R^2 (R_{LL}^2) values of between 0.2 and 0.4 are considered to be equivalent to ordinary least squares (OLS) adjusted-R^2 of between 0.70 and 0.90 (Louviere *et al.*, 2000; McFadden, 1973). A value of 0.3 for the pseudo-R^2 represents a reasonable model fit (Hensher *et al.,* 2007).

2.5.3.2 The likelihood ratio test to compare two models

The superiority of one choice model over another can be tested using the likelihood ratio test if more than one choice experiment model is applied to the same data. The likelihood ratio test to compare two choice models is:

$$LR = -2(LL_{M1} - LL_{M2}) \qquad (2.31)$$

where LL_{M1} and LL_{M2} are the log likelihoods of the same data set for model 1 and model 2 at convergence. The LR is compared to the critical value from a chi-squared distribution table with a chosen level of significance and *n* being the difference between the degrees of freedom of the two models. The two models are said to be statistically different from each other if the null hypothesis is rejected, i.e. the value of LR is greater than the critical chi-squared value (Shen, 2005).

2.6 Conclusion

One of the main rationales for applying choice experiment analysis is that it has the potential to yield information on the scope for efficiency improvement through the adoption of alternative (and more flexible) technological combinations by municipalities to provide water services to their consumers and customers. DCE methodology is a stated preference technique that derives information on decision maker's preferences through the use of specifically designed hypothetical situations. It is a well-established stated preference methodology and highly appropriate to assess trade-off (marginal) values in the levels of water service provided. It does not have the associated “embedding” problems of CVM or as severe potential to incorporate strategic bias. There are a number of key features of the water service provided by South African municipalities; prominent among which are safety and quality of the drinking water, delivery convenience of the service (continuous supply, desired pressure, etc.), sanitation of waste water and disposal into the environment. Chapter 2 has shown that DCE’s can be used to estimate a value for such trade-offs and provide insight into the attributes of the water service that are most important to the individual.

Assuming completeness in preferences, every individual has a preference pertaining to each feature (attribute) of the water service. Some attributes will be valued more highly than others and individuals will be willing to trade-off (substitute) reductions in some attributes for improvements in others. For example, if at a given point in time, an individual prefers sanitation safety to delivery convenience to, it is expected that the individual would be willing to trade a reduction in delivery convenience for an increase in sanitation safety. Such trading may have to take place in groups, as there are typically technical limits to the scope for trading between the municipal supplier of service and each individual customer on the levels of service they wish to receive.

There are many models of choice over levels of attribute that can be estimated. The CL model is the simplest model that is appropriate for the determination of expected WTA/P measures, but has a major pitfall in that it is dependent on the restrictive IIA assumption. This assumption can be tested using the Hausman-test to determine whether the model is sufficient for estimation. If the model assumption is violated, the NL model or RPL model for discrete choice modelling estimation may be preferred. Both models relax the IIA assumption. There are benefits to both models. The NL model allows the analyst to test for alternative (status quo) bias and the RPL allows for heterogeneity in preferences and correlations in the alternatives of the choice sets. Preference of model of choice is typically made after consideration of the results of the various models estimated.

A DCE is applied in four steps. The first step involves the survey design including the construction of the choice sets and design considerations. The second step is the administration of the surveys, including the determination of sample size and data collection. The third step is model estimation. The final step is validity testing. Each step is very important, but none of them are particularly complicated.

Chapter 3: Respondent ratings of the water service they received

3.1 Introduction

The process followed and factors considered in designing choice experiments were outlined in Chapter 2. Key aspects of the first two steps of applying the methodology (design and survey administration) to water service customers served by the three selected municipalities (Breede Valley, Msunduzi and Knysna) are detailed in Appendices A and B. Guidance from other similar studies done, focus group consultation and sampling according to income group and nature were important influences in the design phase. The survey needs to be relevant, concise and informative. It should also be simple and not cognitively burdensome on the respondents. The survey tool should include attitudinal and knowledge based questions, choice options, follow-up questions to the choices and socio-economic questions. Sample selection, integrity of the data captured and sample size requirements were important influences in the survey administration phase. The representativeness of the samples of the relevant populations were not pursued by randomised selection within a sample frame of customers, but by method of interviewing pre-specified number of customers in street areas randomly selected from a sample frame of all street areas.

Chapter 3 describes and analyses the results of the survey, placing particular emphasis on the customer ratings of their municipalities' performance in delivering water services. It provides information on who was surveyed and their perceptions of the nature of this service.

3.2 Survey results

Choice experiment questionnaires were administered during 2012 to a total of 670 water service customers stratified by type (business versus resident) and income group (low and high income resident) served by the Breede Valley, Knysna and Msunduzi local municipalities. Once the data had been collected, it was captured into Microsoft Excel by a trained data processor. During this process the questionnaires were sorted according to survey number and screened for missing observations and potential erroneous data entries. A total of 17 questionnaires were deemed unusable because the responses were incomplete or unclear or inconsistent, or the income of the respondent was insufficient to cover the bids required in the choice experiment. Excluding the 17 unusable questionnaires left 653 for further analysis.

3.2.1 Breede Valley

3.2.1.1 Respondent analysis

Details of the usable responses elicited through the Breede Valley survey are provided in Table 3.1.

Table 3.1: Useable responses from the Breede Valley Survey

Category	**High income**	**Low income**	**Business**	**Total**	**Sample Population**	**No. of billable units**
Administered Number	75	75	75	225	127 597	8 951
Usable Number	75	73	73	221		

*Source: Respective local municipalities (2012)

The sample was drawn from a population of 8 951 billable units and constituted 2.5% of the billable unit population. The respondents from the high income sample population group were better educated and held more full-time employment positions than the poor group (Table 3.2). Males and females were equally represented in the sampled population, in line with the population distribution for gender. The mean age of the high income respondents was higher (50 years old) than that of the poorer respondents (39 years old).

Table 3.2: Summary of the respondent demographics – Breede Valley

Percentage of income class per characteristic level and age in years			
Mean Income	**Level**	**Low income**	**High income**
Education	No education	12%	0%
	Some education	84%	51%
	Tertiary Education	4%	49%
Gender	Male	55%	49%
	Female	45%	51%
Employment	Unemployed	23%	6%
	Employed	77%	86%
	Retired	0%	8%
Mean Age		39 years	50 years

Both the high income and low income respondent groups were solely provided water services from the Breede Valley municipality. All high income respondents paid the municipality for their water services, 77% of the low income group paid for water services from the municipality. Most of the businesses received municipal supplied water services. Only 3% of the respondents were not receiving municipal water services and 5% did not pay for water services from the municipality.

3.2.1.2 Respondent ratings of water service delivery

Most Breede Valley respondents rated safety, delivery convenience and cross-subsidising the water services of the poor as important, irrespective of whether they were from high income or low income groups. The high income group identified the subsidisation of water for the poor as the least important service attribute. The low income respondents rated the safe disposal of waste water and the strength of the flow of water as most important.

All respondents, but especially those in the high income group, were disinterested in cheaper (less convenient) water services, but a majority of business respondents were interested in such options being developed (Figure 3.1).

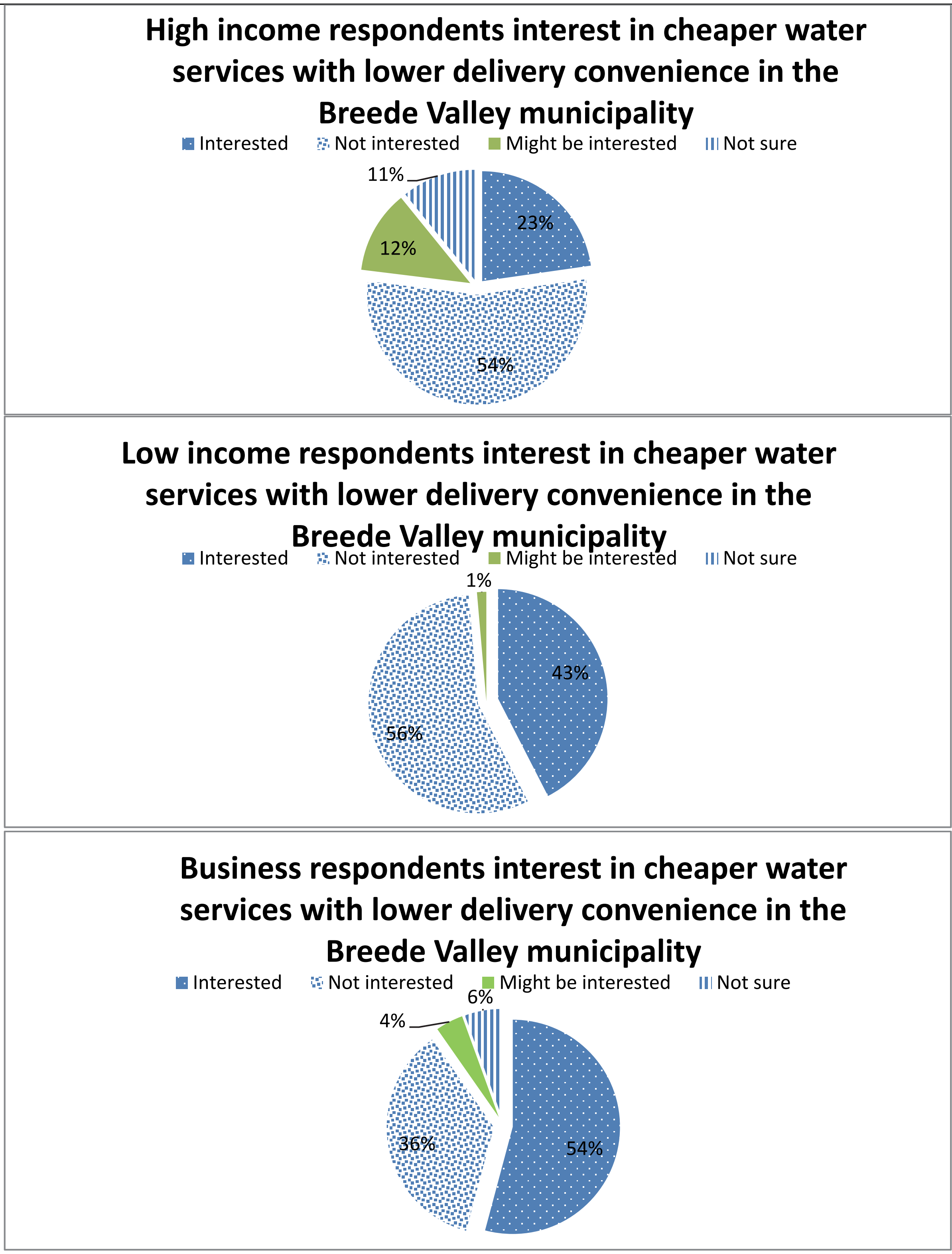
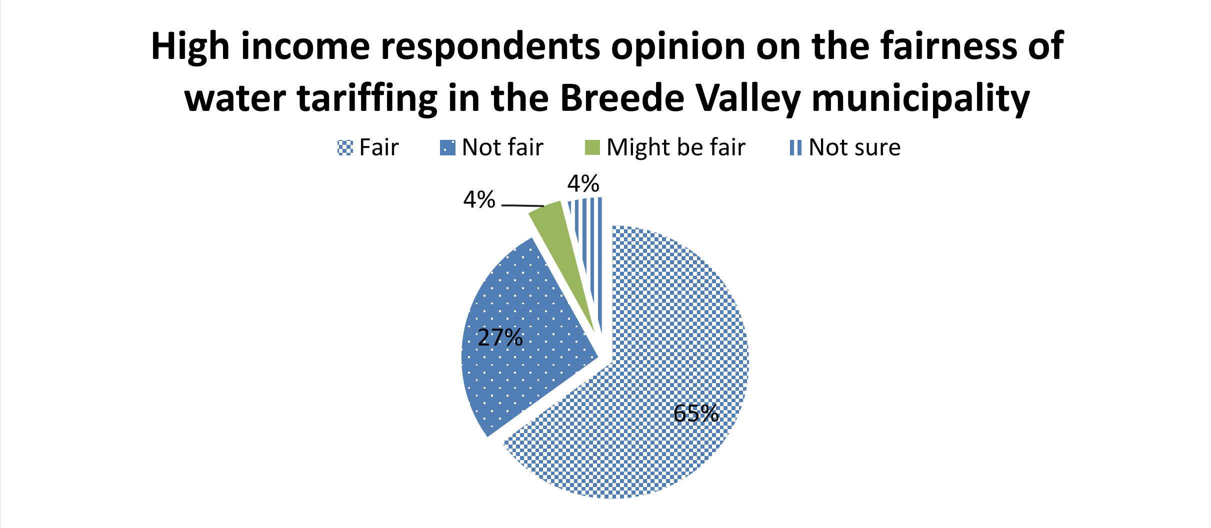
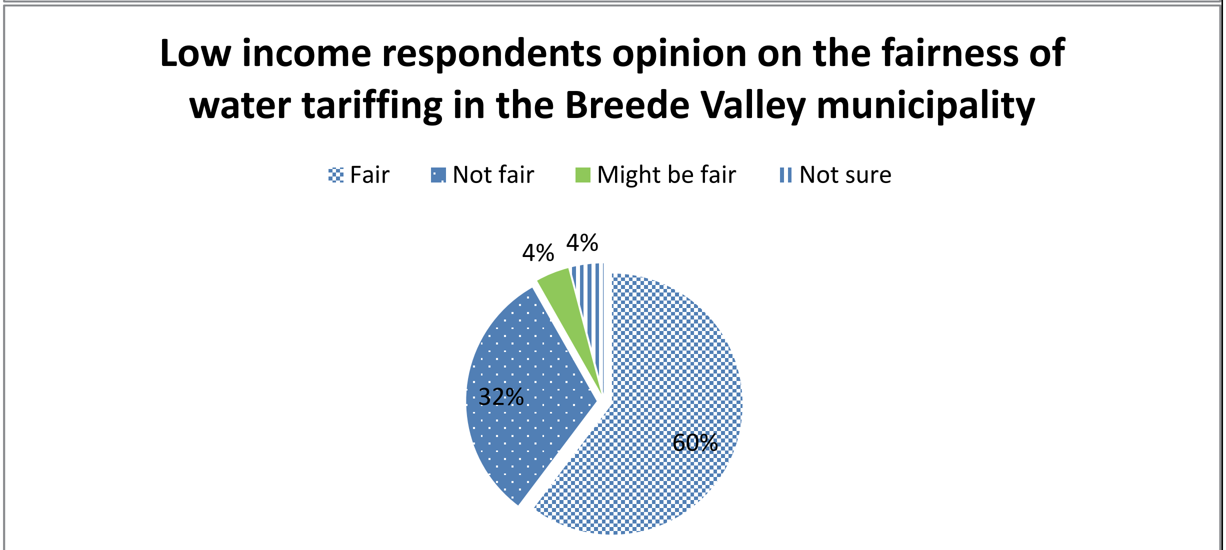


Figure 3.1: Breede Valley consumer interest in cheaper water service options – safe but reduced delivery convenience – percentage of total

Most Breede Valley respondents rated the current water service tariff setting structure as fair and equitable (Figure 3.2).





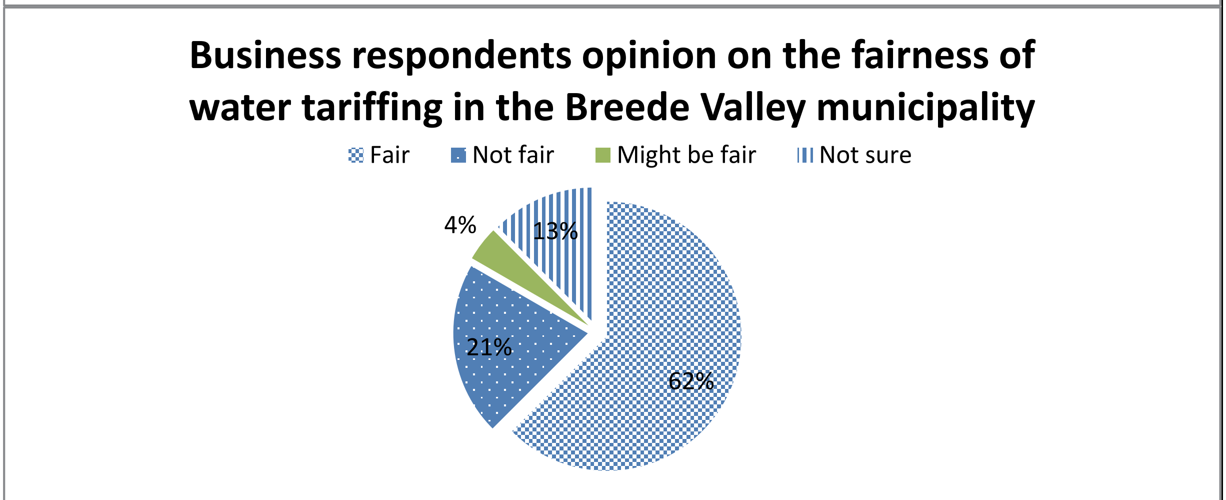


Figure 3.2: The fairness of water service tariff structures – percentage of income class

From Figure 3.2 above it can be noted that a few respondents in each group indicated that they felt that the water tariffing structure was unfair. The highest incidence of this sentiment was felt by the low income respondent group.

The vast majority of the respondents indicated that no attempt had been made by their municipality to determine their demand for different composites making up water service delivery (Figure 3.3). Only 14% of the low income respondents indicated that an assessment had been made in this regard, and the proportions were lower in the other two groups.

Despite municipalities' perceived lack in assessment of respondents preferences for water services, there was a large degree of satisfaction expressed with the water service product mix that was provided by the local municipality (**Error! Reference source not found.**), although this was slightly less evident amongst the low income group.

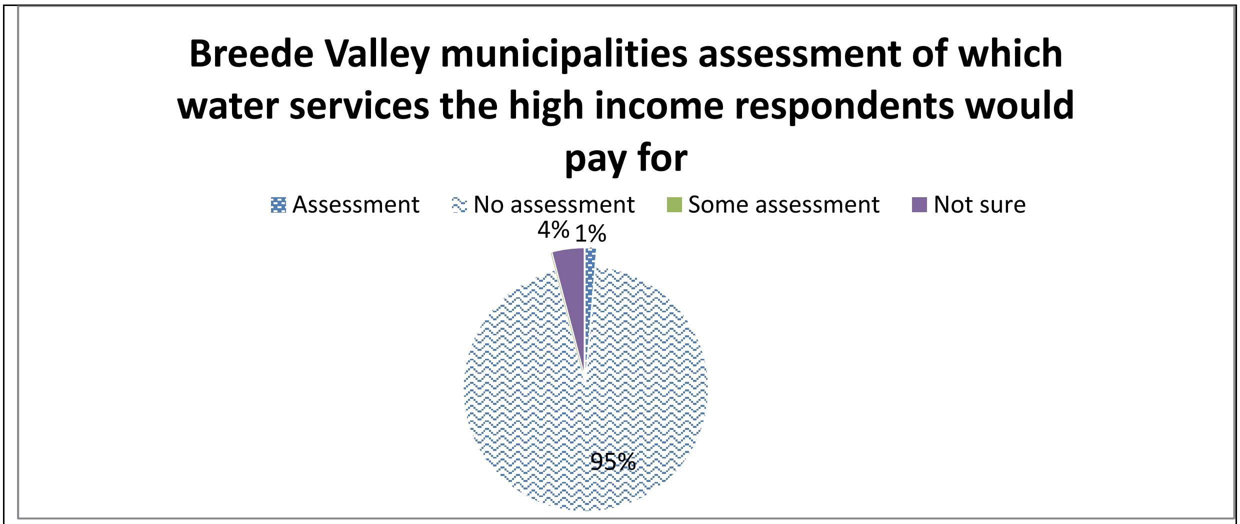
Table 3.3: Demand satisfaction with current water service delivery – percentage of income class

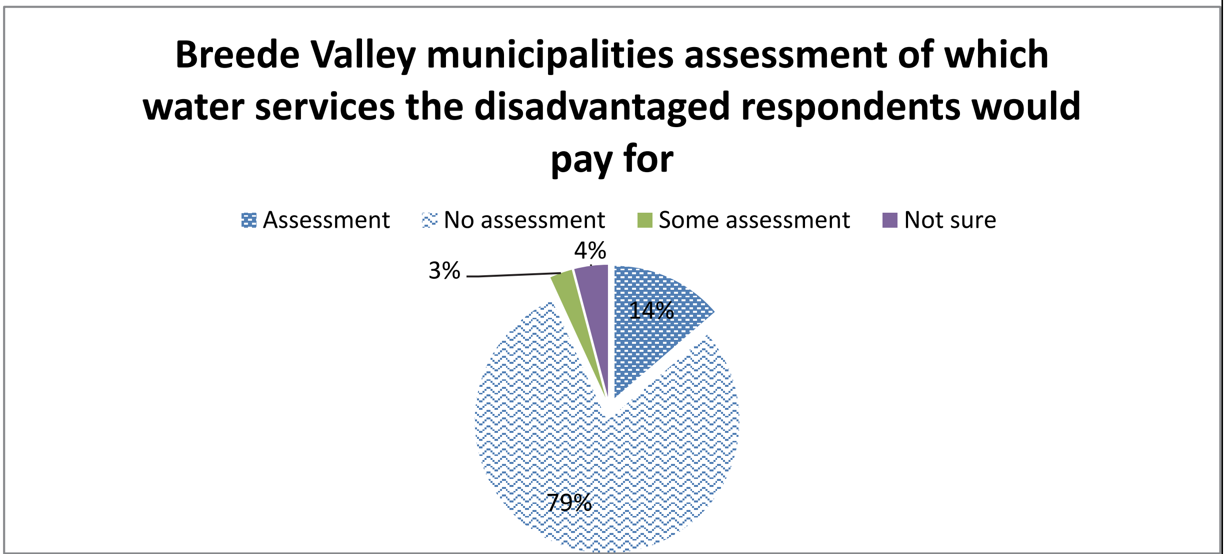
	High income	**Low income**	**Business**
Satisfied	89%	84%	89%
Unsatisfied	11%	16%	11%

The most frequently cited way for the municipality to improve its water services was to improve the quality of service provided at the current price, and the second most popular way was to receive the same quality at a lower charge (**Error! Reference source not found.**) – both ways improving value for money paid.

Table 3.4: Ways to improve demand satisfaction through tariff setting – percentage of income class

Improvement option	**High income**	**Low income**	**Business**
Pay more for a better quality of service	13%	13%	0%
Pay the same and receive a better quality of service	75%	38%	63%
Pay the same and receive the same service	0%	0%	13%
Pay less for the services that I currently receive	10%	38%	13%
Pay less and receive a reduction in the water services I currently receive	0%	0%	0%
Other	0%	13%	13%





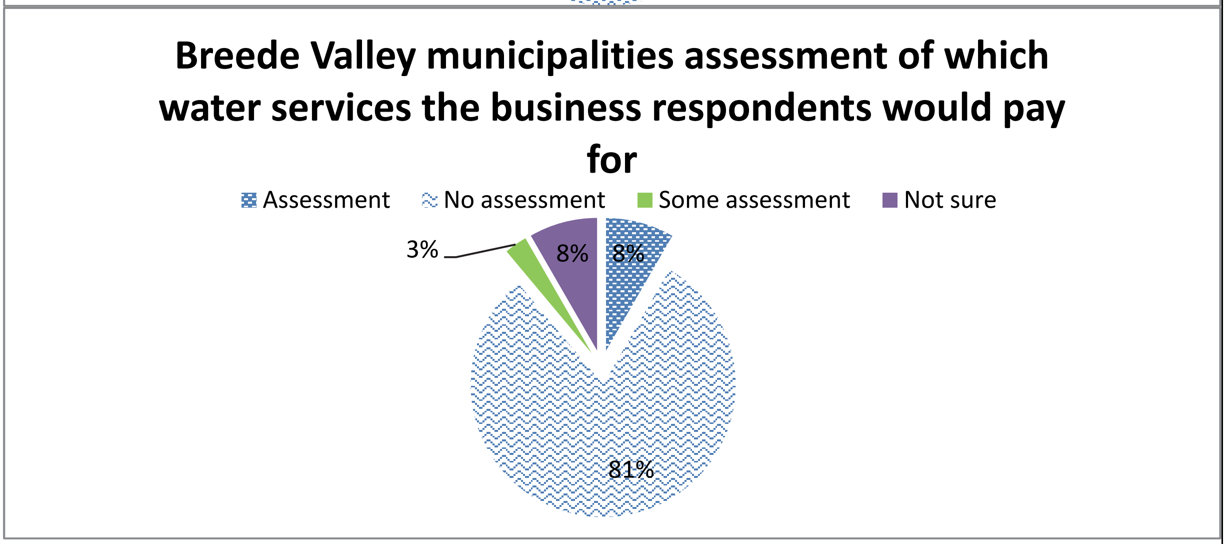


Figure 3.3: Municipal assessment of the demand for different balances in water service delivery (safety of water, disposal and delivery convenience) – percentage of income class

There were differences in preference between the income classes for the way to best structure water service tariffs. The least popular element in the structure was the availability charge.

Table 3.5: Preferred water service tariff structures

	High income	Low income	Business	Weighted Average
Availability charge	15%	4%	20%	13%
Flat tariff	24%	29%	31%	28%
Increasing block tariff	38%	36%	13%	29%
Decreasing block tariff	23%	32%	37%	30%

Most of the high and low income residential customers preferred the increasing block tariff structure to the decreasing one, but business firms marginally preferred the decreasing block tariff structure to the increasing one. Among business firms there was almost equivalent support for the flat, increasing block and decreasing block tariff structures (**Error! Reference source not found.** and Figure 3.4)

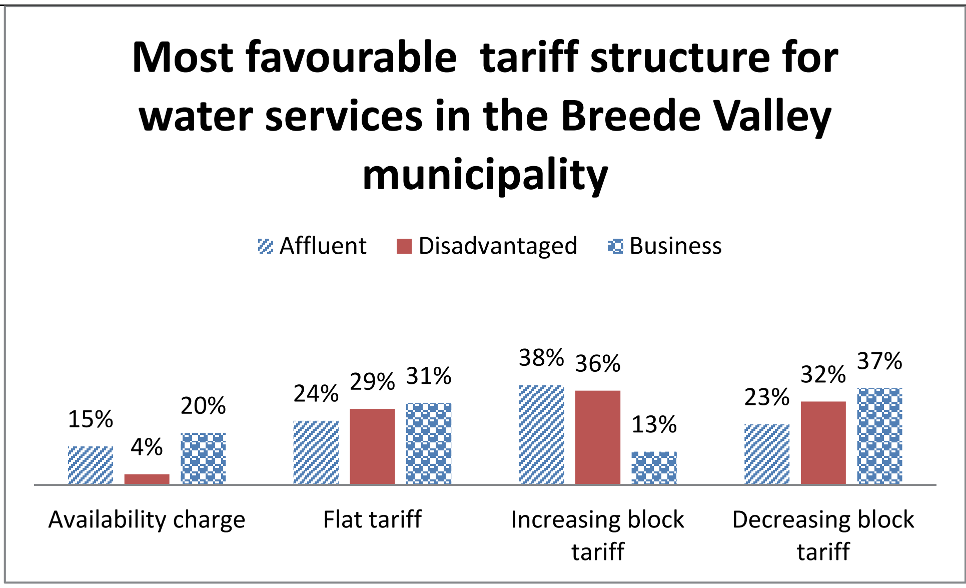


Figure 3.4: Preferred tariff structures

A minority of Breede Valley respondents were of the opinion that a private sector provision would improve the value of water services provided by the Breede Valley municipality (**Error! Reference source not found.**).

Table 3.6: Consumer perceptions on whether value could be improved by private sector water service provision – percentage of income class

Would a private company provide better water services?	High income	Low income	Business
Yes	20%	18%	39%
No	57%	74%	40%
Maybe	8%	4%	8%
Not sure	12%	4%	13%

3.2.2 Msunduzi Valley

3.2.2.1 Respondent analysis

The Msunduzi sample of respondents was drawn from a population of 43 297 billable units and constituted 0.5% of the billable unit population (see Table 3.7).

Table 3.7: Useable responses from the Msunduzi Survey

Category	High income	Low income	Business	Total	Sample Population	No. of billable units
Administered Number	75	75	75	225	618 536	43 297
Usable Number	69	74	74	217		

*Source: Respective local municipalities (2012)

The high income group were more highly educated than the low income group, with 77% of the respondents having a tertiary education (see Table 3.8). The majority of this group was also employed and received an income of between R150 000-R200 000 a year. The low income group were less educated, included a large proportion of female respondents and people who were employed and earning R50 000-R100 000 per year.

Table 3.8: Summary of the respondent demographics – Msunduzi

Percentage of income class per characteristic level and mean income in Rand			
Characteristics	**Level**	**High income**	**Low income**
Education	No education	0%	1%
	Some education	23%	45%
	Tertiary Education	77%	54%
Gender	Male	41%	37%
	Female	59%	63%
Employment	Unemployed	1%	24%
	Employed	96%	62%
	Retired	3%	14%
Mean Age		42	43
Mean Income		R150 000-R200 000	R50 000-R100 000

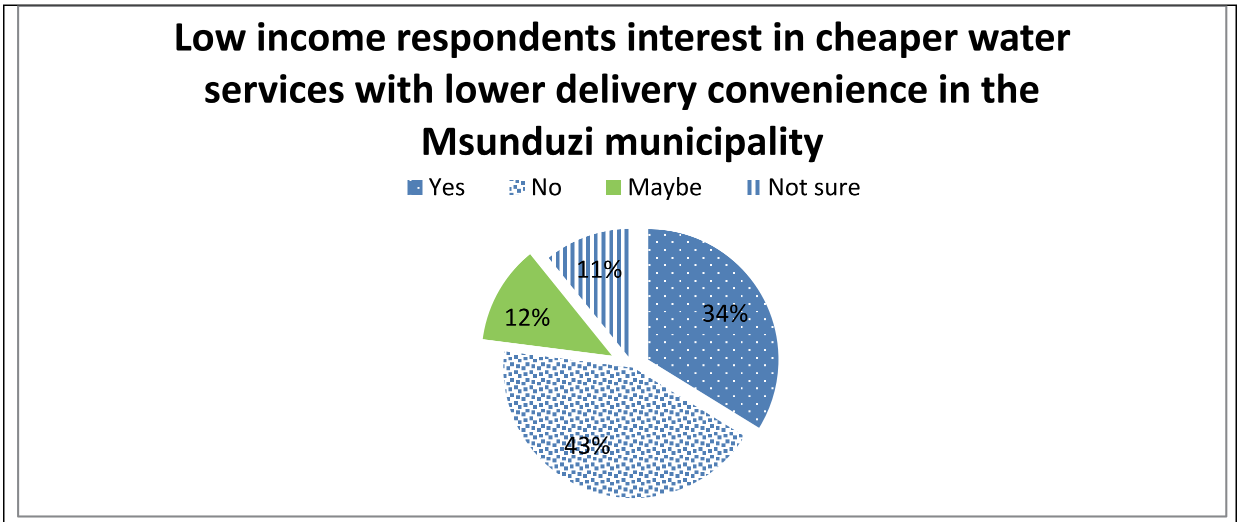
The high income respondents and the low income respondents only received water services from the Msunduzi municipality (no other supplier). The vast majority of business respondents were supplied water services by the municipality. Only 1% of the respondents received water services from another source.

There were big differences in the percentages of respondents that paid for water services in each income group. The majority of the high income respondents and business respondents indicated that they paid the Msunduzi municipality for the water services they received. Only 3% of the high income respondents indicated that they did not pay anything for these services. Approximately half of the low income group indicated that they didn't pay for their water services.

3.2.2.2 Respondent ratings of water service delivery

Most Msunduzi respondents rated all the listed attributes of a water service as important, but only among the low income group was their unanimity that it was important to provide subsidised water to the poor. Significant numbers of the low income group did not think having sufficient pressure to meet fire-fighting requirements was important (also only 71% of high income consumers) and securing enough water to last through droughts. Similarly 19% of high income respondents didn't rate this as important.

A slight majority of business firms were interested in cheaper (less convenient) water service options (Figure 3.5).



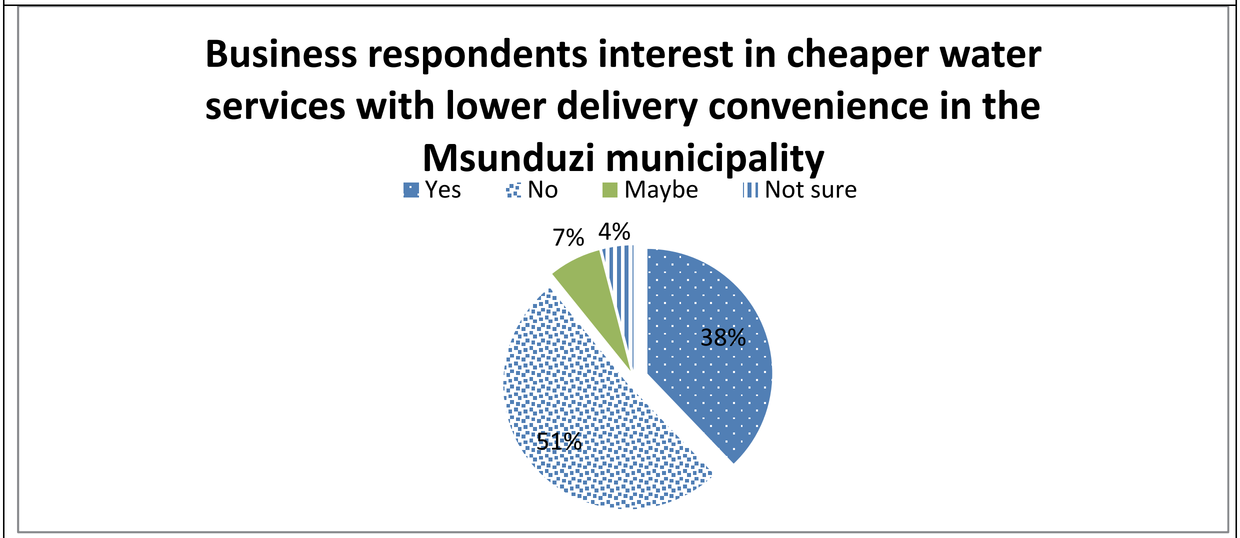


Figure 3.5: Msunduzi consumer interest in cheaper water service options – safe but reduced delivery convenience – percentage of total

There were a considerable number of respondents from each of the groups that were unsure whether they would prefer a cheaper option. This may indicate that the respondents associated a lower price with inferior service delivery.

Most Msunduzi respondents rated the current water service tariff setting structure as unfair, especially those falling in the high income group (Figure 3.6).

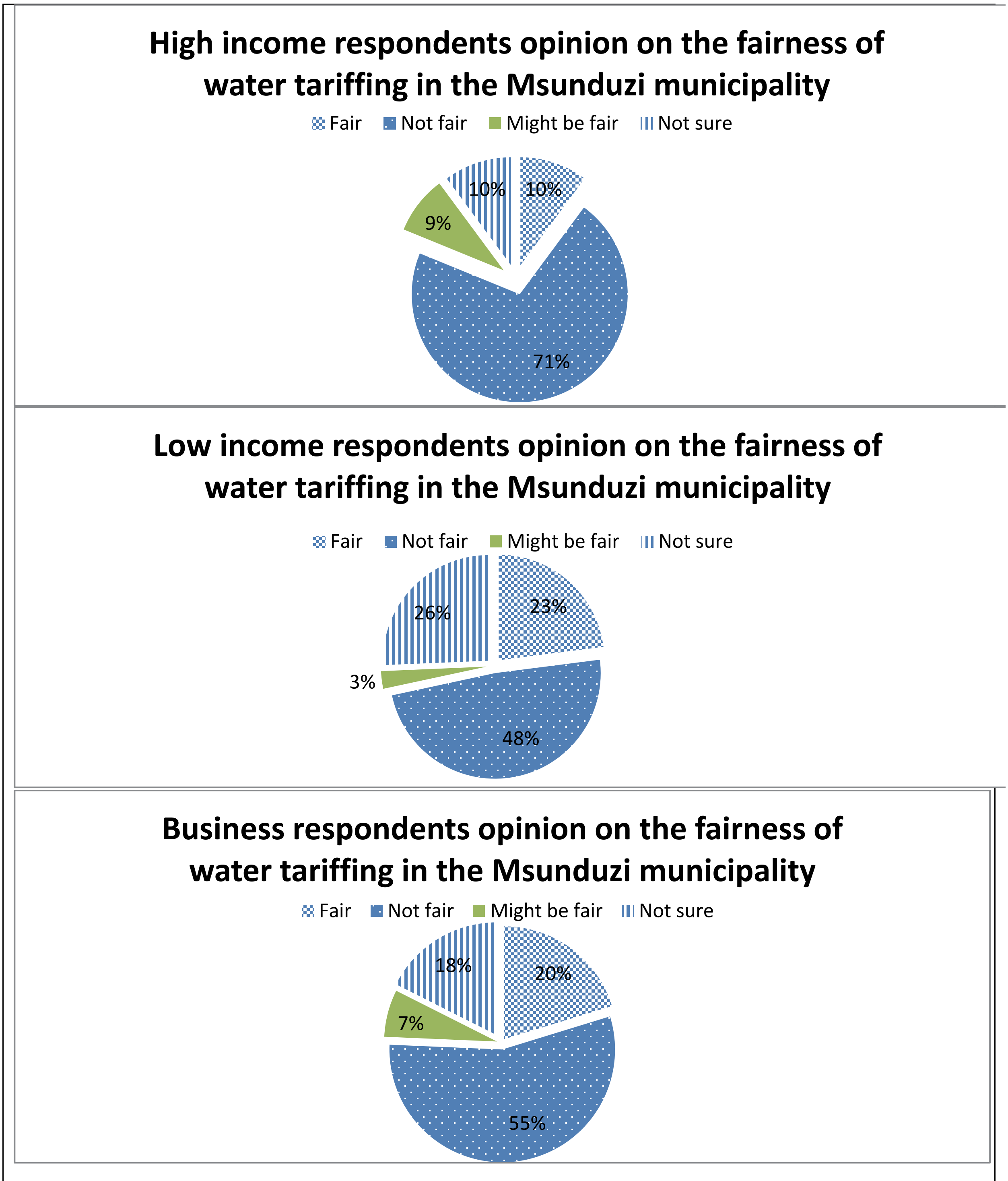


Figure 3.6: The fairness of water service tariff structures – percentage of income class

Overwhelmingly most of the respondents felt the Msunduzi local municipality was making no attempt to assess or determine demand for different composites of the water service delivery package (Figure 3.7).

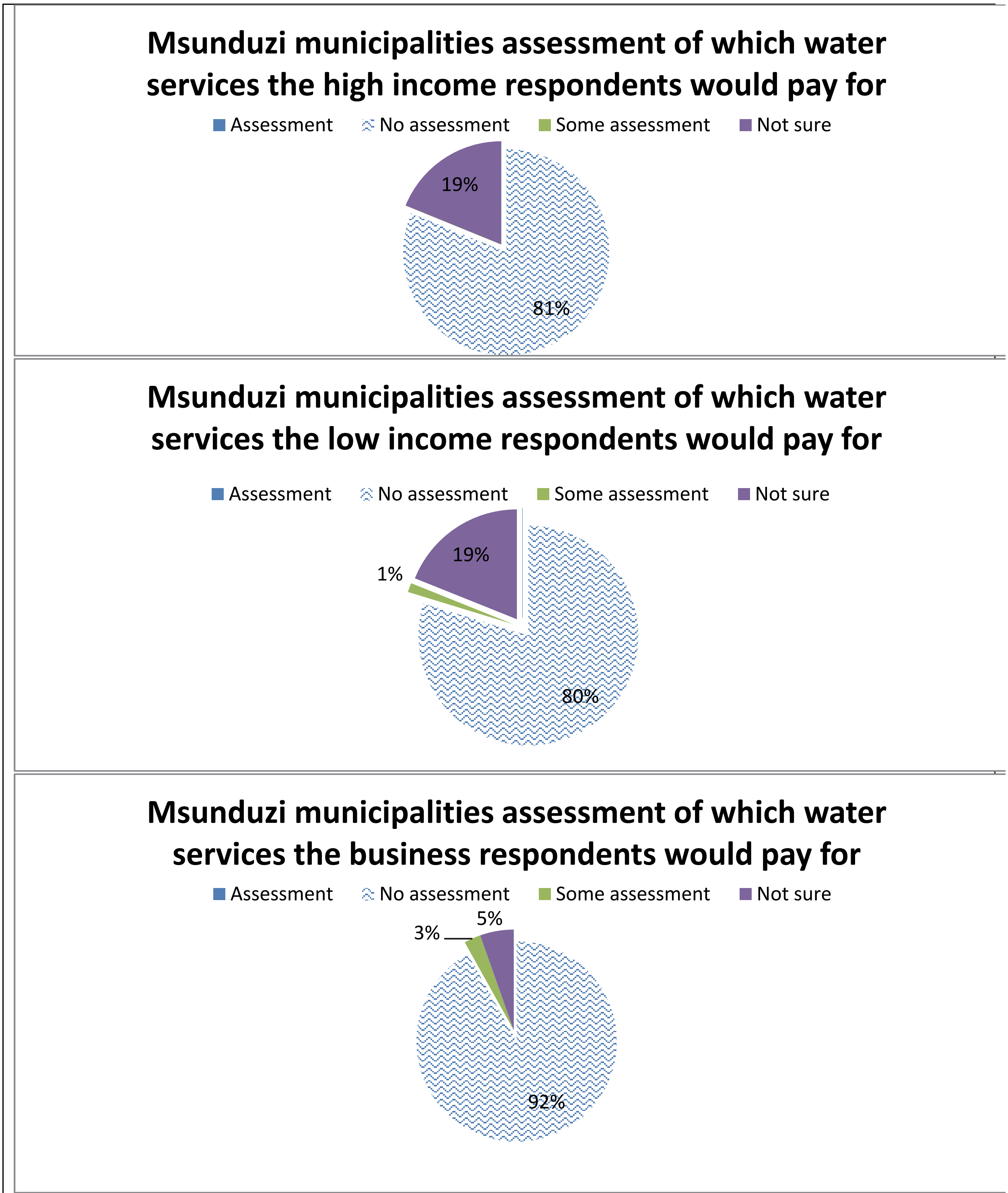


Figure 3.7: Municipal assessment of the demand for different balances in water service delivery (safety of water, disposal and delivery convenience) – percentage of income class

A majority of high income respondents were dissatisfied with the water service product mix that was provided by the municipality, but majorities of the poor and business groups were satisfied by the current services that they received (**Error! Reference source not found.**).

Table 3.9: Demand satisfaction with current water service delivery – percentage of income class

	High income	Low income	Business
Satisfied	37%	57%	77%
Unsatisfied	63%	43%	23%

Among the Msunduzi respondents, the most frequently cited way to improve the service was to receive the same quality at a lower charge (Table 3.10) – more value for money paid.

Table 3.10: Ways to improve demand satisfaction through tariff setting – percentage of income class

Improvement option	High income	Low income	Business
Pay more for a better quality of service	0%	0%	29%
Pay the same and receive a better quality of service	16%	10%	21%
Pay the same and receive the same service	0%	0%	0%
Pay less for the services that I currently receive	73%	62%	43%
Pay less and receive a reduction in the water services I currently receive	7%	10%	0%
6. Other	5%	17%	7%

There were a few of differences between the income classes in preference for water service tariff structure. Least popular was the availability charge. More High income and business consumer respondents preferred the flat or linear tariff structure to any other. Least preferred among the volumetric tariff options was the increasing block tariff structure (Table 3.11 and Figure 3.8)

Table 3.11: Preferred water service tariff structures

Tariff option	High income	Low income	Business	Weighted Average
Availability charge	0%	0%	16%	5%
Flat tariff	58%	38%	27%	41%
Increasing block tariff	9%	19%	32%	20%
Decreasing block tariff	33%	43%	24%	33%

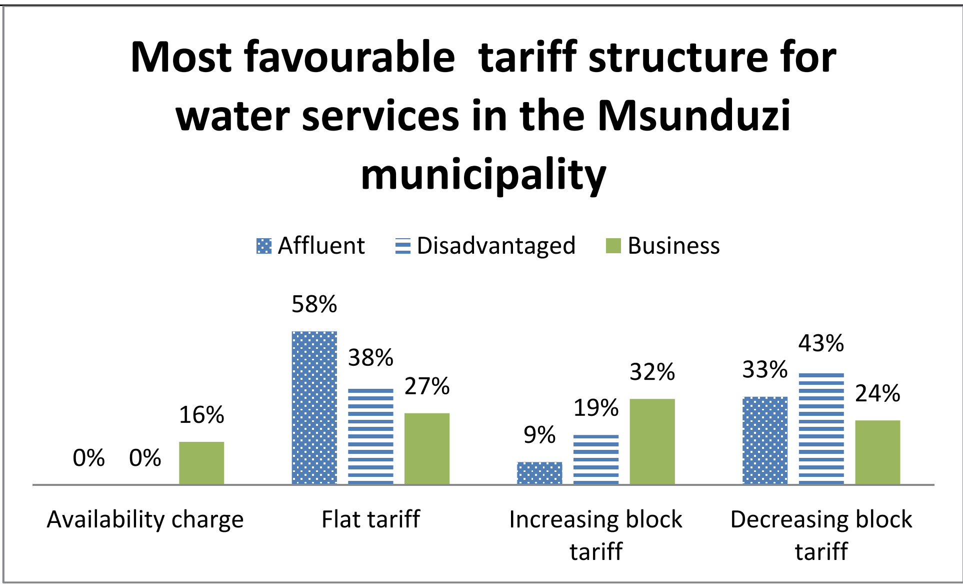


Figure 3.8: Preferred tariff structures

A majority of respondents were of the opinion that a private sector provision would not improve the value of water services provided over that provided by the Msunduzi municipality (Table 3.12).

Table 3.12: Consumer perceptions on whether value be improved by private sector water service provision – percentage of income class

Would a private company provide better water services?	High income	Low income	Business
Yes	26%	20%	45%
No	33%	32%	30%
Maybe	29%	20%	11%
Not sure	12%	27%	15%

3.2.3 Knysna

3.2.3.1 Respondent analysis

The Knysna sample was drawn from a population of 4 553 billable units and constituted 4.7% of the billable unit population (see Table 3.13).

Table 3.13: Useable responses from the Knysna Survey

Category	High income	Low income	Business	Total	Sample Population	No. of billable units
Administered Number	75	77	68	220	65 043	56 801
Usable Number	73	74	68	215		

*Source: Respective local municipalities (2012)

All of the high income respondents indicated that they had received some education and only 5% of the low income respondents indicated that they had no education (see Table 3.14). The majority of the respondents from the high income group were employed and were female. Within the low income group there were almost equal males and females but there was a high unemployment rate (36%). Only 1% of the high income respondent group was retired while none of the low income respondents had retired. The mean income for the high income respondent group was between R200 000 and R250 000 a year. For the low income group the mean annual incomes was less than R50 000.

Table 3.14: Summary of the respondent demographics – Knysna

Percent of income class per characteristic level			
Characteristics	**Levels**	**High income**	**Low income**
Education	No education	0%	5%
	Some education	49%	72%
	Tertiary Education	51%	23%
Gender	Male	27%	51%
	Female	73%	47%
Employment	Unemployed	0%	36%
	Employed	96%	64%
	Retired	1%	0%
Mean Age		40	38
Mean Income (Per year)		R200 000-R250 000	Less than R50 000

3.2.3.2 Respondent ratings of water service delivery

The vast majority of the high income respondents indicated that they paid the Knysna municipality for the water services they receive. Only 3% indicated that their water was provided for free and a further 3% indicated that they paid some other organisation (firm) for water services. A similar situation prevailed among business firms (a larger proportion of the businesses reported that they paid some other firm (not the municipality) for the water services that they received.

Of the low income respondents, 95% reported that they received water services from the municipality but only 23% of these respondents paid the municipality for these services.

Both income groups and business firms rated the listed attributes of a water service as important, particularly water safety, but less so water pressure and providing subsidised water to the poor.

Most respondents, but not in the business firm category, were disinterested in cheaper (less convenient) water services (Figure 3.9).

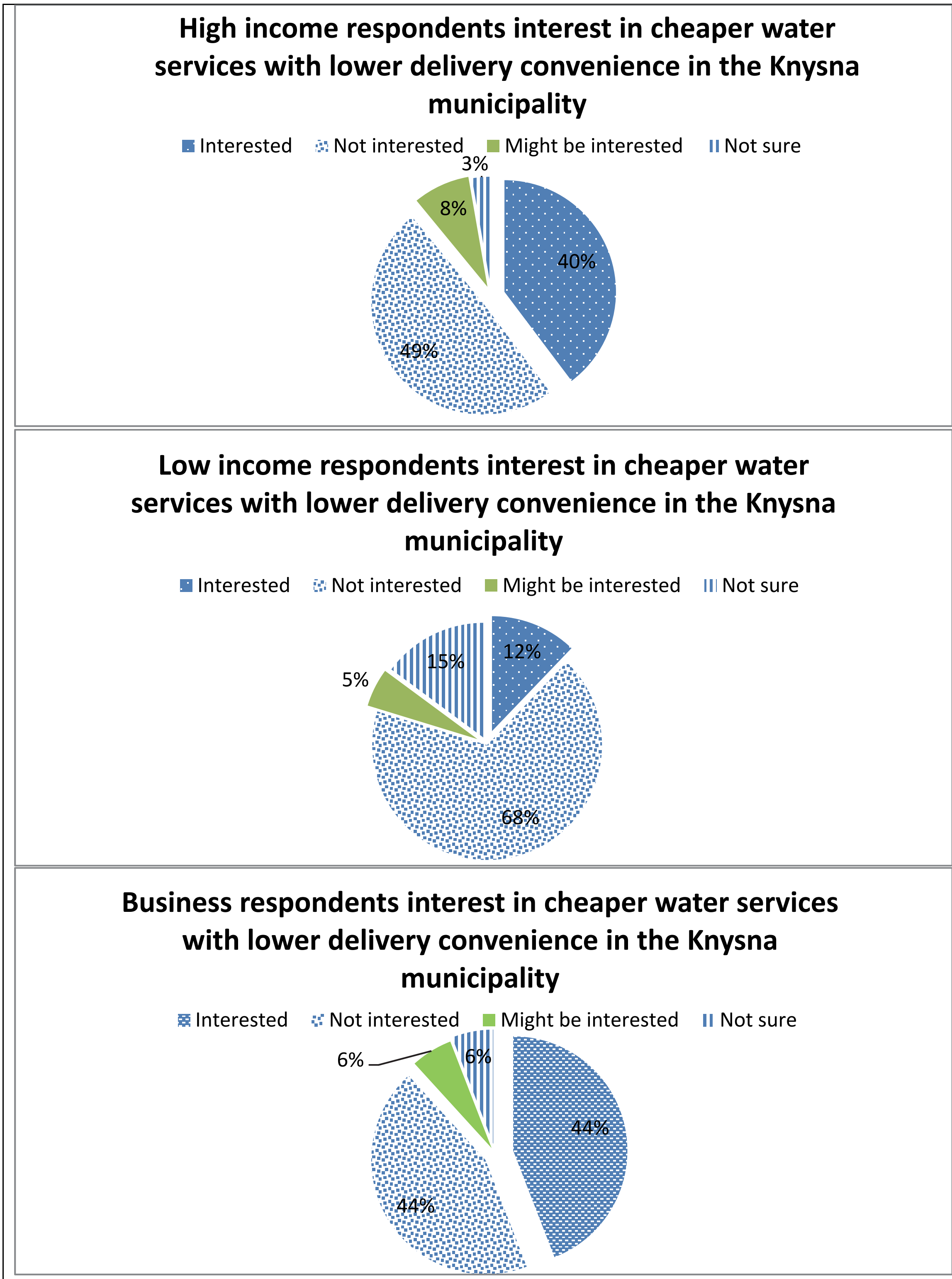


Figure 3.9: Knysna consumer interest in cheaper water service options – safe but reduced delivery convenience – percentage of total

Most Knysna respondents from the higher income class rated the water service tariff setting structure as fair, but most respondents from the poor income class were unsure if the water service tariff setting structure was fair (**Error! Reference source not found.**). Nearly half of the business respondents rated the tariff structure as fair.

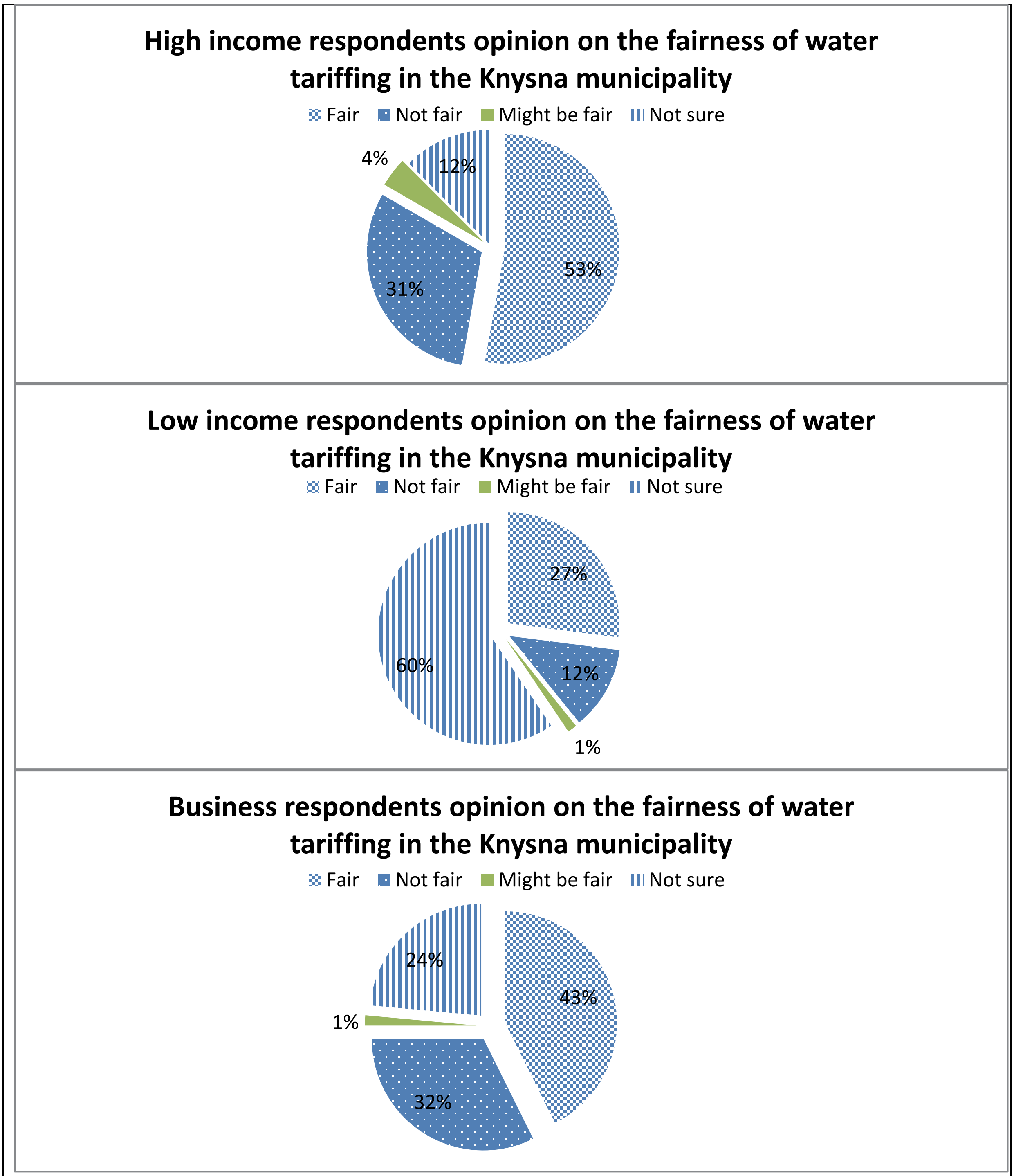


Figure 3.10: The fairness of water service tariff structures – percentage of income class

Overwhelmingly most of the respondents in the survey felt the Knysna local municipality was making no attempt to assess or determine demand for different composites of the water service delivery package (**Error! Reference source not found.**).

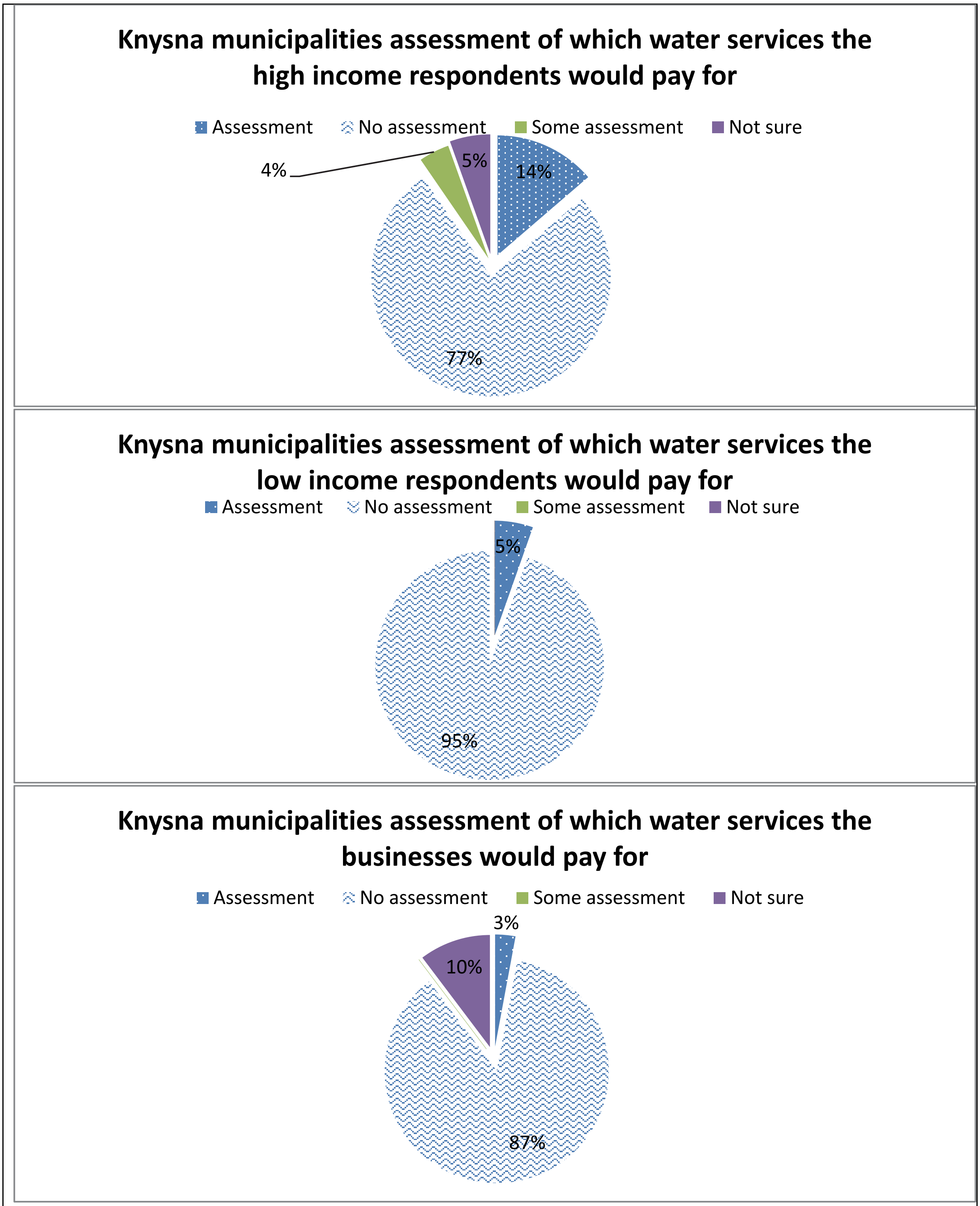


Figure 3.11: Municipal assessment of the demand for different balances in water service delivery (safety of water, disposal and delivery convenience) – percentage of income class

Majorities in all three groups of respondents were satisfied with the water service product mix that was provided by their municipality (Table 3.15).

Table 3.15: Demand satisfaction with current water service delivery – percentage of income class

	High income	Low income	Business
Satisfied	63%	63%	69%
Unsatisfied	37%	37%	31%

Among the high income and business firm respondents, the most frequently cited way to improve the water service was to improve the quality of water service received at the same price (Table 3.16). Most low income respondents felt that ways other than those listed as options offered the most scope to improve their 'demand' satisfaction.

Table 3.16: Ways to improve demand satisfaction through tariff setting – percentage of income class

Options for improvement	High income	Low income	Business
Pay more for a better quality of service	11%	6%	11%
Pay the same and receive a better quality of service	81%	6%	63%
Pay the same and receive the same service	0%	0%	16%
Pay less for the services that I currently receive	4%	11%	0%
Pay less and receive a reduction in the water services I currently receive	0%	0%	0%
Other	4%	78%	11%

There were differences between the income groups with respect to preference for water service tariff structure. Least popular was the availability charge. Most high income and business consumer respondents preferred the flat or linear tariff to any other. On average (for all three groups equally weighted), least preferred among the volumetric tariff options was the increasing block tariff structure (Table 3.17 and Figure 3.12)

Table 3.17: Preferred water service tariff structures

Tariff option	High income	Low income	Business	Average
Availability charge	14%	0%	10%	8%
Flat tariff	21%	23%	35%	26%
Increasing block tariff	59%	58%	22%	46%
Decreasing block tariff	7%	20%	32%	20%

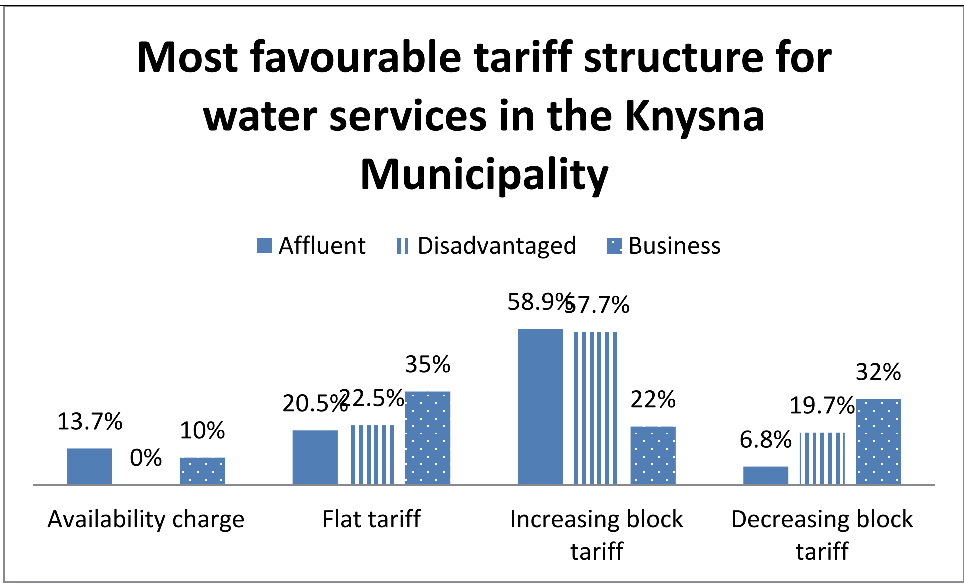


Figure 3.12: Preferred tariff structures

Poor respondents were mostly of the opinion that private sector provision would not improve the value of water services provided over that provided by the Knysna municipality, but the high income and business categories of customer were fairly equally divided on this potential for improvement (Table 3.18).

Table 3.18: Consumer perceptions on whether value be improved by private sector water service provision – percentage of income class

Would a private company provide better water services?	High income	Low income	Business
Yes	27%	25%	32%
No	36%	63%	34%
Maybe	21%	4%	18%
Not sure	16%	8%	16%

3.3 Rating of water service by attribute

3.3.1 Breede Valley

All the listed attributes of the potable water service provided were positively rated by the Breede Valley respondents, particularly potable water safety (**Error! Reference source not found.**). A positive average overall weighted potable water service demand rating of 84% was calculated based on the responses elicited.

Table 3.19: Opinions on attributes of the potable water service provided – percentage of income class

Agreement on attribute statement	High Income	Low Income	Business	Weighted Average
The water is always safe to drink	96%	95%	74%	88%
The water in clear (not murky)	73%	88%	67%	76%
The water has a pleasant taste and smell	80%	83%	82%	82%
The pressure in the pipes is strong	86%	82%	93%	87%
Water restrictions are rarely imposed	88%	82%	83%	84%
Average overall positive rating	85%	86%	80%	84%

All the listed attributes of the waste management water service provided were positively rated by the Breede Valley respondents, particularly consistency of sanitising the water (**Error! Reference source not found.**). A positive average overall weighted potable water service demand rating of 72% was calculated based on the responses elicited. By way of comparison, the Blue Drop rating of this local municipality in 2011 was 85.93% and the Green Drop rating 78.3%. The Breede Valley Blue Drop rating improved a bit in 2012. In this case the supply side benchmarks (blue and green drop ratings) are higher than the demand side ratings calculated (Tables 3.19 and 3.20), but not by much. The pattern is consistent – waste water management is rated inferior to potable water service.

Table 3.20: Opinions on attributes of the sanitation (waste) water management service provided – percentage of income class

Agreement on attribute statement	High Income	Low Income	Business	Weighted Average
The waste water is consistently safely sanitised	80%	88%	78%	82%
There are very few leaks of waste water (sewage)	69%	75%	76%	73%
The infrastructure to sanitise waste water is up to scratch	63%	62%	60%	62%
Overall positive rating	71%	75%	71%	72%

The above positive rating was not trend linked, and is not thought to be part of an improvement or deterioration in the service rendered, so much as a continuation of the type of service provided previously (**Error! Reference source not found.**).

Table 3.21: Consistency in quality of water service provided during the last two years – percentage of income class

Quality of the service	High Income	Low Income	Business
Improved	20%	11%	60%
Unchanged	88%	81%	88%
Deteriorated	10%	10%	33%

3.3.2 Msunduzi

All the listed attributes of the potable water service provided were positively rated by the Msunduzi respondents, particularly potable water safety (**Error! Reference source not found.**). A positive average overall weighted potable water service demand rating of 90% was calculated based on the responses elicited.

Table 3.22: Opinions on attributes of the potable water service provided – percentage of income class

Agreement on attribute statement	High Income	Low Income	Business	Weighted Average
The water is always safe to drink	100%	93%	92%	95%
The water in clear (not murky)	99%	95%	85%	93%
The water has a pleasant taste and smell	100%	92%	73%	88%
The pressure in the pipes is strong	93%	80%	85%	86%
Water restrictions are rarely imposed	96%	88%	85%	90%
Average overall positive rating	98%	90%	84%	90%

All the listed attributes of the waste management water service provided were positively rated by the Msunduzi respondents, but not by the poor consumers (**Error! Reference source not found.**). A positive average overall weighted potable water service demand rating of 59% was calculated based on the responses elicited, much lower than that for the potable water service.

Table 3.23: Opinions on attributes of the sanitation (waste) water management service provided – percentage of income class

Agreement on attribute statement	High Income	Poor/ Low Income	Business	Weighted Average
The waste water is consistently safely sanitised	90%	38%	66%	65%
There are very few leaks of waste water (sewage)	81%	16%	75%	57%
The infrastructure to sanitise waste water is up to scratch	81%	20%	60%	54%
Overall positive rating	84%	25%	67%	59%

The mildly positive rating was not trend linked, and is not thought to be part of an improvement or deterioration in the service rendered, so much as a continuation of the type of service provided previously (**Error! Reference source not found.**).

Table 3.24: Consistency in quality of water service provided during the last two years – percentage of income class

Quality of the service	High Income	Low Income	Business
Improved	13%	5%	14%
Unchanged	80%	72%	66%
Deteriorated	6%	23%	22%

3.3.3 Knysna

Most of the consumers had a positive view on the water service they were provided with, but the high income class of customer and business firms were mostly negative in view, particularly business firms (see **Error! Reference source not found.**). The only attribute that a majority of business respondents scored positively was water pressure (**Error! Reference source not found.**). A positive average overall weighted potable water service demand rating of 61% was calculated.

Table 3.25: Opinions on attributes of the potable water service provided – percentage of income class

Agreement on attribute statement	High Income	Poor/ Low Income	Business	Weighted Average
The water is always safe to drink	54%	85%	49%	63%
The water in clear (not murky)	47%	84%	43%	58%
The water has a pleasant taste and smell	44%	81%	46%	57%
The pressure in the pipes is strong	85%	78%	78%	80%
Water restrictions are rarely imposed	39%	66%	38%	48%
Average overall positive rating	54%	79%	51%	61%

A similar pattern of opinion was found on the waste management water service provided by the Knysna municipality as for potable water service. A majority of the high income domestic household and business consumers held a negative overall rating of the service, mainly due to perception that the waste management infrastructure was not up to standard (**Error! Reference source not found.**). A barely positive average overall weighted potable water service demand rating of 51% was calculated based on the responses elicited, less than that for the potable water service, and the lowest of any water service surveyed at the three municipalities. By way of comparison, the Blue Drop rating of this local municipality in 2011 was 89.76% and the Green Drop rating 60.8%. In this case the supply side performance benchmark (Blue and Green Drop ratings) are significantly higher than the demand side ratings calculated (Table 3.26), although the pattern is the same – waste water management is inferior to potable water service.

Table 3.26: Opinions on attributes of the sanitation (waste) water management service provided – percentage of income class

Agreement on attribute statement	High Income	Poor/ Low Income	Business	Weighted Average
The waste water is consistently safely sanitised	54%	49%	54%	52%
There are very few leaks of waste water (sewage)	53%	83%	55%	64%
The infrastructure to sanitise waste water is up to scratch	40%	39%	31%	37%
Overall positive rating	49%	57%	47%	51%

The positive rating was not trend linked, and is not thought to be part of an improvement or deterioration in the service rendered, so much as a continuation of the type of service provided previously (**Error! Reference source not found.**).

Table 3.27: Consistency in quality of water service provided during the last two years – percentage of income class

Quality of the service	High Income	Low Income	Business
Improved	33%	15%	38%
Unchanged	74%	81%	85%
Deteriorated	43%	6%	32%

3.4 Conclusion

A sample of 653 respondents, about 0.5-2% of the billable unit populations of the Breede Valley, Msunduzi and Knysna local municipalities, were surveyed about their opinions and choices relating to water services provided. An analysis of their responses was presented in Tables 3.1 to 3.27. The respondents were drawn from both high and low income groups and business firms. Most respondents were employed and had some education. No clear trend emerges with respect to willingness to trade-off less water service delivery convenience with cost of service. In all cases a majority of the lower income respondents were disinterested in lower cost, lower convenience service – possibly because they perceived their group as particularly vulnerable to management decisions to reduce their service convenience. Many of the low income group do not reveal their demand for water service as they do not pay for it. There existed greater willingness to consider trades in cost for delivery convenience among the higher income and business firm groups.

Most of the Breede Valley respondents felt the cost recovery tariff structure they faced was fair, but most of the Msunduzi respondents felt that the tariff structure they faced was unfair. Knysna respondents were equally divided over the fairness of their water service tariff structure.

What was consistent between all three of the municipalities was an overwhelming majority view that their municipality made no attempt to assess the nature of their water service demand and their sensitivities to changes in the attributes of the water service provided. This neglect (or disinterest) appears to have less serious welfare consequences within the customer populations served by the Breede valley and Knysna municipalities. Almost 90 per cent of all groups of respondents surveyed in the Breede Valley were satisfied with the current level of water service provided to them. Among all groups (business, high income and low income) about two-thirds of the Knysna respondents were satisfied with the current level of water service provided to them. The same reassurance cannot be offered for the Msunduzi municipality high income water service customers. About two-thirds of the high income respondents in the Msunduzi were dissatisfied with the current level of water service provided to them, but most of the low income and business firms were satisfied.

With respect to the attributes of the water service, customers were happier in all three municipalities with the levels of potable water service than they were with the sanitation service provided. The trends in view reported are broadly consistent with the relevant findings of Blue Drop and Green Drop certification assessments, although the level of discontentment in this demand orientated survey reflects greater intensity of negative sentiment than that captured in the Blue and Green Drop assessments, as well as different perceptions across the customer groups served. Least happy with the composition of the water service package served to them were the Knysna respondents. Most happy were the Breede Valley respondents.

Chapter 4: Analysis of the choices made

4.1 Introduction

The principal claims made in this study are that the analysis of choices made in an experimental context can yield insights into water service customer preference, and that through the estimation of models of such choice inferences can be drawn about how to increase water service consumer welfare. Chapter 4 will demonstrate these claims. Through an analysis of choices made by three identified groups of customers in three selected municipalities will be shown that useful insights can be gained on water service customer preference by group and municipality. Through the estimation of best fit models of the choices of the consumers making up these various water service customer groups it will be shown that marginal valuations may be calculated of the impact of specified changes in the levels of water services. Chapter 2 already argued that such valuations should be taken into account when changes in the levels of service are being considered for technical or cost reasons, as it is a requirement of efficiency that both cost and consumer welfare measures be considered.

Chapter 4 is structured in the following way – the choices of each respondent group are discussed per municipality, first the Breede Valley, then Msunduzi and finally Knysna. For each municipality: the choices made by the various respondent groups are analysed with respect to their preferred water service mix, these choices are used to estimate models that predict the maximum likelihood of choice, the statistical validity of the estimated choice models is considered and finally a preferred model is selected by which to draw consumer welfare deductions, in the form of willingness to pay for marginal improvements in levels of water service.

4.2 Breede Valley respondents

4.2.1 Choices analysis

There were nine choice sets (cards) from which the customers could choose between. The nature of these sets is described in Table 4.1.

Table 4.1: Choice cards (options) and the associated levels

Choice Cards	Flow (pressure)	Continuous supply	Sanitation	Cost (R per kl)
1	Strong	12hrs	best	R3 decrease
2	Strong	24hrs	low	Same cost
3	Medium	6hrs	best	Same cost
4	Medium	24hrs	high	R3 decrease
5	Medium	12hrs	low	R4.50 increase
6	Weak	24hrs	best	R4.50 increase
7	Weak	6hrs	low	R3 decrease
8	Strong	6hrs	high	R4.50 increase
9	Weak	12hrs	high	Same cost

Choice card 1 was the most popular alternative: 87% of the respondents that were presented with this choice card selected it. The least chosen choice card was 7: 96% of the respondents that were presented with this choice card did not select it.

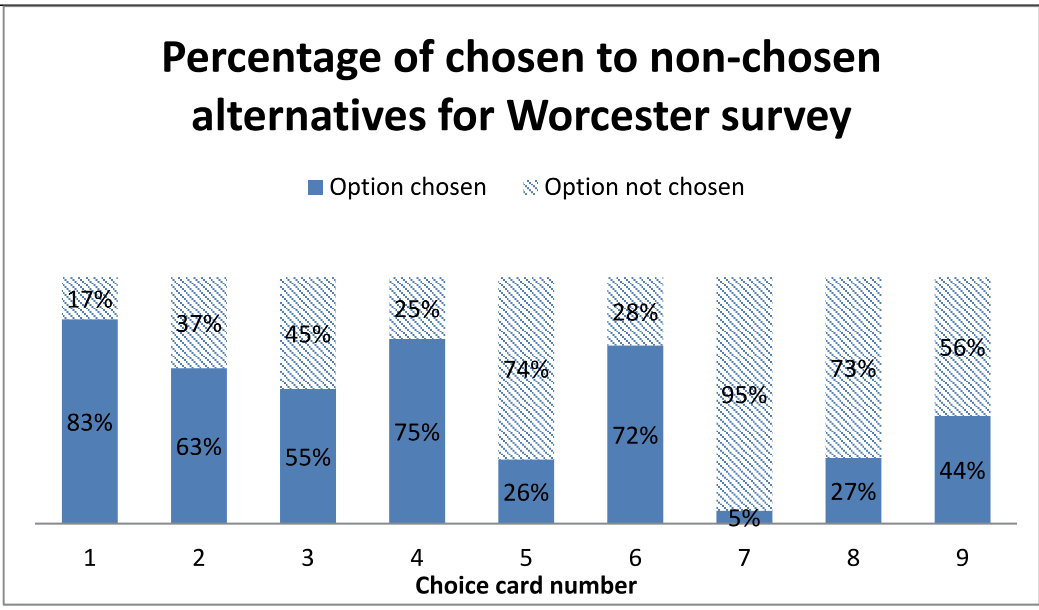


Figure 4.1: Choice card selection

Further analysis of these choices reveals that, for all three groupings of customers, the attributes most popularly selected at the highest levels available were sanitation and continuous supply (Table 4.2).

Table 4.2: Percentage of respondents in the Breede Valley municipality that chose the higher valued attribute level

High Income Respondents				
	Flow	Continuous supply	Sanitation	Cost
Higher valued level	46%	57%	61%	36%
Lower valued level	26%	19%	13%	43%
Same level	28%	24%	26%	22%
Poor/Low Income Respondents				
	Flow	Continuous supply	Sanitation	Cost
Higher valued level	45%	64%	45%	26%
Lower valued level	33%	12%	29%	46%
Same level	22%	24%	26%	27%
Business Respondents				
	Flow	Continuous supply	Sanitation	Cost
Higher valued level	48%	50%	60%	32%
Lower valued level	28%	24%	18%	42%
Same level	25%	26%	23%	27%

4.2.2 Modelling of choices

Three different choice models were estimated for each socio-economic group, a conditional logit (CL) and a random parameters logit (RPL) model (see for further discussion Chapter 2). The software used to estimate these models was NLogit 4.0. All models estimated the respondent's preferences for the levels of attributes presented in the choice sets. All models provided estimates for the effect that a change in the attribute levels would have on the probability that one of the three alternatives would be chosen (Lee, 2012).

4.2.2.1 High Income respondents

A CL model estimate is presented in Table 4.3 while the RPL model is presented in Table 4.4. In this model statistical significance is assessed in terms of the Wald statistic test and Pseudo R^2 test statistic. Under the Wald statistic test the maximum likelihood estimate of the coefficients of interest are compared with a proposed value, with the assumption that the difference between the two will be approximately normally distributed. The square of this difference divided by the variance of the maximum likelihood estimate of the coefficient is compared to a chi-squared distribution. The Wald statistic test takes on a role similar to that of the t-statistic test in multivariate generalized least square models. A similar approximate equivalence applies with respect to the Psuedo R^2. An equivalent statistic to the OLS R-squared does not exist for data analysis through a logistic regression. In logistic regression, maximum likelihood estimates of the coefficients are derived through an iterative process. They are not derived by minimizing variance. For this reason the goodness-of-fit approach taken in OLS is inapplicable. The nearest approximation to the goodness-of-fit statistic in the analysis of logistic models is the Pseudo R^2. These look like R-squared in the sense that they range from 0 to 1 with higher values indicating better model fit, but are not interpreted in the same way as OLS R^2.

Table 4.3: CL model for the high income respondents in the Breede Valley municipality

Variables	Coefficients	Standard Errors	Wald Statistics	*p*-values
Continuous supply	0.124	0.017	7.207	0.000
Flow	0.573	0.140	4.082	0.000
Sanitation	1.465	0.179	8.196	0.000
Cost	-0.047	0.035	-1.326	0.185
Maximum Likelihood estimates				
No. of observations	296	Base LL function	-205.172	
No. of parameters	4	Pseudo R^2	0.451	
Estimated LL function	-112.697	AIC	0.789	

Table 4.4: RPL model for the high income respondents in the Breede Valley municipality

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Flow	2.510	2.970	0.845	0.398
Sanitation	9.846	12.661	0.778	0.437
Continuous Supply	0.664	0.780	0.851	0.395
Non-random parameters in utility functions				
Cost	-0.410	0.574	-0.714	0.475
Derived standard deviations of parameter distributions				
Flow	0.159	1.447	0.110	0.912
Sanitation	8.488	11.949	0.710	0.477
Continuous Supply	0.468	0.551	0.850	0.396
Maximum Likelihood estimates				
No. of observations	296	Pseudo R^2	0.468	
No. of parameters	7	Chi-squared	192.141	
Log-Likelihood function	-109.101	*Degrees of freedom*	7	
Base LL function	-205.172	AIC	0.78447	

Of these two models (CL and RPL) the CL is preferred as it yields the most statistically significant coefficients, while its Psuedo R^2 is only slightly lower than that found for the RPL model. However, neither of the two models estimated are suitable for welfare value calculation as the cost coefficient in both is not significant, a crucial requirement.

4.2.2.2 Low Income respondents

The CL and RPL models for the low income respondents served by the Breede Valley local municipality are shown in Tables 4.5 and 4.6.

Table 4.5: CL model for the Low Income respondents in the Breede Valley municipality

Variables	Coefficients	Standard Errors	Wald Statistics	*p*-values
Continuous supply	0.183	0.023	8.119	0.000
Flow	0.554	0.142	3.906	0.000
Sanitation	0.625	0.146	4.288	0.000
Cost	-0.172	0.038	-4.483	0.000
Maximum Likelihood estimates				
No. of observations	292	Base LL function	-202.399	
No. of parameters	4	Pseudo R^2	0.425	
Estimated LL function	-116.328	AIC	0.824	

Table 4.6: RPL model for the low income respondents in the Breede Valley municipality

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Flow	0.730	0.255	2.863	0.004
Sanitation	0.785	0.241	3.252	0.001
Continuous Supply	0.286	0.088	3.253	0.001
Non-random parameters in utility functions				
Cost	-0.206	0.057	-3.591	0.000
Derived standard deviations of parameter distributions				
Flow	0.178	0.649	0.274	0.784
Sanitation	0.211	1.258	0.168	0.867
Continuous Supply	0.152	0.073	2.076	0.038
Maximum Likelihood estimates				
No. of observations	292	Pseudo R^2	0.436	
No. of parameters	7	Chi-squared	176.678	
Log-Likelihood function	-114.060	*Degrees of freedom*	7	
Base LL function	-202.399	AIC	0.829	

In these two models (reported in Tables 4.5 and 4.6) both show all the coefficient statistics to be significant, but the RPL one has the higher Pseudo R^2 and, for this reason, is preferred. In addition to these two an RPL model was also estimated that included explanatory variable to account for heterogeneity in the coefficient means (Table 4.7). However, statistical significance was weakened by this inclusion and this model was disregarded.

Table 4.7: RPL model for the Low Income respondents in the Breede Valley municipality including explanatory variables to account for heterogeneity in the coefficient means

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Flow	1.531	1.157	1.323	0.186
Sanitation	-0.764	1.042	-0.733	0.463
Continuous Supply	0.400	0.204	1.960	0.050
Non-random parameters in utility functions				
Cost	-0.215	0.063	-3.435	0.001
Heterogeneity in mean				
Flow: Age	-0.010	0.017	-0.590	0.555
Flow: Gender	-0.037	0.197	-0.187	0.851
Flow: Income	-0.015	0.307	-0.048	0.962
Flow: Education	-0.133	0.221	-0.601	0.548
Sanitation: Age	0.007	0.016	0.424	0.671
Sanitation: Gender	0.100	0.197	0.508	0.611
Sanitation: Income	-0.166	0.304	-0.545	0.586
Sanitation: Education	0.483	0.239	2.020	0.043
Continuous Supply: Age	0.000	0.002	-0.188	0.851
Continuous Supply: Gender	-0.020	0.031	-0.652	0.514
Continuous Supply: Income	-0.041	0.051	-0.802	0.423
Continuous Supply: Education	-0.018	0.034	-0.523	0.601
Derived standard deviations of parameter distributions				
Flow	0.325	0.603	0.539	0.590
Sanitation	0.321	0.902	0.356	0.722
Continuous Supply	0.130	0.072	1.802	0.072
Maximum Likelihood estimates				
No. of observations	292	Pseudo R^2	0.463	
No. of parameters	19	Chi-squared	158.261	
Log-Likelihood function	-108.720	*Degrees of freedom*	19	
Base LL function	-202.399	AIC	0.874	

4.2.2.3 Business respondents

The CL and RPL models for the business firm respondents served by the Breede Valley local municipality are shown in Tables 4.8 and 4.9.

Table 4.8: CL model for the business respondents in the Breede Valley municipality

Variables	Coefficients	Standard Errors	Wald Statistics	*p*-values
Continuous supply	0.082	0.014	5.710	0.000
Flow	0.462	0.126	3.652	0.000
Sanitation	1.207	0.153	7.886	0.000
Cost	-0.083	0.035	-2.360	0.018
Maximum Likelihood estimates				
No. of observations	292	Base LL function	-202.399	
No. of parameters	4	Pseudo R^2	0.343	
Estimated LL function	-132.902	AIC	0.938	

Table 4.9: RPL model for the business respondents in the Breede Valley municipality

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Flow	1.264	0.263	4.797	0.000
Sanitation	0.084	0.017	5.050	0.000
Continuous Supply	0.473	0.135	3.500	0.001
Non-random parameters in utility functions				
Cost	-0.087	0.039	-2.259	0.024
Derived standard deviations of parameter distributions				
Flow	0.352	0.718	0.491	0.624
Sanitation	0.010	0.075	0.139	0.889
Continuous Supply	0.001	0.328	0.002	0.999
Maximum Likelihood estimates				
No. of observations	292	Pseudo R^2	0.344	
No. of parameters	7	Chi-squared	139.156	
Log-Likelihood function	-132.821	*Degrees of freedom*	7	
Base LL function	-202.399	AIC	0.958	

In these two models, both show all the coefficient statistics to be significant, and the Pseudo R^2 of both models is virtually equal, but the CL model has the slightly higher Wald statistical significance and was accordingly preferred.

4.2.3 How valid are the estimates generated in the preferred models?

In addition to statistical significance, there are various other criteria that may be applied to assess the statistical validity of the models estimated. Two such criteria are design othogonality and the degree of difficulty and confusion reported by respondents in making their choices.

Design orthogonality can be assessed in terms a test for multi-collinearity between the explanatory variables in the choice models estimated – two relevant tests being the method of auxiliary regressions (Hensher *et al.*, 2005) and Klein's R^2 Rule (Hensher *et al.*, 2005; Klein, 1962).

Table 4.10: Auxiliary regressions and Klein's rule for the test for multicollinearity for the Breede Valley respondents

Dependent variable in the auxiliary regression	Auxiliary regression R^2	R_i^2	F-statistic	Klein's rule R^2
Cost	0.0005	0.0330	3.00	0.2833
Sanitary	0.0015	0.1056		
Continuous Supply	0.0005	0.0328		
Flow	0.0016	0.1161		

There was no multicollinearity present in the Breede Valley survey according to the auxiliary regression test for multicollinearity. This finding was confirmed by the Klein's rule test as the Klein's rule R^2 was larger than the R_i^2 values of the auxiliary regressions.

Further evidence consistent with validity of the choice experiment was that most of the respondents found the choice task set for them realistic and easy (**Error! Reference source not found.** and Figure 4.2)

Table 4.11: Percentage of income class finding the choices easy to make

	High Income	Low Income	Business
Easy	91%	93%	90%
Difficult	7%	6%	10%
I don't know	1%	1%	0%

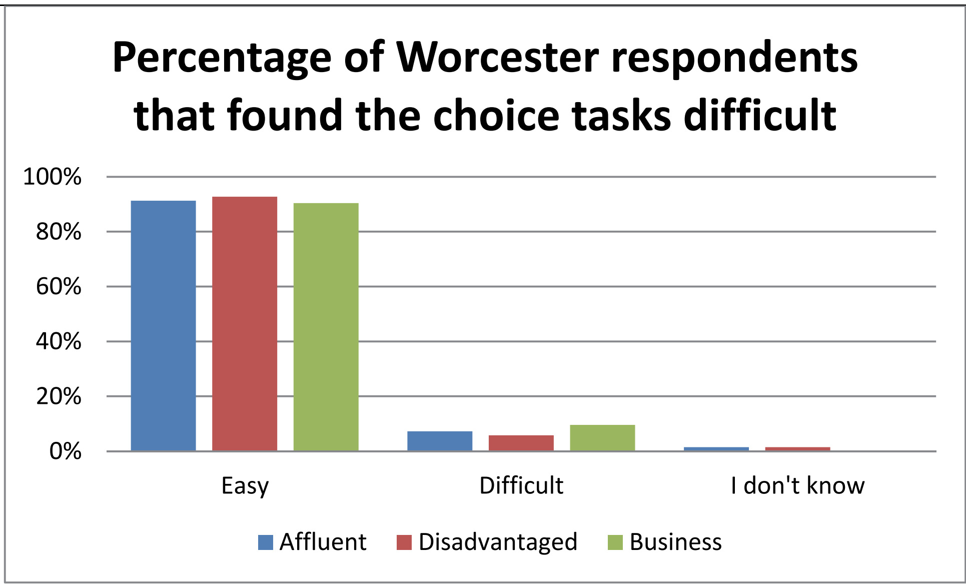


Figure 4.2: Percentage of difficulty of choice task among Breede Valley respondents

The attribute that was most influential in their choices was safety of the drinking water, followed by delivery convenience.

Two validity concerns raised by the respondent responses was their rating of the size of tariff as least important (almost unimportant, see Table 4.12) and the lack of willingness most of the respondents to actually make the trades implicit in their choices (Table 4.13). The lack of importance attached to the tariff is inconsistent with economic theory that the size of tariff is a key element of the choice set.

Table 4.12: The attributes that were the most important influences in choice – percentage response by income class

Attribute	High Income	Low Income	Business
The importance of each item was different for each choice I made	27%	15%	12%
The safety of the drinking water	40%	48%	32%
Sanitation safety	11%	2%	26%
Delivery convenience	17%	26%	28%
Size of tariff	5%	8%	2%

There is only a minority of consumers willing to trade (sacrifice) some delivery convenience for lower cost of service. Least (and most) willing to make such trades were the low income earners (**Error! Reference source not found.**).

Table 4.13: Willingness to trade lower water pressure and some interruptions in flow at a lower cost per kilolitre – percentage response by income class

Would trade delivery convenience for lower cost of service	High Income	Low Income	Business
Yes	19%	26%	23%
No	46%	71%	67%
Maybe	14%	1%	8%
Not sure	20%	1%	3%

4.2.4 Calculating welfare values from statistically preferred predictive models of choice

There were two models estimated for the Breede valley customer groups that lent themselves to the calculation of welfare values from the coefficients – the RPL for the low income group and the CL for the business firms. The results of the calculations (see Chapter 2 for more detail on the formula) are shown in Tables 4.14 and 4.15 respectively.

Table 4.14: Low Income Breede Valley RPL

Attribute	Coefficient estimate	MWTP (R/month)	Level change
Flow	0.730	3.54	Weak to medium or medium to strong
Continuous supply	0.785	3.81	6hrs to 12hrs or 12hrs to 24hrs
Sanitation	0.286	1.39	Strong possibility of leaks to occasional leaks or occasional leaks to negligible leaks
Cost	-0.206	NA	

The highest willingness to pay amongst the low income group falling in the Breede Valley municipality was for an improvement in the continuity of waters service supply. They were willing to pay an extra R3.81 per kl for improved continuity in water supply from 6 hours per day to 12 hours per day or from 12 hours per day to 24 hours.

Table 4.15: Business Breede Valley CL

Attribute	Coefficient estimate	MWTP (R/month)	Level change
Flow	0.082	0.988	Weak to medium or medium to strong
Continuous supply	0.462	5.566	6hrs to 12hrs or 12hrs to 24hrs
Sanitation	1.207	14.542	Strong possibility of leaks to occasional leaks or occasional leaks to negligible leaks
Cost	-0.083	NA	

The highest willingness to pay amongst the business firm group falling in the Breede Valley municipality was for an improvement in the sanitation service. They were willing to pay an extra R14.81 per kl for an improvement in sanitation service from strong possibility of leaks to occasional leaks or from occasional leaks to negligible leaks.

4.3 Msunduzi respondents

4.3.1 Choices analysis

The same nine choice sets (cards) were presented to the customers to choose between, except for changes in the tariff options. Tariff changes more appropriate to the Msunduzi municipal tariff structure were selected. The nature of these sets is described in Table 4.1. Choice card 1 was the most popular alternative: 84% of the respondents that were presented with this choice card selected it. The least chosen choice card was 7: only 16% of the respondents that were presented with this choice card selected it.

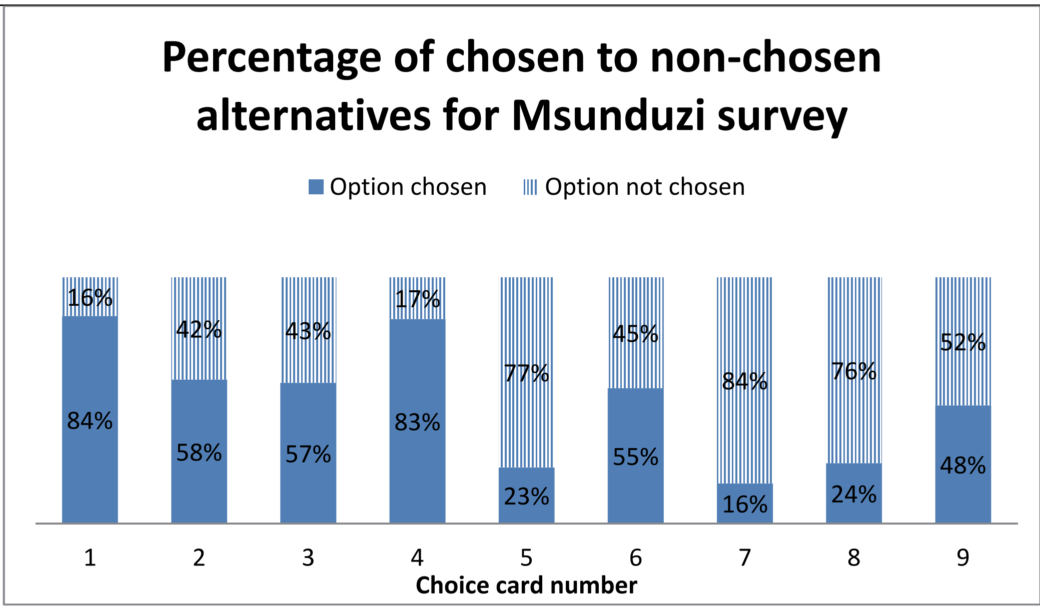


Figure 4.3: Percentage chosen to non-chosen alternatives

Further analysis of these choices reveals that, for all three groupings of customers, the attributes most popularly selected at the highest levels available were sanitation and continuous supply, although flow (water pressure) was almost equally important among the business firms (Table 4.16).

Table 4.16: Percentage of respondents in the Msunduzi municipality that chose the higher valued attribute level

High Income Respondents				
	Flow	Continuous supply	Sanitation	Cost
Higher valued level	42%	56%	52%	20%
Lower valued level	32%	18%	25%	55%
Same level	26%	26%	23%	25%
Poor/Low Income Respondents				
	Flow	Continuous supply	Sanitation	Cost
Higher valued level	41%	53%	50%	19%
Lower valued level	34%	22%	26%	57%
Same level	25%	25%	25%	25%
Business Respondents				
	Flow	Continuous supply	Sanitation	Cost
Higher valued level	50%	51%	58%	32%
Lower valued level	26%	24%	15%	43%
Same level	24%	25%	26%	25%

4.3.2 Modelling of choices

4.3.2.1 High income respondents

The same two models were estimated for all three groups of customers served by the Msunduzi municipality (CL and RPL). Of the two models, for the high income respondents, the CL is preferred as it yields the most statistically significant coefficients, while its Psuedo R^2 is only slightly lower than that found for the RPL model. This model was also suited to welfare value calculation as the cost coefficient is significant (see Tables 4.17 and 4.18).

Table 4.17: CL model for the High Income respondents in the Msunduzi municipality

Variables	Coefficients	Standard Errors	Wald Statistics	*p*-values
Continuous supply	0.113	0.017	6.727	0.000
Flow	0.357	0.133	2.686	0.007
Sanitation	0.746	0.138	5.406	0.000
Cost	-0.255	0.040	-6.388	0.000
Maximum Likelihood estimates				
No. of observations	276	Base LL function	-191.309	
No. of parameters	4	Pseudo R^2	0.376	
Estimated LL function	-119.378	AIC	0.894	

Table 4.18: RPL model for the High Income respondents in the Msunduzi municipality

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Sanitation	4.646	17.753	0.262	0.794
Flow	2.028	7.679	0.264	0.792
Continuous Supply	0.870	3.285	0.265	0.791
Non-random parameters in utility functions				
Cost	-1.127	4.193	-0.269	0.788
Derived standard deviations of parameter distributions				
Sanitation	5.224	21.233	0.246	0.806
Flow	2.798	11.292	0.248	0.804
Continuous Supply	1.839	7.058	0.261	0.794
Maximum Likelihood estimates				
No. of observations	276	Pseudo R^2	0.381	
No. of parameters	7	Chi-squared	145.831	
Log-Likelihood function	-118.393	*Degrees of freedom*	7	
Base LL function	-191.309	AIC	0.909	

4.3.2.2 Low Income respondents

Of the two models (CL and RPL), for the low income respondents, the CL is preferred as it yields the most statistically significant coefficients, while its Psuedo R^2 is only slightly lower than that found for the RPL model. This model was also suited to welfare value calculation as the cost coefficient is significant (see Tables 4.19 and 4.20).

Table 4.19: CL model for the Low Income respondents in the Msunduzi municipality

Variables	Coefficients	Standard Errors	Wald Statistics	*p*-values
Continuous supply	0.087	0.014	6.082	0.000
Flow	0.269	0.121	2.223	0.026
Sanitation	0.711	0.130	5.478	0.000
Cost	-0.293	0.040	-7.414	0.000
Maximum Likelihood estimates				
No. of observations	296	Base LL function	-205.172	
No. of parameters	4	Pseudo R^2	0.341	
Estimated LL function	-135.133	AIC	0.940	

Table 4.20: RPL model for the Low Income respondents in the Msunduzi municipality

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Sanitation	0.994	0.446	2.232	0.026
Flow	0.410	0.225	1.818	0.069
Continuous Supply	0.149	0.067	2.234	0.026
Non-random parameters in utility functions				
Cost	-0.365	0.103	-3.525	0.000
Derived standard deviations of parameter distributions				
Sanitation	0.562	0.966	0.582	0.561
Flow	0.258	1.010	0.255	0.799
Continuous Supply	0.139	0.096	1.447	0.148
Maximum Likelihood estimates				
No. of observations	296	Pseudo R^2	0.348	
No. of parameters	7	Chi-squared	142.806	
Log-Likelihood function	-133.768	*Degrees of freedom*	7	
Base LL function	-205.172	AIC	0.951	

4.3.2.3 Business respondents

Of these two models, for the business firms, the RPL is preferred as it yields the most statistically significant coefficients, and its Psuedo R^2 is higher than that found for the CL model. This model was also suited to welfare value calculation as the cost coefficient is significant (see Tables 4.21 and 4.22).

Table 4.21: CL model for the business respondents in the Msunduzi municipality

Variables	Coefficients	Standard Errors	Wald Statistics	*p*-values
Continuous supply	0.085	0.015	5.849	0.000
Flow	0.720	0.136	5.279	0.000
Sanitation	1.246	0.158	7.889	0.000
Cost	-0.049	0.034	-1.466	0.143
Maximum Likelihood estimates				
No. of observations	296	Base LL function	-205.172	
No. of parameters	4	Pseudo R^2	0.357	
Estimated LL function	-131.961	AIC	0.919	

Table 4.22: RPL model for the business respondents in the Msunduzi municipality

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Flow	9.386	1.090	8.608	0.000
Sanitation	16.687	1.413	11.814	0.000
Continuous Supply	1.743	0.118	14.734	0.000
Non-random parameters in utility functions				
Cost	-0.674	0.174	-3.872	0.000
Derived standard deviations of parameter distributions				
Flow	3.395	4.448	0.763	0.445
Sanitation	11.661	2.537	4.596	0.000
Continuous Supply	1.925	0.221	8.694	0.000
Maximum Likelihood estimates				
No. of observations	296	Pseudo R^2	0.378	
No. of parameters	6	Chi-squared	161.172	
Log-Likelihood function	-124.586	*Degrees of freedom*	7	
Base LL function	-205.172	AIC	0.889	

In addition to these two, an RPL model was also estimated that included explanatory variable to account for heterogeneity in the coefficient means (Table 4.23). However, statistical significance was weakened by the inclusion and as a result this model was disregarded.

Table 4.23: RPL model for the business respondents in the Msunduzi municipality including explanatory variables to account for heterogeneity in the coefficient means

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Flow	3.939	10.817	-0.364	0.716
Sanitation	34.051	33.797	1.008	0.314
Continuous Supply	2.511	2.370	1.060	0.289
Non-random parameters in utility functions				
Cost	-0.445	0.755	-0.590	0.555
Heterogeneity in mean				
Flow: Importance	0.373	1.201	0.311	0.756
Flow: Type	2.529	4.802	0.527	0.599
Sanitation: Importance	-3.867	3.531	-1.095	0.274
Sanitation: Type	-5.048	5.674	-0.890	0.374
Continuous Supply: Importance	0.182	0.520	0.350	0.727
Continuous Supply: Type	-0.683	0.706	-0.968	0.333
Derived standard deviations of parameter distributions				
Flow	3.098	4.891	0.633	0.527
Sanitation	8.017	7.357	1.090	0.276
Continuous Supply	0.666	1.144	0.582	0.560
Maximum Likelihood estimates				
No. of observations	296	Pseudo R^2	0.437	
No. of parameters	13	Chi-squared	176.790	
Log-Likelihood function	-114.004	*Degrees of freedom*	13	
Base LL function	-202.399	AIC	0.868	

4.3.3 How valid are the estimates generated in the preferred models?

Two criteria for assessing validity are design orthogonality and consistency of answers provided to questions in the survey with what would be expected. As argued above, design orthogonality can be assessed in terms a test for multi-collinearity between the explanatory variables in the choice models estimated – two relevant tests being the method of auxiliary regressions (Hensher *et al.*, 2005) and Klein's R^2 Rule (Hensher *et al.*, 2005; Klein, 1962); the former requiring the overall R^2 to be higher than the R_i^2 values of the auxiliary regressions. The tests for multicollinearity in the attributes of the design for the Msunduzi survey are shown in **Error! Reference source not found.**.

Table 4.24: Auxiliary regressions and Klein's rule for the test for multicollinearity for the Msunduzi respondents

Dependent variable in the auxiliary regression	Auxiliary regression R^2	R_i^2	F-statistic	Klein's rule R^2
Cost	0.0004	0.1091	3.00	0.2453
Sanitary	0.0003	0.0888		
Flow	0.0003	0.0723		
Continuous Supply	0.0003	0.0889		

At the 5% level of significance the null hypothesis is rejected indicating that there is no correlation in the design attributes, so not accepting multicollinearity. The application of Klein's rule of R^2 yields a similar conclusion. The Klein's rule R^2 is 0.2453, larger than any of the R_i^2 values of any of the auxiliary regressions.

There was also consistency of answers provided and the answers that would be expected. Furthermore most of the respondents reported that they felt the requested choices were easy to make, but less so for the low income group (**Error! Reference source not found.** and Figure 4.4)

Table 4.25: Percentage of income class finding the choices easy to make

	High Income	Poor/ Low Income	Business
Easy	75%	64%	88%
Difficult	20%	22%	9%
I don't know	4%	14%	3%

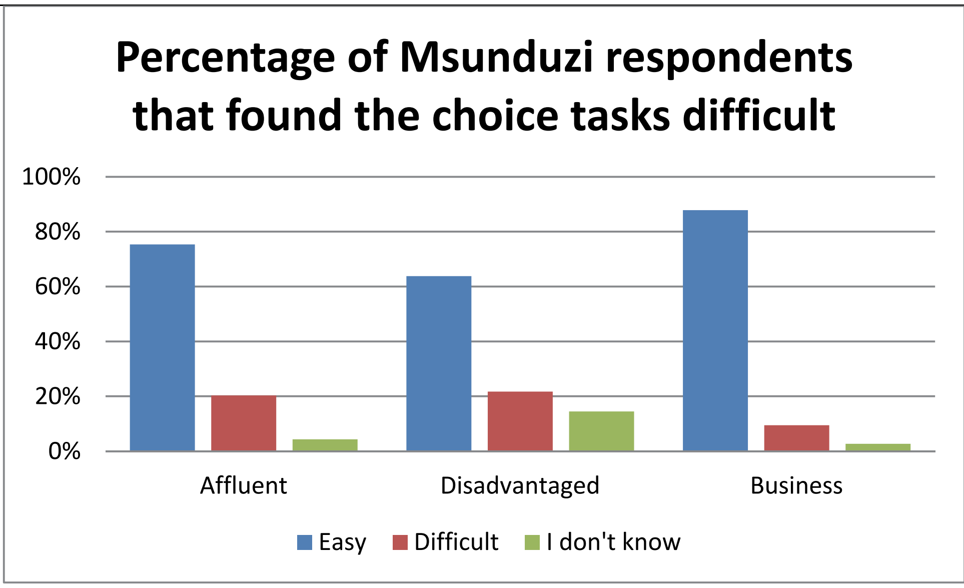


Figure 4.4: Difficulty of choice task among Msunduzi respondents

The attributes that were most influential in their choices were sanitation safety, followed by size of tariff, especially among the business category of respondents (**Error! Reference source not found.**).

Table 4.26: The attributes that were the most important influences in choice – percentage response by income class

Attribute	High Income	Poor/ Low Income	Business
The importance of each item was different for each choice I made	0%	21%	0%
The safety of the drinking water	0%	7%	17%
Sanitation safety	71%	50%	50%
Delivery convenience	7%	14%	0%
Size of tariff	21%	7%	33%

A majority of high income consumers were willing to trade (sacrifice) some delivery convenience for lower cost of service. The least willing to make such trades were the poor (although just under one third were willing to do so), followed closely by business sector respondents (**Error! Reference source not found.**).

Table 4.27: Willingness to trade lower water pressure and some interruptions in flow at a lower cost per kilolitre – percentage response by income class

Would trade delivery convenience for lower cost of service	High Income	Poor/ Low Income	Business
Yes	79%	31%	26%
No	0%	55%	54%
Maybe	2%	4%	12%
Not sure	7%	10%	8%

4.3.4 Calculating welfare values from statistically preferred predictive models of choice

There were three models estimated for the Breede valley customer groups that lent themselves to the calculation of welfare values from the coefficients – the CL for the high and low income groups and the RPL for the business firms. The results of the calculations (see Chapter 2 for more detail on the formula) are shown in Tables 4.28, 4.29 and 4.30 respectively.

Table 4.28: High Income Msunduzi CL

Attribute	Coefficient estimate	MWTP (R/month)	Level change
Flow	0.113	0.44	Weak to medium or medium to strong
Continuous supply	0.357	1.40	6hrs to 12hrs or 12hrs to 24hrs
Sanitation	0.746	2.93	Strong possibility of leaks to occasional leaks or occasional leaks to negligible leaks
Cost	-0.255	NA	

The highest WTP amongst the high income group falling in the Msunduzi municipality was for an improvement in the sanitation of waste water. They were willing to pay an extra R2.93 per kl for improved sanitation in the form of reducing the possibility of leaks from strong to occasional or from occasional to negligible.

Table 4.29: Low Income Msunduzi CL

Attribute	Coefficient estimate	MWTP (R/month)	Level change
Flow	0.087	0.30	Weak to medium or medium to strong
Continuous supply	0.269	0.92	6hrs to 12hrs or 12hrs to 24hrs
Sanitation	0.711	2.43	Strong possibility of leaks to occasional leaks or occasional leaks to negligible leaks
Cost	-0.293	NA	

The highest willingness to pay amongst the low income group falling in the Msunduzi municipality was for an improvement in the sanitation of waste water. They were willing to pay an extra R2.43 per kl for improved sanitation in the form of reducing the possibility of leaks from strong to occasional or from occasional to negligible.

Table 4.30: Business Msunduzi RPL

Attribute	Coefficient estimate	MWTP (R/month)	Level change
Flow	9.386	13.93	Weak to medium or medium to strong
Continuous supply	16.687	24.76	6hrs to 12hrs or 12hrs to 24hrs
Sanitation	1.743	2.59	Strong possibility of leaks to occasional leaks or occasional leaks to negligible leaks
Cost	-0.674	NA	

The highest willingness to pay amongst the business firm group falling in the Msunduzi municipality was for an improvement in the continuity of waters service supply. They were willing to pay an extra R24.76 per kl for improved continuity in water supply from 6 hours per day to 12 hours per day or from 12 hours per day to 24 hours.

4.4 Knysna respondents

4.4.1 Choices analysis

The same nine choice sets (cards) were presented to the Knysna customers, except for changes in the tariff options. Tariff changes more appropriate to the Knysna municipal tariff structure were selected. The nature of these sets is described in Table 4.1. Choice card 1 was the most popular alternative: 87% of the respondents that were presented with this choice card selected it. The least chosen choice card was 7: only 4% of the respondents that were presented with this choice card selected it.

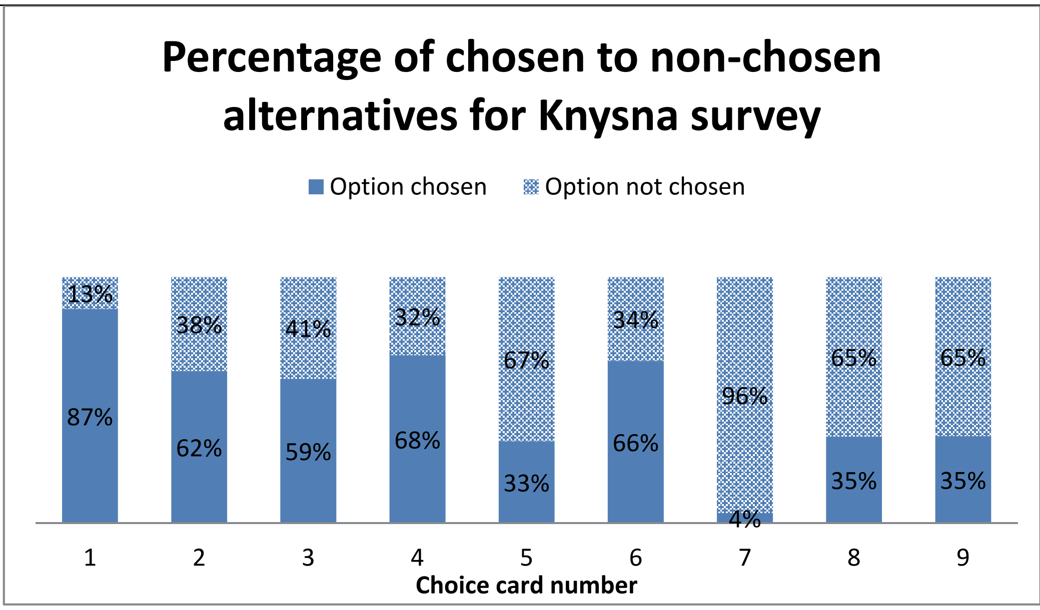


Figure 4.5: Percentage chosen to non-chosen in Knysna

Further analysis of these choices reveals that, for the high income and business firm groupings of customers, the attribute most popularly selected at the highest levels available was sanitation, while for the low income group it was continuous supply (Table 4.31).

Table 4.31: Percentage of respondents in the Knysna municipality that chose the higher valued attribute level

High Income Respondents				
	Flow	Continuous supply	Sanitation	Cost
Higher valued level	50%	50%	59%	33%
Lower valued level	24%	25%	15%	43%
Same level	26%	25%	25%	24%
Poor/Low Income Respondents				
	Flow	Continuous supply	Sanitation	Cost
Higher valued level	50%	63%	49%	35%
Lower valued level	26%	12%	26%	39%
Same level	24%	25%	25%	26%
Business Respondents				
	Flow	Continuous supply	Sanitation	Cost
Higher valued level	49%	47%	59%	31%
Lower valued level	26%	28%	16%	44%
Same level	25%	25%	25%	25%

4.4.2 Modelling of choices

4.4.2.1 High Income Respondents

The same two models were estimated for all three groups of customers served by the Knysna municipality (CL and RPL). Of these two models, for the high income respondents, the CL is preferred as it yields the most statistically significant coefficients, while its Psuedo R^2 is only slightly lower than that found for the RPL model, but neither model estimated yielded results suited to welfare value calculation as the cost coefficient is not significant in either model (see Tables 4.32 and 4.33).

Table 4.32: CL model for the High Income respondents in the Knysna municipality

Variables	Coefficients	Standard Errors	Wald Statistics	*p*-values
Flow	0.857	0.146	5.876	0.000
Continuous supply	0.080	0.015	5.445	0.000
Sanitation	1.249	0.161	7.755	0.000
Cost	-0.043	0.037	-1.168	0.243
Maximum Likelihood estimates				
No. of observations	292	Base LL function	-202.399	
No. of parameters	4	Pseudo R^2	0.370	
Estimated LL function	-127.424	AIC	0.900	

Table 4.33: RPL model for High Income respondents in the Knysna municipality

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Flow	2.873	4.096	0.701	0.483
Continuous Supply	1.044	1.424	0.734	0.463
Sanitation	2.606	3.981	0.655	0.513
Non-random parameters in utility functions				
Cost	0.004	0.072	0.060	0.953
Derived standard deviations of parameter distributions				
Flow	0.560	4.635	0.121	0.904
Continuous Supply	0.898	1.280	0.702	0.483
Sanitation	0.617	4.465	0.138	0.890
Maximum Likelihood estimates				
No. of observations	292	Pseudo R^2	0.418	
No. of parameters	7	Chi-squared	169.137	
Log-Likelihood function	-117.831	*Degrees of freedom*	7	
Base LL function	-202.399	AIC	0.855	

4.4.2.2 Low Income respondents

Of the two models (CL and RPL), for the low income respondents, the CL is preferred as it yields the most statistically significant coefficients, while its Psuedo R^2 is only slightly lower than that found for the RPL model, but neither model estimated yielded results suited to welfare value calculation as the cost coefficient is not significant in either model (see Tables 4.34 and 4.35).

Table 4.34: CL model for the Low Income respondents in the Knysna municipality

Variables	Coefficients	Standard Errors	Wald Statistics	*p*-values
Flow	0.150	0.018	8.203	0.000
Continuous supply	0.750	0.139	5.392	0.000
Sanitation	0.702	0.140	5.014	0.000
Cost	-0.017	0.034	-0.491	0.623
Maximum Likelihood estimates				
No. of observations	296	Base LL function	-205.172	
No. of parameters	4	Pseudo R^2	0.389	
Estimated LL function	-125.3189	AIC	0.874	

Table 4.35: RPL model for the Low Income respondents in the Knysna municipality

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Flow	2.873	4.096	0.701	0.483
Continuous Supply	1.044	1.424	0.734	0.463
Sanitation	2.606	3.981	0.655	0.513
Non-random parameters in utility functions				
Cost	0.004	0.072	0.060	0.953
Derived standard deviations of parameter distributions				
Flow	0.560	4.635	0.121	0.904
Continuous Supply	0.898	1.280	0.702	0.483
Sanitation	0.617	4.465	0.138	0.890
Maximum Likelihood estimates				
No. of observations	296	Pseudo R^2	0.449	
No. of parameters	7	Chi-squared	184.194	
Log-Likelihood function	-113.075	*Degrees of freedom*	7	
Base LL function	-205.172	AIC	0.811	

4.4.2.3 Business respondents

Of these two models, for the business firms, the CL is preferred as it yields the most statistically significant coefficients, and its Psuedo R^2 is only marginally lower than that found for the RPL model. This model was suited to welfare value calculation as the cost coefficient is significant (see Tables 4.36 and 4.37).

Table 4.36: CL model for the business respondents in the Knysna municipality

Variables	Coefficients	Standard Errors	Wald Statistics	*p*-values
Flow	0.049	0.014	3.586	0.000
Continuous supply	0.633	0.131	4.830	0.000
Sanitation	1.135	0.151	7.512	0.000
Cost	-0.104	0.034	-3.054	0.002
Maximum Likelihood estimates				
No. of observations	272	Base LL function	-188.536	
No. of parameters	4	Pseudo R^2	0.313	
Estimated LL function	-129.474	AIC	0.981	

Table 4.37: RPL model for the business respondents in the Knysna municipality

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Flow	0.855	0.456	1.875	0.061
Continuous Supply	0.074	0.033	2.250	0.025
Sanitation	1.958	1.019	1.922	0.055
Non-random parameters in utility functions				
Cost	-0.138	0.064	-2.137	0.033
Derived standard deviations of parameter distributions				
Flow	0.520	1.131	0.459	0.646
Continuous Supply	0.004	0.086	0.047	0.963
Sanitation	1.642	1.259	1.305	0.192
Maximum Likelihood estimates				
No. of observations	272	Pseudo R^2	0.324	
No. of parameters	7	Chi-squared	122.004	
Log-Likelihood function	-127.5341	*Degrees of freedom*	7	
Base LL function	-188.536	AIC	0.989	

4.4.3 How valid are the estimates generated in the preferred models?

Two criteria for assessing validity are design orthogonality and consistency of answers provided to questions in the survey with what would be expected. As in the previous cases, design orthogonality was assessed using the method of auxiliary regressions (Hensher *et al.*, 2005) and Klein's R^2 Rule (Hensher *et al.*, 2005; Klein, 1962). The tests for multicollinearity in the attributes of the design for the Knysna survey are shown in **Error! Reference source not found.**.

Table 4.38: Auxiliary regression method and Klein's rule for the test for multicollinearity for the Knysna survey

Dependent variable in the auxiliary regression	Auxiliary regression R^2	${R_i}^2$	F-statistic	Klein's rule R^2
Cost	0.0005	0.1562	3.00	0.236
Sanitary	0.0007	0.2097		
Flow	0.0002	0.0714		
Continuous Supply	0.0002	0.0670		

The F-statistic is larger than the ${R_i}^2$ values for each of the auxiliary regressions, indicating that the attributes of the design are uncorrelated at the 5% level of significance. The application of Klein's R^2 yielded results consistent with this finding – Klein's rule R^2 for the regression of choice on the attributes was larger than the ${R_i}^2$ values of any of the auxiliary regressions.

The consistency of the answers provided with what would be expected was assessed with respect to several questions; an important one being the ease with which respondents felt they were able to make the requested choices. These answers did not give rise to concern as most of the respondents found the choice task set for them realistic and easy, especially the poor (**Error! Reference source not found.** and Figure 4.6)

Table 4.39: Percentage of income class finding the choices easy to make

	High Income	**Poor/ Low Income**	**Business**
Easy	81%	97%	84%
Difficult	18%	3%	16%
I don't know	1%	0%	0%

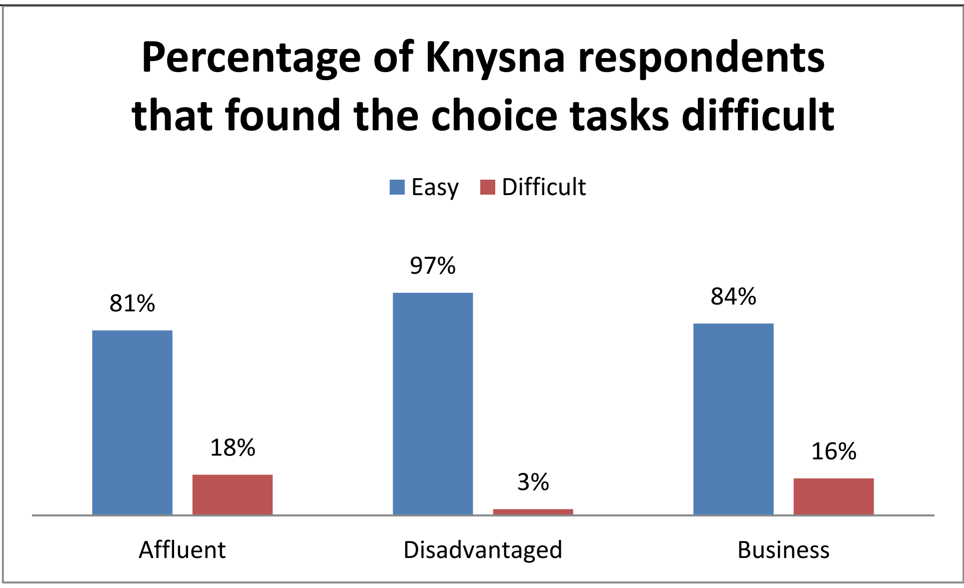


Figure 4.6: Difficulty of choice task among Knysna respondents

The attribute that was most influential in the choices of the high income and business groups was sanitation safety, while that most influential amongst the poor was delivery convenience (Table 4.40). Of some concern was the relative importance rating of safety of drinking water and size of tariff, but perhaps these answers are because there was a perception that, in reality, there was little management flexibility with respect to these factors.

Table 4.40: The attributes that were the most important influences in choice – percentage response by income class

Attribute	High Income	Low Income	Business
The importance of each item was different for each choice I made	8%	1%	10%
The safety of the drinking water	6%	12%	0%
Sanitation safety	50%	34%	55%
Delivery convenience	25%	49%	18%
Size of tariff	7%	4%	10%

The majority of consumers were unwilling to trade (sacrifice) some delivery convenience for lower cost of service. The least willing to make such trades were the poor, while the most willing were business consumers (Table 4.41).

Table 4.41: Willingness to trade lower water pressure and some interruptions in flow at a lower cost per kilolitre – percentage response by income class

Would trade delivery convenience for lower cost of service	High Income	Poor/ Low Income	Business
Yes	24%	10%	29%
No	51%	67%	49%
Maybe	15%	7%	19%
Not sure	10%	16%	3%

4.4.4 Calculating welfare values from statistically preferred predictive models of choice

There was only one model estimated for the Knysna customer groups that lent itself to the calculation of welfare values from the coefficients – the CL for the business firm group. The results of the calculations (see Chapter 2 for more detail on the formula) are shown in Tables 4.42.

Table 4.42: Business Knysna CL

Attribute	Coefficient estimate	MWTP (R/month)	Level change
Flow	0.049	0.47	Weak to medium or medium to strong
Continuous supply	0.633	6.09	6hrs to 12hrs or 12hrs to 24hrs
Sanitation	1.135	10.91	Strong possibility of leaks to occasional leaks or occasional leaks to negligible leaks
Cost	-0.104	NA	

The highest WTP amongst the business firms in the Knysna municipality was for an improvement in the sanitation of waste water. They were willing to pay an extra R10.91 per kl for improved sanitation in the form of reducing the possibility of leaks from strong to occasional or from occasional to negligible.

4.5 Conclusion

Choice analysis confirms much that would be expected – consumers like higher pressure, fewer interruptions on water service, good sanitation of waste water and low tariff costs.

In most cases the conditional logit models yielded more statistically valid predictive fits of the choices of the different categories of respondent than the random parameters logit model.

In no cases were the choice problems found to be overwhelmingly difficult by the respondents and it is deduced that a reasonable degree of (questionnaire) construct validity can be attached to the study.

It was found that for the low income consumers in the Breede Valley Municipality there was a WTP for improved continuity of service, water pressure and sanitation, in descending order.

For all three categories of water service consumers, reliable predictive models could be estimated from the responses elicited in the Msunduzi municipality survey. Business respondents were prepared to pay a lot more for than the others for improvements in service, particularly for improvements in continuity in supply, but also for improved pressure. All three groups were willing to pay approximately R2-3 extra per kl for improved sanitation management reliability.

The Knysna business respondents were willing to pay just under R11 extra per kl to improve sanitation management in their municipality and just over R6 per month to improve continuity of service (Chapter 5).

Chapter 5: Conclusion

Choice experiment analysis enables an assessment to be made of changes to selected levels of water service that consumers currently value most. Being a value derived through the analysis of a defined marginal change (such as of specific improved sanitation) it does not indicate overall value of the service, that is, the value that would be foregone in the absence of any service. This study shows it to provide an indication of changes in the levels of water service (attributes) that would most yield value to the receiving customer. By doing this it can complement investigations into the merit of technical or cost reducing changes in water service provision.

The method has been shown not to be an overly complicated one to apply (Chapters 2 and 3 and Appendices A and B), and the survey that enables it can easily be expanded to incorporate customer satisfaction assessments (Chapter 3).

During 2012 a sample of 0.5 to 2% of the water service consumer billed unit populations in the Breede Valley, Msunduzi and Knysna local municipalities were surveyed about their opinions and the choices they would make, if presented with alternative water service packages. The respondents were drawn from three groups of water service customers – high income earners, low income earners and businesses. Most of the respondents included in the high and low income earning groups were employed and had some education.

It was expected that low income earners, but not high income earners, would have been willing to trade-off less water service delivery convenience with cost of service, but no consistent trend emerged. This study argues that the explanation for this apparent lack of sacrifice delivery convenience lies in the income subsidy implicit in the water service provided to the lower income group. Their relative lack of willingness to trade lower convenience for lower cost reflects their (justifiable) belief that they the lower cost benefit would not be passed on to them, but would be captured as a cost saving by the municipality, i.e. that lower income earners fear such trade-offs would, in practice, work to their disadvantage.

Customer service rating indicated greater satisfaction with the potable water service received than with the sanitation service, and yielded results consistent with Blue Drop and Green Drop certification ratings.

A number of models were estimated that predicted the choice of various identified groups (Chapter 4); many of which yielded statistically significant parameters. These parameters were used to calculate marginal willingness to pay for improved levels of service. A summary of the findings of the marginal willingness to pay for the three water user groups across the three selected municipalities is presented in Tables 5.1, 5.2 and 5.3.

Table 5.1: A comparison of business firms MWTP across three municipalities

Attribute	**Msunduzi MWTP (R/kl)**	**Knysna MWTP (R/kl)**	**Breede MWTP (R/kl)**	**Marginal change in level**
Flow (pressure)	13.93	0.47	0.99	Weak to medium or medium to strong
Continuous supply	24.76	6.09	5.57	6hrs to 12hrs or 12hrs to 24hrs
Sanitation	2.59	10.91	14.54	Strong possibility of leaks to occasional leaks or occasional leaks to negligible leaks

Table 5.2: High income earners MWTP in the Msunduzi municipality

Attribute	**Msunduzi MWTP (R/kl)**	**Level change**
Flow (pressure)	.44	Weak to medium or medium to strong
Continuous supply	1.40	6hrs to 12hrs or 12hrs to 24hrs
Sanitation	2.92	Strong possibility of leaks to occasional leaks or occasional leaks to negligible leaks

Table 5.3: Low income earners MWTP in the Msunduzi and Breede municipalities

Attribute	Msunduzi MWTP (R/kl)	Breede MWTP (R/kl)	Marginal change in level
Flow (pressure)	0.30	3.54	Weak to medium or medium to strong
Continuous supply	0.92	3.81	6hrs to 12hrs or 12hrs to 24hrs
Sanitation	2.42	1.39	Strong possibility of leaks to occasional leaks or occasional leaks to negligible leaks

The following general observations were drawn from these findings;

- Sanitation improvement was the most highly valued improvement among most classes of users and municipalities
- There is considerable dispersion in MWTP for attribute level improvements between the three municipalities selected for this study
- Business firms typically had **higher** marginal valuations for water services than either the high or low income groups
- The difference in marginal valuation between the high and low income groups is **not pronounced** in the three municipalities surveyed.

What deductions about demand at these three municipalities do such findings lead us to? Based on an analysis of the choices the respondents made between alternative water service packages offered to them, this study found the consumers prefer high to low pressure, few to many interruptions in water service, high to low quality water and low to high tariff costs, but with varying intensities. The low income consumers in the Worcester section of the Breede Valley Municipality were willing to pay more for improved continuity of service, but less for higher water pressure and a better sanitation service. Business firm respondents in the Msunduzi municipality were prepared to pay more than the other consumers for improvements in water services, particularly for improvements in continuity in supply, but also for improved pressure. All three groups in the Msunduzi municipality were willing to pay about R2-3 extra per kl for improved sanitation management reliability. Knysna business respondents were willing to pay just under R11 extra per kl to improve sanitation management by their municipality and just over R6 per kl to improve continuity of service (through investment in raw water storage).

These findings indicate the direction that would be appropriate for these municipalities to move if they decide in restructuring the water service packages they offer their consumers, and adopt a more demand orientated (and consumer welfare maximising) strategy and policy goal.

Given the need for municipalities to recover costs while keeping their customers happy, the analysis of the demand satisfaction of water service users is an important area of management information. The discrete choice experiment analysis is one way of generating such information, and the survey on which such analysis is based can be adapted to incorporate the collection of information on how customers rate delivery performance and their perceptions of faults in this delivery.

This study reveals there to be a divergence in the experience of water service customers in different municipalities with respect to perceptions of fairness in the way water services are managed. The Breede Valley respondents mostly felt the cost recovery tariff structure they faced was fair. Most of the Msunduzi respondents felt the one they faced was unfair. Knysna respondents were divided over the fairness of their water service tariff structure. Almost 90 per cent of all groups of respondents surveyed in the Breede Valley were satisfied with the current level of water service provided to them. About two-thirds of the high income respondents in the Msunduzi were dissatisfied with the current level of water service provided to them, but the low income and business groups were mostly satisfied. Among all groups (business, high income and low income), about two-thirds of the Knysna respondents were satisfied with the current level of water service provided to them.

Consistent across the three of the municipalities respondents surveyed was that the overwhelming majority reported that their municipality made no attempt to assess the nature of their water service demand or the sensitivity of their demand to changes in the attributes of the water service provided. Most respondents felt their municipal water service providers took a take-it-or-leave-it position with respect to their water service customers.

The overall conclusion drawn is that discrete choice experiment analysis and the survey on which is based have the potential to yield useful insights into the levels of attributes preferred in the water service mix provided by South African municipalities, and thereby inform water service management thinking on ways to attend to water service consumer welfare and inform the structure of tariffs.

References

ADAMOWICZ, V., & BOXALL, P., 2001. Future Directions of Stated Choice Methods for Environment Valuation. *Choice Experiments: A New Approach to Environmental Valuation*. London, England.

ALPIZAR, F., CARLSSON, F. & MARTINSSON, P., 2003. Using Choice Experiments for Non-Market Valuation. *Economic Issues,* 8: 83-110.

BASKARAN, R., CULLEN, R. & WRATTEN, S., 2009. Estimating the Value of Agricultural Ecosystem Service: A Case Study of New Zealand Pastoral Farming – A Choice Modelling approach. *Australasian Journal of Environmental Management,* 16: 103-112.

BATEMAN, I. CARSON, R., DAY, B., HANEMANN, M., HANLEY, N., HETT, T., LEE, M., LOOMES, G., MOURATO, S., OZDEMIROGLU, E., PEARCE, D., SUGDEN, R. & SWANSON, J., 2002. *Economic Valuation with Stated Preference Techniques: A Manual*. Cheltenham: Edward Elgar Publishing, UK.

BENNETT, J. & ADAMOWICZ V., 2001. Some Fundamentals of Environmental Choice Modelling. *In* Bennett J. & Blamey R., (Eds)*. The Choice Modelling Approach to Environmental Valuation.* Cheltenham: Edward Elgar publishing, UK*.*

DAVIES, A., LAING, R.A. & MACMILLAN, D.C., 2000. The Use of Choice Experiments on the Built Environment: An Innovative Approach. *European Society for Ecological Economics*. Vienna, Austria.

GLASGOW, G., 1999. *A Random Parameters Logit Model for Estimating the Impact of Issues on Vote Choice*. California: University of California.

GLASGOW, G., 2001. *Heterogeneity in Discrete Choice Models*. University of California. [Online]. Available: http://polmeth.wustl.edu/media/Paper/glasg01b.pdf [Accessed 5/03/2012].

GREENE, W.H., 1997. *Econometric Analysis.* 3rd Edition. New Jersey: Prentice Hall.

HANLEY, N. & SPASH, C.L., 1993*. Cost-Benefit analysis and the environment*. Vermont: Edward Elgar Publishing.

HANLEY, N., WRIGHT, R. E., & ADAMOWICZ, W., 1998, Using choice experiments to value the environment: Design issues, current experience and future prospects. *Environmental & Resource Economics*, 11 (3-4): 413-428.

HANLEY, N., MOURATO, S. & WRIGHT, R. E., 2001. Choice modelling approaches: a superior alternative for environmental valuation? *Journal of Economic Surveys,* 15(3): 221-242.

HASLER, B., LUNDHERE, T., MARTINSEN, L., NEYE, S. & SCHOU, S.J., 2005. *Valuation of Groundwater Protection Versus Water Treatment in Denmark by Choice Experiments and Contingent Valuation.* Denmark: National Environmental Research Institute. NERI Technical Report No. 543. [Online]. Available: http://technical-reports.dmu.dk. [Accessed 10/11/2012].

HAUSMAN, J. & MCFADDEN, D., 1984. Specification tests for the multinomial logit model. *Econometrica*, 52: 1219-1240.

HENSHER, D. A., 1982. Functional measurement, individual preference and discrete-choice modelling: theory and application. *Journal of Economic Psychology,* 2 (3): 323-335.

HENSHER, D. A., ROSE, J. M. & GREENE, W. H., 2005. *Applied Choice Analysis: A Primer*. Cambridge, UK: Cambridge University Press.

HOFFMAN, S. & DUNCAN, G., 1988. Multinomial and Conditional Logit Discrete-Choice Models in Demography. Population Association of America. *Demography*, 25 (3).

HOLE, A., 2007. A comparison of approaches to estimating confidence intervals for WTP measures. *Health Economics,* 16: 827-840.

HOSKING, J., 2009. Analysis of a choice experiment for water service evaluation using the Bradley-Terry model. (Unpublished Honours Treatise). Cape Town: University of Cape Town. South Africa.

HOSKING, J., 2013. Generating guidance on the public preferences for the location of wind turbine farms in the Eastern Cape. (Unpublished Masters Dissertation). Port Elizabeth: NMMU.

HOSKING, SG (2011). Investigating the Mechanism and Processes Used in Setting Water Services Tariffs WRC Research Report 1871/1/11.

HOSKING, SG & JACOBY K (2013). Trends in the insight into the growing South African municipal water service delivery problem. WRC Research Report 2087/1/P/13.

HOSKING, SG & NORDEN R (2013). Perspectives on the market processes followed in setting South African water services tariffs. WRC Research Report 2087/2/13.

KJAER, T., 2005. *A review of the discrete choice experiment – with emphasis on its application in health care*. Health economics papers. University of South Denmark.

KLAIBER, H. & VON HAEFEN, R., 2008. *Incorporating Random Coefficients and Alternative Specific Constants into Discrete Choice Models: Implications for In-Sample Fit and Welfare Estimates*. Department of Agricultural and Resource Economics. North Carolina State University.

KLEIN, L., 1962. *An Introduction to Econometrics*. Englewood Cliffs, NJ: Prentice-Hall.

KLING, C. & THOMSON, C., 1996. The Implications of Model Specification for Welfare Estimation in Nested Logit Models. *American Journal of Agricultural Economics,* 78 (1):103-114.

KOPONEN, P., MAKI-OPAS, J. & TOLONEN, H., 2011. *Survey design and administration*. EHES Manual. National Institute for Health and Welfare. Helsinki: Finland.

KOPPELMAN, F. & BHAT, C., 2006. *A self-instructing course in mode choice modelling: multinomial and nested logit models*. U.S. Department of Transportation. Federal Transit Administration. [Online]. Available: http://www.ce.utexas.edu/prof/bhat/COURSES/LM_Draft_060131Final-060630.pdf [Accessed 12/06/2012]

KRAGT, M. & BENNETT, J., 2008. *Developing a survey for valuing changes in natural resource management in the George catchment, Tasmania*. Environmental Economics Research Hub Reports. Australia: Crawford School of Economics and Government. Australia.

KRINSKY, I. & ROBB, A., 1986. On Approximating the Statistical Properties of Elasticities. *Review of Economics and Statistics*, 68 (4): 715-719.

KUHFELD, F., 2010. *Marketing research methods in SAS. Experimental Design, Choice, Conjoint, and Graphical Techniques*. SAS 9.2 Edition. MR-2010. [Online]. Available: http://support.sas.com/techsup/technote/mr2010title.pdf [Accessed 10/11/2012].

LANCASTER, K. J., 1966. A New Approach to Consumer Theory. *Journal of Political Economy* 74: 132-157.

LEE, D., 2012. Willingness-to-pay for and guide management of estuarine recreational services. An Application of the choice experiment method. (Unpublished Doctoral Thesis). Nelson Mandela Metropolitan University. Port Elizabeth, South Africa.

LOUVIERE, J., HENSHER, D. & SWAIT, J., 2000. *Stated Choice Methods, Analysis and Applications*. Cambridge University Press. [Online]. Available: http://assets.cambridge.org/97805217/82753/copyright/9780521782753_copyright.pdf [Accessed 15/02/2012].

LOUVIERE, J., FLYNN, T. & CARSON, R., 2010. Discrete choice experiments are not conjoint analysis. *Journal of Choice Modelling*, 3 (3): 57-72. [Online]. Available: http://www.econ.ucsd.edu/~rcarson/papers/LFCJofCM10.pdf [Accessed 16/10/ 2012].

MCFADDEN, D., 1974. Conditional Logit Analysis of Qualitative Choice Behaviour. *In* Zarembka, P. (Eds.). *Frontiers in Econometrics.* New York: Academic Press.

MCFADDEN, D., 2001. Economic Choices. *American Economic Review*, 91(3): 351-378.

MCFADDEN, D. & TRAIN, K., 2000. Mixed MNL models for discrete response. *Journal of Applied Econometrics*, 15 (5): 447-470.

MAS-COLELL A., WHINSTON MD. & BREEN JR., 1995. *Microeconomic Theory*. Oxford: Oxford University Press.

MAZZANTI, M., 2001. *Discrete Choice Models and Valuation Experiments*. An Application to Cultural Heritage. Siep: University of Rome.

OLIVER, C., 2010. Comparing a contingent valuation of the river inflows into the bushman's estuary with a choice experiment valuation. (Unpublished Masters Dissertation). Port Elizabeth: Nelson Mandela Metropolitan University. South Africa.

SCARPA, R., FERRINI, S. & WILLIS, K., 2005. Performance of Error Component Models for Status-Quo Effects in Choice Experiments. *In* Scarpa, R., Alberini, A. (Eds.) *Applications of Simulation Methods in Environmental and Resource Economics.* Dordrecht: Springer. 247-273.

SHEN, J., 2005. *A review of Stated Choice Method*. Discussion Papers in Economics and Business: 5-27.

SNOWBALL, J. D., WILLIS, K. G. & JEURISSEN, C. 2007. Willingness to pay for water service improvements in middle-income urban households in South Africa: A stated choice analysis. Paper presented at Rhodes University.

WITTINK, D. & NUTTER, J., 1982. Comparing Derived Importance Weights Across Attributes. *Journal of Consumer Research*, 8: 471-474.

WITTINK, D., KRISHNAMURTHI, L. & REIBSTEIN, D., 1990. The Effect of Differences in the Number of Attribute Levels on Conjoint Results. *Marketing Letters*, 1 (2): 113-129.

SOFTWARE USED:
Limdep Nlogit 4.0
Microsoft Excel 2010
SPSS 12.0.1

Appendices

Appendix A: Design of the Survey

A.1 The design of the choice experiment questionnaire

Three CE survey instruments were designed for water service provision within three municipalities – Breede Valley, Msunduzi and Knysna. The Breede Valley Local Municipality falls under the Cape Winelands District Municipality in the province of the Western Cape, the Msunduzi Local Municipality falls under the Umgungundlovu District Municipality in the province of KwaZulu-Natal, and the Knysna local municipality falls under the Eden District Municipality, in the province of the Western Cape.

Initially, the questionnaire design was guided by those of other similar studies undertaken elsewhere. Later, modifications were incorporated over several months, based on insights gained through e-mail correspondence, informal discussions with officials from the relevant personnel from the municipal water servicing sections and others, reference group comment, pilot studies and focus group discussions.

Selected design features of the final questionnaire adopted (see Appendix B) are discussed below.

A.1.1 The inclusion of a status quo or 'opt-out' option

A key design issue was over how to include the status quo in the questionnaire. A large number of valuation studies advocate the inclusion of a status quo or 'opt-out' alternative. Literature suggests that if one is not included, the respondent is forced to pick a scenario that is not necessarily favoured. The inclusion of a status quo or 'opt-out' option, is not always recommended (Qin, 2008). It can create new biases (Scarpa *et al.*, 2004). It also provides an 'easy way out' for respondents if they want to avoid the choice task (Dhar & Simonson, 2001; Kontoleon & Yabe, 2003). It might also be impossible to include a status quo alternative if the current or base scenario has become irrelevant or unfeasible as an option (Adamowicz & Boxall, 2001).

For the purposes of this study, a status quo alternative was included as an option but not a stand-alone one.

A.1.2 Number of choice sets per respondent

The number of choice sets that each respondent must face is considered to be inversely proportional to the complexity of the task at hand (Bateman *et al.*, 2002). There are three qualitative attributes with three levels each, and one cost variable with three levels. This number represents a fairly low task complexity, but the effects of task complexity were not investigated in this study. Many studies recommend a maximum of six choice sets be presented to a respondent (Hasler *et al.*, 2005; Bateman *et al.*, 2002), in order to make the choice task manageable and not cognitively burdensome.

A.1.3 Experimental design

The water consumers in each municipality were presented with choices among levels of four attributes. For each attribute there were three levels. Given the conservative number of attributes and levels chosen, a full factorial design (3x3x3x3 = 81) could be generated using SPSS, yielding 81 different treatment combinations or alternatives. These alternatives were randomly allocated to 81 different questionnaires containing 4 choice sets each. Each choice set had two alternatives, the aim being to reduce the choice task to as simple terms as feasible.

A.1.4 The budget constraint and the inclusion of "cheap talk"

Even though the effects of "cheap talk" within a CE context are inconclusive, it was decided to include a short "cheap talk" section in the design of each questionnaire. The length of the "cheap talk" section included in the questionnaires was only a couple of lines. It was felt that the inclusion of an extensive "cheap talk" section was inappropriate, since it was expected that the negative impacts of increasing the length of the questionnaire would by far exceed the potential benefits arising from the inclusion of a lengthy "cheap talk" section.

In the questionnaires, information on the CE payment was specified so that the respondents were aware of the payment vehicle, as well as the need to consider the constraints on the households' budget.

A.1.5 Additional questions

In the questionnaires, immediately after the choice task four questions were asked regarding respondents' experience of the choice exercise and how they made their choices. The first of these questions (Question 4.1) asked whether the respondents found it easy or difficult to make the choices in the choice sets (Question 3). The aim of this question was to elicit feedback on the reliability of their choices. If respondents indicated that the choice task was difficult, i.e. answered 'Yes' to Question 4.1, they were subsequently asked in Question 4.2, what had made the choice tasks difficult for them.

The answers respondents provided to this question were not intended for data modelling inclusion. One of the statements included as an option, namely, "It was difficult to choose as several factors were important", served to establish the validity of respondent choices, in the sense that it provided opportunity to reveal the application of a compensatory decision-making strategy. Question 4.3 asks the respondents which of the four attributes they put greatest weight on when choosing between the different alternatives. There was also an opportunity for them to state whether it had varied from choice to choice. This question aimed to help identify if the respondent had followed a non-compensatory decision strategy, by focusing on the levels of one attribute only when making choices. If respondents' answered that they took all the attributes into consideration when making choices, the compensatory decision making assumption was most likely not violated (Watson *et al.*, 2004).

Question 4.4 was a policy-orientated question. This question was included as a quasi-validity test.

A.1.6 Socio-economic status questions

Six questions relating to the respondent's socio-economic status were asked in the questionnaires. These questions asked about the respondent's gender, age, place of residence, occupation, household income and educational attainment. The socio-economic and water use information was gathered for the purpose of modelling choice in terms of these variables. As discussed in Chapter One, a section of follow-up questions should be included after the choice task. The follow-up questions for all three municipalities are very similar.

A.2 Water Service concerns as elicited from a pilot study and focus group discussions

A.2.1 Defining the issues from a demand perspective in terms of attribute levels that influence choice

Pilot studies and focus group discussions are an important stage of a CE analysis. They inform the analyst which management challenges need to be addressed. Two pilot studies were undertaken in 2011. One was of 70 residents of the Kouga Local Municipality and another was of 70 businesses of the Nelson Mandela Bay Municipality. The results of these studies were reported in WRC Research Report 1871/1/11. In addition to the pilot studies, specific focus group discussions were held with water service receiving customers in the three targeted municipalities – the Breede Valley, Knysna and Msunduzi.

A.2.2 Key pilot study results and insights gained

The pilot study design of the water service choice experiment was influenced by literature on choice experiments which argue for reduced numbers of attributes and levels and reducing the complexity of the decision making task facing the respondent. An unlabelled design was adopted in which the options were translated into a choice format the user/chooser would find easy to follow.

The pilot studies identified five attributes as being currently important to the relevant users – sewerage disposal, quality of water, security of supply, interruptions to service and rate of flow (water pressure). Two conditional logit models were fitted to the data and yielded mostly significant coefficients. From these model estimates, willingness to pay trade-offs were calculated for what were relevant level improvements among the Kouga Local Municipality residents and businesses in the Nelson Mandela Bay Municipality (NMBM) are shown (Table A.1)

Table A.1: Marginal willingness to pay (WTP) for marginal improvements in water services

Variable	WTP per month (R) per increase in attribute level	
	Kouga residents	NMBM business owners
Sew disposal	57.29	35.93
Quality of water	65.05	62.26
Security	21.90	35.68
Interruptions	9.83	5.51
Rate of flow	-2.77	8.92

The willingness to pay for a marginal improvement in sewerage disposal within the Kouga municipality was R57.29 per month; the relevant marginal improvement being from:

"*many areas affected by disposal and spills of sewerage into the environment*",

to

"*only isolated areas affected by disposal and spills into the environment*".

By way of contrast, the NMBM business owners were willing to pay R35.93 per month for the same marginal improvement.

The quality of water was an attribute both the Kouga residents and NMBM business owners were prepared to pay even higher amounts than this for marginal improvements. Both groups were willing to pay over R60 per month for level improvements.

Improved security of supply was also an attribute that both sets of users were willing to pay highly for per month, R21.90 in the case of the Kouga residents and R35.68 in the case of the NMBM businesses.

The experiment yielded inconclusive values for the rate of flow and interrupted flow attributes. The results shown in the shaded cells are statistically insignificant and included for completion rather than interpretive purposes. A positive willingness to pay could be calculated for less interruption in water flow, but the values were low and findings statistically insignificant. The results suggest that businesses within the NMBM valued rate of flow (water pressure), but not as much as they did the other attributes, but nothing could be concluded in connection with this attribute from the responses of the residents of the Kouga municipality.

The results of the pilot study were taken to indicate that appropriate attributes of water service delivery had been identified, but the following lessons were learned.

(1) There were too many were included and the differences between levels were insufficient in some cases. It was decided that the number of attributes should be reduced to four, each with three levels, and that one of the attributes should remain the tariff charged (so relevant marginal WTP trade-offs could be calculated)

(2) One of the municipal managers in a results feedback session, argued that the levels of some attributes, such as water quality, were not really subject to discretionary variation, but that there was more scope for discretionary variation in delivery convenience attributes. It was decided to not only consider focus group importance weighting as a reference for attribute and level selection, but also level of service variation of interest to the municipal managers of the water service.

(3) The choice experiment analysis could be made more interesting if it were made for each major socio-economic or water service customer group. Three were identified – low income, high income and business firm.

A.2.3 Focus group discussions

Focus group discussions among selected (invited) water service users were held at all three municipalities. At each municipality a local users was selected to assemble and lead the focus group discussion, but the discussion took place within a structured framework of information supplied by a member of the project team about the intention of the exercise and completion of a questionnaire. The key question addressed was what the key attributes were of water service that the different members of the municipality would be prepared to pay for and of these which were the three most important excluding the tariff charged. Water service municipal managers were also asked what attributes and levels they would like to see presented in the questionnaire.

The example of the Breede focus group discussion results is provided below. Similar findings were elicited from other focus group members in the other two municipalities. Leading the Breede Valley focus group discussion was Bridget Zietkiewicz, while leading the Knysna focus group discussion was George Dimopoulos and leading the Msunduzi focus group discussion was Kieth Olivier, all long established and well-connected water service customers and residents in the respective municipalities. Based on these discussions, and those with relevant municipal water service managers, the attributes listed in Table A.2 were deemed currently relevant.

Table A.2: Relevant attribute options for the three municipalities

(1) Security of supply (to coverage of 1 in 20, 1 in 50 or 1 in 100 year droughts) (2) Blue drop status (potable water safety) or not (3) Beyond Blue drop – potable water taste, colour and smell – improve more (4) Green drop status (waste water disposal safety) or not (5) Beyond Green Drop – e.g. reduced unpleasant odour from sewage works or as is (6) Delivery Convenience - 24 hour supply into home service scheduled or less - Water pressure to meet fire-fighting requirement or less (7) Charitable service: - support not metering/charging in defined poor areas (mostly Free basic service) (8) Marketing effort (customer sensitivity) vs take-it-or-leave-it approach to pay-for-service customers by municipality

(9) Supplementation of Fluoride concentration (to 0,7mg/l to improve dental health of children) or not (10) Industrial water options (non-consumptive recycled water) – agric., cooling (11) Other...

The Breede Valley Focus Group met in March 2012. It comprised of the eight members:

Mr Beukes, Breede Valley Municipality, jbeukes@bvm.gov.za, tel 023-3482625

Mr W Faas, Department of Health, tel 023-3484151

Mr ZN Maphingana, Breede Valley Municpality, zmaphingana@bvm.gov.za, tel 023-3482732

Mr R Ontong, Breede Valley Municpality, rontong@bvm.gov.za, 023-3482804

Mrs J van der Merwe, Resident, jackivdm@telkomsa.net, tel 087816282

Mr D Baxter, Resident, dave.baxter1945@gmail.com, tel 0823301945

Miss C Nowasha, Resident, tel 0846460289

Ms B Zietkiewicz, Guesthouse owner (The Habit), 0824441286

They not only identified the10 attributes listed in Table A.2 as important and providing the scope for improvements, they also ranked them in current importance (see Table A.3).

Table A.3: Worcester Focus group ranking of attributes, excluding cost (resident and business combined)

Member → Attribute ↓	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Overall rank**
Security	6	5	3	7	7	7		5	
Blue	1	1	1	4	1	3	1	1	1
Blue +	3		5	1	3	1	2		
Green	2	3	2	6	5	1	4	7	2
Green +	7				4	4	3	1	
Delivery convenience	4	6	6	3	2	6	5	1	3
Charity		4	4					1	
Marketing				2		5	7		
Fluoride		2		5	6		6	5	
Industrial options	5	7	7						

The other two municipality focus group discussion yielded different rankings, but the overall (combined) pattern of ranking replicated the Breede Valley one. Three non-cost attributes consistently ranked as relevant by all members of the focus group (Table 1) were Blue Status, Green Status and Delivery Convenience. Industrial options were not rated as crucially important (top three) by any of the members of the group. Based on this guidance, the same choice experiment was formulated for both residential users and another for firms, with minor differences for the three municipalities, and minor differences between residents and businesses; mainly differences related to the relevant tariffs charged. An example of the Breede Valley questionnaire is provided in Appendix B.

A.3 Sample Design

The sample design objectives were to be representative and randomly selected as was possible. This was achieved by intercept method from randomly selected streets drawn from the different group locations, low income, high income and business. No aggregation objectives were pursued in, or informed, this design. Details of the respondents captured in the various samples are described in Chapter 3.

Appendix B: The Survey instrument administered – an example of the Breede Valley Local Municipality survey

Water Service Management in the Breede Valley local municipality

Survey of the resident's preferences and choices

Chief Researcher: Prof Stephen Hosking, Stephen.hosking@nmmu.ac.za, Tel: 041-5042638
A Water Research Commission project

Question1 :

What do you believe are the important responsibilities of the Breede Valley Municipality relating to water services?

Is it important for the Breede Valley Municipality to:		Important	Somewhat important	Somewhat unimportant	Unimportant	Not Sure
1.1	**Secure enough water to last through droughts**					
1.2	**Supply safe water to drink**					
1.3	**Ensure the safe disposal of waste water**					
1.4	**Provide 24 hour continuous supply of water**					
1.5	**Ensure that the water pressure is high enough to meet fire-fighting requirements**					
1.6	**Provide subsidised water to the poor**					

1.7 Would you be interested in a cheaper water service option that provided safe drinking water but at a lower delivery convenience, e.g. the supply of water was not continuous or the flow was reduced?

Yes ☐ Not Sure ☐
No ☐
Maybe ☐

1.8 Is the Breede Valley water tariff (cost price) structure fair and equitable?

Yes ☐ Not Sure ☐
No ☐
Maybe ☐

1.9 Does the municipality try to find out which water services (safety of water, disposal and delivery convenience) you are willing to pay for (demand) when they provide the water to you?

Yes ☐ Not Sure ☐
No ☐
Maybe ☐

1.10.a. Please indicate how happy you are with the water services you currently pay for and receive:

Satisfied (I am happy with the water services I receive). ☐

Unsatisfied (I am unhappy with the water services I receive). ☐

ONLY FILL IN IF UNSATISFIED:
1.10.b. If you are unsatisfied, is it because you would prefer to:

Pay more for a better quality of service ☐

Pay the same and receive a better quality of service ☐

Pay the same and receive the same service ☐

Pay less for the services that I currently receive ☐

Pay less and receive a reduction in the water services I currently receive ☐

Other:……

1.11 Do you believe that the value you get out of water services would improve if a private company were to provide these services instead of the Breede Valley municipality?

Yes ☐ Not Sure ☐
No ☐
Maybe ☐

1.12 Which is the best way to set the price (tariff) of water in your opinion?

A fixed overall **availability charge** levied on all consumers regardless of income or water consumption (prices changes according to availability of water). ☐

A **flat tariff** per kilolitre of water services provided, levied on all households (everyone pays the same amount for water). ☐

An **increasing block tariff** per kilolitre, tariff increases as the consumption of water per household increases (the current tariff situation). ☐

A **decreasing block tariff** per kilolitre, tariff decreases with increasing water consumption (cheaper rate at higher volumes). ☐

<u>Question 2:</u>

2.1 Do you receive water services from the Breede Valley Municipality?

Yes ☐

No ☐ Where do you get water from?..

2.2 Who do you pay for the water services you receive?

I don't pay (it's free) ☐

Breede Valley Municipality ☐

Someone else ☐

I don't know ☐

2.3 Which of the following is true about the drinking water services that you receive?

a. The water is always safe to drink	True ☐	False ☐
b. The water in clear (not murky)	True ☐	False ☐
c. The water has a pleasant taste and smell	True ☐	False ☐
d. The pressure in the pipes is strong	True ☐	False ☐
e. Water restrictions are sometimes imposed	True ☐	False ☐

2.4 Which of the following is true about the waste water services you receive from the Breede Valley municipality?

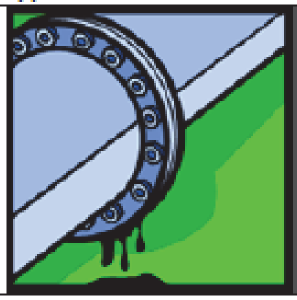
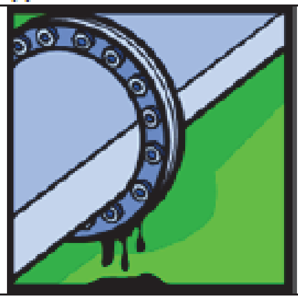
a. The waste water is consistently safely sanitised	True ☐	False ☐
b. There are leaks of waste water (sewage)	True ☐	False ☐
c. The infrastructure to sanitise waste water is not up to scratch	True ☐	False ☐

2.5 Have there been any changes to the water service you have received from the Breede Valley municipality during the past 2 years?

The quality of the service has improved	True ☐	False ☐
The quality of the service has not changed	True ☐	False ☐
The quality of the services has deteriorated	True ☐	False ☐

Other: ………

Choice Card

Attributes	Option A	Option B
Water pressure	 The water pressure is strong (enough to meet fire fighting requirements)	 The water pressure is weak (fire fighting requirements are not met and washing machines will not work)
Interruptions in water supply	 Water services will only be supplied for 6 hours each day	 Water services will only be supplied for 15 hours each day
Sanitation Safety	 There is a risk of occasional leaks of unsanitised waste water into the environment (current situation)	 There is a risk of occasional leaks of unsanitised waste water into the environment (current situation)
Cost	30% increase = R4.38 more per kl of potable water 	No additional payments or reductions in cost of water services will be incurred 
Selection	A	B

Question 4:

4.1 Did you find the choices easy or difficult to make?

Easy ☐

Difficult ☐

I don't know ☐

4.2 If you answered "Difficult" in question 4.1, what made the choices hard?

I did not understand the questions ☐

There was too much information ☐

There were too many important factors to consider ☐

I don't think consumers should have choices in water services ☐

The choices were not realistic ☐

Other: …….

4.3 Which item (if any) was most important to you when you made the choices?

The importance of each item was different for each choice I made ☐

The safety of the drinking water ☐

Sanitation safety ☐

Delivery convenience ☐

Size of tariff ☐

Other: ……….

4.4 If you were offered a water service package with lower water pressure and some interruptions in flow at a lower cost per kilolitre than you pay for at the moment, would this be an attractive option for you?

Yes ☐

No ☐

Maybe ☐

Not Sure ☐

Question 5:

5.1 Gender of respondent: Male ☐ Female ☐

5.2 Age of respondent: ……..

5.3 Where do you live in the Breede Valley Municipality (suburb)?……………………………………………………

5.4 Occupation of respondent: …………………………………………………………………………………………………

5.5 What is the size of your household's total annual gross income?

<u>Please note: this is all income for every member of your household before tax.</u>

Less than R50000 ☐
R50 000 – R99 999 ☐
R100 000 – R149 999 ☐
R150 000 – R199 999 ☐
R200 000 – R249 999 ☐
R250 000 – R299 999 ☐
R300 000 – R349 999 ☐
R350 000 – R399 999 ☐
R400 000 – R449 999 ☐
R450 000 – R499 999 ☐
R500 000 – R749 999 ☐
R750 000 – R999 999 ☐
R1 000 000 and above ☐

5.6 Education of respondent:

No education ☐
Primary School ☐
Secondary School ☐
Matriculation ☐
Technikon diploma ☐
University degree ☐
University Post graduate degree ☐

Capacity Building

Table C.1: Capacity building through Project K5/2087

Student name	**Employment**	**Degree (year awarded)**	**Title of thesis**
Kevin Jacoby	Chief Financial Officer, City Of Cape Town, Cape Town	M Com (2013)	The growing South African Municipal Water Service Delivery Problem
Ryan Norden	Lecturer, Walter Sizulu University, East London	M Com (2013)	Perspectives on the market processes followed in setting South African water services tariffs
Jessica Hosking	Student, Nelson Mandela Metropolitan University	PhD (not yet submitted – more material to be added)	Applying choice modelling as a guide to the provision of water services in South Africa