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Scarcity Of Canterbury's Water: Its Multiple, Conflicting Uses

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SUMMARY

Canterbury freshwater management is the focus of important decisions with significant challenges. Applying choice modelling, this study explores how Canterbury residents value freshwater attributes related to environmental, economic, social and cultural elements of wellbeing. In particular, this study explores how values for Māori cultural element of water resource relate to the other elements. Results indicate that people value all freshwater attributes considered here, with highest willingness to pay for environmental benefits followed by cultural, recreational and employment benefits. The preference ranking can provide useful information for prioritisation of Canterbury freshwater management objectives.

Key words: CHOICE MODELLING, FRESHWATER MANAGEMENT, WILLINGNESS TO PAY, CULTURAL VALUES

INTRODUCTION

Canterbury water management

Canterbury freshwater management is at the point of important decisions with significant challenges. Environment Canterbury (ECan), the regional council of Canterbury, is responsible for the resource management in collaboration with other organisations and groups; the responsibilities for ECan are given through the Resource Management Act (RMA) 1991 – the most important legislation for water management in New Zealand (ECan, 2012a; ECan, 2011/2012). Under the RMA 1991, water management aim to promote social, economic, and cultural well-being as well as health and safety of people and communities. This includes sustainable management of the resource to meet the foreseeable needs of future generations while avoiding adverse effects on the environment and preserving the life supporting capacity of resources (RMA 1991: Part 2). These environmental, social, economic and cultural elements of wellbeing are the quadruple bottom line of New Zealand policy making (Dalziel et al, 2006).

The Canterbury region is to the east of the Southern Alps extending to the Pacific Ocean including Alpine Rivers, foothill and lowland rivers and streams, and lakes (Figure 1). The freshwater resource in Canterbury is recognised to be under pressure yet there exist proposals for further irrigation development and this future water use requires improvement on how water is used, stored and managed (Canterbury Mayoral Forum, 2009; ECan 2011a). For example, the area between Rakaia and Waimakiriri Rivers has been consented additional 30 000 hectares of irrigated land area (Robson, 2011). Some possible environmental impacts include effects on the natural character of the Waimakariri and Rakaia Rivers, the effects on fisheries, dam safety, elevated water tables and flooding, the groundwater quality (e.g., increase in nitrates and microbial contamination) and quality in lowland streams and Lake Ellesmere/Te Waihora (ECan 2012b).

One key challenge for water management highlighted in this research is the complexity of the multiple users and use types of water which often can be conflicting. Morgan *et al* (2002) recognises how water is highly valued in its elements of economic (irrigation and industry), environment (maintaining ecosystems that rely on both surface and groundwater), health (water supply and safe swimming), culture (mahinga kai and mauri[1]) and recreation (fishing, boating and canoeing). This list is similar to that of the 2002 freshwater allocation

[1] Mauri is a life force and in context of freshwater it can represent the physical health of a river ecosystem (Harmsworth et al., 2011; TRONT, 1999; Tipa & Teirney, 2003).

conference hosted by the Ministry of Agriculture and Forestry (MAF) and the Ministry for the Environment (MfE) (Statistics New Zealand, 2004). These multiple uses may have conflicting interests (Canterbury Mayoral Forum, 2009); thus it creates difficulty for policy makers who have to make allocation decisions that consider the wellbeing of the society as a whole. Therefore, information on how these elements are valued is essential in managing the resource.

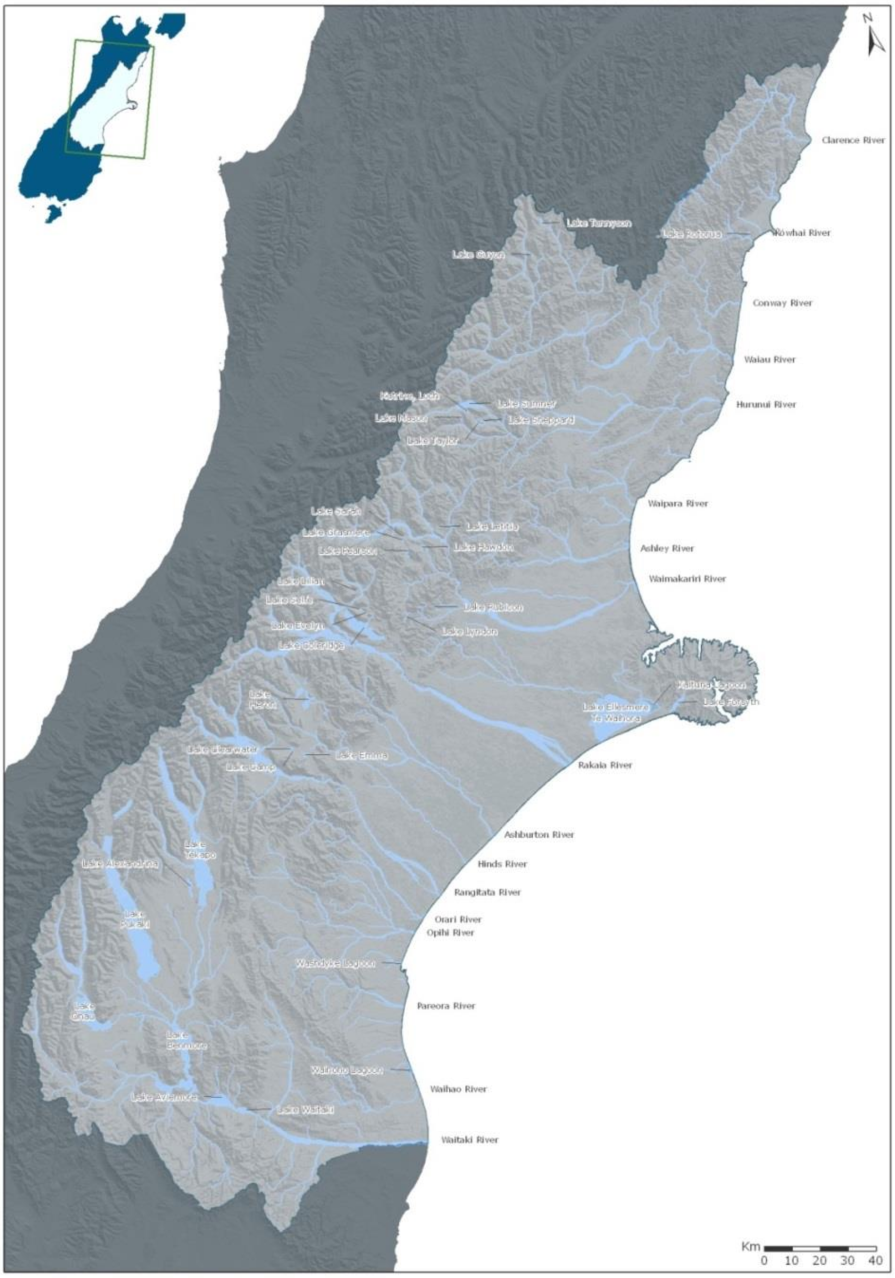

Figure 1. Canterbury rivers and lakes (source: ECan, 2011b)

Theoretically, the problem of multiple and conflicting uses of the water resource can be approached from the economic valuation perspective. This is because economics is a study of scarcity and water is an example of a scarce resource; even though it is renewable, it is not unlimited and there is not enough to provide for all competing uses. The economic value of a scarce resource is based on trade-offs. With the goal of increasing human wellbeing, economic theory provide useful methods to compare, for example, different policy alternatives and what impact these have on society (Freeman III, 2003a). The market theory provides a rule for efficiency; in a point where the scarce resource is used most efficiently and the social benefits are maximised (Kahn, 2005).

Valuing water, however, is not easy given that values can vary according to use. While some uses can be linked to markets (e.g. irrigation helping production), others are not easily transferred into a dollar value (e.g. aesthetic value). In addition, a further complexity arises as water has both private and public good characteristics. By definition, a purely private good is exclusive and rival; and a purely public good is non-exclusive and non-rival (Randall, 1987). For example, intensive farming may impact negatively on water quality (rival) while enjoying the aesthetics of rivers does not typically impact other uses of water (non-exclusive and non-rival). These, amongst other characteristics of water resources can often lead to market failure (Hackett, 2011; Kahn, 2005); thus non-market valuation methodology is required. In this study, a stated preference (SP) method of Discrete Choice Modelling (DCM) is applied. This method is chosen to provide information of how people value the environmental, financial[2], social and cultural values of Rivers in Canterbury. DCM enables ranking of these attributes, and estimation of willingness to pay (WTP). In particular, this study explores how cultural values relate to others. Cultural values here refer to Māori cultural values which are less explored in the SP studies in New Zealand; yet an important element in decision making.

This paper is part of wider PhD research with a number of study objectives. One main objective was exploration of the multiple conflicting values of freshwater and how these differ across the user types of water. This paper focuses on the results from this objective highlighting the Māori culture values around freshwater. This is important because the Māori cultural values are an essential element in the New Zealand policy making. Choice experiment research including a Māori cultural specific attribute has not yet been undertaken in New Zealand[3]. Other research objectives focused on the citizen-consumer dilemma which is a dichotomy recognised by Sagoff (1988) and which raises one question of validity in the SP method – what frame of mind people express their preferences and does it matter; and choice consistency, which is often linked to the choice complexity and respondents' fatigue in the choice experiments (e.g., Carlsson et al, 2012). The latter objective was studied in the framework of choice set ordering and whether it makes a difference in the results. These objectives of the citizen-consumer dilemma and choice consistency are not reported in this paper; however, it is noteworthy that in order to study all these study objectives a total of four surveys were created; this paper reports results of one subsample.

<u>Literature review of cultural values</u>

The cultural values in this study are defined as indigenous Māori cultural values around freshwater. Cultural wellbeing, as part of the 'quadruple bottom line', includes both indigenous and non-indigenous values but is led by indigenous people (Dalziel et al, 2006) while the western (non-indigenous) values are largely reflected in the other dimensions of the resource (Winstanley & Lange, 2008). The indigenous people of New Zealand are Māori. For Māori, the role of water is highly important. Water is taonga[4] or mana[5] that provides and sustains life; inherited from the ancestors, the current generation is expected to respect and protect the resource for the future generations (Te Rūnanga o Ngāi Tahu [TRONT], 1999). According the traditional beliefs, any shifts in mauri[6] (e.g., miss use of the resource) in any

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[22] Economic value of water is interpreted here as the *financial* value. This clarification is needed because total economic value (TEV) comprises a range of values, use and non-use, and in order to distinguish this attribute is only a partial contribution for TEV.

[3] Known to the author

[4] Treasure (TRONT, 1999)

[5] Prestige (Harmsworth et al, 2011)

[6] Life force (Harmsworth et al., 2011; TRONT, 1999)

part of the environment can affect the whole system (Harmsworth et al, 2011). This can lead, for example, Māori being unable to practice their customs and traditions (MfE, 2004). Therefore, water quality and its protection are essential for Māori. The importance of water for Māori is noted at the policy level under the RMA 1991 and in Canterbury, this has been taken account by proposing a stronger inclusion of Ngāi Tahu, a regional tribe of Canterbury, in the decision making (Canterbury Mayoral Forum, 2009).

In order to study cultural values, a number of indicators of cultural values health of rivers and streams in New Zealand were reviewed. On one hand, while the western scientific indicators measure typically precise changes and are highly technical, well tested and peer-reviewed; the cultural methods are more subjective, qualitative and holistic needing in-depth Māori knowledge (Harmsworth et al, 2011). On the other hand, the Māori values of freshwater are not totally distinguished from the western cultural values. For example, Tipa and Teirney (2003) carried out number of interviews with members of Ngāi Tahu and found out several important elements to define river healthy including riverbank condition, river flow, water quality and water is safe to drink, just to mention few. Harmsworth *et al* (2011) found strong correlation between cultural stream health measure and macroinvertebrate metrics which suggest that both indicators should be used together rather than isolated methods. In addition, a choice modelling study by Andersen *et al* (2012) at Waikato (North Island, New Zealand) found more similarities than differences of environmental values between the Māori and non-Māori populations.

<u>Choice modelling literature review</u>

Previously, choice modelling has been used to study issues relating to water resource in Canterbury. For example, Baskaran *et al* (2009) explored public's perceptions towards dairy farming and WTP for lessening the negative environmental effects. They included for example an attribute of water use for irrigation and reduction in nitrate leaching into the waterways; the higher reductions were valued more. Beville (2009) conducted a recreational specific choice experiment to investigate anglers' preferences and "possible drivers of the changes in angler activity" (Beville, 2009, p. 14) while Kerr and Swaffield (2007) used DCM to understand the "changes in aesthetic and recreational values of spring-fed stream" (Kerr & Swaffield, 2007, p. 7). In the latter, the sample consisted of two groups of farmers and one angler group. The most recent studies include Tait *et al* (2011 & 2012) and Marsh and Phillips (2012). Tait *et al* (2011) investigated the public's attitudes on agri-environmental policy and the impacts on rivers' ecology, risk of getting sick from recreation contact and river flows. Marsh and Phillips (2012) evaluated preferences of the potential future land uses and water quality scenarios for the Hurunui River subject to the status quo. They were interested on preferences regarding ecology, fishing, recreation, tributaries and changes in jobs related to Hurunui River. These previous studies provide a useful framework; this study shares similar elements characterising water in its many different elements how it can be used by people. Different to others, this study specifies one attribute for each element of wellbeing part of the decision making in water management. In particular, the cultural element provides new information into the existing literature.

Discrete choice modelling has also been applied into cultural valuation. For example, three studies have focused in Australian Aboriginals. First, Rolfe and Windle (2003) were interested in the protection of Aboriginal cultural sites related to the irrigation development. Their key finding included the cultural heritage attribute was significant and positive with indigenous sample but negative with for the general community samples. "This does not mean that Aboriginal cultural heritage is not valued by the general community, but in terms of the trade-offs between economic development, the general community are more concerned about environmental issues" (Rolfe & Windle, 2003, p. S94). Second, Zander and Garnett (2011) explored the benefits for Aboriginals (including better health, better transfer of indigenous knowledge, less dependency on the government and no additional benefits) from the indigenous land management scenarios. Only “less dependency” was considered as an important benefit, yet somewhat surprising, the highest value for Indigenous land management was found amongst people who may not have direct benefits from the case study region of Northern Australia. In third example, Zander *et al* (2010) were interested on quantifying environmental, recreational and cultural values regarding tropical rivers, in particular the waterholes important to Aboriginal people. The estimated WTP was highest for the cultural attribute, and all respondents valued the cultural, environmental and recreational values but not irrigated agriculture values.

More examples of cultural valuation can be found from Europe. Carlsson *et al* (2010 & 2011) included the cultural environment and cultural heritage element in Marine environment, Lakes and streams, and Clean air studies in Sweden. Domínguez-Torreiro and Soliño (2011) focused on rural development programs in Spain describing recovery and conservation of cultural heritage with an attribute ‘Monuments and traditions at villages’. Birol *et al* (2006a) focused on wetland protection and restoration in Greece. Colombo *et al* (2009) studied conservation of upland hill farming in England including attribute of ‘Cultural heritage’ (change in farm buildings, traditional livestock, and traditional farm practices). Campbell (2007), in his study of rural landscape improvements in Ireland, included a cultural specific attribute of ‘Safeguarding of cultural heritage’. In summary, these studies found that the cultural attribute was valued lowest (Campbell, 2007; Carlsson et al, 2010) or it was the most often ignored attribute (Carlsson et al, 2010); it also may be significant only when people used their own status quo levels as a reference point (Domínguez-Torreiro & Soliño, 2011) or that only some attribute levels were significant (Campbell, 2007). In some cases there was overall significance which reduced within some respondent groups in the latent class analysis (Birol et al, 2006a; Colombo et al, 2009).

In addition, the respondent characteristics may have an impact. Haener *et al* (2001), Tuan and Navrud (2007), Mazzanti (2003) and Hoyos *et al* (2009) found evidence on difference in populations in Canada, Vietnam, Italy and Spain/France, respectively. Haener *et al* (2001) results show difference between two hunting culture populations; Tuan and Navrud (2007) results show significance in number of socio-economic covariates; Mazzanti (2003) results show difference between visitor and local populations; and last Hoyos *et al* (2009) found that Basques share higher WTP for the protection of the natural environment than non-Basques. Similar to Māori culture in New Zealand, the environment plays a large role in the Basque culture. This leads us to the New Zealand example where, recently, Andersen *et al* (2012) studied the difference on preferences between Māori and non-Māori respondents using choice modelling. They did not include a Māori specific attribute; they identified the respondents based on the environmental and Māori identity scores from the list of Likert scale statements. The key finding of this study was that there are potentially more similarities than differences between the Māori and non-Māori population.

METHOD

Discrete choice modelling

Choice modelling is a SP method developed in market and transportation studies; since it has been applied in many environmental valuations. Typically people are asked to fill in a survey that includes a choice experiment (CE). In the CE, people make a number of repetitive choices in a sequence of choice sets, which in this case concerns of the hypothetical water management scenarios. The choice alternatives are described by multiple attributes that vary in their levels across the choice sets (Louviere, 2001). The outcomes can be used to indicate how people prioritise the attributes and to estimate the willingness-to-pay (WTP) values, that here reflect to the four cornerstones of policy making in New Zealand. This can provide useful information for policy makers for example for allocation decisions.

Choice experiment is applied here because it suits well with the interest of multiple values of water. Employing Lancaster's (1966) theory, the utility function of water can be expressed in number of attributes that together give rise to the utility of the resource. The multiple attributes provide information of trade-offs, preference ranking and marginal values of changes (Birol et al, 2006b; Hanley et al, 2001). Other advantage is that the stated preference models are not limited to market values or use values (Bateman et al, 2002) and hence values such as swimming water quality can be incorporated. In addition, CEs are consistent with welfare theory with indirect calculation of WTP; comparisons of changes in utility with the status quo alternative; the econometric models are aligned with theory of rational choice, and last, the model estimates provide a basis to derive the Hicksian surplus (a measure of consumer surplus) (Bateman et al, 2002).

On a downside, the SP methods are generally vulnerable to a number of biases which means that the inaccurate WTP estimates might be misleading for those who aim to use the results in policy decisions. Inaccuracy can be result of respondents unfamiliarity or uninterested for the context (Boxall & Beckley, 2002) or that the estimated WTP is higher than actual WTP (i.e., hypothetical bias) (Carlsson & Martinsson, 2001; Lusk & Schroeder, 2004). In addition, the complex structure (multiple attributes, alternatives, and choice sets) may cause inconsistency across the choice sets or unreliable choices (Carlsson & Martinsson, 2001; Carlsson et al, 2012; Bennet & Blamey, 2001; Hanley et al, 2001). A central criticism has been cognitive difficulty with repeated and complex choices and in what extent the complexity and respondent's lower understanding regarding the task may cause issues of validity of the welfare estimates (DeShazo & Fermo, 2002; Hanley et al, 2001). This may lead into undesirable effects discussed in the literature such as attribute ignorance, ordering effects, status quo bias and choice uncertainty (e.g, Carlsson et al, 2012; Day et al, 2012; Scarpa et al, 2011).

Theoretical framework:

Economic theories of consumer theory provides behavioural framework for choice modelling. "The economic theory of the consumers is very simple: economists assume that consumers choose the best bundle of goods they can afford" (Varian, 2006, p. 20). In other words, consumers maximise their utility. The common assumptions include that people can rank their preferences logically consistently within the limits of constraints (e.g. budget) (Hackett, 2011; Randall, 1987). Thus consumer theory assumes the choices are complete, reflexive and transitive (O'Connell, 1982; Varian, 2006). While these assumptions are valid in theory, they may fail in empirical applications. For example, transitivity can be questioned in the choice experiments where multiple choices allow choice inconsistency, a result for example from the fatigue effect. Moreover, preferences and indifference curves provide basis for the WTP estimation. This estimation is based on the marginal rate of substitution (MRS), the rate in which people is just on the margin of substituting one good (x) for another (Varian, 2006; Holmes & Adamowicz, 2003). WTP is used as an indicator of preferences as people are generally reluctant to pay for something which they do not like (Pearce & Turner, 1990). Thus this provides information on market demand or, alternatively, the benefits people receive (Field, 1997; Hackett, 2011).

Econometric choice models:

Choice modelling explores the preference order and trade-offs between multiple attributes by modelling the choices subject to the attribute levels. The econometric choice models are Random Utility Maximisation (RUM) models (Holmes & Adamowicz, 2003). These models include some assumptions. Firstly utility maximisation gives the behavioural model of decision making (Hensher et al, 2005; Train, 2003) where

$$U_i > U_j \qquad (1)$$

that is the alternative i is chosen over any other alternative j only if it provides highest utility. Secondly, the random utility theory allows researcher to include some uncertainty to this model as the utility is expressed in observed (deterministic, explained) utility (V) and unobserved (stochastic, unexplained) utility (ε)

$$U = V + \varepsilon \qquad (2)$$

(Hanley et al, 2001; Hensher et al, 2005; Holmes & Adamowicz, 2003; Louviere, 2001; Train, 2003). The component V includes information of the attributes (thus choice) (Hensher et al, 2005a) while the component ε reflects the researchers' uncertainty regarding the choice (Holmes & Adamowicz, 2003). The component V includes the multiple attributes and it is usually assumed to be linear in parameters:

$$V = \sum (\beta_k x_{ki})$$

where β is the preference parameter for k attribute with level x (ChoiceMetrics, 2012; Holmes & Adamowicz, 2003). The information of socio-economic factors can also be included here; yet they need to interact with the alternative specific constant (ASC) or attributes as they are constant across the choices (Hanley et al, 2001). The practical approach to model the probability of selecting alternative i by individual n is given by entering the equation (2) into the behavioural model (1)

$$\Pr(i_n) = \Pr(V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}) = \Pr(\varepsilon_{jn} - \varepsilon_{in} < V_{in} - V_{jn}) \text{ for all } i \neq j.$$

(Hensher et al, 2005; Holmes & Adamowicz, 2003; Louviere, 2001; Train, 2003). This format focuses on the trade-offs across the attributes involved in the choice making (Holmes & Adamowicz, 2003). Finally, the different econometric choice models depend on the assumptions placed on the random components and the assumptions of parameters (i.e., are they fixed or random) (Hoyos, 2010). The most common is to use extreme value type I (EV1) distribution (Gumbel distribution) assumption for the error term which leads into the standard choice model, multinomial logit (MNL) (McFadden (1974) and its expansions. In this paper, the random parameter logit (RPL) model and RPL with error component (EC) specification were applied.

The MNL model is often used in the initial data estimation. The advantage is a simple closed form

$$\Pr_n(i) = \frac{\exp\{\mu\beta_i x_{ni}\}}{\sum_{j=1}^{J} \exp\{\mu\beta_j x_{nj}\}}$$

where μ is a positive scale factor, typically set to one (Hensher et al, 2005; Fiebig et al, 2009; Koppelman & Sethi, 2000; Train, 2003). This model allows simplicity of estimation and interpretation while the main downsides are restrictive assumptions including Independently and Identically Distributed (IID) error term and Independence from Irrelevant Alternatives (IIA) (Fiebig et al, 2009; Greene & Hensher, 2007; Hensher et al, 2005; Hoyos, 2010; Koppelman & Sethi, 2000; McFadden, 1974; Train, 2003). Therefore the more flexible models should be considered.

A common example of the more flexible models is a mixed logit model. This model overcomes some limitations of the MNL model, the IIA and IID assumptions, as well as fixed (homogenous) taste parameters across individuals (Fiebig et al, 2009; Hensher et al, 2005; Hensher & Greene, 2003). The mixed model includes two specifications how the randomness is incorporated: in random parameters and error components. Thus there exists observed heterogeneity in parameters and unobserved heterogeneity in the variances of the error components (Greene, 2012). These are based conceptually on the same mathematical functioning but may differ in their interpretation (Train, 2003). In RPL models, the focus is on individual heterogeneity (i.e. the taste differences) by allowing randomness in the parameters (Marsh et al, 2011; Train, 2003). This is introduced by a mixing distribution that is typically defined as normal, lognormal, uniform or triangular distributed (Hensher et al, 2005; Train, 2003). EC model, on the other hand, focuses on the individual specific random effects are associated with the choices and the correlation between the utilities of different alternatives (Campbell et al, 2008; Marsh et al, 2011; Train, 2003).

The conditional probability selecting alternative *i* in the mixed logit models is obtained from the integral of standard logit probability weighted by the mixing distribution $f(\beta)$:

$$P(i_n) = \int L_{ni}(\beta) f(\beta) d\beta$$

where $L_{ni}(\beta)$ is a standard logit and the density function f depends on the distributional parameters (Train, 2003; Hensher et al, 2005). In contrast to MNL, the parameter β is treated now stochastic alongside ε (Hensher et al, 2005; Revelt & Train, 1998, Hensher & Greene, 2003). A simulation method is needed to solve the integral, using commonly Halton method to take R number of draws from the mixing distribution (Hensher et al, 2005). The RPL and EC specifications can be applied separately or together (Greene, 2012) while the models reduce back to the standard MNL model if random parameters have neither variation nor correlation (Greene & Hensher, 2010).

Survey development

The survey development process included a focus group meeting, attribute selection and measurement, population sampling, final survey development and administration. The overall study included three main study objectives which required four different survey versions to enable formal testing of these objectives. The differences across versions occur in the CE question framing[7] and in the way choice sets were ordered in the CE. Otherwise the surveys were identical including two introductory questions about Canterbury's Rivers, a choice experiment, and debriefing questions and demographics.

A focus group was held with nine people aged from 30 to 65 years old with the majority having lived in Canterbury their whole lives. The main goal was to explore what different values people hold for freshwater and then try to combine these into relevant attributes. The discussion resulted in a range of values and issues around freshwater including drinking water, importance for wellbeing, pollution in water (e.g. algae), swimming and fishing, is water safe for children and dogs, balance between increasing farming (dairying) and state of natural environment and recreational use, and farming (run-offs and effluents). The focus group participants appreciated high quality food ("nice steak and milk") that irrigation facilitates. Interestingly, when asking about cultural values, the participants noted both, Māori and non-Māori perspectives, yet had a few detailed comments regarding Māori values.

Attributes:

Review of CE studies and other relevant literature regarding freshwater in New Zealand (e.g. ECan, 2011a; ECan 2009; Kerr & Swaffield, 2007; Marsh, 2010; Marsh & Phillips, 2012; MfE, 2006; Niyogi et al, 2007; Tait et al 2011; Tipa & Teirney, 2003) together with the focus group results were used to construct the final attributes. The final attributes are based on broad category of attributes determined by the four elements of wellbeing, and measurability. This way, (i) the policy relevancy is assured, (ii) measurability increases

[7] Citizen (society as a whole) or consumer point of view (from the point of view of your own welfare)

realism, while (iii) the relevancy of the attributes is comparable to focus group views (Blamey et al, 2002). The final choice experiment design included five attributes.

First, the *Number of jobs* attribute covers the contribution that water use makes to the economy similar to previous CE studies (e.g. Andersen et al, 2012; Kerr & Swaffield, 2007; Marsh, 2010; Marsh & Baskaran, 2009; Marsh & Phillips, 2012). While there are several different commercial uses of water, irrigation has a particularly significant impact on Canterbury's economy and economic benefits (ECan, 2011a). The levels of the number of jobs subject to changes in land use was based on Saunders and Saunders (2012) who estimate 173 jobs for 30 000 hectares of irrigated land area.

Second, the environmental attribute of *Water quality and habitat for plants and animals*. Studies have found a significant relationship between land use changes and water quality, increases in nutrients concentrations in runoff (Carey et al, 2004), and decline in biotic indices downstream (Niyogi et al, 2007). The challenge, however, is measuring water environments by a single attribute. According to Kerr and Swaffield (2007) water resource related CE studies world-wide have tended to highlight five types of environmental attributes: species numbers, presence of vegetation, types of vegetation, water clarity and some metric of chemical composition. The environment attribute in this study is based on the Quantitative Macroinvertebrate Community Index (QMCI) similar to Tait *et al* (2011 & 2012). QMCI captures the overal state of the river or stream health categorised from poor to excellent quality (Stark & Maxted, 2007a&b).

The third attribute is *Water quality for swimming and other contact recreation*. Out of many possible social impacts related to land use changes, recreation was chosen to reflect the social elements of wellbeing. Recreation is a typical attribute in previous freshwater CE studies in New Zealand (e.g., Andersen et al, 2012; Kerr & Swaffield, 2007; Marsh, 2010; Marsh & Baskaran, 2009; Marsh et al, 2011; Marsh & Phillips, 2012; Tait et al, 2011 & 2012). Commonly, swimming seems to capture all recreational water use[8] as noted in Marsh *et al* (2011) while this may overlook other recreational interests that do not require contact with water. In this study, the levels were based on the percentage of swimming sites that are graded good or very good quality based on recent Suitability For Recreation Grade (SFRG) grading (ECan 2012c & 2009) and freshwater management targets (ECan, 2011c).

The fourth attribute is *Water quality for Mahinga kai* (*customary Māori food gathering*). Mahinga kai means "food and other resources and the areas that they are sourced from or in which they grow" (MfE, 2006, p. 41) one example of mahinga kai species is eels (Jellyman & Graynoth, 2010). Mahinga kai is an important part of cultural identity, and necessary in order to continue traditions and keeping tribes together in contemporary society (Tipa & Teirney, 2003). This was chosen in this study to reflect Māori values around water, as mahinga kai is not measured by the western scientific method (MfE, 2006). While worldwide, there are a number of CE studies focusing on cultural heritage values, few studies regarding freshwater resource in Canterbury have included a cultural specific attribute - these are often reflected in other attributes, as in Kerr and Swaffield (2007). Meanwhile, Marsh *et al* (2011) included a native fish and eels attribute, however, referring it more to the quality of water than cultural importance. Andersen *et al* (2012), on the other hand, focused intensively on Māori and environment values; yet; they include no specific attribute dedicated for Māori values only. Thus by including a Māori specific attribute this study provides important new information.

Last, these four elements of wellbeing are traded-off with changes in household expenses (increase in rates). The focus group participants agreed with the increase in rates if they could see the results of this. The final levels of the change in rates were derived from the CE

[8] This was also noted by one commentator within this thesis research.

literature related to Canterbury water. The minimum level was no change ($NZ 0) for the status quo level. The maximum level ($NZ 125) was chosen to be between the maximum levels from most recent studies (Marsh & Phillips, 2012; Tait et al, 2011 & 2012).

Table 1 summarises the final attributes and their levels. The attribute descriptions as seen in the survey can be found in Appendix 1. The shaded levels are status quo levels assuming no change in the management practices thus hypothetical conditions of the rivers in the future. These are 'No change' for Number of jobs and Cost. The status quo level for water quality and habitat is based on the average/median QMCI values which vary according to river type (Hayward et al, 2009) and with the expectations of worsening water quality gives the level 'fair'. The status quo for the swimming water quality is 20 per cent which is closest to the recent SFRG grading (14 % of good/very good sites) (ECan, 2009 & 2012c). Finally, the overall cultural health has been recognised to be moderate to poor at the South Island (Canterbury Mayoral Forum, 2009), thus the level 'below average'. There is, however, a possibility that the respondents perceive the status quo differently or that the status quo alternative is not seen neutral with the two other choice alternatives (Marsh et al, 2011).

Table 1: Final attributes & descriptions

Attribute*	Levels	
	Alternatives A and B	Status quo
JOBS: Number of jobs	– 173, 0 (No change), + 173, + 346	0 (No change)
QMCI: Water quality and habitat	Poor, Fair, Good, Excellent	Fair
SWQ: swimming water quality, % of popular swimming sites graded good/very good	0 %, 20 %, 40 %, 60 %, 80 %	20 %
CHI: Customary Māori food gathering	Poor, Below average, Average, Above average, Exceptional	Below average
COST: Cost to Canterbury households ($NZ/year)	+ 25, + 50, + 75, + 100, + 125	0 (No change)

*Detailed description in Appendix 1

Choice experiment design:

The choice sets were created using a D-efficient design with point priors and the MNL model employing N-Gene software (ChoiceMetrics, 2012). The point prior values were mainly based on the literature. Causal-effects were taken into account in two ways: including some two-way interaction terms, and excluding some unrealistic level combinations. Inclusion of interactions ensures the estimation of these effects. Constraining the level combinations, on the other hand, makes the experiment more meaningful; for example, positive (negative) change in Number of jobs cannot occur with highest (lowest) level of Water quality and habitat as changes in employment was related to increasing in irrigated land area, which assumes further increase in run-offs and thus impacts on water quality. The final design included two alternatives, water management options A and B, and a status quo alternative with fixed levels that was added afterwards. A total of 15 choice sets were used in order to elicit some fatigue effect as this may occur in longer surveys and was part of the research objectives. The sampling list was provided by the Electoral Enrolment list while quota sampling was used to ensure capturing Māori respondents. The overall response rate for the mail surveys was 16 per cent; this was followed by an additional online surveying were respondents were recruited through independent third-parties.

RESULTS

In 2012, the choice experiment survey was administered throughout Canterbury. This resulted in total of 312 surveys that were usable in the analysis. This paper reports a subsample focusing on the survey that had the CE framed under a citizen perspective and which used a standard randomised choice set order (with the same order for all 74 respondents) (Figure 2). This subsample was chosen as it applies the standard question framing employed in environmental valuations (Sagoff, 1988) with a standard choice experiment design. A total of 74 answers provide 1110 choice observations as each participant evaluated 15 choice sets.

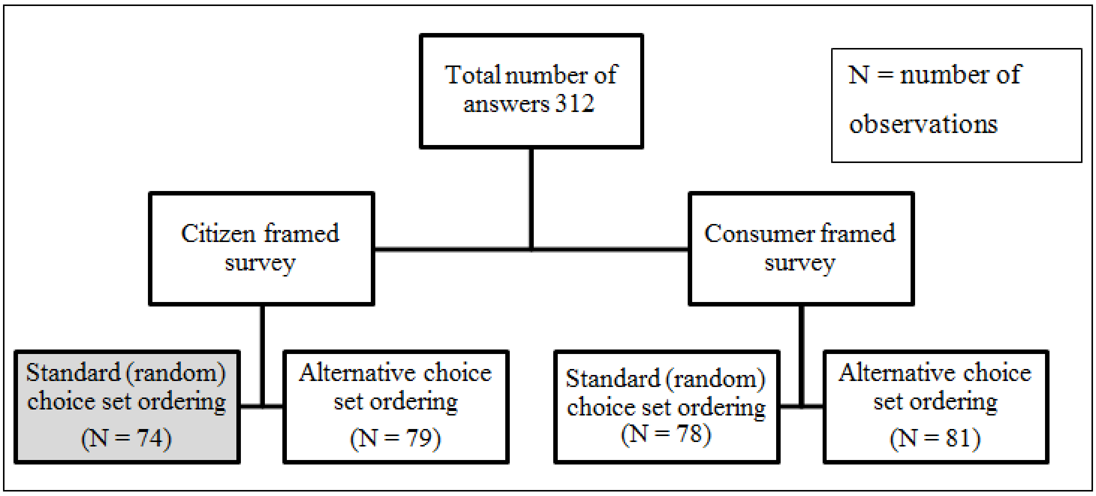

Figure 2. Number of survey responses

The respondents' demographics are summarised in Appendix 2. A typical respondent in this subsample was between 50 and 59 years of age; hold an undergraduate diploma, certificate or degree; earned $NZ 100 000 or more total household income; if employed, worked in the Professional, Scientific, Technical, Administrative and Support services sector; and lived in urban areas, typically in Christchurch. In addition, a number of respondents stated they belong in some organisation or group, mainly Fish & Game.

Overall, the sample was representative in terms of gender and Māori ethnicity. A majority of the respondents were New Zealand Europeans (81 %), while quota sampling resulted eight per cent of Māori respondents, which is slightly higher than the Canterbury average (7.2 %). The age distribution was unrepresentative and also the higher income people (total household income over $NZ 100 000/year) were over-represented compared to the Canterbury average of $NZ 82 055/year (Statistics New Zealand, 2012).

Choice modelling results

The observed choices were modelled specifying a random parameter logit and a random parameter logit-error component model with panel data specification using NLOGIT 5.0. The panel data specification allows the error component to be the same across the choices made by the same individual (Scarpa et al, 2005). The observed choices provide information of the underlying utility function described by the attributes. To allow for preference heterogeneity, all parameter coefficients were assumed to be normally distributed random parameters except the cost attribute. The fixed cost attribute makes the WTP estimation simpler as the WTP estimate follows normal distribution (Train & Weeks, 2005). The alternative specific constant was specified to take the value one for status quo alternative and zero otherwise. This specification can be used to detect status quo bias (Hoyos, 2010; Meyerhoff & Liebe, 2009). Appendix 3 includes estimates from three model specifications: the RPL "base model" with main effects (Model 1), the RPL-EC "cultural health" model with main and interaction effects (Model 2); and the RPL-EC model with non-linear attribute levels (Model 3). The non-linear levels were coded using effects coding (with reference levels poor for QMCI, 0 % for SWQ, and poor for CHI). Model 2 is chosen here for a more detailed discussion as it provides more information in regards to the cultural dimension of water. The other models are provided for comparison for the impacts of the different model specifications.

The "cultural health model" (Model 2 in Appendix 3) has a good statistical model fit with McFadden's pseudo R^2 equal to 0.410. Overall, adding the EC specification and the interaction effects improves the statistical model fit over the base model. All main effects are statistically significant at the 99 per cent level of confidence with expected signs. This implies that respondents, all else being constant, prefer improvement in these attributes. The relative magnitudes of the parameter estimates indicate that people derive most utility from improvement in the quality of habitat; improvement in mahinga kai and food gathering opportunities; increase in swimming water quality; and change in the number of jobs, in this order. The negative estimate for the cost parameter indicates people are less likely to choose alternatives with a higher cost. All assumed random parameters, except SWQ, have statistically significant standard deviation (at 99 % level). This indicates a considerable degree of preference heterogeneity within the respondents. Moreover, the ASC parameter for the status quo alternative is positive and statistically significant (at 99 % level). This suggests some level of status quo bias: people want to maintain the current water management practices. The interactions between the QMCI and CHI attributes and the SWQ and CHI attributes are negative and statistically significant (at 99 % level). The negative interaction can be interpreted as a possible substitute relationship between the attributes (Day et al, 2012). Thus respondents may attach less value for improvements in one water quality attribute the more improvements in other water quality attribute they are offered. A large number of interaction terms with socio-economic characteristics were also tested; out of these, only the CHI*gender[9] is statistically significant (and positive). Inclusion, even though insignificant, of other covariate interactions provides more depth to the interpretation of the cultural attribute. Finally the error component being statistically significant between the alternatives A and B indicates existence of some preference heterogeneity associated with the choice alternatives of management changes that is not accounted in the random parameters (Beville, 2009).

The cultural health model has some similarities and some differences compared to the base model (Model 1) and the model with non-linear effects (Model 3) (see Appendix 3). First, the base model provides similar preference ranking of attributes being statistically significant with expected signs. In contrast, when splitting the water quality attributes (QMCI, SWQ and CHI) into non-linear levels, only some levels are statistically significant. These are 'excellent' QMCI, the levels higher than 20 % of the rivers for SWQ and CHI level above average. As a result only these levels matter for the choices while the insignificant levels can be interpreted to be statistically the same as the reference levels (Hensher et al, 2005a). In addition, as Figure 3 illustrates, QMCI has increasing marginal utility with improved quality levels; whereas the marginal utility increases only until the level 40 % of the rivers with SWQ attribute and above average mahinga kai/food gathering opportunities. This can be seen as a peak in Figure 3. These highest levels were also the only significant levels with QMCI and CHI. Last, the positive and significant ASC coefficient in Model 2 indicates again the status quo bias in the deterministic component of utility whereas in Model 3 the status quo effect is only detected in the stochastic part of utility by the significant correlation between two experimentally designed alternatives (Error component A vs. B) (Olsen et al, 2011; Scarpa et al, 2005).

[9] This interaction was significant but negative when CHI*Male

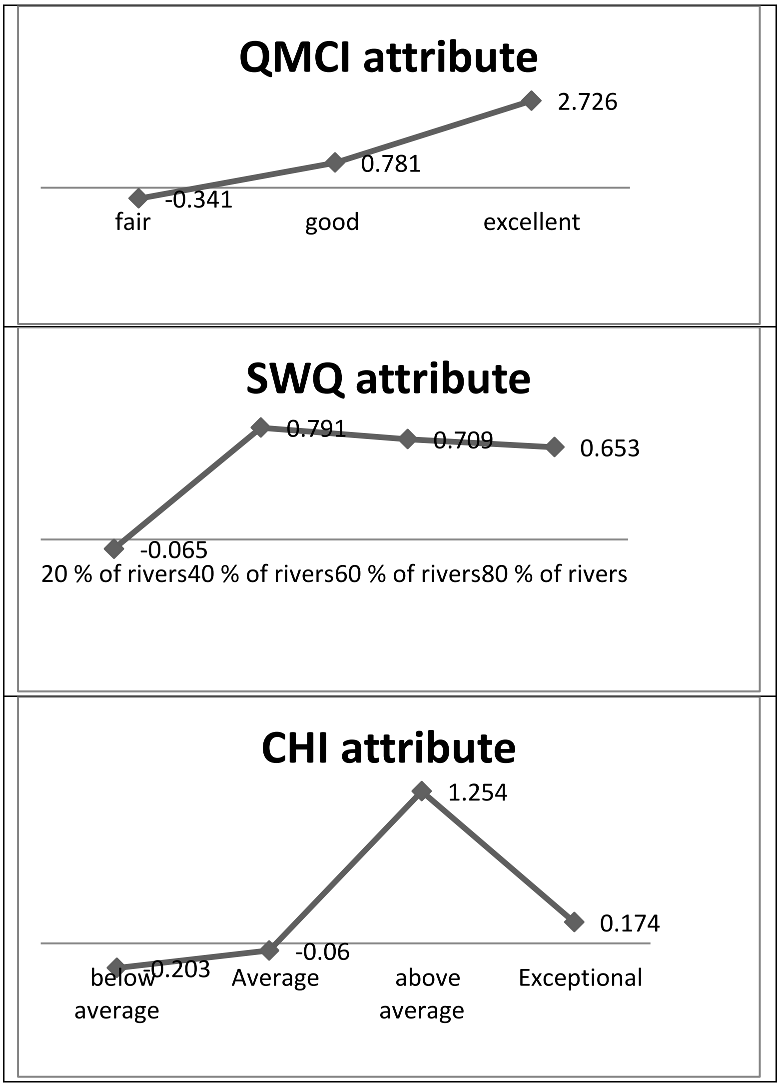

Figure 3. Non-linear effects in the marginal utilities

WTP estimates

The payment vehicle framing for the WTP estimates was annual increase in rates for the next five years. The WTP values were estimated for the cultural health model (Model 2) as it was chosen for the more detailed discussion. The WTP values and confidence intervals are unconditional WTP distributions obtained using the Krinsky-Robb (1986) method with 1000 draws. This approach is commonly used in the literature (e.g., Carlsson et al, 2011; Colombo et al, 2009; Domínguez-Torreiro & Soliño, 2011; Tuan & Navrud, 2007; Zander & Garnett, 2011). The estimates were adjusted by excluding five per cent of the tails in order to exclude any outliers.

Looking at the estimates in Table 2, WTP is highest for the quality of habitat ($NZ 188 per year) followed by Mahinga kai/food gathering ($NZ 101), swimming water quality ($NZ 73), and last for number of jobs ($NZ 0.43 per job). This indicates that people are willing to pay most for the increase in quality of habitat and least for increase in number of jobs due to more irrigated land area.

Table 2. WTP estimates ($NZ per next 5 years)

	Model 2: RPL-EC "Cultural health model"	
	Mean	(95 % Confidence interval*)
JOBS: Number of jobs	0.43	(0.30-0.60)
QMCI: Water quality and habitat	188.27	(134.20-257.50)
SWQ: swimming water quality	73.20	(44.20-109.00)
CHI: Customary Māori food gathering	101.23	(15.50-193.30)

*Krinsky & Robb method where 2.5 and 97.5 percentiles represents the 95 % confidence interval. The WTP estimates were adjusted removing 5 % of the observations in order to exclude outliers due to the infinite tails in the normal distribution.

The respondents were also asked to answer follow-up questions regarding attribute attendance in the choice experiment. Attribute attendance was explored in two questions asking were there any attributes the respondents either ignored or considered to be the most important in their decision making. Looking at Table 3, the most often ignored attributes were CHI and JOBS. Half of the non-Māori respondents stated the Customary Māori food gathering did not matter in their choice making and circa 30 per cent, both Māori and non-Māori, thought so regarding the change in jobs attribute. Meanwhile, the respondents considered the quality of habitat as the most important attribute. The impact of the attribute (non)-attendance can be estimated, for example, by including interactions with the (stated) non-attendance and guiding attributes (Carlsson et al., 2010; Scarpa, et al, 2011).

Table 3. Attribute attendance

	Attributes that didn't matter at all in the choice making (%)		Attribute(s) that mattered most to you (Counts)	
	Māori	Non-Māori	most important	second important
Number of jobs	33.3 %	27.9 %	10	9
The quality of habitat	-	8.8 %	49	7
Swimming water quality	16.7 %	16.2 %	17	13
Customary Māori food gathering	-	50 %	4	8
Payment method	50 %	17.6 %	15	11
Total N	6	68		

DISCUSSION

Canterbury freshwater management is a complex task dealing with multiple users and use types and their conflicting needs. This paper reports the results from a choice experiment survey for possible water management options for Canterbury Rivers where trade-offs were explored across elements of wellbeing. These four elements are essential in policy making in New Zealand. A novel feature was the inclusion of the cultural value as one of the attributes and quota sampling was used to ensure Māori participation (8 % of the sample).

Modelling results indicate people value all freshwater attributes considered here positively (other than cost), with highest WTP for environmental benefits followed by cultural and recreational values. The change in the number of the jobs in the region was valued the least of all attributes. The findings of heterogeneous preferences support the use of random parameter models over the standard MNL model. There was some deterministic evidence for the status quo bias that people would like to remain with the current water management situation, however, this was not case when exploring the non-linear effects of the water quality attributes. All non-linear levels that mattered for the respondents' decision making were higher than the provided status quo levels.

Compared to the literature, the environmental attribute was valued highest (WTP $NZ 188) consistent with good ecology ($NZ 84) in Tait *et al* (2011 & 2012); whereas in Marsh and Phillips (2012) good recreation ($NZ 76) and good river tributaries ($NZ 242) were valued higher than good ecology ($NZ 74). The safe swimming estimates in Kerr and Swaffield (2007) had the WTP range from $NZ 68 to 299, which also includes the swimming water quality estimate ($NZ 73) from this study. The change in number of jobs was valued the lowest consistent with Marsh and Phillips (2012) for the reduction or increase of 250 jobs (-$NZ 220 and $NZ 27, respectively); however, in Marsh and Phillips (2012) 500 more jobs ($NZ 45) was valued before good fishing ($NZ 40). Moreover, the change in employment in Kerr and Swaffield (2007) was valued negatively amongst anglers but positively amongst farmers. Also in the Australian example (Zander et al, 2010), the irrigation income from agriculture was not very important whereas the environment, recreational and cultural services were highly valued.

The cultural attribute was a key interest in this paper and mahinga kai/food gathering was used to describe this. Firstly, this attribute was valued second highest with WTP of $NZ 73. In contrast to some international examples (Campbell, 2007; Carlsson et al, 2010 & 2011), the cultural attribute in this data set was not valued lowest. Secondly, as reflected in the negative interactions, the evidence from this data shows also that respondents may attach less (more) value for improvements in cultural element if more (less) improvements in either swimming or quality of habitat are offered. Thirdly, mainly insignificant interactions with the socio-economic characteristics suggest some uniformity of what Cantabrians want in relation to the cultural attribute. Similar to other New Zealand studies, also Andersen *et al* (2012) suggest focusing on the similarities rather than differences between Māori and non-Māori cultures in the case of the natural environment and values of water.

However, generalizations to the wider public of Canterbury may need to be made carefully as these results are based on a subsample of 74 individuals from the total of 312. More evidence for these results would provide comparison with results from other surveys conducted within this PhD research. Regarding the importance of the cultural element here (second highest WTP) may also need to be interpreted carefully as the cultural element was stated to be the most often ignored attribute within the participants. It is also hard to reflect the differences between Māori and non-Māori respondents as the proportion of Māori was only eight per cent. While this is slightly higher than the Canterbury average (7 %), it is still only 6 respondents within the sample size of 74.

This study contributes to the literature in several ways. First, it adds to a small number of choice modelling studies concerned with water resource and its cultural importance in New Zealand. Therefore it provides important policy implications for those who need to make difficult water management decisions. These decisions include weighting of trade-offs across multiple elements of wellbeing, often associated with cost. This study provides information of such trade-offs indicating that overall, all these four elements of wellbeing matter. The preference ranking provides important insight for policy makers in the freshwater allocation decisions in Canterbury. While there is wide discussion of the intensification in land use and increasing irrigation, care should also be taken for environmental and other values of water.

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Appendix 1. Attribute descriptions as in Canterbury Rivers Survey

Number of jobs: Irrigation and other commercial uses of water support economic growth which provides, for example, jobs to the region.

Water quality and habitat for plants and animals: The type and amount of macro-invertebrates, the species that live in rivers, can be used to indicate the river health and habitat: pollution-sensitive species exist in high quality water, pollution-tolerant species exist in reduced quality water, and only a few species survive in highly polluted water. Based on this, the quality of habitat can be scored from **Excellent** to P**oor.**

QMCI score	Habitat	Description
6 or higher	Excellent	Clean, pristine water and habitat that is un-enriched with no alg Often well shaded and disturbed river in its natural state.
5 to 6	Good	Good water quality and habitat, potential mild pollution
4 to 5	Fair	Fair water quality and habitat with moderate pollution
Less than 4	Poor	Habitat with severe water quality issues: a high level of nutrien enrichment and algae, sedimentation and pollution from variety sources. River is high in temperature and low in oxygen causin decrease in diversity and number of species.

Water quality for swimming and other contact recreation: % of popular swimming sites those are swimmable: Rivers provide a variety of recreational opportunities: such as swimming, fishing, picnics, and kayaking. Contact with polluted water is a potential health risk as it may cause, for example, diarrhea or abdominal pain. Suitability for Recreation Grade (SFRG) provides information for swimming water quality for the popular recreation sites in Canterbury. The assessment is based on the E.coli bacteria and sanitary measurements. The swimmable of a site include here sites that are graded very good and good, meaning water is satisfactory for contact recreation at all times or most times, respectively.

Water quality for mahinga kai (customary Māori food gathering): Mahinga kai is a traditional element of Māori culture. This means gathering food (kai) from the waterway environment. There are number of culturally significant species. This attribute, measured by an index, takes account the amount and variety of these species: The index level of 5 indicates exceptional site where an abundant and good range of mahinga kai species are present, thus site is significant for customary food gathering purposes. The level of 1 indicates a poor site where mahinga kai species are absent.

Cost to households: *Improvements in Canterbury's water management policy could be funded by increasing household rates for a period of five years.*

Appendix 2. Sample demographics

Gender	Survey	Canterbury*
Male	45 %	48.8 %
Female	55 %	51.2 %
Total	74	521 832
Chi-square$_{[d.f.1]}$	0.524	p: (0.469)

Ethnicity	Survey	Canterbury*
Māori	8 %	7.2 %
Chi-square$_{[d.f. 1]}$	0.091	p: (0.762)

Age		
19 or under	2.7 %	7.2 %**
20 to 29	10.8%	12.4 %
30 to 39	17.6%	14.3 %
40 to 49	12.2%	15.1 %
50 to 59	20.3%	12.7 %
60 to 69	16.2%	8.5 %
70 to 79	17. 6%	6.2 %
80 or over	2.7 %	2.2 %**
Total	74	521 832
Chi- square$_{[d.f. 7]}$	43.072	p: (0.000)

Total income ($NZ/year)	
Up to $ 20 000	7.1 %
$20 000 to $40 000	15.7%
$40 000 to $60 000	18.6%
$60 000 to $80 000	8.6 %
$80 000 to $100 000	21.4%
$100 000 or more	28.6%
Total	70

Education	
None	1.4 %
High school	24.7%
Trade/technical qualification or similar	20.5%
Undergraduate diploma/certificate/ degree	35.6 %
Postgraduate degree	17.8%
Total	73

Occupation	
Employed or Self-employed	63.5 %

Sector	
Professional, Scientific, Technical, Administrative & Support services	20.0 %
Retail trade, Accommodation & Food services	17.8 %
Agriculture, forestry & fishing	17.8 %
Health care & Social assistance	11.1 %
Construction	4.4 %
Electricity, Gas, Water & Waste Services	2.2 %
Education and Training	4.4 %
Information, Media & Communications	4.4 %
Tourism	2.2 %
Other	15.6 %
Total (N)	45

Group membership*** (counts)	
Yes (total)	20
Forest & Bird	2
Fish & Game	10
Federated Farmers	3
Other****	8

Local authority	
Christchurch	32.4 %
Selwyn	10.8 %
Waimakiriri	10.8 %
Timaru	8.1 %
Ashburton	4.1 %
Hurunui	4.1 %
MacKenzie	4.1 %
Waimate, Waitaki & Kaikoura	6.6 %
Missing	21 %
Total (N)	74

Living area	
Urban	42.5 %
Rural	34.2 %
Semi- urban/rural	23.3 %
Total (N)	73

*Census, Statistics New Zealand (2006); ** (15-19 years) and (80-84 years); *** Some respondents belong in more than one group; ****e.g., Canterbury Environmental Trust, Mana whenua

Appendix 3. Choice model estimates

	Model 1: RPL "Base model" Coefficient	p-value	Model 2: RPL-EC "Cultural health model" Coefficient	p-value	Model 3: RPL-EC With non-linear effects Coefficient	p-value
ASC (for SQ)	0.596***	0.001	3.583***	0.004	-0.254	0.844
JOBS	0.004***	0.000	0.005***	0 .000	0.006***	0.000
QMCI	1.266***	0.000	1.997***	0 .000		
fair					-0.341	0.198
good					0.781	0.146
excellent					2.726***	0.000
SWQ	0.345***	0.000	0.757***	0 .0000		
20 %					-0.065	0.923
40 %					0.791**	0.045
60 %					0.709**	0.039
80 %					0.653*	0.091
CHI	0.452***	0.000	1.611***	0 .005		
below average					-0.203	0.758
Average					-0.060	0.926
above average					1.254**	0.019
Exceptional					0.174	0.814
COST	-0.011***	0.000	-0.011***	0.000	-0.016***	0.000
QMCHI*CHI			-0.229***	0.003		
SWQ*CHI			-0.120**	0.021		
CHI*Māori			0.517	0.226		
CHI*income			0.012	0.807		
CHI*female			0.523***	0.001		
CHI*education			-0.091	0.183		
CHI*age			-0.063	0.222		
Random parameter standard deviations						
JOBS	0.005***	0.000	0.003***	0.001	0.005***	0.002
QMCI	1.017***	0.000	0.797***	0.000		
fair					0.410	0.242
good					0.140	0.847
excellent					1.763***	0.000
SWQ	0.503***	0.000	0.165	0.125		
20 %					0.239	0.594
40 %					0.720*	0.091
60 %					0.742**	0.029
80 %					0.504	0.230
CHI	0.753***	0.000	0.304***	0.006		
below average					1.930***	0.000
average					1.222***	0.004
above average					0.331	0.500
exceptional					0.036	0.974
Error components A vs B			2.464***	0.000	3.235***	0.000
Log likelihood	-809.829		-719.173		-695.793	
McFadden Pseudo R^2	0.3359		0.4103		0.4294	
AIC	1639.7		1474.3		445.6	
Estimation based on number of						
individuals	74		74		74	
observations	1110		1110		1110	
parameters	10		18		27	

***, **, * denotes the statistical significance at 1%, 5%, 10% levels, respectively; ASC (SQ) = alternative specific constant for status quo (1 if status quo, 0 otherwise); JOBS = Number of jobs; QMCI = Water quality and habitat; SWQ = swimming water quality: % of popular swimming sites those are swimmable; CHI = Customary Māori food gathering; COST = Cost to Canterbury households/ increase in rates ($NZ/year)