Natural Resource Management Investment Choices by Catchment Management Authorities in NSW: Some Modelling and Economic Issues

Dr Bob Farquharson

NSW Department of Primary Industries
Tamworth Agricultural Institute

bob.farquharson@dpi.nsw.gov.au

Abstract
The central question addressed in this paper is how policy makers and environmental/natural resource management decision makers in NSW make the most appropriate use of the large amounts of public funds available for environmental improvement across catchments. These environmental goods include salinity, biodiversity, soils, and riverine ecosystem condition. A case is made for such decision makers to maximise the environmental outcomes to society from the investment of public funds and benefit-cost analysis is proposed as the appropriate framework. A substantial information requirement is implied to predict or measure benefits – in both predicting the quantity of environmental gain from alternative proposals and in the derivation of associated environmental values. The provision of information through (1) bio-physical modelling, and (2) environmental economic valuation methods, is discussed and some issue for Catchment Management Authorities in NSW are canvassed.

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1. Introduction

The Catchment Management Authorities (CMAs) in NSW have a budget ($436 million over 4 years), a mandate (contained in State and Federal legislation), and a time frame (10 years) to generate improvements in environmental goods and services across catchments. The expenditure of such a large amount of public funds begs the public policy question of how best to expend this money on behalf of the NSW public. In this paper I discuss what the natural resource management (NRM) policy objective is and then consider some of the implications in terms of predicting and valuing the gains from alternative investments in environmental or natural resource management (NRM) works.

The problem, of course, is that the environmental assets being considered are non-market goods and a valuation problem immediately arises. But before we value an increase in an environmental assert we must predict how much change there is likely to be. Both these needs imply a missing information problem that must be overcome. Work is progressing in NSW on these issues but some difficulties remain.

The CMAs have a number of different needs with respect to their investment decisions and activities. In general terms they must decide the broad areas in which to invest, or prioritise their operations. Once these priorities are determined they must then choose how to conduct their operations, i.e. decide what types of schemes or instruments they should use to best achieve their objectives. A classification of the type of issues being discussed and the methods used to address these issues is presented.

Existing methods used by the CMAs for prioritisation and project evaluation are discussed and the implications of moving to alternative processes are considered. Time and effort will be needed to generate the information and operational framework for improved NRM decisions making.

In this paper I discuss a number of these issues that have arisen in a project that is developing a decision-support tool for the CMAs in NSW (called TOOLS2). This project is a collaborative project between the NSW CMAs, the NSW Departments of Natural Resources, Primary Industries and Environment and Conservation, and CSIRO.

2. Public policy objectives and approaches for NRM

2.1 Implied policy objectives

At the Australian Government level, the National Heritage Trust (NHT) (see http://www.nht.gov.au/about-nht.html) and the National Action Plan for Salinity and Water Quality (NAP) (see http://www.napswq.gov.au/) are programs that focus on funding at the national, state and local levels to address NRM issues (Farquharson *et al*. 2007). From these sources, there do not appear to be requirements for prioritisation between investments in terms of their expected financial benefits in the planning stages of these programs. The Australian Government has recently announced continuation of funding for the NHT and the NAP programs beyond 2008 when the current funding finishes (Campbell and McGauran 2006). Campbell and McGauran state that the Government 'has a central role in ensuring the maximum return on this significant investment'.

At the NSW State Government level, the Natural Resources Commission (NRC) was established to provide the government with independent advice on a range of NRM issues. The NRC has developed a set of standards and targets for NRM within NSW. The targets 'focus on state-wide NRM investments and provide a means of tracking progress on NRM issues within NSW' (see http://www.nrc.nsw.gov.au). Target 12 relates to 'community' and requires that natural resource decisions contribute to improving or maintaining economic sustainability and social well-being. The NRC standard for quality NRM relates to quality assurance that will, among other things, 'maximise the efficiency and effectiveness of their investments in natural resources' (see http://www.nrc.nsw.gov.au/).

In the NSW State Plan (NSW Government 2006) the priority for better outcomes for native vegetation, biodiversity, land, rivers and coastal waterways includes targeting 'resources to the activities and places with the greatest potential for improvement', and in 'applying new scientific information, tools and market based programs to promote better natural resource management on both public and private land' (p. 121).

Thus the rhetoric of Governments in Australia for NRM is of 'maximising returns', 'maximising the efficiency and effectiveness of investments in natural resources', and 'targeting resources to the activities and places with the greatest potential for improvement'. However, the processes of achieving these 'goals' are not clearly specified or determined. The CMAs are aware of this rhetoric but do not have guidelines on what constitutes 'maximum efficiency', 'better NRM' or 'maximum return'. Nor do they currently have the technical capacity that allows them to advance very far in this direction. The TOOLS2 project aims to address this question.

2.2 Issues arising

As well as the large-scale investments mentioned above, there are also currently new regulatory regimes being imposed for native vegetation planning and water management. There are also 'market-based instruments' being implemented (Grafton 2005), which include investigation of auctions, offsets and cap and trade approaches. These issues and processes together potentially involve large transfers of wealth and/or well being.

The specification of society's goals in making these investments is complex – there are political, social, financial, environmental and economic elements involved. The policy process is currently informed by 'expert advice' (internal and external to the public sector) and influenced by lobby groups. Rent-seeking in the political process suggests that this process is unlikely to improve society's overall well being (McKenzie and Tullock 1981). A superior assessment of policy (*ex post* and *ex ante*) would integrate all elements of change and NRM policy assessment needs to consider how to integrate the divergent impacts of the above elements.

2.3 The need for investment appraisal

Even though there appears to be no specific current administrative requirements for the process used to make NRM decisions, there is a need for CMAs to assess broad priorities to direct NRM investments (Hajkowicz 2004). They also need to decide on funding for individual projects for on-ground activities, and there are investment issues in those decisions. In general, the CMAs in NSW desire to place or direct their investments into the most appropriate areas within the catchment, i.e. to optimise their investments. While *ex post* evaluations can be undertaken after a relevant time period to assess performance, there is a need for a prioritisation and investment framework to be used *ex ante* to develop structure and rigour in making NRM investments for catchment communities.

2.4 Alternative decision frameworks

Alternative decision frameworks can broadly be classified as following economic and non-economic principles. Economic approaches value NRM improvements in dollars worth of social well-being so that they can be offset against input costs or investments, and compared directly between proposals and against investments available across society. Non-economic approaches use scoring and weighting methods to develop an index of NRM improvement which can be compared against investment inputs, but not against other financial options.

The initial question is whether an economic approach should be used to derive relevant information for use in a benefit-cost analysis (BCA) framework to consider NRM investments. The current approaches use science metrics based on field evaluations and some bio-physical modelling to measure environmental/NRM improvements. These measures are compared against project costs for project decision making, or cost-sharing approaches are sometimes used.

An important issue in comparing these approaches is the feasibility (including accuracy of predictions), practicality and cost associated with developing measures of environmental improvements from alternative approaches.

2.5 A classification of public NRM decisions

Different needs are being expressed by NRM decision makers within the CMAs in NSW. One set of needs relates to priority-setting processes for allocation of funds within CMA budgets. Such priorities consider catchment-wide issues and can be utilised (with other information) in developing catchment actions plans (CAPs) used as a basis for specific NRM decisions.

Once the CAPs are in place funds disbursement processes are required, and decisions need to be made about the most appropriate activities to be undertaken. The ‘most appropriate’ requirement can include issues of efficiency and effectiveness in investing and administering funds for public NRM gains. Currently there is a range of methods possible, including MBIs.

Both these needs are for *ex ante* decisions. There are also *ex post* evaluations conducted, see http://www.nrm.gov.au/monitoring/national-evaluations/index.html.

A classification of the issues being considered including the needs of public NRM decision makers is now presented. This has been suggested by Dr Stuart Whitten (CSIRO, personal communication). A 2-level model with interaction is proposed, based on the above considerations, see Figure 1.

In this model the higher-order needs are first determined and these priorities are used as an input to setting or refining the CAPs. Then the mechanisms or instruments are considered in how to best meet each priority area. In the latter process it may be that issues of cost or information requirements preclude work in a specific NRM area. This decision may then lead to a further iteration of priority determination.

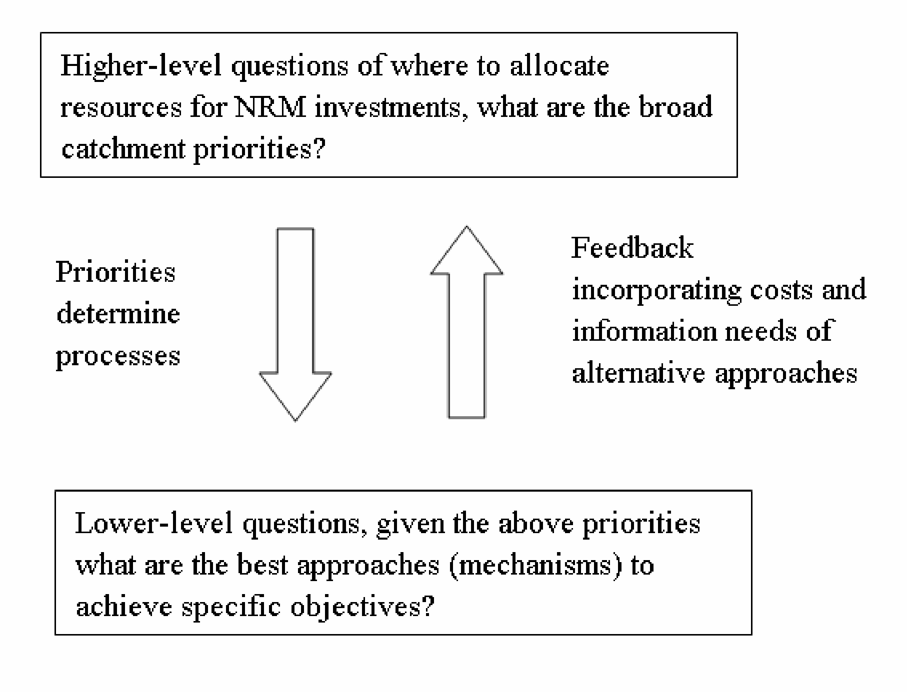

Figure 1. Classification of CMA decision making needs for NRM

2.6 Information failure and NRM decision making

Decision making for public-benefit NRM projects is beset by information problems – this applies to both economic and non-economic approaches. In economic terms the use of bio-physical models addresses the issue identified by Eigenraam *et al*. (2006), of information as a transaction cost. The gathering and exchange of information is a key aspect of environmental management, and two issues arise:

- where information is currently unknown, and must be discovered by, say, scientific inquiry;
- where information is held by some agents but not others (asymmetric information).

The unknown information issue involves the state of an environmental good and how it can be improved by management actions. Scientific modelling and analysis can establish this information. We need to focus on environmental outcomes (Ribaudi 1986) and bio-physical models can be used for this purpose. Wu and Boggess (1999) noted two important environmental information and response effects:

- cumulative effects occur where significant environmental improvements can only be reached after effects reach a certain threshold; and
- pooling effects occur where inter-relationships exist either because environmental benefits interact with each other, or because they are jointly produced by the same resource.

The approach of using separate models for each environmental attribute ignores these pooling effects (Hill *et al*. 2007). Being unable to include either or both of these effects in bio-physical models may lead to sub-optimal outcomes.

3. Bio-physical modelling information for NRM predictions

In this section a discussion is presented of the issues being addressed in the TOOSL2 project, and the section draws heavily on Hill *et al*. (2007). A range of biophysical models is under development for use in the TOOLS2 project. These models are mainly process-driven and will use data captured from a GIS layer using an integrating engine to generate and combine outputs as necessary. Considerable work is needed to revise the models to ensure that there is no unavoidable overlap in the weight that is given to common parameters. Additional work is also underway to allow the outputs of the models to be expressed in a common currency.

A number of challenges are apparent in this project. On the modelling side are issues of scope and scale in predicting outcomes from one or a series of on-ground works proposals. Scope issues relate to predicting more than one environmental attribute change at a single level (eg at a local field). Scale issues relate to predicting changes in single or multiple attributes when issues of geographic extent are important (eg biodiversity across a landscape). For scope, a question is whether the environmental responses are synergistic, where two or more actions together create a greater effect than the addition of their individual effects (i.e. where the whole is more than the sum of its parts). An initial approach is to assume additivity and just add the results for individual effects from the single-attribute models.

Other issues relate to how the model results are standardised for interpretation into a decision framework. If an Environmental Benefit Index (EBI) or Multi-Criteria Analysis (MCA) approach is used, the bio-physical model results need to provide consistent information on which to base the scoring and weighting procedures. If an environmental economic valuation approach is used then the units of predicted environmental gains are important. In either case the translation of model predictions from their outcome units into a decision making process is necessary.

3.1 Scope and scale issues for modelling environmental outcomes

The bio-physical models in the TOOLS2 project are single-attribute models and there are implications from this approach to NRM prediction.

This approach assumes complete independence between, or additivity of, environmental outcomes from proposed management actions, both between locations or scales and attributes. The effect of implementing a particular action at a given location is assumed to be uninfluenced by the effects of actions at other locations. In other words, the combined effect of a set of actions (at multiple locations or a larger scale) is implicitly assumed to equal the sum of the effects of the individual actions if they were each applied on their own.

This assumption of additivity in the scale effects of multiple actions (the cumulative effects of Wu and Boggess (1999)) allows the assessment and ranking of proposed actions to be kept very simple. Violations of the assumption may, however, be quite common in the real world. Consider a simple example in which two large remnant patches of vegetation are separated by cleared land spanning three different properties, and that each of the three landholders is seeking incentive funding to revegetate his or her section of a potential corridor linking the patches. If these three proposals are evaluated independently of one another in terms of predicted benefit for, say, terrestrial biodiversity then they may each receive relatively low scores, because revegetating only a third of the corridor fails to achieve functional connectivity between the patches. All three proposals may therefore rank poorly and fail to receive funding. The real value of these proposals becomes apparent only if interactions between the effects of the individual actions are considered – i.e. the scale effects mean that the whole effect is greater than the sum of its parts.

Some of the models being employed in NSW are starting to address this problem by incorporating spatial interactions into the modelling of benefits expected from sets of management actions. For example, in the case of terrestrial biodiversity work is progressing to link property-level (field-based) assessment techniques more closely to landscape-level (GIS-based) modelling tools, thereby allowing spatially dynamic factors such as connectivity to be considered when assessing the combined benefit of any given set of actions.

The second type of assumption in the basic approach outlined above involves the multiple attributes being assessed – or additivity in the scope of included attributes (the pooling effects of Wu and Boggess (1999)). Modelling these attributes independently precludes any interactive effects. This approach may fail to adequately address possible interactions between attributes. An important distinction needs to be made here between "correlation" and "interaction". Correlation of management effects on different attributes – e.g. where an action generating high benefit for biodiversity also tends to generate high benefit for carbon sequestration – is not, in itself, a problem provided that these mutual benefits are combined sensibly in any subsequent multi-criteria analysis. On the other hand, interaction between effects on different attributes – e.g. where reduced in-stream salinity resulting from a given action enhances, in turn, the benefit for aquatic biodiversity – may need to be addressed through dynamic linking of models (e.g. in this case, output from a salinity model serving as input to an aquatic biodiversity model).

4. Environmental valuation within BCA

The discussion in this section draws significantly on Farquharson *et al*. (2007).

4.1 Advantages of BCA

BCA has strong and consistent foundations in welfare economics (Just, Hueth and Schmidt, 1982, Freeman 1994, p. 10-12, Sinden and Thampapillai 1995, p. 20-3, Grafton *et al*. 2004, section 8.4). It has a tightly defined objective function for society, being the maximisation of total economic surplus based on production costs, exchange and consumer sovereignty (willingness to pay). It is concerned with the 'efficiency' of resource allocation to ensure that policy changes yield marginal benefits greater than the associated marginal costs. Benefits and costs are closely defined in terms of contribution to or detraction from society's well being.

Because of its consistent formulation, BCA allows comparison across different policies. With respect to the values held by individuals, the objective is to assess these according to their own perception of what matters, i.e. based on rational choice. Time effects are embedded through the discounting process to calculate present values. A single numeraire is used to facilitate comparison.

4.2 Challenges for BCA

BCA requires that all impacts be valued in monetary terms. All benefits and costs must be valued in terms of their effects (broadly defined) on humanity (Tietenberg 2003). This does not imply that ecosystem effects are ignored unless they directly affect humans. Many people donate and contribute to causes that improve the environment; hence they express a value of willingness to pay for outcomes for which they receive no direct benefit.

This valuation requirement for NRM benefits represents a challenge when markets are not present to provide a 'window' into the well being of individuals. This is especially the case when policy changes focus on environmental impacts – which is pertinent for NRM policy as mentioned above. Environmental economists have developed methods for non-market valuation which can be utilised for NRM policy evaluations.

4.3 Issues in Economic Valuation of Environmental Benefits

The application of economic valuation techniques to environmental changes is by no means uncontroversial. There are several reasons for this, some of which stem from a misunderstanding of monetisation. The use of money as a standard is sometimes a barrier to wider acceptance. Many people believe that some environmental assets are 'priceless' in the sense that they cannot accept trade-offs involving these assets, or they consider it immoral to place a value on goods such as clean air or water, which are generally seen as a right for all (Ackerman and Heinzerling 2006). However, trade-offs are made all the time with regard to environmental resources, all valuation does is to make the extent of the trade-offs explicit.

Economic approaches express the relative values that society places on different uses of resources in monetary terms, as a convenience. This valuation is about marginal changes, it is not attempting to consider the total loss of a species.

Another concern is that the preferences of individuals, expressed in terms of their willingness to pay, reflect only self-interest, while social decisions should be made out of concern for the public interest. However, in reality, preferences may have all kinds of motives, including a concern for others, for future generations, for different species, etc.

In addition to these philosophical concerns regarding the appropriateness of environmental valuation techniques, more substantive issues have been raised concerning valuation methodology particularly in relation to stated preference techniques and benefit transfer.

4.3.1 Methodological concerns with stated preference techniques and benefit transfer

A number of methodological concerns have been identified with the Contingent Valuation (CV) method which has been the predominant stated preference technique to date. A primary concern is the potential for survey respondents to give biased answers. Tietenberg (2003) summarises four types of potential bias that have been the focus of a large amount of research. These are strategic bias, information bias, starting point bias and hypothetical bias. An expert panel (National Oceanic and

Atmospheric Administration (NOAA) 1993) considered that suitably designed surveys could eliminate or reduce these biases to acceptable levels and it provided specific guidelines for determining whether studies are suitably designed.

4.4 Cost of environmental valuations

The cost of undertaking original environmental valuations using CM is of the order of $100,000 to $140,000 depending on the type of survey methodology used (Dr Bob Dumsday, URS Australia, personal communication). Only highly contentious cases where large values are involved will warrant direct data collection exercises. The question is whether this amount is justified to obtain realistic and reliable value estimates. There is potential for relevant environmental values to be adopted from other studies (Rolfe and Bennett 2006). An alternative is for CM studies to be conducted in a representative sample of catchments for key environmental services and then benefit transfer to be used for all CMAs in NSW. An example is the report of URS Australia (2006).

4.5 Stated Preference Methods

For non-use environmental assets there is no relevant market behaviour to observe. In such cases a hypothetical or contingent market must be constructed using questionnaires. This is the basis for the stated preference methods.

Drawing on advances in market research and cognitive psychology, the stated preference methods have been applied widely in environmental economics over the past three decades. These techniques are used to determine willingness to pay for a good, even though the respondent does not currently use it directly, nor intends to use it in the future.

Two of the main categories of stated preference methods that are used to estimate the willingness to pay for non-use environmental assets and services are CV and CM.

4.5.1 Contingent Valuation Method

The CV method is a survey technique that attempts direct elicitation of individuals' (or households') preferences for a good or service. It does this by asking the respondents in the survey a question or a series of questions about how much they value the good or service. People are asked directly to state or reveal what they are willing to pay in order to gain or avoid some change in provision of a good or service.

A contingent market defines the good itself, the institutional context in which it would be provided and the way it would be financed. The situation the respondent is asked to value is hypothetical (hence, 'contingent'), although respondents are assumed to behave as if they were in a real market. Structured questions and various forms of 'bidding game' can be devised involving yes/no answers to questions regarding maximum willingness to pay. Econometric techniques are then used on the survey results to find the mean bid values of willingness to pay. Carson (2000) provides a guide to the use of CV.

4.5.2 Attribute Based Stated Choice methods

A recently-emerged alternative to CV is Attribute Based Stated Choice (ABSC) methods (Grafton *et al*. 2004). These methods present a set of alternatives which are defined by attributes, including the price or payment. The choice sets of alternatives are developed from experimental designs which allow the attributes to be uncorrelated and yield un-confounded estimates of the parameters of the conditional indirect utility function (Grafton *et al*. 2004).

Applications of ABSC methods generally follow 7 steps (Grafton *et al*. 2004):

1. Characterise the decision problem: identify the problem and decide how to frame the decision problem;
2. Attribute-level selection: define the number of attributes and determine the levels for each attribute, these must be understandable by the respondent;
3. Experimental design development: construct the choice tasks, alternatives or profiles that will be presented to the respondents;
4. Questionnaire development: determine the format of survey, pre-test the questionnaire;
5. Sample size and data collection: determine sample size based on considerations of data accuracy and survey cost;
6. Model estimation: these methods are based on random utility theory. Determine the most appropriate estimation method;
7. Policy analysis and decision support: use the model results to generate welfare measures, or predictions of behaviour, or both, for policy analysis or part of decision support.

These methods are useful in the valuation of the attributes of a scenario, or where the decision involves choosing from a set of alternatives. The design and analysis using these methods is based on random utility theory and is consistent with the theoretical underpinnings of CV (Grafton *et al*. 2004).

4.5.3 Choice Modelling

CM (see Bennett and Blamey 2001,) is perhaps the main ABSC method used for environmental valuation. The elements of CM that are common with CV are that the attribute scenarios are hypothetical choice sets. The questionnaire formats are also broadly similar. The key difference is that under CM willingness to pay is only elicited indirectly through a process of observed trade-offs made by respondents. Thus whereas CV directly asks for willingness to pay CM infers it from choices made by respondents across a sequence of options.

CM is based around the idea that any good can be described in terms of its attributes and the levels that these take. Changing attribute levels will essentially result in a different “good” being produced and it is on the value of such changes in attributes that CM focuses. By choosing over these different “goods” including the implicit price attribute, respondents reveal the value of the other attributes indirectly. A well structured CM questionnaire is designed to ensure that there is no correlation between attributes to enable the model to determine the importance of each attribute.

CM conveys four pieces of information that may be of use in a policy context:

- the attributes that are significant determinants of the values that people place on non-market goods;
- the implied ranking of these attributes amongst the relevant populations. For example, in forests the relative rankings of different types of trees and how these rank relative to improved access;

- the value of changing more than one of the attributes at once (for instance, if a management plan results in a given increase in wildlife protection but reduction in recreation access);
- as an extension of this the total economic value of a resource or a good.

These trade-off values are the strength of CM compared to CV, which provides an aggregated willingness to pay value but rarely more detailed information on the values of specific parts of the whole package. This latter information is far more relevant in a policy context.

4.6 Benefit Transfer

Benefit transfer is not strictly a valuation technique, but it involves 'borrowing' an estimate of willingness to pay from one site (the study site) and applying it to another (the policy site). What is borrowed may be a mean value which is not adjusted or a mean value which is modified to 'suit' the new site. Or it may be a whole benefit function that is transferred.

The attraction of benefit transfer is that it avoids the cost of engaging in primary studies and saves time. However substantial care must be taken to ensure the validity of transferring values from one site to another. The OECD (1995) noted that whilst benefit transfer studies are common the validity of these transfers is rarely tested.

One elementary procedure is to borrow an estimate of willingness to pay from the study site and apply it to the policy site. However, such transfers are easily invalidated by differences in the:

- socio-economic characteristics of the relevant populations;
- physical characteristics of the study and policy sites;
- proposed change in provision between the sites of the good to be valued; and
- market conditions applying to the sites for instance the availability of substitutes.

There are a number of ways to adjust benefit transfer values:

1. expert judgement, i.e. experts make a judgement about how the willingness to pay will vary between sites;
2. re-analysis of existing study samples to identify sub-samples of data suitable for transfer;
3. meta-analysis of numbers of estimates permitting the estimation of cross study benefit functions applicable to policy sites.

5. An economic approach for CMAs in NSW

CM has a number of advantages over existing methods used by CMAs to derive estimates of benefits from NRM projects for investment decision making. However, there can be substantial costs associated with CM studies. In proposing a practical approach for CMA decision making, two alternatives are possible using CM and benefit transfer.

One approach is to consult pre-existing studies and transfer an appropriate estimate to the target area, i.e. use benefit transfer (van Beuren and Bennett 2004). The ENVALUE database developed by the NSW Environment Protection Authority is a source of values for Australian conditions, and there are similar databases in other countries. The main issue with adaptation of these values to current needs is representativeness and possible errors with the process, an issue that van Beuren and Bennett (2004) addressed.

The second possibility is to conduct specific studies for particular purposes on a representative sample of catchments and use benefit transfer to utilise the values on a broader context. The study by URS Australia (2006) is an example of this approach. If a large amount of information is required in a relatively consistent framework (eg NRM values for the 13 CMAs in NSW), then such an approach could be cost-effective.

A pilot study (URS Australia 2006) aimed to estimate the non-market values associated with improved environmental health in a representative selection of Victorian rivers. Its purpose was to provide a source of value estimates for use in benefit transfer to inform cost-benefit analyses of river health investments. The study valued attributes for three rivers with potentially seven more to be done. These 10 representative river studies can then be used to provide river health/environmental values for the 50 rivers in Victoria.

The research design involved choosing a number of rivers representative of river types, and then selecting representative people both inside and outside the catchments (urban and rural) to develop values.

This study is the first of its type in Victoria dealing with unpriced values associated with improvements in river health. These difficult-to-quantify values can be large in comparison with market-based values for improvement, and are often ignored in policy decisions. Ignoring these values can lead to serious underestimation of the returns to investment in river health. In policy terms, the results can be incorporated into BCA and provide support for decisions on funding of projects and programs in river health.

6. Discussion

While Government rhetoric for NRM decisions on funding and priorities is to make the most of these funds and maximise return on investment, the CMAs in NSW have no way of addressing this issue with their current tools and capacities. Current non-economic approaches used by the CMAs have a number of problems with the accuracy and consistency of the estimates, and they are not suitable for an investment framework. BCA is capable of providing such a framework so long as it incorporates estimates of economic values arising from NRM investments. This includes non-market environmental benefits. Such benefits can be estimated using the CM technique. CM represents the most advanced economic technique for non-market valuation and is suitable for deriving marginal values associated with attributes of environmental services. A judicious approach to CM valuation and the appropriate use of benefit transfer will allow a practical approach to NRM decisions making in NSW.

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