



Analysis

Using resident perceptions of values associated with the Australian Tropical Rivers to identify policy and management priorities

Silva Larson^a, Natalie Stoeckl^{a,b,c,*}, Barbara Neil^a, Riccardo Welters^a^a School of Business, James Cook University, Townsville, Australia^b Cairns Institute, James Cook University, Townsville, Australia^c Centre for Tropical Water and Aquatic Ecosystem Research, James Cook University, Townsville, Australia

ARTICLE INFO

Article history:

Received 13 July 2012

Received in revised form 2 July 2013

Accepted 5 July 2013

Available online xxxx

Keywords:

Ecosystem assessments

Importance and satisfaction

Personal values

Social values

Water

ABSTRACT

Many rivers in the world are facing changes due to increased development needs, and these changes impact on a range of values people associate with these rivers. We use a non-monetary tool in a mail-out survey of 291 households to assess the importance of social and cultural values of the Australian Tropical Rivers and identify associated management priorities. Nine river values were included in the assessment: bequest, existence, recreational fishing, other types of recreation, aesthetics, teaching, water for human life, water for other life and commercial use. Of these, the most important values identified by respondents were biodiversity, human life, and bequest, with widespread agreement across respondents about their importance. Management priorities were assessed using the Index of Dissatisfaction (IDS). Although commercial values ranked sixth out of nine in terms of importance they emerged as the highest priority using IDS. This is because they received the lowest levels of satisfaction, associated with concerns over issues such as pollution, overuse and lack of monitoring. Thus, the main policy issue in this region might not be one of protecting commercial values, but of addressing concerns relating to the commercial use of water, and its potential negative impact on ecological and social values.

© 2013 Published by Elsevier B.V.

1. Introduction

Fresh water availability is one of the most pressing global issues, with many countries facing challenges posed by increasing demand for limited water supplies, as well as increasing contamination of surface and groundwater. This has implications for policy and the planning processes required to secure adequate supplies into the future. In Australia, recent severe droughts across wide areas in the south have re-invigorated debates about the development potential of the north of Australia and its contribution to meeting the challenges of population growth and development (Jackson et al., 2008; Quiggin, 2006). Several large-scale developments have been proposed for water resources in the north, including the transportation of perceived 'plentiful' water from the north to the south and the mass relocation of populations from the south to the north (Taylor et al., 2011). At the moment, however, most rivers in Northern Australia (hereafter referred to as Tropical Rivers or TR) have largely unmodified flow regimes and are comparatively free from the impacts associated with intensive land use (Douglas et al., 2005).

In Australia, historic assessments of natural resources, including rivers, used market values to determine importance, concentrating on the ability of natural resources to increase production and thus earn money (Jackson et al., 2008). For the last few decades, policy makers have insisted that ecological values also be considered in natural resource assessments. As such, a body of knowledge about the ecological importance of TR is growing (Blanch et al., 2005; Douglas et al., 2005; Faggotter et al., 2011; Harris, 2001; Van Dam et al., 2008). In more recent years, natural resource management agencies have also been put under increased pressure to consider the social dimensions of resource management. This trend is in line with international developments as a growing number of countries and international agencies and organisations require that social and cultural considerations be included when assessing the potential for economic development in river catchments (Arthington et al., 1998; Dyson et al., 2003; Instream Flow Council, 2004; King et al., 2003; Tharme, 2003). Data and information about the social and cultural values associated with natural resources, however, remain sparse compared to data and information about ecological and market values (Martín-López et al., in press).

Thus, this paper attempts to further our understanding of the importance of social and cultural values relative to other values associated with the rivers, and to improve our understanding of factors that influence the preferences of individuals (i.e., their perceptions of the relative importance of different types of values). Specifically in Section 3.1, we report on a range of values which residents of Northern

* Corresponding author at: School of Business, James Cook University, Townsville, Australia. Tel.: +61 7 4781 4868; fax: +61 7 4781 4019.

E-mail addresses: silva.larson@jcu.edu.au (S. Larson), natalie.stoeckl@jcu.edu.au (N. Stoeckl), barbara.neil1@jcu.edu.au (B. Neil), riccardo.welters@jcu.edu.au (R. Welters).

Australia associate with Tropical Rivers and use this data to assess the importance of different social and cultural values relative to other market and non-market values. We then investigate the relationship between the stated importance of different values and the socio-economic and demographic characteristics and personal orientations of respondents (Section 3.2). Finally in Section 3.3, we combine data about respondents' satisfaction with the current state of the river values and about their perceived importance of those values, to identify management and policy priorities.

2. Background and Methods

2.1. Study Region

Covering an area of more than 1.3 million km², the Tropical Rivers (TR) region of Australia extends across 55 catchments from the Kimberleys in Western Australia to the east side of Cape York in Queensland (Fig. 1). The region includes some of Australia's largest river systems both by size, such as Flinders, Roper, Victoria and Fitzroy rivers; and by volume, such as Nicholson and Mitchell rivers (NGIS Australia, 2004). These TR and groundwater systems are estimated to contain roughly 70% of Australia's fresh water resources (Land and Water Australia, 2005), and to account for approximately 65% of run-off (Chartres and Williams, 2006). Figures such as these give one the impression that the north is 'rich' in water resources, yet these highly aggregated statistics mask the fact that very little perennial water exists in this area. Australian river systems have the most variable annual flow regimes in the world (McMahon, 1992; Puckridge et al., 1998). Many rivers in the TR region do not flow at all for six to nine months of the winter dry, and then flood extensively during the wet season (Kennard et al., 2010). Where perennial streams exist, they are typically fed by groundwater.

This temporal and geographic scarcity of water has evidently influenced European settlement (Jackson et al., 2008; Larson, 2010a). Despite the fact that the TR region covers approximately 15% of Australia's mainland, it is home to only 310,000 people, fewer than 2% of all Australians (Taylor et al., 2011). These people are mainly engaged in agriculture and mining, or employed by the government (Larson and Alexandridis, 2009).

There is a significant gap between rich and poor in the TR region. Indeed, the bifurcation of society in Northern Australia into "haves" and "have nots" has received significant attention in both literature and political circles (Robins and Dovers, 2007; Stoeckl et al., 2013) and has been declared by some scholars to be a "persisting problem" (Taylor et al., 2011). As an example, Larson and Alexandridis (2009)

highlight that median individual incomes in the 'richest' parts of the region (parts dominated by employment in the mining sector), are almost 5 times greater than median incomes in the 'poorest' catchments (dominated by an unemployed population receiving a passive income from government).

2.2. Development of the Survey Instrument: Selecting the Values to be Assessed and the Valuation Method

The survey instrument was developed in two stages: firstly, values to be assessed were selected, and then the valuation method was chosen.

When selecting values for assessment, we were cognizant of the fact that values are embedded in socio-cultural context, so valuation exercises need to be conducted with the relevant people or communities (TEEB, 2010). In this project, we focused on the perspectives of residents of the TR region – future research could usefully compare the views of residents with those of non-residents. We first collated information elicited by previous studies (Department of Agriculture, Fisheries and Forestry, 2003; Jackson, 2005; Stoeckl et al., 2006; Toussaint et al., 2001; Woodward et al., 2008; Zander and Straton, 2010) through engagement with the communities across the TR region.

We then tested these extensive lists of values using two additional focus group discussions in the upper reaches of the Mitchell River Catchment, Queensland. These were attended by 11 representatives of relevant stakeholder groups, including Indigenous organisations; those associated with the agriculture, mining, and/or tourism industries; and government agencies. The focus group discussions had two objectives: to devise a comprehensive list of the values which the participants held for TR; and to ask participants to group those values into categories which they felt were appropriate. The lists of values devised were extensive, with multiple examples. Using cognitive mapping (Borgatti, 1996; Brown, 1992) and a pile sorting technique (Coxon, 1999; Rosenberg and Kim, 1975), we asked participants to group individual items from those lists into similar themes. Groups of values thus defined correlated well with previous empirical studies within the region; with the findings of previous focus groups; as well as with the concepts identified in the literature.

A questionnaire was then developed using statements describing different values that were generated during the focus group discussions:

- I like to use the river for recreational fishing (referred to later in text as 'Fishing').
- The rivers give water for drinking; they also keep plants and animals alive – and I use these for food (Water for human life).

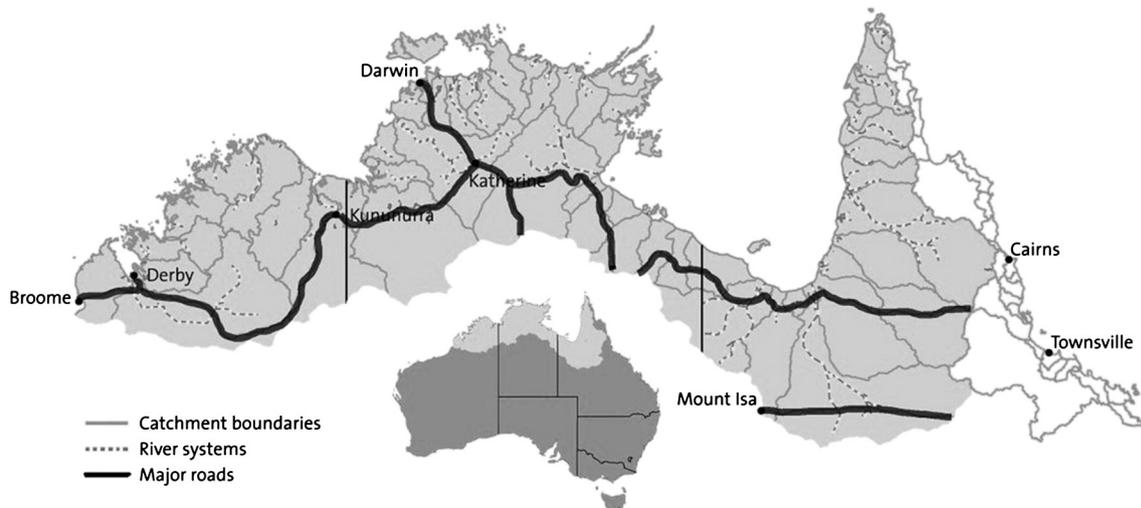


Fig. 1. Tropical Rivers region in Northern Australia.

- The river keeps a variety of plants and animals alive (Water for other life).
- Water is used for commercial and economic purposes: irrigating crops, processing minerals, hydroelectricity, tourism (Commercial and economic purposes).
- I like to meet friends and family at the river, or use the river for swimming, picnics, boating, water skiing and other types of recreation (Recreation).
- The river gives me peace of mind; I like to look at it; it inspires me (Aesthetics).
- The river allows me to maintain customs, connect with history, remember ancestors; rivers are a good place for teaching/learning (Teaching).
- I don't go to the river, but I like to know it is there (Existence).
- I like to know that the river will be there for my children/grandchildren (Bequest).

Finally, it is important to note that the list comprises six examples of social and cultural values: Fishing, Recreation, Aesthetics, Teachings, Existence and Bequest; and three examples of other (non-social/cultural) values: Water for human life, Water for other life and Commercial purposes. This wide range of values was deliberately included to facilitate a comparison of social and cultural values relative to other types of values.

Literature on different economic valuation methods and techniques for quantifying the benefits or costs of environmental goods and services in monetary terms is vast. Readers are directed to [Bateman et al. \(2002\)](#), [Getzner et al. \(2005\)](#), [Hanley and Barbier \(2009\)](#), [Rietbergen-McCracken and Abaza \(2000\)](#) and [TEEB \(2010\)](#) for detailed reviews; suffice to say here that the scientific quality of monetary valuations and their pertinence for policy decrease as system complexity and value plurality increase ([O'Connor and Frame, 2008](#)). It is particularly difficult to generate estimates of the monetary 'worth' of non-use values since they are often related to moral, religious or aesthetic properties, for which markets usually do not exist ([TEEB, 2010](#)). Thus, in addition to the economic valuation techniques, study of the social and cultural values might be usefully complemented by other approaches in order to inform decision-making ([Martín-López et al., in press](#); [TEEB, 2010](#)).

In this study, we decided to test a non-dollar denominated stated preference technique. This point-based technique was developed by [Larson \(2009, 2011\)](#) and previously tested in a regional Australian context. Essentially, the method is a contingent ranking method that scores relative preferences in quantitative though non-monetary terms. Each respondent, i , is asked to give each value, k , an importance score (I_{ik}) on a scale from 0 not important at all to 100, most important; more than one value can receive the same importance. The method also elicits current satisfaction with the state of the values, by asking each respondent, i , to indicate, on a scale of 0 to 100, how satisfied he or she is with the current state of the each value, k , tested, yielding a satisfaction score (S_{ik}). Again, more than one value could receive the same satisfaction score.

Thus, following selection of the values to be assessed and the valuation method, the survey instrument was devised to elicit the following information from respondents:

- (i) the importance of each of the nine values selected for assessment and listed above;
- (ii) the satisfaction with the current state of each of the nine values selected for assessment; and
- (iii) a number of socio-demographic characteristics and value orientations (discussed in more detail below).

2.3. Data Collection and Analysis

Primary data were collected via mail-out questionnaire using [Dilman's \(2007\)](#) technique. First, post codes which lay either partially or entirely within the study region were identified and data relating to the total population and the number of occupied private dwellings for each post code on the 2006 Census night were gathered. In an

attempt to ensure a geographically stratified sample, we randomly selected 1 in 20 households from each post code, up to a maximum of 100 households, from a commercially purchased data base (Media M, Melbourne, Victoria).

In the first instance, 2500 surveys were mailed out to those residents. Following the technique, a reminder letter was sent out three weeks later, with a third and final reminder and second survey sent after another three weeks to those who had not responded to either of the previous two requests. Thirty seven percent of addresses were either incomplete or the addressee was no longer at that address (a common problem in remote parts of Australia). As such, we estimate that around 1560 surveys reached their intended recipients, of which 252 were returned in time, with sufficient information to be included in the analysis (return rate of 18%). Of those, 177 were received from Queensland; 42 were from Western Australia; and 33 were from the Northern Territory. The questionnaires were supplemented by 39 surveys completed through one-on-one interviews in the Upper Mitchell, Queensland, specifically targeting Indigenous residents who typically have low response rates in mail-out surveys ([Stoeckl et al., 2011](#); [Zander and Straton, 2010](#)). During face-to-face interviews, the researcher read the questions from the mail-out survey and recorded the answers provided by the participant. During the analyses stage, face-to-face and mail-out samples were first tested separately to explore potential bias due to the survey method. As there was no difference in findings, only the combined results are reported here.

Of the completed total of 291 surveys, an equal number was received from males and females ([Table 1](#)). More than a quarter of respondents was born in the same region in which they were living when asked to complete the questionnaire, and more than half planned to stay in the area at least until they retired – if not, for the rest of their lives. A majority of respondents have been living in the area for more than 15 years.

Sectors of the economy in which respondents were employed correspond well with the overall employment statistics for the region ([Larson and Alexandridis, 2009](#)). However, some of the demographic characteristics of respondents were not consistent with the broader population. Some 90% of respondents were non-Indigenous, despite the fact that nearly one quarter of the population of the TR region is Indigenous, and despite one-on-one surveys specifically targeting Indigenous respondents. In addition, the average age of the respondents was higher than that for a region overall (54 versus 33 years, respectively).

Primary data thus collected was used in a number of analyses. First, mean importance scores for the nine values tested in the survey were calculated and compared. Second, in order to test for potential differences between preferences of different respondents, we investigated the relationship between stated values and the socio-economic, demographic and personal orientations of respondents. Socio-economic and demographic characteristics of respondents included in the analysis are listed in [Table 1](#). However, the survey also included a set of questions determining personal orientations of the respondents. This approach is based on seminal work by [Schwartz \(1992, 1994\)](#), who selected 56 orientations to represent 11 universal types while investigating how values are formed and how they affect individuals' behavioural decisions. Based on Schwartz's work, [Stern \(1999, 2000\)](#) and [Stern and Dietz \(1994\)](#) developed a New Environmental Paradigm (NEP) scale that provides a measure of different groups and incorporated this scale with research into attitudes towards environmental values. The instrument was further developed and tested for its validity and reliability across different countries by [de Groot and Steg \(2007\)](#). The instrument is based on respondents indicating their agreement, using Likert scale, with the 15 personal orientation statements ([Table 2](#)). Using factor analysis maximum likelihood extraction method and Varimax rotation with Kaiser normalisation, our sample collapsed into four orientations: Biocentric/altruistic (esteeming nature and others); Egocentric (esteeming self); Conservative/family (esteeming tradition and family life); and those that most esteem Varied life ([Table 2](#)).

Table 1
Characteristics of survey respondents.

Characteristics of respondents		n	% sample
State of residence	Queensland	216	74.2
	Northern Territory	33	11.4
	Western Australia	42	14.4
Gender	Male	144	49.5
	Female	147	50.5
Age group	Under 29	12	4.1
	30–39	33	11.4
	40–49	68	23.5
	50–59	69	23.8
	60–65	42	14.5
	Over	66	22.8
Born in the area	Yes	76	26.2
	No	214	73.8
Number of years lived in the area	Less than 5	43	15.2
	6–10 years	39	13.8
	11–15 years	33	11.7
	More than 15 years	167	59.2
How much longer living in the area	For the rest of my life	129	44.5
	Until I retire	29	10.0
	I am not sure	132	45.5
Children	Yes	227	77.9
	No	64	22.1
Aboriginal or Torres Strait Islander?	Yes	28	9.7
	No	262	90.3
Born overseas	Yes	44	15.2
	No	245	84.8
Highest level of education/training completed	Primary school	36	12.4
	High school to year 10	78	26.9
	High school to year 12	44	15.2
	Trade/apprenticeship/TAFE	62	21.7
	University	69	23.8
Primary source of household income	Government employment	69	23.8
	Agriculture	27	9.3
	Mining	26	9.0
	Industry and transport	42	14.4
	Services	42	14.4
	Government support	62	21.3
Business owner	Self-funded/investments	18	6.2
	Yes	60	20.6
Annual income category	No	231	79.4
	Under 20,000	44	15.9
	20–35,000	40	14.5
	35–50,000	34	12.3
	50–75,000	39	14.1
	75–100,000	41	14.9
	100–150,000	39	14.1
Over 150,000	16	5.8	
Not stated	23	8.3	

n = number of respondents.

Stepwise ordinary least squares (OLS) regressions were used to explore the relationship between the importance assigned to each river value and (a) socio-demographic (SD) characteristics of respondents

Table 2
Four-factor construct solution indicating personal orientations of the respondents.

Personal preferences:	Biocentric/altruistic	Egocentric	Conservative/family	Varied life
Unity with nature (fitting into nature)	.723			
Respecting the earth (harmony with other species)	.829			
Equality (equal opportunity for all)	.320			
World at peace	.411			
Curious (interested in everything, exploring)	.457			
Protecting the environment (preserving nature)	.191		.191	
Self discipline (self restraint and resistance to temptation)	.398		.336	
Honouring parents and elders (showing respect)			.814	
Social justice (correcting injustice, care for the weak)			.397	
Family security (safety for loved ones)			.544	
Wealth (material possessions, money)		.345		
Authority (the right to lead or command)		.748		
Influential (having an impact on people and events)		.610		
An exciting life (stimulating experiences)		.564		
Varied life				.904

(as listed in Table 1); and (b) their personal orientations (PO) (as summarised in Table 2). Recognising the likely association between the independent variables, we also used stepwise OLS to regress PO against SD. Predictors were saved and then importance scores were regressed against SD and the predicted values of PO, thus controlling for the possibility of endogeneity. This test was only done with a sample of 193 respondents for which POs were collected. In the stepwise regression procedure, independent variables are entered one (step) at a time. The stepwise procedure stops when further inclusion or removal of variables produces a statistically insignificant model. Consequently, final models are statistically significant at the 5% level, as are all the variables within them.

In the third set of analysis, data were used to infer management and policy priorities using the Index of Dissatisfaction (IDS) approach (Larson, 2010b, 2011). The approach combines importance and satisfaction scores with the proportion of respondents assigning positive scores to the value. To be more specific, for each value, k , there are N respondents, of whom n_k ($n_k \leq N$) indicate that k is of at least some importance to their overall wellbeing. Consequently, the mean importance (across all n_k individuals) of value k is calculated as:

$$\bar{I}_k = \frac{\sum_{i=1}^{n_k} I_{ik}}{n_k}$$

The satisfaction score each individual assigned to each item (S_{ik}) is then used to calculate a dissatisfaction score ($D_{ik} = 100 - S_{ik}$), and to calculate mean dissatisfaction (across all n_k individuals) for value k :

$$\bar{D}_k = \frac{\sum_{i=1}^{n_k} D_{ik}}{n_k}$$

An Index of Dissatisfaction (IDS_k) for value k , can then be calculated by multiplying the proportion of respondents providing importance and satisfaction scores to value k by mean importance and by mean satisfaction for value k :

$$IDS_k = \frac{n_k}{N} \cdot \bar{I}_k \cdot \bar{D}_k$$

The mean importance, mean satisfaction and the proportion of respondents assigning scores to each respective value are thus combined and values are ranked from highest to lowest. Being a compound index, items can appear at the top of the table if they are considered to be important by many respondents or if many are dissatisfied.

3. Results

3.1. Importance of Social and Cultural Values Relative to Other Values

The importance of social and cultural values relative to other market and non-market values was tested first. Respondents assigned highest importance to values of rivers associated with Water for other life, Water for human life, and Bequest (Fig. 2). Moreover, it appears that these three values were held in high regard by a broad cross-section of the community: standard deviations associated with the highest ranked values are lower than those associated with other values, and confidence intervals are narrow and do not intersect with other confidence intervals. Bequest was the highest scoring social/cultural value, followed by Aesthetics and Recreation.

3.2. Differences in Preferences across Respondents

The relationship between the importance assigned to each value, socio-demographic characteristics (SD) of respondents and their personal orientations (PO) was explored next. In the first instance, we used stepwise ordinary least squares (OLS) regressions to look at the relationship between the importance of different values and SD. These models only had predictive powers between 4.3 and 22.3%. Next, we used both SD and PO as independent variables in the (stepwise) OLS regressions – although we tried two different versions of these models – the first simply entering SD and PO variables; the second controlling for the possibility of endogeneity by taking a two-stage approach (firstly regressing PO against SD, and then regressing importance against SD and the predicted values of PO from step one). This improved the predictive power of models for all the values tested, to between 11% for Commercial values and 29.8% for Teaching. Detailed results of all models are presented in Appendix A; Table 3 summarises key findings.

Indigenous status appears to be the single most common determinant – having a positive influence on the importance assigned to Aesthetics, Fishing and Teaching, and a negative score for Existence. Those with children were more apt to assign high importance to Water for human life and Bequest values; males and those who own their own

businesses were more likely to assign high importance to Commercial values; and those whose primary source of income came from the mining industry placed Water for other life lower than others.

Personal orientations also emerged as common determinants. Those classified as ‘egocentric’ were more likely to attach high importance to Water for other life, Bequest, and Recreation, and lower importance to Existence values; while conservatives were likely to attach higher importance to Aesthetics, Existence and Teaching values.

Interestingly, location did not impact many values. Those living in Western Australia were likely to assign lower importance to Commercial values than those living elsewhere, and those living in the Northern Territory were likely to assign lower importance to Water for human life. But in all other cases, state of residence had no statistically significant influence on importance when controlling for other factors.

3.3. Management and Policy Priorities

In the next set of analysis, data were used to infer management and policy priorities using the Index of Dissatisfaction (IDS) approach. As noted in the Methods section, IDS is a compound index, and thus, items can appear at the top of the table if they are considered to be important by many respondents, or if many are dissatisfied. In our study, high levels of dissatisfaction about issues associated with the commercial use of water brought Commercial values to the top of the table (Table 4). Commercial values were followed by Water for human life, Water for other life and Bequest, and these scores were dominated by the high importance of these values. Table 4 also summarises some of the key issues raised by respondents who, in addition to being asked to indicate their level of satisfaction with each value, were also asked to specify reasons for their dissatisfaction with the condition of values listed. Resident concerns related to commercial use included, but were not limited to issues associated with: pollution, pricing, overuse, lack of certainty in supply, allocations, and lack of monitoring. Most often, respondents expressed concerns or fears about what might happen to river values in the future (e.g., the potential for pollution and higher prices), rather than about what was actually happening now.

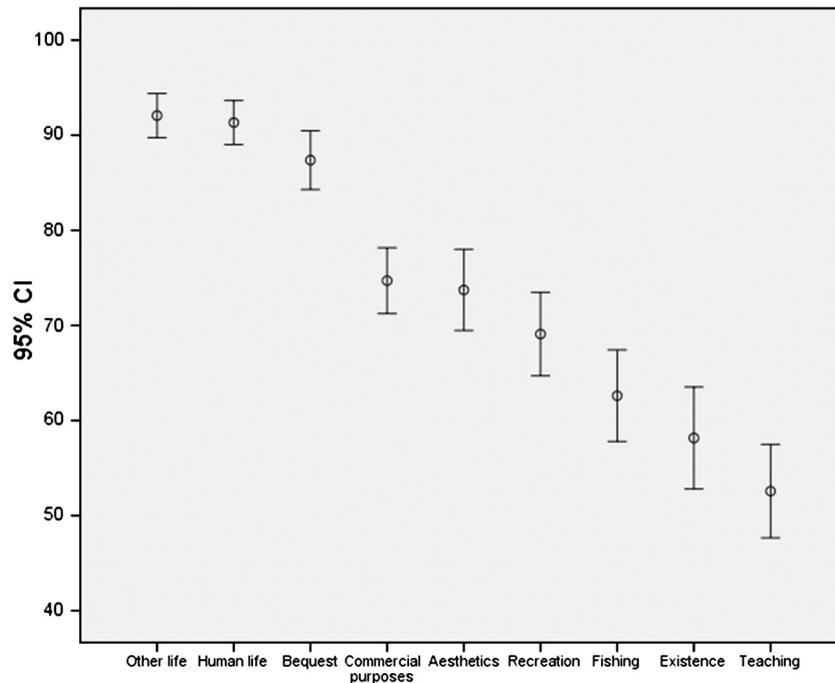


Fig. 2. Confidence intervals for importance scores assigned by respondents to a cross-section of values of the rivers.

Table 3
Characteristics of respondents determining the importance of nine values tested (n = 193).

	Water for life	Water for human life	Commercial	Bequest	Aesthetics	Recreation	Fishing	Existence	Teaching
Male			+						
Age	–								
Has children		+		+					
Indigenous					+		+	–	+
Resident of NT		–							
Resident of WA			–						
Education									–
Income from mining	–								
Passive income from government	–								
Passive income from investments								+	
Owns business			+				+		
Conservative					+			+	+
Varied life	–								
Biocentric									
Egocentric	+			+		+		–	
Adjusted R ²	0.122	0.152	0.081	0.168	0.067	0.058	0.103	0.108	0.223

NT = Northern Territory; WA = Western Australia.

A plus-sign indicates that the variable was found to have a positive, and statistically significant (5%) relationship with the importance score assigned to the corresponding value; a negative sign indicates the relationship was negative and statistically significant (5%); a blank indicates no statistically significant relationship.

4. Discussion

The nine different values that were identified for assessment in this case-study were: Water supporting human life; Water for other life; use in Commercial ventures; future generations (Bequest); Existence; recreational Fishing; other types of Recreation; Aesthetics; and Teaching. Importantly, the list comprised six examples of social and cultural values, and three examples of other (non-social/cultural) values: Water for human life, Water for other life and Commercial use; allowing for comparisons to be made across different types of values.

On average, respondents allocated the highest importance to Water for other life and Water for human life, followed by Bequest values, thus indicating that some social and cultural values are regarded equally high, relative to other values. This finding is in agreement with the previous work of Zander and Straton (2010) and Jackson et al. (2011a) for the TR region and Raymond et al. (2009) for the Murray–Darling Basin. However, some literature suggests that local residents tend to attach higher values to provisioning services than national or global agents, who attach more value to regulating or cultural services (Hein et al., 2006; TEEB, 2010). These later findings are not supported by our study.

The importance of cultural services is gaining political recognition worldwide (EPA, 2009; TEEB, 2010; UK NEA, 2011). For example, the Minister for the Environment in New Zealand has special powers to give pre-eminence to preservation of ‘outstanding amenity or intrinsic values’ of waters in their natural or altered state as a matter of ‘national significance’ (Lennox et al., 2011). Both policy makers (Land and Water Australia, 2005) and scientists (see for example Douglas et al., 2011) in the TR region agree that rivers are not only important for the water that they can provide to facilitate economic development, but also that tropical aquatic ecosystems and the rich biodiversity they support are of biological, social and cultural value. This is a position in agreement with findings of our resident surveys.

That there is a high level of consensus about the importance of rivers for other life, human life and bequest is a positive finding for management and planning. Different stakeholders often attach different values to ecosystem services depending on their cultural background or the impact that the service has on their living conditions (Hein et al., 2006; Kremen et al., 2000) – however the literature suggests that consensus of opinions is an important starting point in policy making that will help ensure plans meet socio-economic as well as ecological considerations (Brown and Raymond, 2007; McDonald, 2009; Sarkar and Margules, 2002; Wallace, 2007).

Several socio-demographic characteristics and personal orientations were found to be significant determinants of the importance

assigned to different values, but models had relatively low predictive powers. In the case of Commercial value, Aesthetics, Recreational value, Fishing and Existence, models explained under or around 10% of variation only. Similarly, low explanatory powers for models investigating the importance of Fishing, Recreation value, Aesthetics and Biodiversity were found in the Great Barrier Reef region of Australia by Larson et al. (2013). These low predictive powers might be partially attributable to sample size (190 to 260 observations were included in the different regressions in this study). However, as some models explained more than 25% of variation, that is unlikely to be the sole cause.

Some models may have low explanatory power because personal choices and beliefs are not singularly linked to personal characteristics (Myers and Diener, 1996); Commercial, Aesthetic, Existence and Recreational values might be examples of the types of values most likely to appeal to a wide range of people. For example, Raymond et al. (2009) tested for more than 30 ecosystem services of rivers and found the “highest intensity of agreement” among stakeholders for the Recreational and Existence values. Our study finds “intensity of agreement” for Water for other life, Water for human life and Existence values; but more disagreement on other values.

The model with the highest predictive power was for Teaching values, which was of highest importance to Indigenous respondents with conservative/family orientations and low educational levels. A study by Zander and Straton (2010) also found that the willingness-to-pay of Aboriginal Australians was significantly higher than that of non-Aboriginal Australians for river attributes related to cultural values. Both findings are indeed in line with nation-wide recognition that natural land, water and sea-scapes are essential for maintenance of Indigenous customs and ancestral links (for example, Jackson, 2005; Jackson et al., 2011b).

State of residence was also identified as a significant determinant for two values. Regrettably, the size of our dataset did not allow us to conduct further spatially disaggregated analysis. Studies elsewhere in Australia suggest that people living in coastal settlements assign greater importance to the environmental values than those living further inland (Larson et al., 2013), so the spatial analysis is an area worthy of further research.

Including the indicators of personal orientations improved the predictive power of most models, however, the usefulness of personal orientations information is diminished by the fact that such data is not readily available; rather, it needs to be collected as primary data. Existing studies suggest that the personal orientations most strongly implicated in activating pro-environmental behaviours are biospheric

Table 4

Index of Dissatisfaction (IDS) for river values across the TR region; higher values indicate greater importance, dissatisfaction and/or a higher per cent of respondents providing information about the value.

Rivers for...	Mean I ^a	Mean S	% selecting	IDS	Reasons for dissatisfaction (concerns)
... Commercial purposes?	78	70	95	22	– Pollution (from mines) – Use/over-use by tourism, irrigation, commercial, domestic – Need for better monitoring – The cost of water and uncertainty about future access – Need for capture and storage (need for dams) and for improved water recycling
... Human life?	93	79	98	19	– Poor water quality (chemicals) – Boundaries and regulations/Government restrictions – Use/over-use (too many bores/cattle watering points, exports to Perth, tourists) – Need for capture and storage (store rain water) – Need to improve environment around rivers, more trees – Concern for the future – water is not looked after
... Other life?	95	81	97	18	–
... Bequest?	92	79	95	18	–
... Fishing?	72	75	87	16	– Difficulty of access/need for permits – Rivers overfished and overcrowded by fishers
... Recreation?	78	78	89	15	– Presence of crocodiles – Many rivers/waterholes inaccessible – Lack of rangers and attention by Council
... Teaching?	66	72	80	15	– Uncertainty with access; – Insufficient acknowledgment of Indigenous rights
... Aesthetics?	81	79	91	15	–
... Existence?	80	78	73	13	– Crocodiles ^b

^a These mean values do not exactly coincide with those presented in Fig. 2 because they only include data from respondents who answered both the importance and the satisfaction questions relating to each factor.

^b This comment most likely explains why some people do not use the rivers for recreational purposes but instead simply enjoy them for their 'existence' value.

and altruistic orientations (Karp, 1996; Stern et al., 1995, 1999). However, in our study, conservative/family orientation emerged as the most significant predictor, featuring as a positive predictor of all values except Recreation. This is an interesting finding as traditional orientations have been reported in the literature as negatively associated with pro-environmental norms (Stern, 2000). However, rather than being opposed to environmental goals on grounds of principle or religion (Stern, 2000), traditional Outback Australian culture is quite specific in that it is historically rather pro-environmentalist (see for example the work of Jackson et al. (2011b) in the TR region, or Larson (2010c) in Lake Eyre Basin region).

That Water for other life, Water for human life and Bequest values are considered to be more important than other values in this region, is interesting information by and of itself, but it does leave open the question of: where should one focus one's managerial/policy attention? Our last set of analyses – using the IDS – indicates that it is on Commercial values that policy makers may need to focus most effort on. This is not because people feel that Commercial values are more important than other values. Rather, it is because of consistent feelings of dissatisfaction with the commercial use of water. Moreover, it seems that most concerns seem to focus on issues about what might happen in the future (particularly with respect to water quality and water availability), rather than on issues confronting respondents today. However, it is also possible that Commercial values did not receive high importance as residents believed that benefits from commercial developments might accrue to someone else, while they will bear the costs. This is a worthy proposition, explored elsewhere (see Stoeckl et al., 2012, 2013).

Concerns over commercial developments however concur with other research: 'negative values' are often associated with degrading processes (or threats) operating on specific ecosystem services (Raymond et al., 2009), hence, the fear of what might happen in the future. Similar findings were also reported in other parts of Australia. For example, the study of the Lake Eyre Basin region found that most angst among residents were due to uncertainty related to future use and perceived lack of monitoring of water use (Larson, 2010c); while a citizen's jury deliberations conducted in Far North Queensland identified lack of scientific knowledge about the potential future negative impacts of a

road re-development on the rainforest and the coral reefs as a major point of confrontation (Niemeyer and Blamey, 2005). In both studies, concerns were expressed both in relation to lack of knowledge about the long-term and incremental environmental impacts as well as lack of monitoring of compliance with the rules and legislations. Thus, in line with these studies, we propose that in the TR region, early development of a comprehensive and agreed upon monitoring programme for projects that impact upon the regions' river systems, would be likely to enhance the trust of the stakeholders and improve perceptions about government's abilities to manage the resources equitably and efficiently. Policy and decision makers would need to not only put in place procedures to ensure that development is not harmful, but also ensure comprehensive communication of such procedures to residents. Comprehensive mechanisms that would allow for monitoring and evaluation of biodiversity, socio-cultural or other values important to local communities, should also be ensured.

The most common metric in economic valuations is 'dollars'. Some critics however, maintain that reliance on monetary metric has plagued many ecosystem service assessments, as it fails to incorporate non-monetary values that are critical to understanding the relationship between society and nature (e.g., Christie et al., 2006; MA, 2005; Norgaard, 1998; Wilson and Howarth, 2002). Gómez-Baggethun et al. (2010) suggest that the trend towards monetisation and commodification of ecosystem services is partly the result of a move from the Classical economics conception of nature's benefits as use values, into their conceptualisation in terms of exchange values in Neoclassical economics. Furthermore, such approaches imply unlimited substitution between the monetised values and thus acceptability of trade-offs (Gasparatos, 2010).

Gasparatos and Scolobig (2012), in their typology of sustainability assessment tools, classify currently used tools into monetary (valuation and aggregation tools); biophysical tools; and indicator tools. However Gasparatos (2010) warns that all of the tools exhibit different embedded value judgments (for example, in what is considered relevant data or how data is to be handled, who and in which capacity should be considered and involved during the decision making process etc.) and that these embedded value judgments can affect the outcome

of the evaluation. Indeed, [Martín-López et al. \(in press\)](#) found that methods used to elicit values actually shape and define the values being elicited. In their view, the prevalence of biophysical and monetary value domains in scientific literature entails two main concerns: (1) the ecosystem service concept reflects in a limited extent the concerns of their beneficiaries, and (2) ecosystem service assessment results are biased towards the information provided by markets at the expense of other value-articulating institutions. Thus, they argue, development of a comprehensive methodological approach in which biophysical, socio-cultural and monetary value domains can be explicitly considered and integrated into decision making processes remains one of the key challenges for ecosystem services research.

[Gasparatos \(2010\)](#) further argues that the choice of an evaluation tool is in most cases made by the analyst(s) without taking into consideration the needs, wants and values of the stakeholders. In other words, by choosing the tools, the analyst “subscribes to” and ultimately “enforces” a particular worldview as the legitimate yardstick to measure the performance of a project – and this worldview might not be compatible with the worldview of the affected stakeholders. However, [Martín-López et al. \(in press\)](#) further argue that if the choice of the techniques used for assessment effectively determines the result; then ecosystem service research should combine different and irreducible value-domains in order to properly inform environmental decision-making process ([de Groot et al., 2010](#); [Tallis and Polasky, 2009](#)).

We propose in this paper that non-monetary valuation tools might be an avenue worth further exploring. The tool used in this paper relies upon the subjective assessment by individuals, meaning that, like most economic valuation methods, it is inherently anthropocentric ([Gasparatos and Scolobig, 2012](#)). However, by allowing stakeholders to elicit the relevant values and their relative importance, this tool might potentially be seen as more ‘legitimate’ in the eyes of the affected stakeholders ([Gasparatos, 2010](#)). Furthermore, absence of ‘dollars’ means that the assessment system is not one where an individual’s preferences are weighted by their income or wealth before aggregation ([Jacobsen and Hanley, 2009](#)). Moreover, this approach does not require one to aggregate across services (instead, aggregating across individuals) or to invoke ‘expert opinion’ to determine the importance of services prior to aggregation (as is sometimes done in multiple criteria analysis, for example). This means that the system is not entirely reductionist and it does not require one to assume substitutability of services ([Gasparatos and Scolobig, 2012](#)). We thus suggest that future studies should explore these types of non-monetary methods, as using holistic methods allows one to assess the importance of different types of values, in relation to each other. This is particularly important when wishing to provide information to policy makers who are often required to address trade-offs and set priorities.

5. Conclusions

In this paper, we have demonstrated an application of a non-monetary system for assessing and comparing the relative importance of a range of different ecosystem services or values, associated with Australia’s Tropical Rivers. The nine different values identified for assessment comprised six examples of social and cultural values: future generations (Bequest); Existence; recreational Fishing; other types of Recreation; Aesthetics; and Teaching, and three examples of other (non-social/cultural) values: Water for human life, Water for other life and Commercial use. Of those, the top three values identified by respondents as the most important were Water for other life, Water for human life, and Bequest. Socio-demographic and economic attributes of the respondents as well as personal orientations were found to have only limited influence on the scores. The assessment of values was conducted using a

non-monetary valuation tool and we propose this type of approach as an avenue worthy of further exploration.

We also combined information about the importance of different values with levels of satisfaction with them, to identify management and policy priorities using the Index of Dissatisfaction. Commercial values emerged as the highest priority. This is, however, not because Commercial values were considered to be important – it ranked sixth out of nine values in terms of importance – but because the satisfaction associated with this value was lowest. Evidently, the issue here is not one of protecting or promoting Commercial values, but of addressing problems and concerns relating to the commercial use of water, and the potential negative impact of this particular type of use on ecological and social values – either now, or in the future.

Acknowledgements

This research (reported in this paper) was funded by the Northern Australia Water Futures Assessment (NAWFA), the Australian Government’s National Environmental Research Program and James Cook University. This project was developed in collaboration with research partners from TRaCK (Tropical Rivers and Coastal Knowledge). We gratefully acknowledge the contribution to this research made by the Mitchell River Catchment Traditional Owners (The Western Gugu Yalanji; The Mulliridgee; The Barbarum, The Kuku Djungan and Gugu Mini). We also thank the focus group participants; interviewees and hundreds of anonymous householders who took the time to complete our survey.

Appendix A

Appendix Table

Characteristics of respondents determining importance levels for each of nine values tested, where: SD = model based on socio-demographic characteristics only (n = 253); PO = model based on personal orientations only (n = 208); SD + PO = model combining socio-demographics and personal orientations (n = 193); and SD + predicted values of PO = socio-demographics tested against predicted POs (n = 193).

How important are rivers for...	Determinants used in analysis	Most important determinants of importance (stepwise multivariate tests):	Predictive capacity*
... Other life?	SD	↓ Older	0.043
		↓ Mining	
	PO	↑ Conservative/family	0.041
		↑ Varied life	
	SD + PO	↑ Biocentric	0.131
		↓ Mining	
		↓ Passive income from government	
		↑ Indigenous	
		↓ Male	
		↑ Varied life	
	SD + Predicted values of PO	↓ Older	0.122
		↓ Mining	
... Human life?		↓ Passive income from government	
		↑ Egocentric	
		↓ Varied life	
	SD	↑ Has children	0.152
		↓ Resident of NT	
	PO	↑ Conservative/family	0.090
		↑ Egocentric	
	SD + PO	↑ Has children	0.207
		↓ Resident of NT	
		↑ Conservative/family	
		↑ Egocentric	
	SD + Predicted values of PO	↑ Has children	0.152
	↓ Resident of NT		

Appendix Table (continued)

How important are rivers for...	Determinants used in analysis	Most important determinants of importance (stepwise multivariate tests):	Predictive capacity [*]
... Commercial purposes?	SD	↑ Owns business ↓ Resident of WA ↑ Male	0.081
	PO	↑ Conservative/family	0.054
	SD + PO	↑ Conservative/family ↑ Industry and transport ↑ Agriculture ↑ Passive income from investment	0.110
	SD + Predicted values of PO	↑ Owns business ↓ Resident of WA ↑ Male	0.081
<i>Social and cultural values:</i>			
... Bequest?	SD	↑ Has children	0.154
	PO	↑ Conservative/family ↑ Egocentric	0.136
	SD + PO	↑ Has children ↑ Conservative/family ↑ Varied life ↑ Egocentric ↑ Services	0.245
... Aesthetics?	SD + Predicted values of PO	↑ Egocentric ↑ Children	0.168
	SD	↑ Indigenous ↑ Has children	0.062
	PO	↑ Biocentric/altruistic ↑ Conservative/family	0.115
... Recreation?	SD + PO	↑ Biocentric/altruistic ↑ Conservative/family ↑ Indigenous	0.144
	SD + Predicted values of PO	↑ Indigenous ↑ Conservative/family	0.067
	SD	↑ Indigenous ↑ Egocentric	0.074
... Fishing?	SD + PO	↑ Biocentric/altruistic ↑ Egocentric ↓ Older ↑ Biocentric/altruistic	0.114
	SD + Predicted values of PO	↑ Egocentric	0.058
	SD	↑ Indigenous ↑ Owns business	0.103
... Existence?	PO	↑ Egocentric ↑ Conservative/family	0.107
	SD + PO	↑ Egocentric ↑ Conservative/family ↑ Indigenous ↑ Owns business ↑ HH Income	0.171
	SD + Predicted values of PO	↑ Indigenous ↑ Owns business	0.103
... Teaching?	SD	↑ Indigenous ↑ Passive income from investment ↓ Resident of WA	0.083
	PO	↑ Conservative/family ↑ Egocentric	0.070
	SD + PO	↑ Conservative/family ↑ Egocentric ↑ Passive income from investment ↓ Resident of WA	0.123
... Teaching?	SD + Predicted values of PO	↑ Conservative/family ↑ Passive income from investment ↑ Egocentric ↓ Children	0.108
	SD	↑ Indigenous ↑ Resident of QLD ↓ Education	0.223
	PO	↑ Biocentric/altruistic ↑ Conservative/family ↑ Egocentric	0.150

Appendix Table (continued)

How important are rivers for...	Determinants used in analysis	Most important determinants of importance (stepwise multivariate tests):	Predictive capacity [*]
	SD + PO	↑ Biocentric/altruistic ↑ Conservative/family ↑ Indigenous ↓ Resident of NT ↓ Education	0.298
	SD + Predicted values of PO	↑ Conservative/family ↑ Indigenous ↓ Education	0.223

* Adjusted R².

References

- Arthington, A.H., Brizga, S.O., Kennard, M.J., 1998. Comparative Evaluation of Environmental Flow Assessment Techniques: Best Practice Framework. Occasional Paper 25/98. Land and Water Resources Research and Development Corporation, Canberra, Australia.
- Bateman, I., Carson, R.J., Day, B., Hanemann, M., Hanleys, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Pearce, D., Sugden, R., Swanson, J., 2002. Economic Valuation with Stated Preference Technique: A Manual. Edward Elgar, Cheltenham, UK.
- Blanch, S., Rea, N., Scott, G., 2005. Aquatic Conservation Value of the Daly River Catchment. WWF Australia, Sydney.
- Borgatti, S., 1996. Anthropac 4.0. methods guide. Analytic Technologies, Natick, MA.
- Brown, S.M., 1992. Cognitive mapping and repertory grids for qualitative survey research: some comparative observations. *Journal of Management Studies* 29, 287–307.
- Brown, G., Raymond, C., 2007. The relationship between place attachment and landscape values: toward mapping place attachment. *Applied Geography* 27, 89–111.
- Chartres, C., Williams, J., 2006. Can Australia overcome its water scarcity problems? *Journal Development Sustainable Agriculture* 1, 17–24.
- Christie, M., Hanley, N., Warren, J., Murphy, K., Wright, R., Hyde, T., 2006. Valuing the diversity of biodiversity. *Ecological Economics* 58 (2), 304–317.
- Coxon, A.P.M., 1999. Sorting Data: Collection and Analysis. Sage Publications, Thousand Oaks, CA, USA.
- de Groot, J.I.M.D., Steg, L., 2007. Value orientations and environmental beliefs in five countries: validity of an instrument to measure egoistic, altruistic and biospheric value orientations. *Journal of Cross-Cultural Psychology* 38 (3), 318–332.
- de Groot, R.S., Alkemade, R., Braat, L., Hein, L., Willemsen, L., 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological Complexity* 7, 260–272.
- Department of Agriculture, Fisheries and Forestry, 2003. The National Recreational and Indigenous Fishing Survey [Online]. Available: http://www.daff.gov.au/_data/assets/pdf_file/0011/23501/final_recsurvey_report.pdf (Accessed 13 July 2011).
- Dilman, D.A., 2007. Mail and Internet Surveys: The Tailored Design Method. John Wiley & Sons, San Francisco, CA.
- Douglas, M., Bunn, S.E., Davies, P.M., 2005. River and wetland food webs in Australia's wet-dry tropics: general principles and implications for management. *Marine and Freshwater Research* 56, 329–342.
- Douglas, M., Jackson, S., Setterfield, S., Pusey, B.J., Davies, P.M., Kennard, M.J., Burrows, D., Bunn, S.E. (Eds.), 2011. Northern Futures: Threats and Opportunities for Freshwater Systems. Charles Darwin University Press, Darwin, Australia.
- Dyson, M., Bergkam, G., Scanlon, J. (Eds.), 2003. Flow. The Essentials of Environmental Flows. IUCN, Switzerland and Cambridge, UK.
- EPA (U.S. Environmental Protection Agency), 2009. Valuing the Protection of Ecological Systems and Services. U.S. Environmental Protection Agency, Washington, D.C.
- Faggotter, S., Burford, M., Robson, B.J., Webster, I.T., 2011. Nutrients and Primary Production in the Flinders River. CDU Press, Darwin, Australia.
- Gasparatos, A., 2010. Embedded value systems in sustainability assessment tools and their implications. *Journal of Environmental Management* 91, 1613–1622.
- Gasparatos, A., Scolobig, A., 2012. Choosing the most appropriate sustainability assessment tool. *Ecological Economics* 80, 1–7.
- Getzner, M., Spash, C., Stagl, S., 2005. Alternatives for Environmental Valuation. Routledge, New York, NY.
- Gómez-Baggethun, E., de Groot, R., Lomas, P.R., Montes, C., 2010. The history of ecosystem services in economic theory and practice: from early notions to markets and payment schemes. *Ecological Economics* 69, 1209–1218.
- Hanley, N., Barbier, E.B., 2009. The Price of Nature. Edward Elgar Publishing Limited, Cheltenham, U.K.
- Harris, G.P., 2001. Biogeochemistry of nitrogen and phosphorus in Australian catchments, rivers and estuaries: effects of land use and flow regulation and comparisons with global patterns. *Marine and Freshwater Research* 52, 139–149.
- Hein, L., van Koppen, K., de Groot, R.S., van Ierland, E.C., 2006. Spatial scales, stakeholders and the valuation of ecosystem services. *Ecological Economics* 57, 209–228.
- Instream Flow Council, 2004. Instream Flows for Riverine Resource Stewardship, Revised edition. (Cheyenne, WY).
- Jackson, S., 2005. Indigenous values and water resource management: a case study from the Northern Territory. *Australian Journal of Environmental Management* 12, 136–146.

- Jackson, S.U.E., Stoeckl, N., Straton, A., Stanley, O., 2008. The changing value of Australian tropical rivers. *Geographical Research* 46, 275–290.
- Jackson, S., Stoeckl, N., Larson, S., 2011a. The social, cultural and economic significance of tropical aquatic ecosystems: a diversity of values. In: Pusey, B. (Ed.), *Aquatic Biodiversity in Northern Australia: Patterns, Threats and Future*. CDU Press, Darwin, NT, pp. 173–190.
- Jackson, S., Finn, M., Woodward, E., Featherston, P., 2011b. Indigenous Socio-economic Values and River Flows. CSIRO Ecosystem Sciences, Darwin (www.csiro.au/.../Indigenous-socio-economic-values-and-river-flows-report.pdf).
- Jacobsen, J.B., Hanley, N., 2009. Are there income effects on global willingness to pay for biodiversity conservation? *Environmental and Resource Economics* 43, 137–160.
- Karp, D.G., 1996. Values and their effects on pro-environmental behavior. *Environment and Behavior* 28, 111–133.
- Kennard, M.J., Pusey, B.J., Olden, J.D., Mackay, S.J., Stein, J.L., Marsh, N., 2010. Classification of natural flow regimes in Australia to support environmental flow management. *Freshwater Biology* 55, 171–193.
- King, J., Brown, C., Sabet, H., 2003. A scenario-based holistic approach to environmental flow assessments for rivers. *River Research and Applications* 19, 619–639.
- Kremen, C., Niles, J.O., Dalton, M.G., Daily, G.C., Ehrlich, P.R., Fay, J.P., Grewal, D., Guillery, R.P., 2000. Economic incentives for rainforest conservation across scales. *Science* 288, 1828–1832.
- Land and Water Australia, 2005. *The Tropical Rivers Program*. Land and Water, Canberra, Australia.
- Larson, S., 2009. Communicating stakeholder priorities in the Great Barrier Reef region. *Society and Natural Resources* 22 (7), 650–664.
- Larson, S., 2010a. The socio-economic features of Northern Australia. In: Gerritsen, R. (Ed.), *North Australian Political Economy: Issues and Agendas*. CDU Press, Darwin, pp. 1–17.
- Larson, S., 2010b. Regional wellbeing in tropical Queensland, Australia: developing a dis-satisfaction index to inform government policy. *Environment and Planning A* 42, 2972–2989.
- Larson, S., 2010c. Designing robust water planning institutions in remote regions: a case of Georgina and Diamantina catchment in Australia. *Water Policy Journal* 12 (3), 357–368.
- Larson, S., 2011. *From Individual Wellbeing to Regional Priorities: Concepts and Measures to Assist Policy Makers*. Cambridge Scholars Publishing, Newcastle upon Tyne, UK (180 pp.).
- Larson, S., Alexandridis, K., 2009. *Socio-economic Profiling of Tropical Rivers*. CSIRO Sustainable Ecosystems, Townsville.
- Larson, S., De Freitas, D.M., Hicks, C., 2013. Sense of place as a determinant of people's attitudes towards the environment: implications for natural resources management and planning in the Great Barrier Reef, Australia. *Journal of Environmental Management* 117, 226–234. <http://dx.doi.org/10.1016/j.jenvman.2012.11.035>.
- Lennox, J., Proctor, W., Russell, S., 2011. Structuring stakeholder participation in New Zealand's water resource governance. *Ecological Economics* 1381–1394.
- MA (Millennium Ecosystem Assessment), 2005. *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC.
- Martín-López, B., Gómez-Baggethun, E., García-Llorente, M., Montes, C., 2013. Trade-offs across value-domains in ecosystem services assessment. *Ecological Indicators*. <http://dx.doi.org/10.1016/j.ecolind.2013.03.003> (in press).
- McDonald, R.I., 2009. The promise and pitfalls of systematic conservation planning. *PNAS* 106, 15101–15102.
- McMahon, T.A., 1992. World hydrology: does Australia fit? *Hydrology and Water Resources Symposium*. National Conference Publication, 83/2. The Institution of Engineers.
- Myers, D.G., Diener, E., 1996. The pursuit of happiness. *Scientific American* 274, 54–56 (May).
- NGIS Australia, 2004. *Australia's Tropical Rivers – Data Audit [Online]*. Land and Water, Canberra, Australia Available at: <http://lwa.gov.au/files/products/river-landscapes/pr040674/pr040674.pdf> [Accessed 27 June 2011].
- Niemeyer, S., Blamey, R., 2005. *Deliberation in the Wilderness: The Far North Queensland Citizen's Jury*. Land and Water Resources Research and Development Corporation, Canberra, Australia.
- Norgaard, R.B., C. Bode with the Values Reading Group, 1998. Next, the value of God, and other reactions (A response to The value of the world's ecosystem services and natural capital by Costanza et al.). *Ecological Economics* 25 (1), 37–39.
- O'Connor, M., Frame, B., 2008. In a Wilderness of Mirrors: Complexity, Confounded Metanarratives and Sustainability Assessment. Centre d'Économie et d'Éthique pour l'Environnement et le Développement (C3ED), Cahiers du C3ED, France.
- Puckridge, J.T., Sheldon, F., Walker, K.F., Boulton, A.J., 1998. Flow variability and the ecology of large rivers. *Regulated River* 9, 55–72.
- Quiggin, J., 2006. Urban water supply in Australia: the option of diverting water from irrigation. *Public Policy* 1, 14–22.
- Raymond, C.M., Bryan, B.A., Hatton, MacDonald D., Cast, A., Strathearn, S., Grandgirard, A., Kalivas, T., 2009. Mapping community values for natural capital and ecosystem services. *Ecological Economics* 1301–1315.
- Rietbergen-McCracken, J., Abaza, H., 2000. *Environmental Valuation: A Worldwide Compendium of Case Studies*. Earthscan, London, UK.
- Robins, L., Dovers, S., 2007. NRM regions in Australia: the 'haves' and the 'have nots'. *Geographical Research* 45, 273–290.
- Rosenberg, S., Kim, M.P., 1975. The method of sorting as a data gathering procedure in multivariate research. *Multivariate Behavioral Research* 10, 489–502.
- Sarkar, S., Margules, C.R., 2002. Operationalizing biodiversity for conservation planning. *Journal of Biosciences* 27 (4), 299–308.
- Schwartz, S.H., 1992. Universals in the content and structure of values: theoretical advances and empirical tests in 20 countries. *Advances in Experimental Psychology* 25, 1–65.
- Schwartz, S.H., 1994. Are there universal aspects in the structure and contents of human values? *Journal of Social Issues* 50 (4), 19–46.
- Stern, P.C., 1999. Information, incentives, and proenvironmental consumer behavior. *Journal of Consumer Affairs* 22, 461–478.
- Stern, P.C., 2000. Psychology, sustainability, and the science of human-environment interactions. *American Psychologist* 55, 523–530.
- Stern, P.C., Dietz, T., 1994. The value basis of environmental concern. *Journal of Social Issues* 50 (3), 65–84.
- Stern, P.C., Dietz, T., Guagnano, G.A., 1995. The new environmental paradigm in social psychological perspective. *Environment and Behavior* 27, 723–745.
- Stern, P.C., Abel, T., Guagnano, G.A., Kalof, L., 1999. A value-belief-norm theory of support for social movements: the case of environmentalism. *Human Ecology Review* 6 (2), 81–97.
- Stoekli, N., Stanley, O., Jackson, S., Straton, A., Brown, V., 2006. *An Assessment of the Social and Economic Values of Australia's Tropical Rivers Program*. CSIRO and James Cook University, Land and Water Australia.
- Stoekli, N., Esparon, M., Stanley, O., Farr, M., Delisle, A., Altai, Z., 2011. *Socio-economic Activity and Water Use in Australia's Tropical Rivers: A Case Study in the Mitchell and Daly River Catchments, Tropical Rivers and Coastal Knowledge Commonwealth Environmental Research Facility, Darwin*. <http://www.track.gov.au/publications/registry/905>.
- Stoekli, N., Neil, B., Welters, R., Larson, S., 2012. Resident perceptions of the relative importance of socio-cultural, biodiversity, and commercial values in Australia's Tropical Rivers. Report for the North Australia Water Futures Assessment. James Cook University, Townsville, Australia.
- Stoekli, N., Jackson, S., Pantus, F., Finn, M., Kennard, M., Pusey, B., 2013. An integrated assessment of some of the financial, hydrological, ecological and social impacts of 'development' on Indigenous and non-Indigenous people in Northern Australia. *Biological Conservation* 159, 214–221.
- Tallis, H., Polasky, S., 2009. Mapping and valuing ecosystem services as an approach for conservation and natural resource management. *Annals of the New York Academy of Sciences* 1162, 265–283.
- Taylor, A., Larson, S., Stoekli, N., Carson, D., 2011. The haves and have nots in Australia's Tropical North – new perspectives on a persisting problem. *Geographical Research* 49 (1), 13–22.
- TEEB, 2010. *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations*. Earthscan, London, UK.
- Tharme, R.E., 2003. A global perspective on environmental flow assessment: emerging trends in the development and application of environmental flow methodologies for rivers. *River Research and Applications* 19 (5–6), 397–441.
- Toussaint, S., Sullivan, P., Yu, S., Mularty Jr., M., 2001. *Fitzroy Valley Indigenous Cultural Values Study: A Preliminary Assessment*. Water and Rivers Commission, Perth, Australia.
- UK NEA, 2011. *The UK National Ecosystem Assessment Technical Report*. UK National Ecosystem Assessment, UNEP-WCMC, Cambridge, UK.
- Van Dam, R., Bartolo, R., Bayliss, P., 2008. *Ecological risk assessment for Australia's northern tropical rivers*. Sub-Project 2 of Australia's Tropical Rivers – An Integrated Data Assessment and Analysis (DET18). Environmental Research Institute of the Supervising Scientist, National Centre for Tropical Wetland Research, Darwin, Australia.
- Wallace, K.J., 2007. Classification of ecosystem services: problems and solutions. *Biological Conservation* 139, 235–246.
- Wilson, M.A., Howarth, R.B., 2002. Valuation techniques for achieving social fairness in the distribution of ecosystem services. *Ecological Economics* 41, 431–443.
- Woodward, E., Jackson, S., Straton, A., 2008. *Water Resources of the Howard River Region, Northern Territory: A Report on the Social and Cultural Values of a Stakeholder Assessment of Water Use Scenarios*. CSIRO Sustainable Ecosystems, Darwin, Australia.
- Zander, K.K., Straton, A., 2010. An economic assessment of the value of tropical river ecosystem services: heterogeneous preferences among Aboriginal and non-Aboriginal Australians. *Ecological Economics* 69 (12), 2417–2426.