Integrating Science and Economics in Australian River Management*

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1. Introduction

Over the past decade, there has been a growing policy interest in the allocation of water in Australia. This interest has arisen with increasing awareness across the community of the overall shortage of water supply to satisfy the array of competing demands. Extractive users of water – for domestic water supply, industry and most significantly for irrigated agriculture – have found themselves in competition for available supplies. Furthermore, conservationists have drawn attention to the declining environmental health of many Australian rivers and have sought the intervention of governments to reduce the extent of extractive use to create greater 'environmental flows'.

A number of significant policy initiatives have resulted. For extractive uses of water, more comprehensively defined property rights have been formulated. Trading of these rights in newly established water markets is becoming an integral part of the irrigation farmer's business management. Furthermore, to establish the overall scarcity of water for extractive uses in river systems, governments have established 'caps' on the amount of water that can be extracted. Simultaneously, the setting of these caps has determined the amount of water that is left in the rivers to ensure the health of their ecological systems.

Whilst the trading of water rights between competing extractive users is still in comparative infancy and there is still much to be done in terms of refining the institutional structures that underpin the emerging water markets, there are clear signs of improved economic efficiency in the use of water. Higher marginal value uses of water such as vineyards are beginning to out bid lower marginal value uses such as irrigated pastures for dairying. Water is being used in different geographical locations to reflect these changes. The results are increases in the overall value being generated for society through the use of water extracted from rivers.

A shortcoming in the reforms being implemented is in the process of determining the extent of the extractive water use caps. Conceptually, the amount of water being extracted from a river should be set at the level whereby further extractions would generate the same value to society as that to be enjoyed by holding that water in-stream. This is the familiar equi-marginal principle that defines economic efficiency in the allocation of resources between competing uses. The reality of setting caps in Australia has for the most part been a political process whereby the interests of

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competing water users have been weighed up by politicians with the assistance of bureaucrats. The danger of this type of approach, as is well known by scholars of political economy, is the emergence of inefficient outcomes in response to rent-seeking behaviour.

From an economist's perspective, the preferable way for the cap to be set is for the political process to be informed by analyses of the marginal benefits of extracting water and the marginal benefits of water used for environmental flows.

The difficulty faced in implementing this process is the estimation of many of the benefits associated with environmental flows. This is because they are not bought and sold in markets and are hence not readily valued in monetary terms. For instance, the ecosystem service of water quality control provided by healthy riverine wetlands has public good characteristics that preclude it from being marketed. The so-called 'non-use' values enjoyed by people who like to know that rare and endangered species whose habitats are adversely impacted by water extraction are protected are similarly outside the reach of markets.

So whilst economists have well-established theoretical and practical market-based methods for estimating the benefits enjoyed by society from extractive water uses, the set of tools used for estimating the values of the non-market benefits associated with environmental flows in rivers is still relatively new.

The purpose of this paper is to outline two studies that have been carried out in Australia with the goal of providing decision makers with information on the value of non-market benefits associated with environmental flows in rivers. The studies demonstrate the capacity for non-market valuation tools to aid in the decision making process but more fundamentally show the importance of linking good science – in predicting the environmental outcomes of alternative environmental flow regimes – with good economics – in estimating the values society places on those outcomes.

Both of the studies reported used Choice Modelling (CM) to estimate the non-marketed environmental values of environmental flows. It is therefore appropriate that the next section of the paper is devoted to a brief review of what CM is. In subsequent sections, the two studies are reported. The first involved rivers in the state of New South Wales and the second focused on the Murray River, which for a large proportion of its length forms the border between the states of Victoria and New South Wales. In the final section of the paper, some thoughts on what implications theses Australian studies have for the analysis of alternative management options for the Mekong River and particularly for the possible integration of non-market values into water allocation models for that river.

2. What is Choice Modelling

Choice Modelling is a 'stated-preference' method of estimating non-market environmental values. In a CM application, survey respondents are asked to make a sequence of choices between a 'do nothing' resource management alternative and a number of different options for change. The choice questions are presented in a standardised format, with all the options described to respondents in terms of a set of attributes. Hence, in a study of non-market values arising from environmental flows in a river, alternative management options may be described in terms of three attributes: number of endangered fish species protected, the area of wetland protected and the amount of the payment that is required of respondents for the change to be implemented.

The answers of respondents to a CM questionnaire provide a large source of information on the trade-offs that people are willing to make in choosing between alternative futures. The process of analysing the data involves an investigation of how changes in the levels taken by each of the attributes affect respondents' choices. For instance, it would be expected that options that provide more fish species in a river would be selected more frequently than those offering fewer species, given that everything else is held constant. Similarly, options that cost more would be expected to be less popular.

It is from the observations of the probabilities of options being selected across the choices provided that respondents' willingness to make trade-offs across options and between attributes can be inferred. In turn this allows the choice modeller to estimate how much respondents on average would be willing to pay in order to have more of a single attribute (called an implicit price) and to secure a change from the status quo to a specific future option.

The first step taken in a CM application is to design the questionnaire. This is an important step because the level of complexity inherent in a choice modelling questionnaire is high with its sequence of choice questions, each of which involves the comparison of two or more options described using up to four or five attributes. In other words, the cognitive burden imposed by a choice modelling questionnaire means that its design is of critical importance.

Part of this design process is the selection of the attributes used to describe the choice options. Attributes must reflect the factors of interest to decision makers (ie what can be changed) as well as the interests of those who will be affected (ie what matters to people). Hence, the inputs of the decision makers and scientists as well as the general public are important at this stage. The use of focus groups – small groups of around eight people brought together to go through the issues involved in the study and to critique drafts of the questionnaire – are regarded as best practice in this regard.

Another key component of the questionnaire design is the structuring of the mixture of options presented to respondents in the choice sets. To be able to understand the impact of changes in the attribute levels on choices, it is important from a statistical perspective to have respondents exposed to a wide array of possible combinations of attribute levels. To do this, an 'experimental design' is used to make a selection of attribute level combinations that covers the full range of possibilities.

Further steps in applying CM involve the distribution of the questionnaire to the selected sample, the collation of the data and its analysis. Questionnaire delivery can be by mail, by telephone or in person. The number of respondents who complete the CM questionnaire will be a key factor in determining the statistical strength of the estimates produced.

The results obtained from a CM application are of two types – implicit price estimates for the individual attributes and estimates of the value of changing from the status quo to a particular option. The implicit price estimates are useful in finding out the relative strength of peoples' preferences for different aspects of change. They can be used for developing plans that are fine tuned to target where best value can be achieved.

The estimates of value for specified changes from the status quo are of particular interest because they are consistent with the requirements of a cost benefit analysis. Furthermore, because these estimates are in a functional form, that is, value is expressed as a function of the levels of the attributes and the socio-economic characteristics of respondents, value estimates for an array of potential options can be derived. This means that a single CM application can be used to find out the optimal strategy rather than simply vetting single proposals.

A particular feature of the CM approach is the possible inclusion of a variety of different attributes. This enables both environmental and social attributes of change to be investigated and valued.

The strengths of the CM approach are its capacity to generate a large amount of information about peoples' preferences in a single operation and its ability to avoid some of the biases that have caused another of the stated preference non-market valuation techniques - the contingent valuation method - to be criticised. Hence, it has the flexibility to cover a wide range of value contexts and to provide information about an array of possible options. As well, the incentives to over or under state their preferences are much reduced for respondents largely because it is so difficult for them to work out choice strategies that will be in their best interest. Telling the truth is usually the default strategy for people in such situations.

The weaknesses of the technique are mostly to do with its complexity. Without very careful design of the questionnaire, the cognitive burdens of a CM questionnaire can be daunting for respondents. Where this is the case, the danger is for low response rates or for responses that are distorted through the use of decision 'heuristics'. This means that respondents answer the choice questions by using choice rules such as 'always choose the option with the highest number of species protected' or 'always choose the middle option' and do not consider the full range of information presented to them.

The complexities of CM also extend to the application of the technique. The use of experimental designs requires specialist knowledge as does the statistical analysis of the choice data collected.

3. New South Wales Rivers

The water reform process undertaken by the New South Wales (NSW) Government required a "better balance in water use by a more explicit and careful sharing of water resources between the environment and water users" (Department of Land and Water Conservation 1998). To pursue this goal, regional Catchment Management Authorities (CMAs) have been established across the state to advise the government on water sharing arrangements that are deemed appropriate for rivers in each region.

The CMAs are made up of people who can bring different types of expertise to the discussions.

To formulate such advice, the CMAs will find useful information relating to the biophysical consequences of alternative water sharing arrangements. For instance, predictions of the impacts on the number of fish species present in a river and the quantities of irrigated crops harvested given increased allocations of water to agriculture would be relevant.

The aim of the research presented here was to assist the CMAs in formulating their advice to the NSW Government through the estimation of the non-marketed community values associated with the protection of riverine environments across the state. CM was the technique used.

The approach taken in this study was to divide the rivers of NSW into five "bio-geographic regions". One river from within each region was selected, and the environmental values of the rivers in these "representative" rivers were estimated in five separate CM applications.

The four attributes[1] used to describe the environmental condition of the rivers were:

- Water quality, as indicated by the suitability of the river for alternative recreational uses (riverside picnicking, boating, fishing (WQ1)and swimming (WQ2));
- Healthy riverside vegetation and wetlands (VEG);
- Native fish species present (FISH); and
- Waterbirds and other fauna species present (BIRD)

After consultations with river ecologists and policy advisers, regions and "representative rivers" were selected. The rivers selected for analysis (along with their region of location) were:

- Bega River (BEG)(southern, coastal)
- Clarence River (CLA)(northern, coastal)
- Georges River (GEO)(urban)
- Murrumbidgee River (MUR)(southern, inland)
- Gwydir River (GWY)(northern, inland).

To identify any effect on values that relate to respondents' location of residence – and hence proximity to the river, samples of people living in catchment and outside of catchment were surveyed.

The structure of the study is summarised in Table 1.

[1] See Bennett, Morrison and Harvey (2000) for details of the process employed to select these attributes.

Table 1: *Study structure*

Representative River	Within Catchment sample	Outside Catchment sample
BEG	✔	
MUR	✔	✔
GEO	✔	
CLA	✔	
GWY	✔	✔

Five separate questionnaires were designed around the five "representative" rivers for the within catchment surveys. In order to ensure the comparability of results from each survey, the questionnaires used were structurally identical. Differences between the questionnaires related to divergent biophysical characteristics of the rivers only. Maintaining the questionnaire structure across the samples enables the statistical testing for differences between the attribute values estimated for each river and its local population. These tests enable the detection of differences in attribute values that are due to differences in the biophysical features of the rivers and socio-economic characteristics of the local residents.

The outside catchment questionnaires were designed to parallel their respective within catchment questionnaires. This again was to ensure comparability of results across the questionnaire versions.

The questionnaires were developed through a process of consultation with experts, community consultation and peer review.

The questionnaires[2] contained several elements:

- background information about the catchment,
- a scenario description (ie explaining why people should have to pay for improving river health and what this will achieve),
- a series of choice sets, and
- debrief questions.

In the choice sets, respondents were presented with a number of river management options from which they were asked to choose their preferred option. In each set, one option always represented the current situation, and the other two options represented improvements to river health brought about by actions such as the exclusion of stock from river banks, the construction of sediment traps and the control of feral animals and plants. Each of the "change" options were associated with a specific cost to the respondent in the form of a on-off levy on 2001 water rates. Each respondent was presented with five such choice set questions.

The ecological information used in the questionnaires was gathered through an extensive literature review. This review relied heavily on information provided by

[2] Copies of the questionnaires used are available upon request to the author.

NSW Fisheries, the NSW Environment Protection Authority, NSW Department of Land and Water Conservation, NSW National Parks and Wildlife Service and the Healthy Rivers Commission.

Information on fish species was drawn from information supplied by NSW Fisheries. Information on fauna species was based on data from the Wildlife Atlas at NSW National Parks and Wildlife Service. The recreational opportunities data were derived from water quality data sources in the NSW Department of Land and Water Conservation. Information on vegetation was derived from a range of sources.

To implement the research design, seven samples of 900 respondents were drawn from "Australia on Disk", a listing of people based on the telephone directory. For the five "within catchment" samples, respondents were selected at random on the basis of postcodes relating to the corresponding river catchments. For two of the catchments (Gwydir and Murrumbidgee) further samples of 900 respondents were drawn from "outside" of these catchments across the whole state.

A four stage surveying process was employed. First, an introductory letter advising those drawn in the sample that they would shortly be receiving a questionnaire was dispatched. Second, the questionnaire was mailed with an accompanying letter and a reply paid envelope. A reminder card comprised the third stage and a re-mail of the questionnaire to those yet to respond completed the process[3].

The overall response rate achieved was 37.8%, ranging from 28.7% to 45.9% across the sub-samples. This response rate compares favourably with other mail surveys of this genre (Mitchell and Carson 1989).

The samples tended to self select toward older, wealthier better educated respondents who were male.

The choice data collected in the surveys were analysed statistically to detect relationships between the level of the environmental attributes used to describe the options available, the socio-economic characteristics of the respondents and the probability of respondents choosing particular options.

From these relationships, the trade-offs that respondents were willing to make between the attributes were defined and attribute values (or *implicit prices)* were estimated.

[3] Barbara Davis and Associates and National Mailing and Marketing Pty Ltd were tasked with the sample selection and co-ordination of the survey.

Table 2: *Attribute Value Estimates ($ per household)*

	VEG	FISH	BIRD	WQ1	WQ2
in					
BEG	$2.32	$7.37	$0.92	$53.16	$50.14
CLA	$2.02	$0.08*	$1.86	$47.92	$24.73
GEO	$1.51	$2.11	$0.67*	$48.19	$27.28
MUR	$1.45	$2.58	$1.59	$53.43	$20.35
GWY	$1.49	$2.36	$1.89	$51.31	$60.21
Out					
MUR	$2.17	$3.81	$1.80	$30.50	$60.68
GWY	$2.01	$3.43	$0.55*	$29.19	$30.35

* insignificant coefficients in model at the 5 percent level.

The models underpinning these estimates were able to explain a relatively large proportion of the total variability evident in the choice data[4]. The environmental attributes were consistently found to be significant in explaining the choice data and respondents' age and income were also found to be significant influences, confirming *a priori* expectations.

The units of measurement of the attribute value estimates displayed in Tables 2 are dollars per unit of each attribute. For instance, from the Bega River survey, the Fish Specie attribute value can be interpreted as:
On average, respondent households in the Bega Valley value the presence of an additional fish specie in the river at $7.37 per household.

The units used to measure the attributes are different for each attribute. Whilst the fish attribute value is per additional species, the vegetation attribute is per an additional percent of the river having healthy riverside vegetation and wetlands. The water quality (recreational opportunities) attribute has a different interpretation because, unlike the other attributes its unit of measurement was qualitative rather than quantitative. The water quality attribute is thus broken up into two "levels" – "fishable"(WQ1) and "swimmable"(WQ2). The attribute values associated with these levels are the value, on average, that a respondent household holds for an improvement in the river's water quality from its current level "suitable for fishing and boating along its length" to the point where it is either swimmable or fishable along its length. For instance:
On average, each respondent household in the Clarence River sample values an improvement in river water quality that would make it safe for fishing along the length of the river at $47.92.

The use of qualitative, discrete levels for the water quality attribute requires further interpretation when a change occurs that lies between the defined levels. For example, if a management change causes an improvement in water quality from boatable to fishable from 40 percent of the river's length to 60 percent of its length, it is necessary to adjust the attribute value estimates because they are predicated on the improvement

[4] Adjusted rho squared statistics for the models ranged from 0.21 to 0.41, with values greater than 0.2 being regarded as robust.

occurring over the entire length of the river. The adjustment required necessarily involves an assumption regarding the behaviour of value as less of the river is affected. The most straightforward assumption that can be made in this regard is that the relationship between value and length of the river affected is linear. In other words, if an extra 20 percent of the river is affected, the value associated with the improvement is 20/60 percent (ie 33%) of the value estimate for the whole river. Using the Gwydir as an example:

On average, each respondent household in the Gwydir River sample values an improvement in river water quality that would make it safe for fishing ***along 66 percent*** *of the river at $25.65.*

Because the units of measurement are different across the attributes, the value estimates for the different attributes are not directly comparable. Hence the value estimates for the water quality attributes, swimming and fishing, may initially seem comparatively large. However, the differences may not be so great once differences in the units of measurement are taken into account.

Comparisons are directly possible between the same attributes across different rivers and different samples. These results of these comparisons indicate that:

- The estimates of attribute values related to the direct use of rivers (swimming and fishing) tend to be larger for the within catchment respondents than those estimated for the comparable outside catchment sample.
- The estimates of values associated more with the ecological condition of the rivers (the so-called existence values associated with vegetation, fish and other fauna) are larger for the samples of respondents living outside the catchments compared to the value estimates for the within catchment samples.
- Attribute value estimates generated from within catchment samples are predominantly different across rivers.

Value estimates for a wide range of possible river management options for rivers across NSW can be derived from the results presented here. As an example suppose that a river management option under consideration in a catchment on the south coast would increase the vegetation attribute by five percent, ensure the reintroduction of two fish species and improve the water quality across 15 percent of the length of the river from boatable to fishable. If the catchment has a household population of 4,000 then the within catchment aggregate value estimate is $80,981. Given a NSW population of approximately 1.8m households[5], the appropriate aggregation calculation for the (maximum) outside catchment values is $31.97m.

The total value (maximum) to all the people of NSW of the improved river environment provided by that specific proposed management option is therefore in the order of $32m[6]. This benefit can be compared against the costs of achieving it. Similar calculations can be performed for different policy options for different rivers across the rivers of NSW using the data generated from this research.

The implementation of such results in the policy context requires scientists to provide predictions of the levels taken by the attributes used in the CM under alternative

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[5] The figure of 2.5 people per household is used as a base-line for this calculation. ABS data indicate an average household size of 2.7 for the 1996 Census (www.abs.gov.au) however, the trend in this figure is downward.

[6] For details of the calculations, see Bennett and Morrison (2001).

management strategies. In this way, values can be assigned to those strategy outcomes. It is important to note however that the approach requires scientists to respond to the policy process rather than being an integral part of it.

4. The River Murray[7]

Under its Living Murray Initiative, the Murray Darling Basin Commission considered three Environmental Flow Reference Points (EFRPs), that is, increases in average annual flows in the River Murray of 350, 750 and 1,500 GL.

To facilitate predictions of biophysical outcomes of EFRPs for various zones of the River Murray, as well as the River Murray as a whole, the MDBC commissioned a Scientific Reference Panel (SRP) to develop an Environmental Flow Decision Support System (EFDSS) called the Murray Flow Assessment Tool (MFAT).

MFAT aimed to define and predict the outcomes of alternative management strategies in terms of five attributes:

- floodplain vegetation;
- wetlands;
- native fish;
- waterbirds; and
- algal bloom control.

Hence, MFAT was the primary tool for science to be introduced to the decision making process. To transform the MFAT predictions into estimates of community value suitable for use in a consideration of the relative merits of the alternative flow strategies, a CM study was commissioned. The CM study was therefore an opportunity to link together science and economics in the policy making process.

To use the MFAT attributes to develop choice sets for the CM questionnaire, it was necessary to identify a metric for the measurement of each attribute and the range within which policy options (EFRP) may span.

Initial consultations with the SRP in relation to MFAT indicated that it would predict attribute outcomes on a scale of 0 to 1. However, to incorporate this type of output into the CM application required a 'translation' from the MFAT index of 0 to 1 to information that can be readily understood by members of the public. For instance, if the MFAT predicts the native fish habitat index to be 0.35 for the whole river for a particular EFRP, what does that mean to the lay public?

To develop this 'translation', the SRP provided descriptive predictions of the attribute outcomes given no new management initiatives as well as a statement of the current health of the River. The descriptive predictions for each attribute that were provided by the SRP were in lengthy prose, a form not suitable for a CM questionnaire.

Examination of the attribute outcome descriptions led to an exploration of the possibility of detailing each attribute using two descriptors:

- a single quantity (abundance) descriptor; and

[7] See Gillespie and Bennett(2003) for more details.

- a single quality (species/community) descriptor.

It was considered that such descriptors would enable the information feeding into the CM application to be:
- as quantitative as possible (to improve the linkage between the MFAT outcome predictions and the CM results); and
- as objective as possible (lessening the chance of misinterpretations of what is meant by words such as ‘many’, ‘some’ and ‘much’).

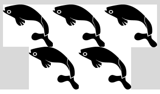
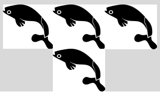
However, the scientific complexities involved meant that the SRP could not deliver the desired level of quantitative information through MFAT. Instead, the SRP provided a range of discrete condition categories for each attribute that were considered to cover the range of conditions for the whole river under the EFRPs and potential management scenarios that would be considered by the MDBC.

Some simplification of the condition categories was necessary if respondents to the CM questionnaire were to be able to understand it. A simplified version of the condition categories and their meanings was therefore further developed through an iterative process with the SRP.

The following provides the condition categories, descriptors and levels developed for each of the environmental attributes that were eventually developed for the CM study.

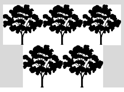
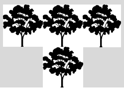
The condition categories were considered to represent the range of levels that potential policy options may span. These bundles of conditions also relate to different 0 to 1 scores that will be estimated by MFAT for the different River management scenarios.

Native Fish

Score	Years of good fishing*	Status of currently endangered species
	6 years out of 10	Uncommon but not threatened
	5 years out of 10	Uncommon and locally threatened
	4 years out of 10	Some local extinctions
	3 years out of 10	Extensive local extinctions
	2 years out of 10	Some permanent losses from the river

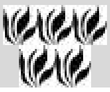
* Good fishing means that you don’t need extensive local knowledge to catch native fish including Murray Cod, Golden Perch, Mulloway, Mullet and more.

Floodplain Vegetation

Score	Diversity of native species*	Forest and grassland condition
	High in many locations	Most in good health, and some areas regenerated
	High in some locations	Most in good health across their current area
	Moderate	Some in moderate to good health, others showing signs of degradation
	Poor	Most showing signs of degradation across their current area
	Low	Most permanently degraded, and in a reduced area

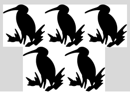
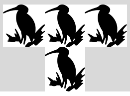
* Diverse floodplain vegetation includes a wide variety of native trees, shrubs and grasses including river red gums, black box, lignum, moira grass and water couch.

Wetlands

Score	Diversity of native species	Wetlands*
	High	Most in good health, and some areas regenerated
	High	Most in good health across their current areas
	Moderate	Some in moderate to good health, others showing signs of degradation.
	Moderate	Most showing signs of degradation across their current area
	Low	Most permanently degraded, and in a reduced area

* Including wetlands listed as of regional, national or international significance (eg Coorong, Barmah-Millewa and Hattah Lakes)

Waterbirds

Score	Diversity of native species*	Abundance
	High	Uncommon sightings of over 20,000 birds at some wetlands
	High	Uncommon sightings of over 10,000 birds at some wetlands
	Moderate	Rare sightings of over 10,000 birds at few wetlands
	Moderate	Rare sightings of over 5,000 birds at a few wetlands
	Low	Extremely rare to see more than 5,000 birds at any wetland

* High diversity means a wide range of native waterbird species including colonial nesting birds such as ibis, herons, spoonbills and egrets, waterfowl such as pink-eared ducks, grey teal and freckled ducks and also pelicans, black swans and cormorants.

Algal Blooms

Score	Occurrence of moderate toxic algal bloom (water not suitable for drinking)	Occurrence of severe toxic algal bloom (water unsuitable for drinking or industrial use)
	2 years in 10	1 year in 30-50 years
	3 years in 10	1 year in 20
	4 years in 10	1 year in 20
	5 years in 10	1 year in 20
	7 years in 10	1 year in 20

The SRP also identified the condition categories that currently prevail for the whole river and those that would prevail in 20 years time if nothing new is done.

With attribute definition, descriptions and levels identified from a scientific perspective it was possible to begin consultation with the community[8]. This consultation process includes focus groups, pilot testing of the questionnaire and questionnaire implementation.

Participants in the focus groups sessions were selected to be representative of the four main sub-populations originally considered to form the population of people who would benefit from alternative River management strategies:

- people living adjacent to the River in the Upper Catchment
- people living adjacent to the River in the Lower Catchment
- the broader population of people living in NSW and Victoria
- residents of Adelaide.

Eight focus group sessions were undertaken in all. Two in Sydney, which were used to represent Australians living outside the Murray River Valley, two in Adelaide, two in Albury (upper Murray River) and two in Mildura (lower Murray River). Each focus group involved 9 or 10 people.

For each location, an afternoon focus group session and an evening session was undertaken. This was to facilitate attendance by a cross section of people including those in the workforce.

The focus group sessions incorporated a number of stages. Broadly, these included the consideration of the attributes generated from the 'supply side' analysis, the analysis of respondents' initial level of awareness and the vetting of communication aspects of a number of initial drafts of a CM questionnaire. Conceptually, the attributes being modelled by MFAT provided a starting point for consideration of the relevant attributes for the CM application.

However, it was important to examine if these attributes being used MFAT were meaningful to the potential respondents of the CM application.

The approach used was for focus groups to identify the aspects of the environment that they would like to know about with respect to future management options for the River Murray. The attributes identified by SRP were not provided to the groups at this stage. While there was a diverse range of responses, the main environmental attributes referred to by focus group participants were found to be broadly consistent with those developed by the SRP in MFAT.

The attributes, metrics and level ranges developed with the SRP were embedded into the structure of a questionnaire, suitable for distribution by mail. The draft questionnaire was in two parts:

- an information sheet; and
- a questionnaire.

[8] It should be noted that the fine tuning of attribute description and levels continues throughout the community consultation process.

The information sheet contained:

- A map - showing the extent of the River Murray and locations along it;
- Background information - describing the extent of the River and providing basic facts on usage of the River.
- A brief statement of the issue – introducing the issue in question, namely that the River Murray is in poor health.
- A key to River health - introducing the "scores" to indicate River health with respect to the five environmental attributes.
- Scores for the current health of the river and the health of the river in 20 years time if no river health improvement initiatives are undertaken.

The questionnaire contained:

- An introduction – outlining the purpose of the survey, the importance of the information being gathered (so as to encourage participation), the time commitment involved, an assurance of confidentiality, a contact for further enquiries and information on how to return the completed questionnaire.
- A detailed statement of the issue - describing the decline in River health and the main causes of this decline.
- Statement of potential options – outlining potential options for improving the health of the River Murray including:
  - increasing the amount of water left in the river for the environment;
  - installing fishways;
  - resnagging areas of the River Murray;
  - providing wetland regulators;
  - raising and lowering of weir pools; and
  - improving barrage operation.
- Payment vehicle for raising money to implement options - the payment vehicle originally proposed was a one-off levy on Council rates.
- Framing statement– reminding respondents of their budget constraint and all the other things they have to spend money on so that they do not give untoward weight to the issue in the questionnaire.
- An introduction to the choice sets – to help respondents comprehend the choice set questions that follow.
- The choice sets – providing respondents with a choice of varying environmental outcomes for different levy amounts including the environmental outcome if no levy and no new River health initiatives are undertaken.
- Follow-up questions – to explore the motivations behind respondents' choices and detect response aberrations (such as payment vehicle protests and perfect embedding), difficulty in understanding the questions, the plausibility of the setting etc.
- Socio-economic and attitudinal data – to facilitate explanation of respondent answers in the econometric model and to test representativeness of the sample.

As well as examining the attributes of relevance to consumers, the focus group sessions were used to test the content and communication aspects of the questionnaire design including the:

- first impressions of the questionnaire;
- likelihood of respondents completing and returning the questionnaire;

- questionnaire structure and design;
- River health key;
- plausibility of the options for improving River health;
- acceptability of the payment vehicle;
- number and design of choice sets including levy amounts; and
- follow-up questions.

Following focus group testing and a process of peer review, a revised questionnaire and information sheet incorporating appropriate comments was developed.

At this stage of the project's development, the Australian Government announced a decision regarding an initial allocation of water for environmental flows in the River Murray. This decision effectively 'overtook' the research process that had been started and so the project was suspended pending further government deliberations on the future of the river. Whilst this attenuation of the research means that no results are yet available, the project development described in this section shows how science and economics can be integrated into the policy process. Science and economics become part of a systematic process designed to provide decision makers with information that is directly relevant to choices involving alternative river management strategies.

5. Lessons for the Mekong

The two studies reported above have important messages for those developing decision support systems for the Mekong River system.

First the Australian situation reminds us that irreversibility is a real issue. In the space of only 200 years of European settlement, the environmental decline of many rivers in the southern areas of the continent, largely resulting from excessive rates of extraction has been dramatic and in some places irreversible. This is a 'wake-up call' to those with river management responsibilities in developing countries to ensure that the environmental condition of rivers and their associated ecologies are monitored and assessments made periodically of the relative marginal benefits and marginal costs of permitting further extractions.

Second, recognising that understanding the science of river systems is a key step. But the science has to be directed to learning what would happen to riverine ecologies under alternative management strategies. In other words, scientific research needs to be targeted toward cause-effect predictions grounded in the practicality of river management.

Thirdly, it is important to understand that science by itself is not enough. It's just as important to know how people value the changes that science enables us to predict. It is only with such knowledge that trade-offs between competing water uses can be weighed up. This means that there is a key role to be played by economists in estimating both marketed impacts of river management strategies (eg additional or lost irrigated agricultural production) and non-marketed impacts (additional or lost species of fish). However, this role must be played in association with the science input. How this integration of economics and science can take place has been a feature of the two studies reported here and is the final lesson to be drawn.

In the NSW Rivers study, the economic valuation exercise was undertaken in consultation with scientists but not as an integrated part of an overall process. Values of scenarios required that scientists made predictions of river management strategy outcomes after the completion of the CM exercise. In contrast, the River Murray study involved the completion of the scientific modelling of river ecosystem behaviour concurrent with the development of the CM application. The two were developed together in order to have an integrated approach to the decision support system. Clearly, the latter approach is preferable in that the possibilities of a mis-match between science and economic inputs and outputs are largely eliminated.

The prospect therefore is for models that are built with the aim of predicting the impacts of alternative management strategies for the Mekong to involve both science and economic components. This is already a feature of the work of Ringler in that flow regimes are tracked through the river system and economic impacts predicted. However, the models so far developed have not focused on environmental attributes of the river. This therefore presents an opportunity for the existing models to be refocused and integrated with a CM application along with standard market valuation exercises so that an overall decision support system can be established.

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