

Kloos, Julia; Tsegai, Daniel W.

**Working Paper**

## Preferences for domestic water services in the Middle Olifants sub-basin of South Africa

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Julia Kloos,  
Daniel W. Tsegai

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**Preferences for domestic  
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Walter-Flex-Strasse 3

D – 53113 Bonn

Germany

Phone: +49-228-73-1861

Fax: +49-228-73-1869

E-Mail: [zef@uni-bonn.de](mailto:zef@uni-bonn.de)

<http://www.zef.de>

**The authors:**

**Julia Kloos**, Center for Development Research (ZEF), University of Bonn, Germany  
(contact: [jkloos@uni-bonn.de](mailto:jkloos@uni-bonn.de))

**Daniel W. Tsegai**, Center for Development Research (ZEF), University of Bonn, Germany  
(contact: [dtsegai@uni-bonn.de](mailto:dtsegai@uni-bonn.de))

# Preferences for domestic water services in the Middle Olifants sub-basin of South Africa

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# Preferences for domestic water services in the Middle Olifants sub-basin of South Africa

## Abstract

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Using household survey data, this study investigates preferences for domestic water services in the Middle Olifants sub-basin of South Africa. Water is a relatively scarce resource in South Africa that is distributed unevenly both geographically and seasonally as well as socio-politically. For a water management addressing the policy objectives of efficiency in use, equity in access and benefits and long-term sustainability, economic valuation of the different water uses is required. In order to detect households' preferences, a choice experiment of the various water services was conducted. Results suggested the presence of preference heterogeneity and therefore, a latent class model was applied, dividing households into homogeneous groups according to their preferences. Four distinct groups of households could be identified which differ significantly in terms of their socio-economic characteristics, their attitudes toward pricing of water and their satisfaction with current water service levels. Willingness to pay (WTP) estimates of different water service characteristics in all groups indicate that households are willing to pay higher prices for a better and more reliable water services provision. But the amount households are willing to pay differs among the groups. This information is helpful for policy-makers to enable the design of water services in the Middle Olifants according to preferences of local households. Besides, WTP estimation can provide a basis for setting water tariffs.

## Kurzfassung

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In dieser Studie werden Präferenzen für die Wasserversorgung und damit verbundener Dienstleistungen im Flusseinzugsgebiet „Mittlerer Olifant“ untersucht. Wasser ist eine sehr knappe Resource in Südafrika, die sowohl geographisch und zeitlich als auch sozio-politisch ungleich verteilt ist. Zu einem erfolgreichen Wassermanagement im Hinblick auf eine sozial und ökonomisch optimale Wassernutzung und auf lange Sicht nachhaltigem Umgang mit den vorhandenen Wasserressourcen ist u.a. eine ökonomische Bewertung der verschiedenen Wassernutzer notwendig. Um Präferenzen für die Nutzung unterschiedlicher Dienstleistungen feststellen zu können, wurde ein „Choice-Experiment“ durchgeführt. Bei der Analyse der damit generierten Daten wurde festgestellt, dass Haushalte unterschiedliche Präferenzen haben. Um dieses abbilden zu können, wurde ein „Latent Class“ Modell verwendet, welches Haushalte entsprechend ihrer Präferenzen in homogene Gruppen oder Klassen einteilt. Damit konnten vier klar trennbare Klassen entdeckt werden, welche sich signifikant in ihren sozio- ökonomischen Charakteristika sowie ihrer Einstellung gegenüber einer Einführung von Preisen für die Wasserversorgung und ihrer Zufriedenheit mit der gegenwärtigen Wasserversorgung unterscheiden. Die Zahlungsbereitschaft für die Änderungen einzelner Bereiche der Dienstleistungen zur Wasserversorgung wurde separat für jede einzelne Gruppe berechnet. Diese Zahlungsbereitschaft zeigt, dass Haushalte im „Mittleren Olifant“ durchaus bereit sind, für eine verbesserte Versorgung mit Wasser zu zahlen. Die Höhe der Zahlungsbereitschaft variiert allerdings je nach Gruppenzugehörigkeit. Diese Erkenntnisse sind wichtig für die politischen Entscheidungsträger in Südafrika, da sie es ermöglichen, die gegenwärtige Wasserversorgung entsprechend den Präferenzen der Haushalte anzupassen. Zudem kann die berechnete Zahlungsbereitschaft die Festsetzung von Wasserpreisen wesentlich erleichtern.

# Preferences for domestic water services in the Middle Olifants sub-basin of South Africa

## 1 Introduction

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The Olifants River basin in South Africa is a semi-arid region which includes water user groups like growing industrial zones, rapid and uncontrolled growing settlements, large and small-scale farming with irrigation activities as well as power plants. It is the third most water stressed basin in South Africa (DWAF, 2004). The Olifants River is of special ecological importance because it enters the Kruger National Park. Severe overexploitation of water resources at the expense of the maintenance of ecological functions and the availability of water for basic human needs occurs in the Middle Olifants - a sub-basin of the Olifants River basin. Especially the predominant rural population in the sub-basin are still disadvantaged in their access to potable water for domestic purposes (Levite and Sally, 2002; DWAF, 2004).

The South African water policy was fundamentally reformed and under the new water law, new institutions have been established in all water management areas. They are responsible for water resource planning at the catchment level. Water resources management in these areas is supposed to address the new policy goals of equity in terms of access to and benefits from water, economically optimal water uses and long term sustainability including ecological functions. Since current water use practices do not fulfil these requirements, a reallocation of water from low to high value uses and in a way that promotes social equity and sustainability is needed. Despite the recognition that water is an economic good (Dublin principles), the prevailing approach to water allocation in South Africa is primarily administrative. In other words, it is based predominantly on the relevant administration to allocate water in order to reach the above policy goals (PDG, 2004). Due to the complexity caused by physical, economic and socio-economic dependencies, research in order to assist the new institutional settings which provide information on an economic valuation of all water uses at the catchment level is essential.

To date, only a few studies aiming at the economic valuation of (mostly urban) domestic water uses in South Africa (Goldblatt, 1999; Banda et al., 2007; Veck, 2000; Jansen and Schulz, 2006) have been conducted. Furthermore, data concerning water prices and respective quantities used for domestic purposes is rarely available (see Jansen and Schulz, 2006 for an application in Cape Town) and especially for basic water services such as public taps or boreholes, neither prices nor any measurement of quantities exist. Thus, non-market valuation techniques such as Contingent Valuation, Travel Cost Method, Hedonic Pricing and Choice Experiments needed to be used (Veck, 2000). Goldblatt (1998) showed a frequency distribution of WTP in cents per 25 liters and for monthly payment in Rand<sup>1</sup>/month. About 26% of the people were willing to pay 30-40 cents/m<sup>3</sup>, 20% between 20 and 30 cents/m<sup>3</sup> and 16% less than 20 cents/m<sup>3</sup>. Banda et al. (2007) applied the Travel Cost Method in combination with Contingent Valuation in the Steelpoort sub-

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<sup>1</sup> Rand is the South African currency (1 USD = 8.39 Rand, May 2009)

basin of the Olifants and discovered that households using public taps are willing to pay (WTP) 4.03 Rand/m<sup>3</sup> and households using river water 6.15 Rand/m<sup>3</sup> for improved availability and improved quality. Farolfi et al. (2007) measured WTP in Swaziland and reported WTP for a higher quantity to fall between 6.82 SZL and 7.13 SZL<sup>2</sup> per month. Two studies were conducted so far to detect preferences for different water sources and water services in South Africa (Hope and Garrod, 2004; Snowball et al., 2007). Hope and Garrod (2004) did not aim at estimating WTP and thus did not include price as an attribute. Snowball et al. (2007) analyzed preferences using a choice experiment in Grahamstone West (South Africa) focusing on WTP toward water quality issues, breakdowns and water pressure.<sup>3</sup> The Choice Experiment (CE) approach was chosen for economic valuation of water services.

The paper is organized as follows: chapter two gives an overview of the water policy reform in South Africa and describes the economic and institutional settings in the relevant area—the Middle Olifants sub-basin. Chapter three presents the methodology and gives some background information on the applied choice experiment and the employed discrete choice models for analysis purposes. Results are summarized in chapter four and final conclusions are drawn in chapter five.

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<sup>2</sup> SZL (stands for Swaziland Lilageni) is the official currency for Swaziland (1 USD = 8.47 SZL, May 2009)

<sup>3</sup> So far, it has been applied quite a few times to economic valuations of water services (Hensher et al., 2005; MacDonald et al., 2005; Yang et al., 2006; Nam and Son, 2004).

# Preferences for domestic water services in the Middle Olifants sub-basin of South Africa

## 2 Study area

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### 2.1 Water policy reform in South Africa

Under the South African Apartheid Regime, water policy aimed at the use of water to strengthen economic growth in the country rather than enhancing the population's access to water (Goldin, 2005). Water rights were provided according to the riparian principle so that right and access to water were linked to the property of land. But through a series of land related laws, 87% of the country's land was set aside for the white population (Turton et al., 2004; Page 354). Most municipalities and townships provided water services to the residents, but at lower standards to the black population than to whites. As these inequalities - not only with regard to water- became more and more obvious, withholding of payments (usually at monthly rates) for water (and also for other municipal services) by black communities became an effective form of protest against the apartheid regime in the 1980s (McDonald, 2002). The government still continued to supply water to those communities to prevent the former political tension from increasing. Due to this, a "Culture of Non-payment" for services evolved in South Africa (King, 2004, Goldin 2005).

With the introduction of democracy to South Africa in 1994, improving and equalizing living conditions of the black population were among the main objectives of the new government. A far-reaching reform process of the whole water sector was strived for. The major stages of water policy development in South Africa were - including constitutional developments - the development of the Water Law Principles (1996), the White Paper on National Water Policy for South Africa (1997), the National Water Act (1998) and their implementation through the National Water Resource Strategy (2002) (de Coning and Sherwill, 2004). The Water Law Principles were further developed and formulated as the "White Paper on National Water Policy for South Africa". The Water Service Act (1997) and the National Water Act (NWA) (1998) followed, which provide the legal framework of water use in South Africa. The Water Services Act (1997) guarantees the right to basic water and sanitation services to everyone. The government is committed to ensure an equal, efficient and sustainable provision of water and sanitation services. It defines roles for the new institutional setting, conditions for the provision of water, priority of securing water for drinking purposes against other uses, standards of water quality as well as norms and standards for domestic water tariffs. It promotes user charges to be based on the volume of water used wherever it is possible to represent full financial and economic costs of water supply (Hedden-Dunkhorst, 2005).

The National Water Act (1998) deals with the management of water as a national resource<sup>4</sup>. In this Act, water is considered as a national good, fulfilling social and economic functions. It gives comprehensive provisions for the protection, use, development, conservation, management and control of water resources (Backeberg, 2006). The NWA is based on four objectives: social equity, ecological sustainability, financial sustainability and economic efficiency. It promotes an integrated water resources management under a new decentralized institutional framework. Decisions fall under the competences of the local government, so that a greater participation in decision making processes is possible. The new institutions are the Catchment Management Agencies (CMA) and the Water User Associations (WUA) which are supposed to ensure an equal and beneficial water use for the benefit of all people (address poverty, generate economic growth and create jobs). Priority in water allocation is given to securing the “National Reserve”, which consists of the “Ecological Reserve” and a “Domestic Reserve” to meet basic human needs. The NWA also provides the legislative framework for the change from riparian water rights into a system of water licenses. This change dissolves the connection of land ownership and water access and, therefore, leads to the introduction of water use rights rather than the previous rights of ownership (property rights). Licenses are introduced to facilitate water allocation to the different water users. The Act allows for the imposition of water use charges and a restriction of water use to avoid overuse of water resources at the expense of the “National Reserve”.

Since 1994, the national Department of Water Affairs and Forestry (DWA) is responsible for the implementation of the new water policy. Decentralization aims at the provision of a sustainable and cost efficient management and allows for an easier participation of stakeholders in decision making and shifts responsibility from DWA to CMAs. Their tasks are to develop a catchment management strategy, organize licensing processes and monitor water use rights, impose charges, as well as monitor water quality. At the local level, WUAs as organizations of individual water users are in charge of the distribution of water and the representation of the interests of all water users (Hedden-Dunkhorst, 2005). According to the Water Service Act (1997), the institutional organisation of water and sanitation services is split up into different levels. At the local level, Water Service Authorities (WSA) and Water Service Providers (WSP) represent the main institutions involved in domestic water provision. To ensure a provision of water for basic human needs, the free basic water policy of the South African government was implemented in 2000. A provision with 25 liters per day and capita (l/dc) equivalent six kilo litres per household per month (an average household consists of eight people) free of charge was introduced. This amount of water is supposed to be provided from a water source in less than 200 meters from the dwelling. The free water policy should be financed through the combination of increasing block tariffs and re-distributed tax income (“Equitable Share”). Any quantity above the 25 l/dc is subject to water tariffs. Implementation of the free basic water policy is still missing in many areas.

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<sup>4</sup> The actual implementation of the Act is described in the National Water Resources Strategy (NWRS).

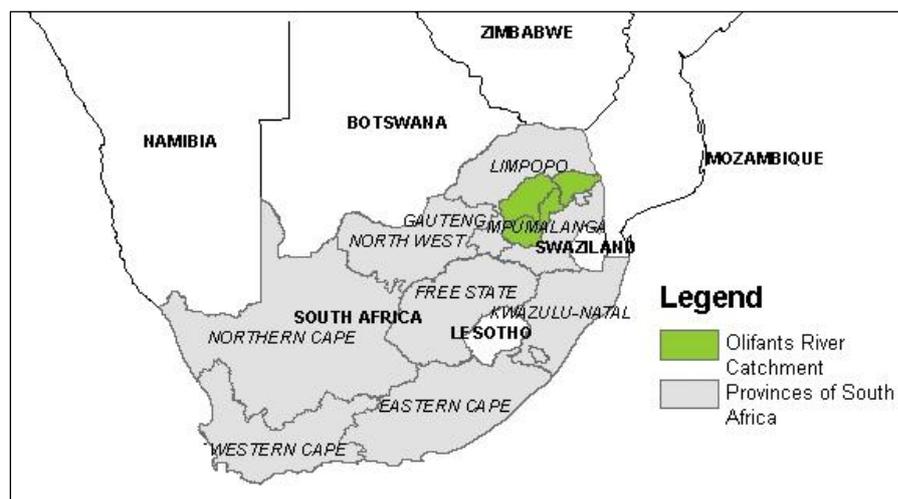
# Preferences for domestic water services in the Middle Olifants sub-basin of South Africa

## 2.2 Olifants River Catchment

### 2.2.1 Socio-economic conditions

The Middle Olifants is part of the Olifants River Catchment (54,000 km<sup>2</sup>), located north of Johannesburg and Pretoria. The Olifants River Catchment constitutes a Water Management Area (WMA) under the NWA (1998). It lies within administrative boundaries of the provinces Limpopo, Mpumalanga and Gauteng.

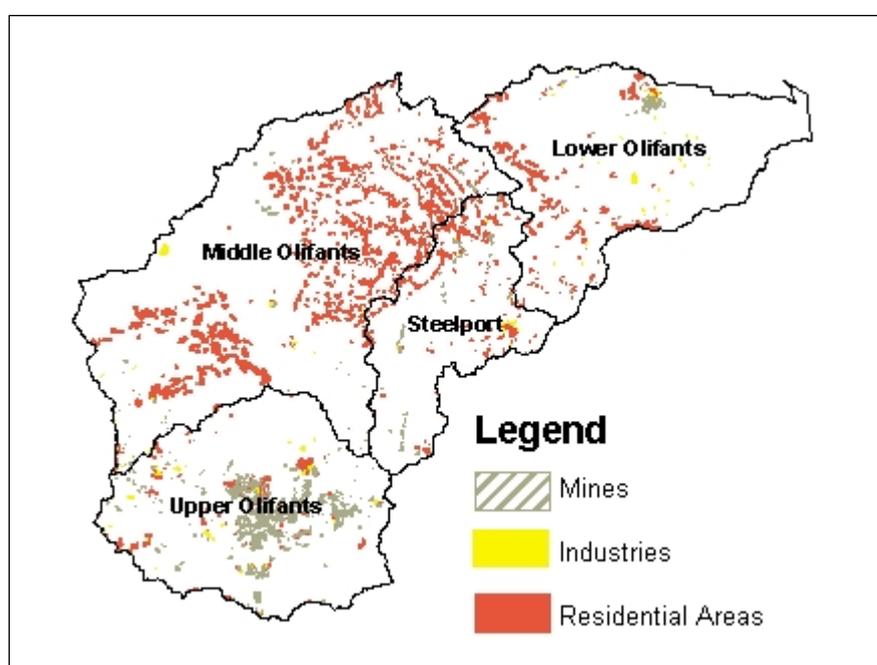
Figure 1: Olifants River Catchment



The Olifants River Catchment has a predominantly rural character, with 67% of the people classified as living in rural areas. The rural communities are concentrated in the former homeland areas Lebowa, KwaNdebele, Boputhatswana and Gazankulu (DWAf, 2003a). Former homelands constitute only 26% of the area but house 60% of the population (see figure 2) (van Koppen, 2008). As a consequence of past inequities, a large proportion of the basin's population is extremely poor and lacks access to basic services such as clean water and adequate sanitation (Ashton et al., 2003; Levite and Sally, 2002). Poverty is widespread among the population of the Olifants River Catchment with 32% of all households in the basin having no income at all. The annual incomes of another 30% of the households are less than 1 USD per day (SSA, 2003; Magagula, 2006 as cited in van Koppen, 2008). Besides, it experiences large-scale migration from rural areas to urban settlements. The unemployment rate of the residents was about 45% in 1994 - above the South African average of 29% (DWAf, 2003b). The most important sectors in terms of contribution to the Gross Geographical Product (GGP) of the Olifants are Mining (22.1%), Manufacturing (18.2%), Electricity (15.9%), Government (15.6%) and Agriculture (7%) in 1997 (DWAf, 2003a). Only 5% of the GDP of South Africa is generated in the Olifants.

Among the sectors, about 50% of the formally employed labour force is employed by the government, while 21% are involved in the mining sector and 19% in the agricultural sector (DWAF, 2003b). Land use consists mainly of irrigated and dry land farming and grazing. Close to 4,400 km<sup>2</sup> of the cultivable land is currently irrigated (DWAF, 2004). Almost all irrigation takes place in the commercial farming sector, which is dominated by white farmers possessing 95% of the irrigated area (Levite and Sally, 2002). Lowering groundwater tables and over extraction in these areas are reported (DWAF, 2004). There also exist a number of abandoned irrigation schemes, mainly small-scale schemes which are currently being reconstructed as poverty eradication initiatives.

Figure 2: Sub-basins of the Olifants River Catchment



### 2.2.2 Water resources and use

The Olifants River Catchment was divided into four sub-areas to facilitate adaption of the water management plans to local circumstances. The Middle Olifants sub-basin (22,550 km<sup>2</sup>) was selected as study area, because of its severe water imbalance caused by increasing water shortages (it is the most stressed sub-basin in the Olifants basin) and its variety of water using sectors. Also high inequalities in access to water are still prevailing (Levite and Sally, 2002). National research on economic valuation so far focused on different parts of the Olifants such as Steelport sub-basin (Hassan and Farolfi, 2005; Banda et al., 2007).

Most of the surface runoff originates from the higher rainfall in southern and mountainous parts of the Olifants River Catchment, with distinct surface drainage channels

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absent from the Spring-bok - a flat area in the north-west of the WMA (DWAF, 2003a). Several large dams have been constructed on the Olifants River and its tributaries, and surface water resources are already highly developed. Large quantities of groundwater are abstracted for rural water supplies throughout the water management area. The greatest use of groundwater occurs in the Middle Olifants sub-basin where most of the rural population lives and where large quantities of groundwater are needed for irrigation in the Springbok Flats area (DWAF, 2003a). Economic development and population growth produced increasing pressure to bear on the water resources of the Olifants River Catchment. Since available water is limited, intensive competition between the growing water user sectors emerged. In the catchment, agriculture (57%) is the largest water user sector, followed by power generation (19%) and domestic, industrial and mining purposes (19%) (DWAF, 2003a). Comparing availability and requirements per sub-basin, the water balance of the Olifants River Catchment reveals a severe deficit. The “National Reserve”, cannot be maintained as it is claimed in the NWA (1998) and zero flow in the dry season was already experienced in the Kruger National Park. In addition to that, severe water quality problems exist in certain areas due to the on-going and old-abandoned mining operations (Levite and Sally, 2002). Furthermore, operational problems leading to water shortages in the domestic sector in the Western Highveld area even reduce the available potable water. This imbalance between requirements of the NWA (1998) and the Water Service Act (1997) and the current situation in the Olifants River basin necessitates a water management that reallocates water.

Water must be used in an economically optimal way: efficient use (shift from low value to high value uses) combined with the achievement of social equity in access and sustainability of use. The current approach to a better allocation in South Africa is rather administrative than driven by market forces. It is predominantly the responsible institution (CMA) that deals with the allocation of water and the set up of prices. But economic information on water uses by different water users at the Catchment level is missing. Especially economic valuation of water in non-productive uses such as domestic water use is rather rare. Therefore investigation of the current water uses practices and economic valuations of all water users are essential for an improvement of the Water management. This paper seeks to contribute to the literature by providing a clearer picture of household water use habits and the value that they attach to different water services in order to encourage improvement of the current situation of water supply in the Middle Olifants. Other authors address valuation of the mining sector (see Linz and Tsegai, 2009) and costs of providing water in the Middle Olifants (see Tsegai et al., 2009).

### 3 Methodology

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A Choice Experiment (CE) is a type of stated preference method for economic valuation that arose from conjoint analysis (Louviere, 1988). In contrast to the latter, respondents do not rank or rate different alternatives, but are asked to choose one among several alternatives proposed to them. An important part in the choice construction process is the identification of the relevant alternatives and their respective characteristics (“attributes”) from which the respondent is supposed to choose the most preferred one. Choice experiments are analyzed using discrete choice models.

#### 3.1 Discrete choice models

Choice modelling is based on random utility theory. The basic assumption embodied in the random utility approach to choice modelling is that decision makers are utility maximizers, i.e., given a set of alternatives the decision maker will choose the alternative that maximizes utility. The utility of alternative  $i$  for individual  $n$  ( $U_{ni}$ ) is assumed to consist of a deterministic component ( $V_{ni}$ ) and a random error term ( $\varepsilon_{ni}$ ). It is assumed in general that they are independent and additive:

$$U_{ni} = V_{ni} + \varepsilon_{ni} \quad (1)$$

The deterministic component  $V$  consists of a vector of attributes  $X$  (of the choice experiment and, additionally, socio-economic variables) is often represented by the following linear form

$$V_{ni} = \beta'X_{ni} = \sum_k \beta_k X_{nik} \quad (2)$$

$k$  = number of attributes. A universal set of alternatives  $C$  exists, from which for each respondent available alternatives in a choice set  $C_n$  are relevant. The vector of coefficients  $\beta$  will be estimated statistically. Since the error term  $\varepsilon$  cannot be observed, choices cannot be predicted deterministically but probabilities have to be derived. Therefore, the appropriate econometric model is a discrete choice model expressing the probability that one alternative is chosen according to the assumption of utility maximizing behaviour of the individual (Train, 2003, page 18). Depending on the specification of this distribution, different discrete choice models arise. Multinomial Logit models (MNL) can be derived by assuming that the error term  $\varepsilon$  is Independently and Identically Distributed (IID) following an extreme value Type I distribution (also referred to as Gumbel-distribution). This implies the behavioural assumption of the

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Independence of Irrelevant Alternatives (IIA). That is, it is assumed that the relative probabilities of some alternatives being chosen are unaffected by the introduction or removal of other alternatives (Hausman and McFadden, 1984). Nested logit models are derived under the assumption of a type of generalized extreme value distribution. Probit models are derived under the assumption of a multivariate normal distribution and for mixed logit models it is assumed that one part of the distribution follows IID and one part can follow any distribution specified by the researcher. When the mixing distribution is discrete, the Latent Class (LC) model arises (Train, 2003, pages 18-21). MNL models assume - besides IID-Error terms- homogeneity among respondents; heterogeneity is very difficult to examine. This limitation can be relaxed to some extent by interacting individual-specific characteristics with selected choice attributes or by dividing the sample into sub-samples (e.g. high income- low income sub-sample to be analyzed separately). However, this method is limited because it requires an *a priori* selection of key individual characteristics and attributes and only involves a limited selection of individual specific variables (Boxall and Adamowicz, 2002). Besides, including interactions not accounted for in the experimental design may induce multicollinearity into the model (Louviere et al., 2000). One way of circumventing this difficulty is by estimating more advanced models such as the mixed logit or the LC model. Both models are able to account for heterogeneity in the deterministic component ( $V_{ni}$ ) but in different ways; mixed logit models assume different preferences for all respondents while LC models assume that some groups of respondents with more homogeneous preferences exist<sup>5</sup> (Boxall and Adamowicz, 2002; Hynes et al., 2008). Studies comparing the results of the two models suggest that none of them could be found to be unambiguously statistically superior (Provencher et al., 2002; Greene and Hensher, 2003; Provencher and Moore, 2006). In general, the LC approach is semi parametric; therefore, it does not require the analyst to make specific assumptions about the distributions of parameters across individuals, which the mixed logit model requires (Greene and Hensher, 2003). The LC model yields probabilities in each class. This means that although each respondent is assumed to belong to one class, uncertainty about a respondent's class membership is taken into account. Scarpa et al. (2005) and Provencher and Moore (2006) recommend the use of LC models when preferences are assumed to lie closely together or even cluster. Another reason for using the LC model is that the population is readily divided into homogeneous classes. For policy recommendations this classification is helpful, since policies can be designed for different classes of people. Especially if socio- demographic variables are important factors influencing class membership, knowing a person's socio-demographic variables helps understand his or her preferences and the likelihood to choose certain goods or services over others.

LC models are a sort of mixed models but their mixing distribution is finite compared to a continuous distribution for a mixed logit model. With number of groups of a LC model approaching sample size, the model comes close to the mixed logit model (Train, 2003). The simultaneous classification of respondents according to their characteristics and choice

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<sup>5</sup> An alternative approach is to investigate heterogeneity through the random component of utility using covariance heterogeneity model [Bhat, 1997].

behaviour into homogeneous groups (“classes”) of the population will be presented in the following. The utility of alternative  $i$  as attached to it by respondent  $n$  given class membership to class  $s$  can be calculated as follows:

$$U_{ni|s} = \beta_s X_{ni} + \varepsilon_{ni|s} \quad (3)$$

For each class a unique parameter vector  $\beta_s$  is estimated in order to accommodate for heterogeneity. Assuming that IIA holds within classes (so error term  $\varepsilon_{ni|s}$  is distributed IID and follows an Extreme Value Type I or Gumbel distribution) the probability of choosing alternative  $i$  being in class  $s$  becomes:

$$P_{ni|s} = \frac{\exp(\mu_s \beta_s X_{ni})}{\sum_{j \in C_n} \exp(\mu_s \beta_s X_{nj})} \quad (4)$$

According to equation 4, the scale parameters  $\mu_s$  are allowed to vary between classes, but are commonly assumed to equal 1. Class membership can be assigned to each respondent by the class membership likelihood function. The classification variables influencing membership can be socio-demographic variables, attitudes and perceptions or other motivational factors (so called concomitant variables or covariates)  $Z$  so that classes can be simultaneously built upon choice preferences and covariates. The class-membership likelihood function  $M$  for respondent  $n$  belonging to class  $s$  can be calculated as follows:

$$M_{ns} = \alpha \gamma_s Z_n + \zeta_{ns} \quad (5)$$

Assuming  $\zeta_{ns}$  to be IID and Extreme Value Type I distributed across individuals and classes, the probability of respondent  $n$  belonging to class  $s$  is given by:

$$P_n(s) = \frac{\exp(\alpha \gamma_s Z_n + \zeta_{ns})}{\sum_{s=1}^S \exp(\alpha \gamma_s Z_n + \zeta_{ns})} \quad (6)$$

With  $\gamma_s$  as class specific parameters,  $Z_n$  as covariates of the respondent and  $\alpha$  as scale parameters representing the scale across the class membership functions. The class-specific parameters express the influence of the covariates on the probability of belonging to a certain class. Since equation 4 was conditional on being in a particular class, the unconditional joint probability of a set of choices  $T(n)$  made by a respondent and that he belongs to class  $s$  is expressed as follows:

$$P(T(n)) = \sum_{s=1}^S * \left[ \left( \frac{\exp(\alpha \gamma_s Z_n)}{\sum_{s=1}^S \exp(\alpha \gamma_s Z_n)} \right) * \left( \prod_{t=1}^T \frac{\exp(\mu_s \beta_s X_{nit})}{\sum_{j \in C_n} \exp(\mu_s \beta_s X_{njt})} \right) \right] \quad (7)$$

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But the scale parameters  $\mu_s$  and  $\alpha_s$  are not identifiable and commonly assumed to equal 1 (Boxall and Adamowicz, 2002, page 426). With  $\alpha = 0$ ;  $\beta_s = \beta$  and  $\mu_s = \mu$  the LC model collapses back into the MNL model. The sample log-likelihood function that is maximized to obtain the parameters  $\beta_s$  and  $\gamma_s$  is given by (where  $I_i$  is an indicator variable for the observed choice)

$$L = \sum_n \sum_{i \in j} I_i \ln P(T(n)) \quad (8)$$

The set of choices  $T(n)$  made by respondent  $n$  is assumed to be independent of each other given class membership. This is equivalent to the axiom of local independence that means within a class, variables are assumed to be independent. In LC models, IIA assumption holds true within each class because the number of classes is increased until IIA is maintained. This is due to the fact that fewer classes would not yield the predicted choices between alternatives consistent with observed choices in the sample<sup>6</sup> (Vermunt and Magidson, 2005, page 13). Estimation of equation 8 is usually done using maximum likelihood. However, the LC model cannot be estimated unless the number of classes  $S$  is given. To detect the appropriate number of classes, Information Criteria are used instead of likelihood ratio tests. Likelihood ratio tests cannot be applied because the test-statistic is not asymptotically  $\chi^2$  distributed (Wedel and Kamakura, 2000, page 91). Since log-likelihood value decreases with increasing number of classes, the information criteria usually include penalty terms. The most commonly used information criteria are (Vermunt and Magidson, 2005):

- Akaike Information Criterion (AIK)
- Modified Akaike Information Criterion (MAIK or AIC3)
- Bayesian Information Criterion (BIK)
- Consistent Akaike Information Criterion (CAIC)

But despite the usefulness of the information criteria, the objective of the study and the interpretation of the class membership parameter estimates need also to be taken into account when determining the number of classes (Scarpa and Thiene, 2005; Hynes et al., 2008; Ruto et al., 2008). Applications of LC models in economics - mainly environmental economics- are found in the area of recreation demand done by Provencher et al. (2002), Boxall and Adamowicz (2002), Scarpa and Thiene (2005), Morey et al. (2006) and Hynes et al. (2008). Other approaches can be summarized under the topic of “landscape valuation”, for example, Milon and Scrogin (2006) and Edward et al. (2008). There are also applications dealing with valuation of animal breeds such as Scarpa et al. (2003) and Ruto et al. (2008). Applications in various fields are Hu et al. (2004), Scarpa et al. (2006), Kontoleon and Yabe (2006) and Chalak et al. (2008).

To our knowledge, the only application so far of a LC model dealing with preferences of residents for water services was conducted by Scarpa et al. (2005). They conducted two choice experiments analyzing preferences for so called “Service factors”: “Area flooding by sewage”,

“River quality”, “Nuisance from odour and flies”, “Cost of service” presented in the first experiment and “Water amenities for recreation”, “Quality of bathing water” and “Cost of service” in the second. Results of a mixed logit and a LC model indicate the presence of heterogeneous preferences, the LC model points to four distinct groups. Covariates for class membership were not included. At a later stage they estimated distributions of posterior WTP estimates for the different service factors. In their conclusions, the use of a LC model is favoured due to the fact that this segmented information potentially is more appropriate for water companies since it offers readily interpretable heterogeneity in terms of the classes which mixed logit does not (Scarpa et al., 2005).

### 3.2 Design of Choice experiment

CEs focus on the different characteristics or attributes of alternatives. When respondents compare alternatives with different attribute levels, they are forced to make trade offs and thus marginal rates of substitution between attributes can be isolated (Boxall et al., 1996). CEs are particularly useful when goods or resources have to be valued, which are multidimensional/multi attribute (consisting of many different characteristics, which are typically provided in combination with each other) and where the trade offs between the attributes are of particular interest. It is often more useful for policy-makers to know how specific changes in characteristics of a resource or service alter welfare than the presence or absence of a good as a whole (Hanley et al., 2001, Page 447). Since water services are typically comprised of various attributes such as frequency of the service, quantity and quality of water provided, reliability of the supply, occurrence of break-downs, distance to water source etc., they belong to multidimensional goods or services. South African water authorities often cannot provide a very good water service especially in the rural and poor areas, so information about how households’ trade-off different service attributes is very useful to design water services that fit to households’ preferences. CEs also avoid an explicit elicitation of WTP and instead work with expressed choices (Hanley et al., 2001). For these reasons given the situation of water services in the Middle Olifants, CE was selected as the appropriate method to reflect households’ WTP for improved services.

But CE also has some drawbacks. First of all, the method is quite cognitively demanding, especially when many choice sets are presented and they differ for lots of attributes and attribute levels. This might cause a use of ‘rule of thumb’ for choosing an option instead of solving the complex underlying utility function. Furthermore, with an increasing number of choice sets that have to be evaluated, learning and fatigue effects (Bradley and Daly, 1994) may occur. It is important for the researcher to identify all important attributes the good or service comprises of, since attributes and their levels, especially price levels, will impact on the calculation of welfare estimates (Hanley et al., 2001). Louviere et al. (2000) advise researchers to spend as much time and effort as possible in the set-up of the choice experiment and to clarify relevant attributes and

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<sup>6</sup> The information criteria would indicate a higher number of classes.

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levels in focus group discussions in order to make choices as realistic as possible (Louviere et al., 2000).

To address these drawbacks, the CE in the present survey was designed as simple and realistic as possible. No more than three levels were chosen for each attribute to avoid overstraining respondents. In addition to that, expert interviews, extensive pretesting and focus group discussions were conducted with the aim of providing respondents with the relevant levels and attributes of the alternatives later on in the experiment. A pilot study of 40 respondents was used to confirm the applicability of the choice experiment. The relevant attributes and levels of the CE are presented in table 1.

**Table 1: Attributes and levels of CE**

<i>Attributes</i>	<i>Levels</i>
FREQUENCY (days of supply per week)	5-6-7
CONSUMPTION (in liter per day and person)	50-100-150
RELIABILITY (hours of supply per day)	12-18-24
PRICE (in Rand/m <sup>3</sup> )	5-6-7
PAYMENT	Monthly-every 6 months- prepaid

The statistical software package SAS 9.1 was used to generate the experimental design of the choice experiment. Following Kuhfeld (2005) to reduce the design size, an optimal fractional factorial design was developed, which maximizes the amount of information that can be extracted from a design and minimizes correlation between attributes. The presence of multicollinearity in the experimental design was tested for using the method of auxiliary regressions (see Gujarati, 1995). The design was blocked into two groups, each of them equally often represented in the sample. The six choice sets proposed to each respondent comprise of three unlabeled options and a fourth “opt-out”-option (“Keep status-quo”).

### 3.3 Sampling procedure

Main data collection took place from August to November 2007. Sampling procedure followed the approach of sampling for choice experiments as suggested by Hensher et al. (2005). Sample size was determined to be 475 households. Based on a database of the National Department of Water Affairs and Forestry (DWAF), households were stratified according to their area of residence (urban-rural) and their main water source (Private Tap inside the house, Yard connection, Public Tap and other water sources). It was necessary to come up with two different choice experiments depending on the current water situation. Due to that, the sampled households were split into two groups:

- Choice Experiment I (unlabeled experiment): Households having private in-house connection and Households having yard connections in urban areas
- Choice Experiment II (labeled experiment): All households not belonging to Choice experiment II

This division into two separate choice experiments was necessary to come up with attributes and attribute levels that are meaningful to all respondents. During focus group discussions it became obvious that private tap connections are also linked to better service attributes in terms of frequency and reliability and that these households are also familiar with pricing of water, while others are not.

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## 4 Results

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In the following section, results of the choice experiment dealing with the alternative “Private Tap inside the house” are presented. A Wald-test of linear restrictions (see Greene, 2008) was conducted in order to check whether the influence of the coefficients of attributes can be represented best in a linear way or whether nonlinear effects are present. The categorical attribute “PAYMENT” and the numerical variable “CONSUMPTION” of the CE are dummy-coded and thus reveal nonlinear effects instead of linear effects. For example, moving from a consumption of 50 up to 100 l/dc may not be equally advantageous as moving from 100 to 150 l/dc. The estimated coefficients are to be interpreted relative to the normalised base-line level, which is always the first attribute level. Dummy coding was selected since it allows for an easy and straightforward interpretation of the coefficients and later on the willingness to pay-estimates. The price attribute as well as “FREQUENCY” and “RELIABILITY“ are design-coded with the actual numerical attribute-levels. The use of quadratic terms for “PRICE” was explored and rejected.

First, the results were analyzed using a multinomial logit model (MNL model). This model is often described as the workhorse-model for discrete choice analysis (Train, 2003; Louviere et al., 2000). Although demanding strong assumptions, the model can still be found in literature often and might outperform sophisticated discrete choice models in terms of prediction capabilities as found by Provencher and Bishop (2004) as well as Provencher and Moore (2006). Hensher et al. (2005) advise to spend time exploring the results provided by the MNL model since many statistically significant effects remain in advanced models (Hensher et al., 2005). But the MNL model imposes strong assumption of IID-error terms. This assumption was rejected by means of a Hausman-test (Hausman and McFadden, 1984). Since the Hausman-test cannot be maintained, the random error components are correlated between choices and do not have equal variances. Violations of the IIA assumption render the MNL model inappropriately (Blamey et al., 2000). Consequently, coefficients and WTP-estimates are not reliable. An MNL model including interactions reveals that heterogeneity among households is present in the data, but IID-error terms were rejected as well. Therefore, a more advanced model which captures heterogeneity better and does not impose the strong IIA-assumption is needed. Including interactions in MNL models requires *a priori* selection of the variables suspected to influence preferences. LC models do not need a selection of variables but allow for an inclusion of all important variables. These variables explain group membership of households in groups with homogeneous intra-group preferences. The variables that were regarded as possibly providing meaningful interpretation of the groups or classes are described in table 2 below.

**Table 2: Covariates**

<i>Covariates</i>	<i>Variable definition</i>
<b><i>Socio-economic variables:</i></b>	
Household size	Number of household members
Age of respondent	
Gender of respondent	1= Male
Income	Total household income in Rand/month
<b><i>Water service:</i></b>	
Quantity	Quantity of water in m <sup>3</sup> used per month and household
Service	Service index of current water service
Bill	1= Paid
<b><i>Perceptions:</i></b>	
Satisfaction	Satisfaction with current water service, 1=overall satisfied
Acceptance	Stated acceptance of pricing of water, measures the household's attitude toward pricing of water
Importance	1= Price indicated as being the most important attribute

Including all covariates, LC models up to six classes were estimated. The following table (Table 3) gives an overview of the models' statistics which revealed the best model fit for all alternative specifications. Determination of the optimal number of classes requires an assessment of the information criteria BIC, AIC and AIC3. Since the log-likelihood decreases steadily with an increasing number of classes, the information criteria provide help for determining the appropriate number of classes.

**Table 3: Model statistics**

<i>No. of classes</i>	<i>LL</i>	<i>BIC(LL)</i>	<i>AIC(LL)</i>	<i>AIC3(LL)</i>	<i>CAIC(LL)</i>	<i>Class. Err.<sup>7</sup></i>	<i>R<sup>2</sup>(0)</i>	<i>R<sup>2</sup></i>
1-Class	-1015,85	2071,9	2047,709	2055,709	2079,9	0	0,1886	0,1389
2-Class	-975,693	2087,03	2005,385	2032,385	2114,03	0,0411	0,2405	0,1928
3-Class	-928,561	2088,22	1949,121	1995,121	2134,22	0,0365	0,2929	0,2475
4-Class	-891,038	2108,628	1912,076	1977,076	2173,628	0,0302	0,3186	0,2757
5-Class	-868,892	2159,79	1905,784	1989,784	2243,79	0,0681	0,369	0,3284
6-Class	-838,709	2194,877	1883,418	1986,418	2297,877	0,0421	0,3612	0,3202

<sup>7</sup> Classification error

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The BIC criterion is lowest for the one-class model while the AIC3 criterion suggests use of the 4-class model. Though at a lower rate, AIC keeps decreasing. In order to examine whether the 4 class model significantly improves model fit, conditional bootstrapping was conducted with 500 draws. The test statistic is defined as  $-2(LL_s - LL_{s+1})$  with  $s$  as the number of classes to be tested. The estimated bootstrap p-value is defined as the proportion of bootstrap samples with a larger  $-2LL$ -difference value than the original sample (Vermunt and Magidson, 2005). With  $p = 0.000$  the 4-class model improves model fit significantly. But despite the usefulness of the information criteria, the objective of the study and the interpretation and significance of the class membership parameter estimates should be considered when selecting the appropriate number of classes (Scarpa and Thiene, 2005; Ruto et al., 2008). Since many parameters are significant and classes are interpretable, results of the 4-class model as suggested by AIC3 will be used in the following. Table 4 and 5 present the estimation results of the 4-class model.

**Table 4: 4-Class model for choices**

	<i>Class 1</i>	<i>Class 2</i>	<i>Class 3</i>	<i>Class 4</i>
R <sup>2</sup>	0.2002	0.2272	0.4833	0.1585
R <sup>2</sup> (0)	0.2712	0.2607	0.5497	0.1769
Attributes	Coefficient	Coefficient	Coefficient	Coefficient
FREQUENCY	0.6978*** (0.1225) <sup>8</sup>	0.814*** (0.1303)	1.9848*** (0.4065)	0.9252*** (0.3163)
CONSUMPTION				
50 liter	0	0	0	0
100 liter	-0.0218 (0.2311)	2.083*** (0.285)	2.214*** (0.4974)	-0.1998 (0.5333)
150 liter	-0.049 (0.19)	1.6219*** (0.2479)	2.007*** (0.4511)	0.4832 (0.4433)
RELIABILITY	0.1392*** (0.0178)	0.222*** (0.0274)	0.3061*** (0.0725)	0.0743* (0.0448)
PRICE	-0.2733*** (0.1054)	-1.0224*** (0.1624)	0.0498 (0.2479)	-1.5467*** (0.3428)
PAYMENT METHOD				
Monthly	0	0	0	0
Every 6 months	-0.4504*** (0.168)	0.6424*** (0.2338)	-0.8176* (0.4633)	0.0367 (0.5054)
Prepaid	-1.497*** (0.2431)	-0.7469*** (0.2348)	1.0514*** (0.4007)	-1.1989** (0.598)
NONE	3.3223*** (0.9199)	3.269*** (0.993)	10.7953 (8.2295)	-0.0781 (1.7662)

\*, \*\* and \*\*\* indicate significance levels at 10%, 5% and 1% respectively

<sup>8</sup> Standard error in parenthesis

Table 5: 4-Class model for classes

	<i>Class 1</i>	<i>Class 2</i>	<i>Class 3</i>	<i>Class 4</i>
INTERCEPT	0	-33.0867** (11.5782)	-3.1787 (2.3157)	-5.0592 (5.3192)
SIZE	0	1.3609 (0.8295)	-0.178 (0.2409)	-2.6126** (1.2581)
GENDER (1=male)	0	0.1594 (1.6108)	0.5953 (0.6927)	-6.1291 (3.1018)
AGE	0	-0.6886 (0.2196)	-0.0313 (0.0307)	0.3957 ** (0.1661)
INCOME	0	-0.0011*** (0.0004)	0.0002* (0.0001)	-0.0007* (0.0004)
QUANTITY	0	0.207*** (0.0661)	0.0113 (0.0155)	0.0825** (0.0386)
SERVICE	0	7.9875*** (2.6478)	0.8676 *(0.3938)	-1.497 (1.3946)
BILL (1=paid)	0	-3.6544 (2.3043)	0.3934 (0.7201)	-6.3229 (3.2329)
SATISFIED (1=satisfied)	0	18.1557 *** (6.0576)	0.322 (0.9717)	5.8083 (3.5172)
ACCEPTANCE	0	2.915* (1.3049)	-0.6262** (0.3111)	0.5008 (1.031)
IMPORTANCE (1= Price)	0	-8.9803 (4.1435)	0.4064 (0.8299)	7.4119** (3.3248)

\*, \*\* and \*\*\* indicate significance levels at 10%, 5% and 1% respectively

The classes differ with respect to the covariates. The influence of the covariates for class one is normalized to zero, so that the covariate parameters of classes two, three and four have to be interpreted relative to class one. Class one has the biggest share with 39% of the households, class two of 34%, class three of 18% and class four of 9%. Choices of class one members are significantly influenced by the attributes “FREQUENCY”, “RELIABILITY”, “PRICE” and “PAYMENT METHOD”. The price-coefficient is lowest among all classes reflecting that class one members are the least price sensitive with a coefficient of about -0.3. They favour a higher frequency and reliability but coefficients are the lowest of all classes. They reject both ‘payment every six month’ and more strongly the ‘prepaid payment’ methods.

Class two members differ from class one members with respect to certain covariates. Class two members have significantly less income than members of class one with an average total income in that class of 6500 Rand per month and household. The lower income may be the reason for the higher price sensitivity in this class with a coefficient of about -1. Members of class two demonstrated stronger agreement with the idea of water pricing than other classes. These households have higher actual water consumption per month, which is reflected in the estimated coefficient for the attributes „CONSUMPTION" in the CE. Both consumption-levels are found to be significant and their estimated coefficients are quite high, indicating that these households prefer higher consumption levels according to their high actual consumption. Additionally, class two members are found to have stated significantly more often that they are overall satisfied with their current water services (“SATISFIED”), which is probably related to the finding that their current water services (“SERVICE”) are significantly better than those

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received by class one and class four members. Class two members were also found to choose the status quo in 10% of the cases (see table 6).

Class three is noticeable due to the finding that the price coefficient is not significantly influencing the choice of those households. Additionally, parameter coefficients are quite high for “FREQUENCY”, “RELIABILITY” and “CONSUMPTION” so these households have strong preferences for high quality service. Concerning the covariates, households in this class have a significantly higher income, are already receiving a good water service (“SERVICE”) and stated that they are less willing to pay for water (“ACCEPTANCE”) than households in other classes. The missing price significance and the high quality preferences may be explained in two ways: households having a high income may prefer high standards irrespective of the price levels given in the experiment. For those households probably higher price levels would have been needed to detect a significant influence of prices. Second, households in this class indicated that they are less willing to pay for water. This might be an indication that some of the households always chose the best options but are not actually willing to pay for it.

Class four members are characterized by the strongest price sensitivity with a coefficient of -1.5. These households dispose of little income; class average is with 2900 Rand per month and household very low compared to members of class one, which have on average 7400 Rand per month and household. They also chose price significantly more often as the most important attribute influencing their choice (“IMPORTANCE”) than households in other classes. Households tend to opt-out in 28% of all cases (see Table 6). They have strong preferences to keep their status-quo than to choose a better service at higher prices. Households of class four are found to be significantly smaller (in size) than other households and respondents of class four were slightly older. These households were also found to have higher water consumption per person, but this finding is not reflected in the coefficients of “CONSUMPTION”. Both consumption levels were insignificant.

**Table 6: Choice of „Opt-out“-option in % of total choices**

<i>Class 1</i>	<i>Class 2</i>	<i>Class 3</i>	<i>Class 4</i>
0.3%	10%	0.01%	28 %

The results of table 4 indicate that class three should be considered with care. The latent class model allows detecting this class and separated its choices from others, who made more reliable choices. A simple model such as MNL would not have detected those households and their choices would bias WTP estimates upward. The information from Table 4 can be used to get further insights into the welfare impacts of the service attributes. As above willingness to pay estimates can be calculated for each attribute level using the formula for changes in a single attribute k to

$$WTP_s = -1 \left( \frac{\beta_{ks}}{\beta_{PRICE_s}} \right) \quad (9)$$

which is equivalent to the ratio of the two marginal utilities (Blamey and Chapman, 1999).

Table 7: Willingness to pay estimates for each class (in Rand/m<sup>3</sup>)

Attribute	Class 1		Class 2		Class 3	Class 4	
	WTP	CI	WTP	CI		WTP	CI
FREQUENCY	2.5529*** (0.9493)	(0.6921; 4.4137)	0.7962*** (3.0958)	0.5419; 1.0506)		0.5981*** (0.1723)	(0.2604; 0.9358)
100 l/dc	-0.0797 (0.8401)	(-1.7264; 1.567)	2.0374*** (0.3139)	(1.422; 2.6527)		-0.1292 (0.3466)	(-0.8085; 0.5501)
150l/dc	-0.1791 (0.7093)	(-1.5695; 1.2112)	1.5864*** (0.2486)	(1.099; 2.0738)	Not sign.	0.3123 (0.2657)	(-0.2084; 0.8331)
RELIABILITY	0.5094*** (0.1847)	(0.1473; 0.8714)	0.2171*** (0.0278)	(0.1626; 0.2716)		0.048** (0.0245)	(0; 0.096)
6 months	-1.6479** (0.8733)	(-3.3597; 0.0638)	0.6283*** (0.207)	(0.2225; 1.0341)		0.0237 (0.3265)	(-0.6162; 0.6637)
Prepaid	-5.4771*** (1.9135)	(-9.2277;- 1.7264)	-0.7305*** (0.2124)	(-1.1469;- 0.3141)		-0.7751** (0.3295)	(-1.4211;- 0.1291)
100-->150 l/dc	-0.0994 (0.9622)	(-1.9854; 1.7866)	-0.4509** (0.242)	(-0.9253; 0.0233)		0.4415 (0.3246)	(-0.1946; 1.0778)

CI= Confidence interval

WTP estimates for class three are not presented here since their price coefficient is insignificant resulting in insignificant WTP estimates. The WTP estimates differ obviously to a great extent between the different classes. Regarding the WTP for a higher frequency, class one is willing to pay more than three times as much as that of classes two and four. Households in class four have the lowest WTP for all attributes. Class two members have a strong and significant WTP for both consumption levels. With regard to prepaid payment all classes have a negative WTP, among them members of class one showing the strongest negative WTP.

## 5 Summary and Conclusions

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The prevailing inequality in access to water services and the ongoing reform process of the water management in South Africa reveals the need to know more about domestic water use and households' WTP for different water services at the Catchment Management level. In this paper, a CE method was applied to provide information for non-market valuation of water services. When interpreting findings of the CE, it has to be kept in mind that these findings are based on stated preferences and that it is not actual behaviour that is reflected. Preference elicitation and the accounting of possibly heterogeneous preferences showed that preferences vary between four distinct groups of households. Group sizes differed among the four classes with class one being the biggest class consisting of 39% of all sampled households, followed by class two (34%), class three (18%) and class four (9%). These groups were found to differ significantly in terms of socio-economic characteristics as well as attitudes and satisfaction. Identifying these characteristics provides a richer understanding of the source of heterogeneity of preferences. Households are in general willing to pay for better water services in terms of frequency and reliability. But how much they are willing to pay differed across the four groups. Unfortunately, WTP estimates for class three members are all insignificant and hence not reliable. In this class, it would be interesting to differentiate between individuals lacking a significant influence of price (because the price levels of the experiment were set low) and those individuals ignoring price and hoping to get a better service for free (Free riders). Unfortunately, the five class solution did not split up this class as desired. Information on group sizes, the characteristics of the classes and estimates of the magnitude of WTP to move from the current situation to an improved one is very useful for policy makers to allow for comparison with the actual costs of the respective service improvements. It also gives insight into the priority of certain service attributes indicated by a higher WTP. All classes appreciate a higher frequency of supply, but WTP for it is highest for members of class one. A higher consumption would only be appreciated by members of class two who are WTP for both increased consumption levels. These findings can help water service providers to set appropriate water tariffs and design adequate water services for the Middle Olifants sub-basin.

## References

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- Ashton, P., Love, D., Mahachi, H. and Dirks, P. H. M. (2003). An overview of the impact of mining and mineral processing operations on water resources and water quality in the Zambezi. Limpopo and Olifants catchments in Southern Africa. Report Research Report No. ENV-P-C 2001-042. 336 pp. MMDS Southern Africa. [www.naturalresources.org](http://www.naturalresources.org).
- Backeberg, G. R. (2006). Reform of user charges. market pricing and management of water: Problem or opportunity for irrigated agriculture? *Irrigation and Drainage*.55:1-12.
- Banda, B., Farolfi, S. and Hassan, R. (2007). Estimating water demand for domestic use in rural south africa in absence of price information. *Water Policy*. 9(5):413-128.
- Bhat, C. R. (1997). An endogenous segmentation mode choice model with an application to intercity travel. *Transportation Science*. 31(1):34-48.
- Blamey, R., Bennett, J. W., Louviere, J. J., Morrison, M. D., and Rolfe. J. (2000). A test of policy labels in environmental choice modelling studies. *Ecological Economics*. 32:269-286.
- Blamey, R. J. and Chapman, G. R. (1999). Choice modeling: assessing the environmental values of water supply options. *Australian Journal of Agricultural and Resource Economics*. 4(3):337-357.
- Boxall, P. C. and Adamowicz, W. (2002). Understanding heterogeneous preferences in random utility models. a latent class approach. *Environmental and Resource Economics*. 23(4):421-446.
- Boxall, P. C., Adamowicz, W. L., Swait, J., Williams, M., and Louviere, J. (1996). A comparison of stated preference methods for environmental valuation. *Ecological Economics*. 18:243-253.
- Bradley, M. and Daly, A. (1994). Use of the logit scaling approach to test for rank-order and fatigue effects in stated preference data. *Transportation*. 21:167-184.
- Chalak, A., Balcombe, K., Bailey, A., and Fraser, I. (2008). Pesticides. preference heterogeneity and environmental taxes. *Journal of Agricultural Economics*. 59(3):537-554.
- de Coning, C. and Sherwill, T. (2004). An assessment of the water policy in south africa (1994 to 2003). WRC report no tt232/04. Water Resource Commision (WRC).
- DWAF (2003a). Olifants Water Management Area. Overview of water resources availability and utilisation. Number P WMA 04/000/00/0203.

## Preferences for domestic water services in the Middle Olifants sub-basin of South Africa

- DWAF (2003b). Olifants Water Management Area Water Resources Situation Assessment. Main report.
- DWAF (2004). Olifants Water Management Area. Internal Strategic Perspective. Version 1.
- Edward, M., Thiene, M., De Salvoc, M., and Signorello, G. (2008). Using attitudinal data to identify latent classes that vary in their preference for landscape preservation. *Ecological Economics*. 68:536-546.
- Goldblatt, M. (1999). Assessing the effective demand for improved water supplies in informal settlements. a willingness to pay survey in Vlakfontein and Finetown. *Johannesburg. Geoforum*. 30:27-41.
- Goldin, J. (2005). Trust and Transformation in the Water Sector. PhD thesis. Department of Political Studies. University of Cape Town.
- Greene, W. H. and Hensher, D. A. (2003). A latent class model for discrete choice analysis: contrasts with mixed logit. *Transportation Research Part B*. 37:681-698.
- Hanley, N., Mourato, S., and Wright, R. E. (2001). Choice modelling approaches: A superior alternative for environmental valuation? *Journal of economic surveys*. 15(3):435-462.
- Hassan, R. and Farolfi, S. (2005). Water value. resource rent recovery and economic welfare cost of environmental protection. a water sector model for the Steelpoort sub-basin in South Africa. *Water SA*. 31(1):9-16.
- Hausman, J. and McFadden, D. (1984). Specification tests for the multinomial logit model. *Econometrica*. 52(5):1219-1240.
- Hedden-Dunkhorst, B. (2005). Integriertes Wasserressourcen-Management (IWRM). Suedafrika auf dem Weg zum integrierten Wasserressourcen-Management: Erfahrungen mit einem neuen Konzept. pages 159-178. *Nomos*.
- Hensher, D., Rose, J., and Greene, W. H. (2005). *Applied choice modelling*. Cambridge University Press.
- Hope, R. A., Garrod, G. (2004). Household preferences to water policy interventions in rural south africa. *Water Policy*. 6:487-499.
- Hu, W., Hnnemeyer, A., Veeman, M., Adamowicz, W., and Srivastava, L (2004). Trading off health. environmental and genetic modification attributes in food. *European Review of Agricultural Economics*. 31(3):389-408.
- Hynes, S., Hanley, N., and Scarpa, R. (2008). Effects on welfare measures of alternative means of accounting for preference heterogeneity in recreational demand models. *American Journal of Agricultural Economics*. 4:1011-1027.
- Jansen, A. and Schulz, C. E. (2006). Water demand and the urban poor. a study of the factors influencing water consumption among households in Capetown, South Africa. *The South African Journal of Economics*. 74(3):593-609.

- King, N. (2004). *Sustainable Options: Development Lessons from Applied Environmental Economics. The economic value of water in South Africa.* University of Cape Town Press. Cape town.
- Kontoleon, A. and Yabe, M. (2006). Market segmentation analysis preferences for GM derived animal food in the UK. *Journal of Agricultural and Food Industrial Organization.* 4(1), Article 8.
- Kuhfeld, W.F. (2005). *Marketing Research Methods in SAS. Experimental Design, Choice, Conjoint, and Graphical Techniques.* January 1, 2005, SAS 9.1 Edition, TS-722. <http://support.sas.com/techsup/technote/ts722title.pdf>
- Levite, H. and Sally, H. (2002). Linkages between productivity and equitable allocation of water. *Physics and Chemistry of the Earth.* 27:825-830.
- Linz, T. and Tsegai, D. W. (2009). *Industrial Water Demand analysis in the Middle Olifants sub-basin of South Africa: The case of Mining, ZEF – Discussion Papers On Development Policy No. 130, Center for Development Research, Bonn, April 2009, pp.27.*
- Louviere, J., Hensher, D., and Swait, J. (2000). *Stated Choice Methods. Analysis and Application in Marketing. Transportation and Environmental Valuation.* Cambridge University Press.
- Louviere, J. J. (1988). *Analyzing decision making: Metric conjoint analysis. Technical report. Sage University Papers Series No. 67. Newbury Park CA.*
- MacDonald, D. H., Barnes, M., Bennett, J., Morrison, M., and Young, M. D. (2005). Using a choice modelling approach for customer service standards in urban water. *Journal of the American Water Resources Association (JAWRA).* 41(3):719-728.
- McDonald, D. (2002). You get what you pay for: Cost recovery and the crisis of service delivery in South Africa. *Alternatives.* 28(3).
- Milon, J. W. and Scrogin, D. (2006). Latent preferences and valuation of wetland ecosystem restoration. *Ecological Economics.* 56:162-175.
- Morey, E., Thacher, J., and Breffle, W. (2006). Using angler characteristics and attitudinal data to identify environmental preference classes. *Environmental and Resource Economics.* 34(1):91-115.
- Nam, P. K. and Son. T. V. H. (2004). Household demand for improved water services in ho chi minh city: A comparison of contingent valuation and choice modelling estimates. *Economics and Environment Network (EEN).*
- National Water Act (1998). Republic of South Africa Government Gazette. Cape Town. South Africa.
- PDG (2004). *Economic considerations in water allocation promoting equity. efficiency. sustainability and poverty alleviation. Technical report. Palmer Development Group.*

## Preferences for domestic water services in the Middle Olifants sub-basin of South Africa

- Provencher, B., Baerenklau, K. A., and Bishop, R. C. (2002). A finite mixture logit model of recreational angling with serially correlated random utility. *American Journal of Agricultural Economics*. 84(4):1066-1075.
- Provencher, B. and Bishop, R. C. (2004). Does accounting for preference heterogeneity improve the forecasting of a random utility model? *Journal of Environmental Economics and Management*. 48(1):793-810.
- Provencher, B. and Moore, R. (2006). A discussion of "Using angler characteristics and attitudinal data to identify environmental preference classes: A latent class model". *Environmental and Resource Economics*. 34:117-124.
- Ruto, E., Garrod, G., and Scarpa, R. (2008). Valuing animal genetic resources: a choice modeling application to indigenous cattle in kenya. *Agricultural Economics*. 38:89-98.
- Scarpa, R., Drucker, A. G., Anderson, S., Ferraes-Ehuan, N., Gomez, V., Risopatron, C. R. and Rubio-Leonel, O. (2003). Valuing genetic resources in peasant economies: the case of hairless creole pigs in yucatan. *Ecological Economics*. 45:427-443.
- Scarpa, R. and Thiene, M. (2005). Destination choice models for rock climbing in the northeastern alps: A latent-class approach based on intensity of preferences. *Land Economics*. 81(3):426-444.
- Scarpa, R., Thiene, M. and Galletto, L. (2006). Consumers wtp for wine with certified origin: Latent classes based on attitudinal responses. In Paper presented at the 10th joint conference on Food, Agriculture and the Environment. Duluth, Minnesota. August 27-30. Center for International Food and Agricultural Policy.
- Scarpa, R., Willis, K., and Acutt, M. (2005). *Econometrics Informing Natural Resource Management*. Chapter: Individual-specific welfare measures for public goods: a latent class approach to residential customers of Yorkshire Water. Edward Elgar Publisher.
- Snowball, J., Willis, K., and C. Jeurissen (2007). Willingness to pay for water service improvements in middle-income urban households in South Africa: A stated choice analysis. The Economic Society of South Africa (ESSA). Paper delivered at the 2007 Conference of the Economic Society of South Africa.
- Swait, J. (2007). *Valuing Environmental Amenities Using Stated Choice Studies A Common Sense Approach to Theory and Practice*. Chapter: Advanced Choice Models. Pages 229-293. Springer Netherlands.
- Train, K. (2003). *Discrete choice models with simulation*. Cambridge University Press.
- Tsegai, D. W., Linz, T. and Kloos, J. (2009). Economic analysis of water supply cost structure in the Middle Olifants sub-basin of South Africa, ZEF – Discussion Papers On Development Policy No. 129, Center for Development Research, Bonn, April 2009, pp.20.

- Turton, A., Meissner, R., Mampane, P., and Seremo, O. (2004). A hydropolitical history of south africa's international river basins. Technical Report No. 1220/1/04. Water research Commission Report.
- van Koppen, B. (2008). Redressing inequities of the past from a historical perspective: The case of the olifants basin, South Africa. *Water SA* 34(4):432-438.
- van Koppen, B., Jha, N. and Merrey, D. (2002). Redressing racial inequities through water law in South Africa. Old contradictions revisited? Technical report. Research Paper 03.
- Veck, G. A., Bill, M. (2000). Estimation of the residential price elasticity of demand for water by means of a contingent valuation approach. Water Research Commission Report No. 790/1/00.
- Vermunt, J. K. and Magidson, J. (2005). Latent Gold 4.0 Choice User's manual.
- Water Service Act (1997). Republic of South Africa Government Gazette. Cape Town. South Africa.
- Wedel, M. and Kamakura, W. A. (2000). Market Segmentation: Conceptual and methodological foundations. Kluwer Academic Publisher. Boston. Dordrecht. London.
- Yang, J., Pattayanak, S., Johnson, F., Mansfield, C., van den Berg, C., and Jones, K. (2006). Unpacking demand for water service quality. evidence from conjoint surveys in Sri Lanka. World Bank Policy Research Working Paper 3817.