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Trade-offs between development, culture and conservation – willingness to pay for tropical river management among urban Australians

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Abstract

Australia's system of tropical rivers constitutes one of the largest and least changed drainage networks in the world. However increasing demand for water in parts of Australia, along with ongoing drought, is increasing pressure to develop these rivers. This paper reports the results of a choice experiment (CE) to assess the benefits of different management strategies for three tropical rivers in northern Australia: the Daly, Mitchell and Fitzroy Rivers. The CE was carried out using a survey mailed to Australian urban populations. The results showed that 90% of Australians were willing to pay a once-off payment for the management of tropical rivers. Respondents who had visited or lived near the rivers were willing to pay more for cultural, recreational and environmental services than those who had not. Respondents classed as 'developers', who made up only 4% of the 684 respondents, considered a substantial income from irrigated agriculture as important. Unlike 'environmentalists' and 'neutrals', 'developers' were unwilling to pay for high quality recreational fishing or for having floodplains in good environmental condition. All groups, however, were willing to pay for high cultural values.

Key words: Australia; choice experiment; compensating surplus; cultural values; recreational values; tropical rivers

1. Introduction

Global challenges to water resources and surrounding ecosystems, such as urbanisation, population growth, land use change and increased irrigation, construction of dams, pollution, climate change and other impacts related to human activities and economic growth need to be addressed urgently (World Water Assessment Programme, 2009). While public awareness of the need to better manage and protect water has grown over the last decade (World Water Assessment Programme, 2009), and sustainable management of river systems is on policy and research agendas worldwide, economic assessments of the multiple use of water resources is relatively recent, even though it is critical if water policy is to be equitable and effective (see e.g. Prato, 2003; Hanley et al., 2006; Moran and Dann, 2008; Birol et al., 2010).

Australia's tropical river and wetland systems form one of the greatest river drainage networks in the world (Lukacs and Finlayson, 2008) and are widely recognised as a significant ecological and social asset (Australian Tropical Rivers Group, 2004). Unlike many other river systems in Australia and tropical river systems worldwide, Australian tropical rivers are largely intact ecologically and have not been overly regulated and fragmented (Finlayson et al., 2005). However, there are ambitions for rapid development of tropical northern Australia, both as an opportunity in itself and in response to extended drought in southern Australia, particularly in the formerly well-watered but over-allocated Murray-Darling basin (Australian Government, 2009, p.95). Within the last five years there has been strong political advocacy for the ideas that north Australia should be the "food bowl for Asia" (Australian Government, 2009, p.95) and that water should be piped south from northern Australia (Barnett, 2008). The presence of substantial mineral and energy resources in this region is expected to increase development pressure and demand for fresh water in the future.

If development does go ahead and emphasis is largely placed on irrigated agriculture, economic benefits may accrue to investors and some local communities but not everyone will benefit financially, and both the quality and quantity of water in rivers are likely to decline. If development is tempered with conservation, river health may be maintained, securing other direct and indirect benefits for Australian society, but some economic benefits will be foregone. Policy makers are currently assessing both costs and benefits of development and conservation to determine the long-term consequences of their decisions for tropical rivers. While local communities and stakeholders are being included in consultations about how they value Australian rivers and their aspirations for them, the values of urban and southern-dwelling Australians need also to be incorporated into the discussion, not least because urban Australians are a significant source of ongoing natural resource management funding in the future, both voluntarily and through tax subsidisation. Studies documenting the assets and values of Australia's tropical rivers (for example Woinarski et al., 2007; Lukacs and Finlayson, 2008; Bartolo et al., 2008; Jackson et al., 2008) have only considered the views of people living in the north. Historically, however, people of the southern cities of Australia, where most Australians live, have often asserted their political influence concerning conservation in the north, sometimes against the prevailing views of those present in the north at the time (e.g. declaration of Kakadu National Park). Failure to understand the value placed on tropical rivers by urban Australians across the whole country would underestimate the total economic value (TEV) of tropical rivers and at the same time would underestimate the environmental costs of developing these rivers.

This project has therefore aimed to identify and quantify the ecosystem services that flow from the assets of Australia's tropical rivers to the broader Australian society. To undertake the study we targeted residents of six large urban centres where 60% of Australians live

(Australian Bureau of Statistics, 2009). The study used a choice experiment (CE) to assess urban Australians' willingness to pay (WTP) for four non-market ecosystem services provided by Australia's tropical rivers: (1) supporting services provided by floodplain in good environmental condition (for example, habitat for a diversity of plants and animals); (2) recreational services provided by a river in good condition for fishing; (3) cultural services provided by waterholes in good condition for Aboriginal activities; and (4) provisioning services provided by income from irrigated agriculture (see Table 1). We conduct these calculations for three case study rivers: the Daly River in the Northern Territory, the Fitzroy River in Western Australia and the Mitchell River in Queensland. We hypothesise that the magnitudes of urban Australians' WTP for environmental, cultural, recreational and production ecosystem services of tropical rivers differ as follows:

1. Respondents who can be characterized as 'environmentalists' have a higher WTP for river management strategies that support the rivers' environmental values, and a lower WTP for their production values, than development oriented Australians.
2. Urban Australians who have some kind of connection to and knowledge of tropical rivers, because they have visited them or lived there, have a higher WTP for management strategies that ensure the rivers' environmental, cultural and recreational values than those who have never visited.
3. The closer urban Australians live to the catchments of tropical rivers, the higher their WTP for river management strategies that support environmental, cultural and recreational values.

Hypotheses two and three embody the concept of a sense of place. Places are geographical sites that are distinguished from the general environment and to which they feel a sense of intimate connection (Tuan, 1977). Such connections can arise from visits to a place without actually living there (hypothesis two) or the identification with a site that comes from local residency (hypothesis three). Following evaluation of the services provided by tropical rivers we aim to calculate the compensating surplus (CS) for the following three different hypothetical tropical river management strategies:

1. strongly in favour of conservation ("conservation first"),
2. strongly in favour of development ("development first")[1]
3. development constrained by conservation.

2. Economic framework and methodology

Many potential costs and benefits may be relatively easy to identify and quantify in dollar terms. Others are less apparent and so may be excluded from the evaluation of alternatives. The total economic value (TEV) framework (Bateman et al., 2002) helps to classify costs and benefits of each type. People across Australia derive different and complex values from tropical rivers and for different group of users, the values can fall under different categories (Table 1). Use values that have markets are the most straightforward, for example, the direct extraction of water for primary industry. Currently these production values are important for local enterprises involved in agriculture and pastoralism but in the future are expected to assume importance for developers from other parts of Australia. Tropical rivers attract tourists from all over Australia and from abroad (mainly for fishing) and are also essential for many environmental values, both in the streams themselves and also in the habitats for many native plants and animals provided by wetlands and estuaries. Tropical rivers have cultural significance to Aboriginal Australians, being an integral part of songs, ceremonies, hunting and collecting, and other activities that bind people to their country (Toussaint et al., 2005;

[1] Development was described to respondents as being associated with irrigated agriculture leading to food production, infrastructure expansion and job creation.

Jackson et al., 2005, 2008). These cultural values would be considered as indirect use-values for Aboriginal Australians, while they would be categorized as have existence values and bequest values for other Non-Aboriginal Australians. Likewise, for urban Australians who have never visited the tropical river catchment areas, the recreational value would fall under option value because they maintain the opportunity to use them for fishing etc. in the future. For Australians who live nearby and urban Australians who visit the region for fishing etc., the recreational value would be a direct use-value.

[Table 1 here]

Use values are relatively straightforward to measure because transactions reflecting their demand and supply can be revealed in the market. Placing a monetary estimate on non-use values, option and indirect use values requires special techniques which do not rely on market behaviour. Only stated preference methods, using responses from surveys, are able to assess the TEV (Bateman et al., 2002). The two most common approaches under this method are contingent valuation (CV) and choice experiments (CE) (Mitchell and Carson, 1989; Bateman et al., 2002)

2.1. Choice experiments

We apply a CE in this study because CE is a multi-attribute preference elicitation technique while CV can only evaluate natural assets as a whole. We used the CE to assess the TEV of tropical rivers, expressed by fours ecosystem services they provide to urban Australians (Table 1). In a CE, respondents are asked to choose their preferred scenario (alternative) out of a number of presented scenarios (usually between two and five). Ranking or best-worst scaling of the presented alternatives are also common in some CE designs. In this study the alternatives presented to respondents represent different management alternatives for tropical rivers. By varying the levels of the attributes of the management alternatives, we are able to draw conclusions about respondents' trade-offs between the ecosystem services the management strategies provide and hence on their relative values.

CE are based on the random utility framework, expressing respondents' behaviour reflected by their choices. The random utility framework is based on the hypothesis that respondents make choices based on the attributes along with some degree of randomness (the random component) which helps the researcher reconcile theory with observed choices (Scarpa and Willis, 2010). Only the non-random, deterministic, component is observable to the researcher while the error component is unobservable (Train, 2003). The observable component reflects respondents' indirect utility functions and the error component describes other factors or attributes of a good apart from the stated attributes but which also influence respondents' choices. If the error component follows the predetermined distribution of independent and identical distributes (iid) according to a type I extreme value distribution, a conditional logit (CL) model can be derived (Train, 2003). However, because of the stringent assumption of independence of irrelevant alternatives (IIA), the CL model is now usually replaced by other more flexible models such as nested logit (NL) or random parameter logit (RPL) models (Carlsson et al., 2003; Hoyos et al., 2009). In this study we apply panel RPL models because they can further detect unobserved heterogeneity between respondents by allowing the coefficients associated with observed variables to vary randomly over respondents (Train, 2003). In a RPL, the probability function does not have a closed-form solution like the one specified from a CL model and has to be specified by the researcher. This distribution can be, for example, normal, log-normal, uniform or triangular (Train, 2003). A detailed description of RPL models is given in Train (2003), Hensher and Greene (2003) and Hensher et al. (2005b).

2.2. Welfare measurement

CE conforms to Lancaster's consumer theory (1966), suggesting that the value placed on a good is a reflection on its attributes and thereby permitting the estimation of part-worths as a welfare measure (Mallawaarachchi et al., 2006). The part-worths estimates can be either positive, signifying respondents' maximum willingness to pay (WTP) for an attribute or negative, signifying their minimum willingness to accept (WTA) compensation if they become worse-off when choosing an alternative with an unfavourable attribute (Freeman, 2003). The calculation of part-worths is straightforward when CL models applied have a closed form. In this case, part-worths are derived by calculating the ratio $-\beta_j / \beta_{price}$, where β_j is the coefficient for the river management attribute and β_{price} is a monetary attribute which is associated with the payment vehicle. The calculated welfare estimate represents the marginal rate of substitution between prices and traits, *ceteris paribus*. Obtaining welfare estimates from RPL models is more complex because they have to be approximated through simulation (Thiene and Scarpa, 2009). Following the approach outlined by Thiene and Scarpa (2009), we used the statistical package R to draw a large number of variates (10000 draws) from the random parameter for the relevant river management attribute (β). The payment vehicle (α) was non-random without a standard deviation. Secondly, we combined the β and α into pairs in order to compute the values of $WTP/WTA^r = \alpha^r / \beta^r$ for each replicate r. We then took the mean of all 10000 replications as well as 25th and 75th percentiles.

Different management strategies for tropical rivers result in different incremental conditions of the provided services and therefore in welfare changes for Australians who use these services. Hence, apart from the estimations of part-worths for single attributes/services we estimate the compensating surplus (CS) for three hypothetical different river management strategies (see Table 7). CS has become popular as a means of measuring welfare changes of the set of attributes used in the CE (see e.g. Haab and Hicks, 1997; Rolfe et al., 2000) and can be expressed by $-(V_1 - V_0)/\beta_{price}$ (Hanemann, 1999). β_{price} is constant over all scenarios and V_1 is the utility from a scenario after a change and V_0 is the utility from the *status-quo* scenario ("Development first"; see Table 7).

3. Data

3.1. Study site

Australia's tropical rivers region stretches across approximately 1.3 million km^2 of the northern part of the continent, including parts of Western Australia, the Northern Territory and Queensland. The three case study rivers within that region are: the Fitzroy River (catchment 96,000 km^2) in Western Australia, Daly River (53,000 km^2) in the Northern Territory and Mitchell River (73,000 km^2) in Queensland (Figure 1). Combined, the Mitchell, Daly and Fitzroy Rivers discharge approximately 33,000 GL/yr (CSIRO, 2009) with a total of only about 63,000 ML used each year for agriculture (Australian Natural Resources Atlas, 2000). Each of these tropical river systems are comprised of waterways, wetlands, aquifers, riparian vegetation, groundwater dependent ecosystems, and aquatic communities and species, some of which are endemic to the region and/or rare, threatened and endangered. The major economic activities that take place in all three regions are cattle grazing, mining, commercial fishing, tourism and a small amount of irrigated and dryland agriculture.

[Figure 1 here]

The main use for water in Australia is for irrigation (75% - 18 000 from 24 000 GL per year in 1996/97). The second largest use is urban and industrial, accounting for approximately 20% of the annual water use in Australia (Australian Natural Resources Atlas 2000). Most water is being used in New South Wales (42% 10 000 from 24 000 GL per year in 1996/97), followed by Victoria (6000 GL per year) and Queensland (3000 GL per year). Only 53 GL of water is used per year in the Northern Territory and 710 GL per year in Western Australia where two of the three tropical rivers originate. The Mitchell, Daly and Fitzroy Rivers discharge approximately 33,000 GL/yr (CSIRO, 2009) with a total of only about 63,000 ML used each year for agriculture (Australian Natural Resources Atlas, 2000).

3.2. Sampling

The questionnaire was mailed-out to six different cities. For each river, two cities were selected, the capital city of the jurisdiction (state or territory) in which the river is located and one other city in southern Australia. The overall response rate was slightly better than anticipated, on average 32% (Table 2). The total sample size was 708 before data cleaning (Table 2).

[Table 2 here]

3.3. Data collection and experimental design

The survey was mailed-out to randomly sampled households from a list obtained from the Australian White Pages® and a marketing company. The survey method followed a modified Dillman technique (Dillman, 2007). Respondents were asked to choose between three options for seven to eight choice sets. Figure 2 includes an example of a choice set. Every choice set contained a *status-quo* option, Option 3, which is what might happen if there is maximum development with minimal conservation management. No hypothetical costs would occur for those respondents who chose this option. Options 1 and 2 describe what might happen if development were to be combined with management but the management would incur some hypothetical costs. The choice sets were presented page by page and the associated question read: “If these three are the ONLY options available for the Mitchell (Daly or Fitzroy) River region, which one would you want to see?”

[Figure 2 here]

Table 3 shows these attributes and the levels used in the choice experiment. Levels in bold indicate *status-quo* levels. We chose four of the attributes so that they fall into one of the categories of the TEV underlying our economic framework (see Table 1). The fifth attribute is the payment vehicle, associated with the costs of the chosen management alternative. We chose a once-off payment as payment vehicle because we regarded it as realistic and unlikely to be rejected. The attributes are explained in more detail in Zander and Straton (in press).

[Table 3 here]

3.3.1. Experimental design

The number of possible combinations of attributes and levels we selected for the choice sets were 3^4*4^1=324 (see Table 3). Respondents can only be presented with a fraction of these possibilities because too many choices can lead to boredom, confusion and inconsistencies (Ortúzar, 2000; Holmes and Boyle, 2005). The experimental design thus aimed to create the choice sets efficiently, i.e. to maximize efficiency criteria or equivalently minimise error criteria (Campbell, 2007). Using the software package Ngene, (Collins et al., 2007) we created 48 unlabeled alternatives. We blocked two of them plus the *status-quo* alternative into a series of choice sets, using a D-efficiency criterion. This resulted in 24 choice sets, one of which was logically inconsistent and deleted. The remaining 23 choice sets were blocked into three versions (A, B or C) containing seven or eight choice sets. Only one of the three versions was included in a questionnaire.

Because the sample size, and thus the design, was constrained by the survey budget, we used a Bayesian procedure to maximize information gain (e.g. Sándor and Wedel, 2002). The information about the necessary priors was taken from a literature search on similar choice model studies (for example, Rolfe et al., 2000; Birol et al., 2006; Rolfe and Prayaga, 2007). Our final design has a D-error of 0.00066 and a B-error of 31.47% (see Ferrini and Scarpa, 2007 for more details on efficient designs). The minimum sample size for this design was 45 per version (i.e. about 135 in total).

4. Results

4.1. Socio-economic background of respondents

Table 4 gives an overview of relevant respondents' characteristics. Only four respondents (<1%) identified themselves as Aboriginal or Torres Strait Islanders. This is reasonable given that Aboriginal and Torres Strait Islander people make up 2.5% of the Australian population (Australian Bureau of Statistics, 2009). With respect to key socio-economic factors, the three catchments areas seemed to be homogenous (Table 4). Across all catchments, the mean age was 52-53 years and the share of male respondents was slightly higher. The majority of respondents in all catchment areas had children (about 80%) and about 40% were highly interested in tropical rivers. The preference for development options for tropical rivers was also very similar across the three catchment areas with only a few respondents being strongly in favour of development (3%-6%) ("DEV"), about 40% being in favour of some form of conservation ("CON") and about half of the respondents favouring development with conservation ("NEUTRAL"). There a larger share of respondents had either visited the Daly river or lived nearby (74%) than was the case with the Mitchell (65%) or Fitzroy rivers (50%).

[Table 4 here]

4.2. Results of the choice experiment

We used Limdep 8.0 Nlogit 3.0 (Greene, 2003) to estimate the choice models. The cost attribute was included in the models as a continuous variable. All other attributes are treated as discrete variables. Therefore, for each attribute with L levels we created L-1 discrete variables in order to avoid perfect dependence. The omitted level of each attribute was considered the base level. We took the level of the *status-quo* option as the base level for each attribute: “small size of floodplain in good condition”, “1-star fishing quality”, “poor condition of waterholes” and “high income from irrigated agriculture”.

We estimated panel-RPL models drawn from 150 Halton draws for the entire data set as well as for sub samples for the three rivers and for two different clusters of cities (capital cities, including the three capital cities of the state/territory containing each river, versus southern cities). The coefficient of the cost attribute (the payment vehicle) was specified to be non-random in all models, so as to facilitate the estimation of the distribution of welfare measures (Hensher et al., 2005a). All other attributes were assumed to be normally distributed. The results are reported in Table 5. The majority of respondents chose to pay for river management; in only 6% of the choices was the *status-quo* option chosen (see Table 4). All models showed good levels of parametric fit with ρ^2 values around 0.35, indicting extremely good fit (i.e. ρ^2 between 0.2 and 0.4; Hensher and Johnson 1981). All coefficients are highly significant for the overall model (first column of Table 5). The coefficients of the significant attributes accorded with a priori expectations in all six models and the derived standard deviations confirm there is unobserved heterogeneity across respondents. The coefficient of the cost attribute was found to be negative, confirming that increasing levels of cost for river management strategies contributed negatively to respondents’ utility. Greater magnitudes of the coefficients for the standard deviations than for the mean coefficients, indicating relatively large heterogeneity across respondents, were found, in particular, for the medium levels “3-star fishing quality”, “medium-sized healthy floodplains” and “medium income from irrigated agriculture”.

[Table 5 here]

The welfare estimates for the significant attributes are presented in Table 6, grouped by the four ecosystem services and the different components of the TEV they represent (see section 2). Respondents from the entire sample were willing to pay $126 for an increase of fishing quality from “1-star” to “4-star” and $74 from “1-star” to “3-star”, *ceteris paribus*. This further implied that the marginal WTP for an increase from “3-star” to “4-star” was $52. The highest absolute marginal WTP estimates were for cultural services (condition of waterholes important to Aboriginal people). Respondents from the entire sample seemed to experience a welfare loss from “low income from irrigated agriculture” compared to “high income from irrigated agriculture” and would need $96 compensation, *ceteris paribus*, in order not to become worse-off. In comparison, respondents were, on average, willing to pay $35 for medium income over high income from irrigated agriculture. The values were found to be similar between respondents evaluating the three rivers but respondents from the southern cities had a higher WTP for cultural, environmental and recreational values of tropical rivers than respondents from the capital cities of the jurisdictions where the rivers occur.

The 25th and 75th percentiles (Table 6) reflect some unobserved preference variations in the population, which are especially noticeable for the attributes “3-star fishing quality”, “medium income from agriculture” and “medium-sized healthy floodplains”. This suggests that some respondents gain from the relevant attributes while some lose.

[Table 6 here]

4.2.1. Differences in preferences among users

Different panel RPL models were estimated for different groups of respondents in order to test our hypotheses. We do not present the model results here but only the welfare estimates.

The detailed model results can be requested from the first author. In order to test our hypothesis 1 that ‘green’ thinking Australians had a higher WTP for environmental values of tropical rivers, we ran separate models for ‘environmentalists’, ‘developers’ and ‘neutral’ urban Australians. These classifications came from responses to a question about preferences for conservation and/or development (see Table 4). Table 6 shows that environmentalists were indeed willing to pay more than ‘neutral’ respondents for medium and large of floodplains in good environmental condition. Development-oriented Australians were indifferent towards medium-sized healthy floodplains and had a high negative utility from large floodplains in good environmental condition (-$119), i.e. they needed to be compensated for lack of developments that affected floodplains. This finding suggests that developers considered that the expansion of areas providing ecosystem services, in this case floodplains, was not consistent with development. The results in Table 6 suggest that production values of tropical rivers were more important to ‘neutral’ respondents and developers, as environmentalists did not distinguish between “medium income from irrigated agriculture” compared to “high income from irrigated agriculture”. However, all respondents, even environmentalists, preferred “high income” over “low income from irrigated agriculture”.

Urban Australians who have visited the tropical rivers region or have lived there were about three times more willing to pay for medium-sized healthy floodplains than the *status-quo* and almost four times more for a large healthy floodplain (Hypothesis 2; Table 6). The WTP for cultural values also differed significantly (Table 6). Respondents who have visited or lived there had a higher WTP than respondents who had not visited or lived there for waterholes important to Aboriginal people in good or ok condition compared to those in poor condition. The same applies to the recreational values; respondents who had visited rivers or lived near them had twice the WTP for “3-star” and “4-star fishing quality” compared to “1-star quality”. Our hypothesis that respondents who had some connection to tropical rivers, and presumably better knowledge of them, showed higher WTP for environmental, recreational and cultural values was confirmed.

The model results also confirmed that respondents from Darwin were more willing to pay for environmental values, for cultural values and for recreational values than those from other cities (Brisbane, Canberra, Melbourne, Perth, Sydney) (Hypothesis 3). Furthermore, respondents from cities other than Darwin seemed not to be concerned about “medium income from irrigated agriculture”, while respondents from Darwin preferred the medium level over a “high income from irrigated agriculture” (Table 6). The negative preference for “low income from irrigated agriculture” only differed slightly between respondents from Darwin and respondents from the other cities (difference of $15).

4.2.2. Compensating surplus (CS) for management strategies

To calculate the CS we used the previous WTP/WTA estimates of the single attributes and aggregated them to obtain the TEV of management strategies with a set of attribute levels. The CS are approximated by simulation (Train, 2003). We considered three scenarios for future management of tropical rivers (Table 7). Strategy 3 was the *status-quo* in the experimental design, a strategy in which there are no additional costs associated with management and in which the volume of water extracted for irrigation is at a maximum currently allowed by legislation. The results are given in Table 8.

[Table 7 here]

[Table 8 here]

Given the positive coefficients and the WTP estimates for almost all attributes that differ from the *status-quo* option, any conservation management is likely to yield a welfare gain. The results showed that all respondents derived the highest utility from “development constrained by conservation” with the Darwin households showed the highest CS for this strategy. They were willing to provide a once-off payment of $667, on average, for “development constrained by conservation” and $514, on average, for a “conservation first” scenario. “Development first” provided the lowest value to urban Australians, due to the lack of cultural, environmental and recreational services. The CS for “development first” was positive only because some respondents preferred “high income from irrigated agriculture”. We also tested a “development first” scenario in which income from irrigated agriculture was not considered at all and CS became close to zero.

5. Discussion and policy implications

In earlier phases of Australian history there was an unquestioned assumption that development of the north for agriculture was in the interest of the country (e.g. Kerr, 1975), even if the economic returns were doubted (Davidson, 1965) and never quite eventuated. More recently ambitions to develop the north (Australian Government, 2009, p.84) or move the water south (Barnett, 2008) have been criticised not only on economic grounds (Kimberley Expert Panel, 2006) but also for environmental and cultural reasons (Australian Government, 2009, p.95). However there has been no attempt before now to quantify the values the broader Australian public now places on rivers in the country’s north.

The results of this survey suggest that public support from the cities where the bulk of Australia’s population lives now favours development that is strongly constrained by concerns for Aboriginal culture and, to a lesser extent, by environmental values. Very few people in any city, of those sufficiently motivated to complete the questionnaire, identified themselves as ‘developers’. Support for unbridled agriculture is at best limited and, even among the ‘developers’, there is a concern that the cultural values of rivers are not compromised, even if higher environmental and tourism values are viewed as a cost that needs to be set against profits from irrigated agriculture. This response was remarkably uniform across the country with only Darwin marginally different, the respondents there being more likely to favour a low agriculture option than southern respondents.

The proportion of those willing to respond included a high proportion of those who had visited the tropical rivers region or had lived nearby. While there is no way to determine whether this is representative of the country, it was apparent that those who had visited and seen the rivers for themselves were more likely to value their environmental, recreational and cultural attributes.

The results of the choice model can be used in benefit-cost analysis. However, we only looked at the benefits of tropical river management and have not assessed the costs. Many of the costs are from opportunities foregone as the environmental and cultural values of the river are currently relatively high. Only active modification to the landscape would affect these values. However there is a strong tradition of caring for country among Aboriginal Australians that is gradually being formalised through funding for ranger groups. Aboriginal rangers maintain the environmental quality of rivers by judicious fire management that reduces erosion that can occur after uncontrolled fires (Russell-Smith et al., 2006) and through control of weeds and feral animals. They also maintain cultural values through helping retain connection to country. However, while payment of rangers for management can represent a cost, health and social benefits are emergent properties from active engagement with country (Burgess et al., 2009; Garnett et al., 2009) that may result in a net positive return on investment (Garnett et al., 2009). Thus the only cost might be foregone profits from agriculture. This is confirmed by the results of our study.

This study stands out because, unlike many other studies using CE (e.g. Hanely et al., 2006; Birol et al., 2010; Zander and Straton, in press), we did not constrain the sample population to local respondents/users in northern Australia where the tropical rivers are located but sent out the survey to respondents in southern Australia as well. Our research suggests that urban people of southern Australian cities, even those who have never visited the northern rivers, are willing to pay substantial amounts of money to maintain cultural and environmental values. No longer can proposals for large scale northern agriculture or for shifting water south be viewed as inevitable. We have demonstrated that urban Australians, who account for the majority of the Australian society, obtain higher welfare from tropical river management based on “development constrained by conservation” or “conservation first” than from a “development first” strategy. This is a paradigm shift in Australian public opinion that has yet to be translated into legislation or policy. Instead there remains strong political support for a model of development that most respondents to this survey were willing to pay to avoid.

6. Conclusions

This paper has presented an application of a choice experiment among urban Australians to assess their WTP for the ecosystem services of tropical rivers and their preferences for a range of management strategies. This information fills a gap in understanding about the preferences of broader Australian society for some non-market ecosystem services of Australia’s tropical rivers, thus assisting decision-makers with their complex task.

Using data from a mail-out survey, we estimated different panel-RPL models for different users of the water of tropical rivers. We concluded that the majority of urban Australians were willing to contribute once-off payments for the management of tropical rivers, in particular to ensure high cultural, environmental and recreational services of the rivers. Income from irrigated agriculture was not perceived as very important, and at medium level compared to high or low income, if pursued at all. We further concluded that a sense of place and connection to the tropical rivers region contributed positively to the willingness to pay for river management strategies that ensure environmental, cultural and recreational services. We further found that environmentalists had a larger willingness to pay for environmental, cultural and recreational values than 'neutral' respondents or developers. Although development-oriented urban Australians placed no value on the recreational services of the three tropical rivers, and derived negative utility from their environmental services, rivers' cultural services were nevertheless valued. Further work can assess the value of a wider range of costs and benefits to enable more detailed analysis of the welfare impacts of development scenarios. It will also be important to specify on whom the costs and benefits will fall over time.

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Tables

Table 1: The total economic value (TEV) of Australians tropical rivers for urban Australians

	Component of TEV	Value/Service for urban Australians	Proxy in this study
Use-values	Direct use-value	- Production/ Provisioning value - (Recreational value)	- Income from irrigated agriculture (- Quality of fishing)
	Indirect use-value	- Environmental/ Supporting value	- Size of floodplain in good environmental condition
	Option value	- Recreational value	- Quality of fishing
Non-use value	Existence value	- Cultural value*	- Condition of waterholes important to Aboriginal people
	Bequest value	- Cultural value*	- Condition of waterholes important to Aboriginal people

*This could fall under indirect use-values if the urban Australians are of Aboriginal origin.

Table 2: Sampling and respond rate for mail-out survey – by cities

	Fitzroy river			***Daly rive***			***Mitchell river***			***Total***		
	Melbourne	Perth	All	Sydney	Darwin	All	Canberra	Brisbane	All	Southern cities	Capital cities	All
Population size	3.6m	1m	4.6m	4m	0.1m	4.1m	0.5m	1.5m	2m	8.1m	2.6m	10.7m
Response rate in %	33%	33%	33%	32%	34%	33%	29%	27%	28%	32%	32%	32%
Returned questionnaires	372	359	731	300	493	793	351	368	719	1023	1220	2243
Completed questionnaires	123	118	241	97	168	265	103	99	202	323	385	708

Table 3: Attributes and levels used in the choice experiment

Attribute	***Levels****
Area of floodplain in good environmental condition	**Small**, Medium sized, Large
Quality of the river for recreational fishing	**1-Star**, 3-Star, 4-Star
Conditions of waterholes important to Aboriginal people	**Poor**, Ok, Good
Income from irrigated agriculture	Low, Medium, **High**
Cost of management plan	**0**, 10, 50, 100

*the *status-qu*o levels are indicated in bold

Table 4: Respondents' charcteristics

Characteristic	All	Daly	Mitchell	Fitzroy
Number of respondents	684	264	174	246
1) Age				
Mean ("AGE")	52	53	52	52
Std. Deviation	14	13	15	15
Range	17-93	18-87	20-93	17-88
2) Gender				
Female (%)	45%	46%	42%	46%
Male (%) ("MALE")	55%	54%	58%	54%
3) Respondents with children ("CHILD")	82%	83%	80%	82%
4) Respondents with very high interest in tropical rivers ("HIGHINT")	44%	47%	42%	41%
5) Respondents strongly in favour of developing rivers ("DEV")	4%	4%	6%	3%
6) Respondents strongly in favour of conserving rivers ("CON")	43%	44%	42%	42%
7) Respondents favouring neither conservation nor development ("NEUTRAL")	50%	50%	47%	52%
8) Respondents that live near or have visited rivers (LIV_VISI")	63%	74%	65%	50%
9) Respondents with family or friends owning land in the river catchment area ("LAND")	18%	19%	31%	10%
10) Respondents that are members of or donate to environmental organizations ("DONATE")	20%	17%	25%	19%
11) Respondents who identified themselves as Aboriginal or Torres Strait Islander ("ATSI")	0.9%	0.7%	2.4%	0%
12) Respondents who are or whose family is involved in farming ("FARM")	17%	9%	31%	15%
13) Respondents that always chose the *status-quo* option	6%	4%	7%	8%
14) Location				
Melbourne	17%	0%	0%	47%
Sydney	15%	38%	0%	0%
Perth	19%	0%	0%	52%
Darwin	23%	62%	0%	0%
Canberra	10%	0%	38%	0%
Brisbane	16%	0%	62%	0%
15) City group				
Capital city	58%			
Southern City ("SOUTH")	42%			
16) River				
Fitzroy ("FITZ")	36%			
Daly	39%			
Mitchell ("MITCH")	25%			

Table 5: Results of panel-RPL models for the three rivers and for two clusters of cities

	All	River			Clusters of cities	
Variable		***Daly***	***Fitzroy***	***Mitchell***	***Southern cities***	***Capital cities***
Medium sized floodplains	0.631***	0.890***	0.722***	0.958***	0.837***	0.765***
(Standard Error)	(0.109)	(0.208)	(0.210)	(0.189)	(0.168)	(0.175)
Large floodplains	1.458***	2.023***	1.569***	1.537***	1.665***	1.963***
	(0.137)	(0.223)	(0.272)	(0.285)	(0.247)	(0.209)
3-Star fishing quality	0.858***	1.305***	1.070***	0.824***	1.109***	0.620***
	(0.149)	(0.285)	(0.278)	(0.266)	(0.287)	(0.170)
4-Star fishing quality	1.479***	1.990***	1.719***	1.324***	1.970***	1.717***
	(0.121)	(0.238)	(0.219)	(0.208)	(0.187)	(0.200)
Good waterholes	2.806***	2.727***	3.767***	2.482***	3.714***	2.913***
	(0.164)	(0.229)	(0.347)	(0.318)	(0.278)	(0.219)
Ok waterholes	1.907***	1.606***	2.342***	1.958***	2.469***	1.673***
	(0.198)	(0.320)	(0.382)	(0.357)	(0.319)	(0.270)
Low income from agriculture	-1.185***	-0.591***	-1.487***	-1.713***	-1.024***	-1.351***
	(0.111)	(0.153)	(0.228)	(0.258)	(0.188)	(0.151)
Medium income from agriculture	0.400***	0.469**	0.443	0.347	0.747**	0.329*
	(0.166)	(0.233)	(0.295)	(0.344)	(0.315)	(0.192)
Cost of management	-0.012***	-0.013***	-0.014***	-0.009***	-0.020***	-0.009***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Standard deviations (normal)						
Medium sized floodplains	1.078***	1.373***	1.547***	0.326	0.582**	1.791***
(Standard Error)	(0.164)	(0.277)	(0.254)	(0.367)	(0.229)	(0.219)
Large floodplains	1.836***	1.757***	2.433***	2.927***	2.242***	2.347***
	(0.145)	(0.223)	(0.273)	(0.368)	(0.260)	(0.197)
3-Star fishing quality	1.567***	2.004***	1.795***	0.569*	1.788***	0.717*
	(0.242)	(0.349)	(0.487)	(0.318)	(0.443)	(0.408)
4-Star fishing quality	1.996***	2.510***	1.912***	1.599***	1.854***	2.269***
	(0.146)	(0.278)	(0.242)	(0.219)	(0.199)	(0.198)
Good waterholes	2.987***	2.166***	3.684***	2.973***	3.044***	2.983***
	(0.179)	(0.215)	(0.370)	(0.384)	(0.253)	(0.230)
Ok waterholes	1.945***	2.341***	2.517***	1.696***	2.368***	2.543***
	(0.221)	(0.378)	(0.462)	(0.351)	(0.362)	(0.329)
Low income from agriculture	1.621***	1.287***	2.058***	1.870***	1.797***	1.502***
	(0.135)	(0.207)	(0.293)	(0.261)	(0.222)	(0.162)
Medium income from agriculture	1.394***	0.794**	1.420***	2.086***	2.771***	1.197***
	(0.183)	(0.382)	(0.364)	(0.384)	(0.369)	(0.249)
Log likelihood function	-3648.94	-1365.37	-1235.63	-970.05	-1430.07	-2131.30
Number of observations	5111	1981	1833	1297	2119	2992
Number of respondents	684	264	246	174	295	389
Adjusted R^2	0.35	0.37	0.38	0.31	0.38	0.35
Chi squared	3932.13	1621.97	1556.25	909.67	1795.77	2311.50
Halton draws	150	150	150	150	150	150

*** = significant at the 0.1% level; ** = significant at the 1% level; * = significant at the 5% leve

Table 6: Willingness to pay for different values of tropical rivers (mean and .25/.75 percentiles in AUS$)

	Irrigated agriculture				Cultural values of waterholes				Recreational fishing quality				Floodplains in good environmental condition			
	Low income*		**Medium income***		**Good condition****		**Ok condition****		**3-star quality*****		**4-star quality*****		**Medium size******		**Large size******	
Variable	***Mean***	***25%, 75%***	***Mean***	***25%, 75%***	***Mean***	***25%, 75%***	***Mean***	***25%, 75%***	***Mean***	***25%, 75%***	***Mean***	***25%, 75%***	***Mean***	***25%, 75%***	***Mean***	***25%, 75%***
Whole sample (N=684)	-96	-189, -7	35	-45, 112	238	67, 403	162	51, 269	74	-16, 160	126	12, 236	54	-8, 114	124	19, 225
Respondents who evaluated the Daly River (N=264)	-44	-112, 22	37	-5, 78	213	98, 323	127	3, 246	103	-3, 205	156	23, 284	71	-22, 160	158	61, 251
Respondents who evaluated the Fitzroy River (N=246)	-104	-205, -6	not significant		274	92, 448	170	47, 289	79	-10, 163	125	31, 215	53	-23, 127	115	-5, 230
Respondents who evaluated the Mitchell River (N=174)	-188	-330, -49	not significant		281	54, 500	221	91, 345	93	49, 134	150	28, 268	107	82, 131	176	-48, 391
Respondents in capital cities (N=295)	-50	-112, 10	40	-55, 131	188	84, 289	125	44, 204	57	-5, 116	100	36, 161	42	22, 62	85	8, 159
Respondents in Southern cities (N=389)	-147	-262, -37	39	-53, 127	329	101, 549	191	-4, 378	70	15, 123	195	22, 362	88	-49, 220	223	43, 395
Developers (N=30)	-129	-229, -35	123	-66, 304	130	8, 247	185	21, 343	not significant		not significant		not significant		-119	-281, 36
Environmentalists (N=295)	-66	-152, 16	not significant		288	107, 462	166	58, 270	106	4, 203	158	24, 287	91	13, 167	192	64, 316
"Neutral" people (N=340)	-109	-201, -20	63	-25, 149	224	77, 365	149	12, 280	55	-27, 135	132	36, 224	47	-19, 110	117	8, 221
Darwin-based people (N=163)	-85	-196, 21	73	-1, 143	303	64, 532	184	-24, 383	136	-19, 285	271	42, 490	74	-53, 196	222	77, 361
People in southern/western Australia (N=521)	-100	-186, -18	not significant		226	55, 390	115	72, 155	81	-15, 173	101	13, 205	53	13, 92	135	10, 256
People who have never visited rivers (N=253)	-64	-116, -14	27	-51, 103	182	69, 292	115	29, 198	51	-28, 128	90	28, 149	30	-10, 68	60	-9, 127
People who have visited rivers (N=431)	-124	-246, -7	45	-64, 149	311	93, 519	182	35, 323	96	56, 134	190	31, 344	103	12, 189	232	54, 402
Environmentalists not having visited rivers (N=98)	-39	-94, 14	not significant		191	90, 289	155	63, 243	99	28, 168	92	37, 144	52	4, 98	92	24, 158
Environmentalists having visited rivers (N=197)	-121	-247, 1	not significant		462	222, 692	199	132, 262	118	12, 220	211	-18, 431	176	78, 270	393	190, 590

* base level = High income; ** base level = Poor condition; *** base level = 1-star fishing; **** base level = Small size

Table 7: Hypothetical future scenarios and their compensating surplus for different users (in AUS$)

	Attribute			
Strategy	Area of floodplain in a good environmental condition	Quality for recreational fishing	Conditions of waterholes important to Aboriginal people	Income from irrigated agriculture
”Conservation first”	Large	4-star	Good	Low
”Development constrained by conservation”	Medium	3-star	OK	Medium
“Development first” (*status-quo*)	Small	1-star	Poor	High

Table 8: Compensating surplus of management scenarios for different users (in AUS$)

	All respondents	Developers	Environmentalists	"Neutral" people	Darwin-based people	People who visited rivers	People who have not visited
"Development first" (*status-quo*)	66	25	59	66	98	87	43
"Development constrained by conservation"	462	172	403	449	667	593	297
"Conservation first"	374	132	310	346	514	457	229

Figures

Figure 1: Study site - Australian's tropical rivers and the three focal catchments

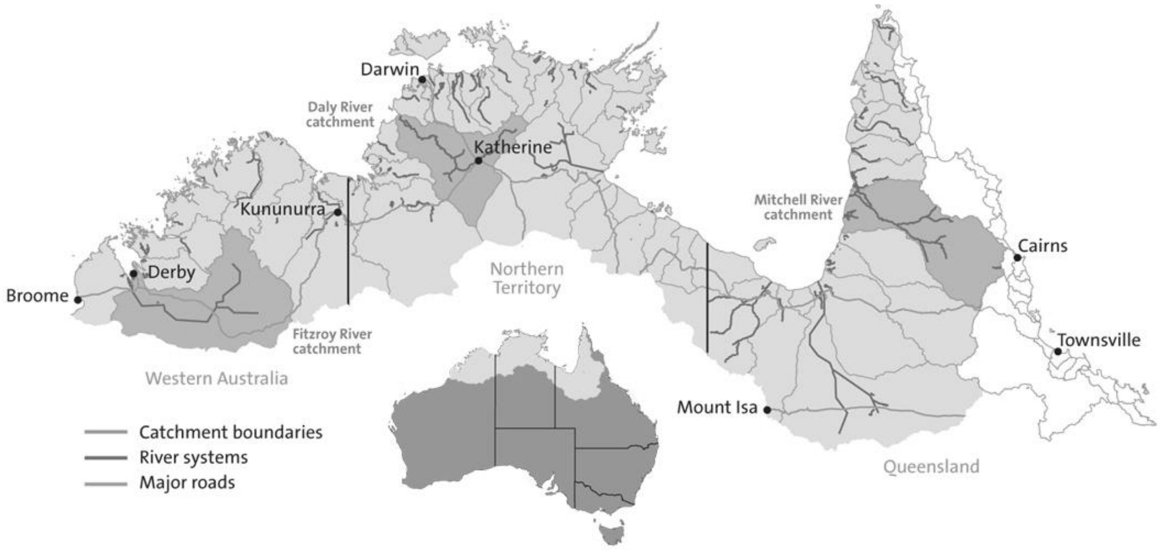
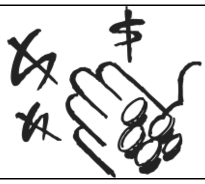


Figure 2: Example of a choice set for the Mitchell River catchment

What could the Mitchell River look like?		**Option 1**	**Option 2**	**Option 3**
Area of floodplain in good environmental condition		6,000 km^2	12,000 km^2	6,000 km^2
Quality of the river for recreational fishing		3-star	3-star	1-star
Condition of waterholes important to Aboriginal people		Ok	Ok	Poor
Income from irrigated agriculture		$13 m/yr	$13 m/yr	$70 m/yr
How much would I pay each year?		$10	$50	NIL
I prefer (tick or cross one box only) ☒		☐	☐	☐