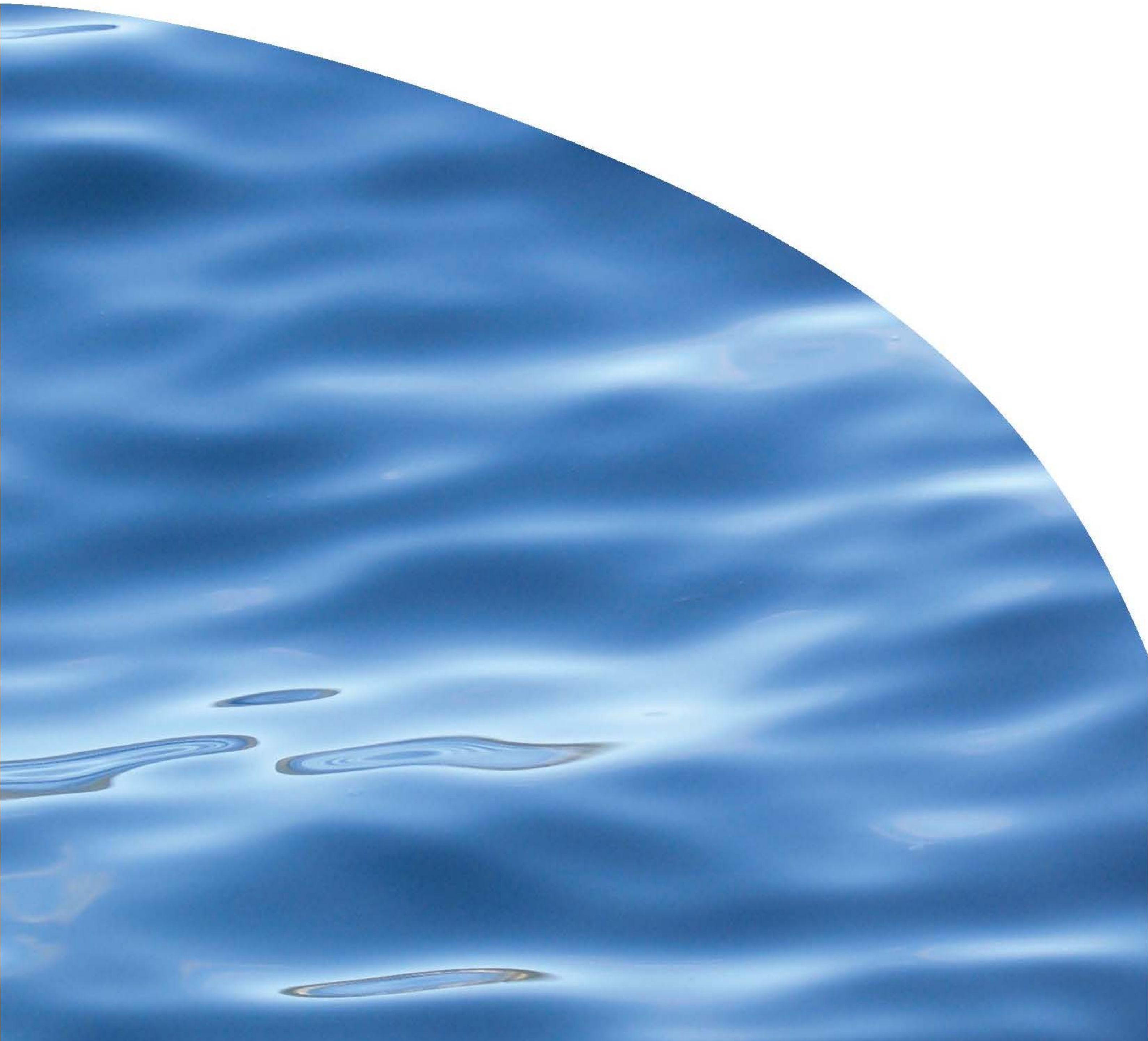
REPORT NO. 2569

TOOLS FOR WORKING WITH FRESHWATER VALUES



TOOLS FOR WORKING WITH FRESHWATER VALUES

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EXECUTIVE SUMMARY

This report describes a number of tools that may be of use to regional councils and their communities as they undertake planning processes to implement the National Policy Statement Freshwater Management 2014 (NPSFM 2014).

The NPSFM 2014 directs New Zealand's regional councils to set objectives and limits in their regional plans for all freshwater bodies, based on values. Although the term 'values' has multiple meanings, as used in NPSFM 2014, the term generally refers to *things that have value or meaning*, *i.e.* things that are worth protecting or maintaining. In the context of some tools, the term 'value' refers to *how much* worth something has, implying that the value of one thing can be compared to the value of something else.

These are complex concepts and there are a number of considerations to bear in mind when working with values. For example, categories of values are simplifications that approximate the complexity of how people value water bodies, and such categories often overlap.

Another important consideration is that value, as perceived by someone, is not always well-defined, stable and hence measurable, as tools based on economics tend to assume. Rather, values are often constructed in context. That is, how a person's feelings for a freshwater system or place manifest themselves depends not only on the person's experiences but also on context-specific matters, such as how a question is asked and by whom.

Also, coastal users are freshwater stakeholders. Estuaries, harbours and beaches ultimately reflect what happens in freshwater systems, so coastal values matter for freshwater management too.

This report describes several tools for identifying and understanding values, which are particularly suited for scoping the issues to be addressed in a planning process. Tools for assessing and balancing values are also described – these generally come into play as councils and communities are considering possible solutions and how these will be implemented via policy. Table 1 summarises the tools described in this report, showing which of these tasks (identifying, understanding, assessing, balancing) each tool is suited for.

This report does not provide a comprehensive list of all tools that could be used, and both the way they have been categorised and the appropriate uses are not always clear-cut. For this reason, these categories should be taken as indicative rather than definitive. There also could be a revision to this report in the future, incorporating other tools based on further insights and experience.

Table 1. Suitability of methods for identifying (ID), understanding (U), assessing (A) and balancing (B) freshwater values.

Method	ID	U	A	B	Notes
Participatory values mapping	√	*	*		Enables wide input, representative sample difficult. Interest groups may try to influence results.
Watershed Talk	√	√	*		Tool for small groups to build understanding of alternative views. Costly to use for wider public.
The Natural Step's ABCD method		√		*	Used to develop vision and action plan. Works best when participants have shared goals.
Foresight engine		√		*	Values are implicit. Largely untested as a tool for balancing values or achieving consensus.
100% Pure Conjecture		√		*	Values are implicit. Largely untested as a tool for balancing values or achieving consensus.
Conservation modelling: Zonation	*	*	√		Developed for aquatic biodiversity only.
Bayesian networks	*	√		*	Can be simple or complicated; work can be done as part of scientific investigations for plan change.
Decision support system: UPSW[1]		√		√	Designed for urban setting. Would need resources to adapt for other areas.
Decision support system: WISE[2]		√		*	Would need resources to adapt for other areas. Can be part of science for plan change.
Mediated modelling	*	√		*	Needs resources, most can be done as part of scientific investigations for plan change.
River Values Assessment System (RiVAS)	√	*	√		Use to assess rivers for specific values. Quick and inexpensive. Categories involve simplification.
Total economic value	*		*		Framework with categories of values for assessment using specific valuation methods.
Ecosystem services	*		*		Framework with categories of values for assessment using specific valuation methods.
Cost benefit analysis (CBA)				√	For a limited number of policy alternatives, where most values can be estimated in financial terms.
Market valuation			√		For market goods and services, *e.g.* as a component of CBA.
Revealed preference			√		For sites with features that influence financial decisions, *e.g.* as a component of CBA.
Stated preference	*	*	√		Can be used with CBA for non-market goods and services where values are pre-formed and stable.
Benefit transfer, *e.g.* InVEST[3]			√		When estimates of local values are not available and resources for original study not available.
Hui	*	√	√	√	Consult tangata whenua regarding local protocols (see Glossary for definition of Māori terms).
Structured decision making	*	√	√	√	Comprehensive, complemented by other methods when dealing with complex systems.
WaterWheel	√	*	√	*	Complements other methods, *e.g.* expert modelling and structured decision making.
Deliberative multi-criteria evaluation	*	√	√	√	Comprehensive, can work with other methods. Uses weighting to resolve values differences.

√ Method designed or suitable for the indicated task. * Method has some aspects that can assist with this task.

[1] Urban Planning that Sustains Waterbodies
[2] Waikato Integrated Scenario Explorer
[3] Integrated Valuation of Ecosystem Services and Trade-offs

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GLOSSARY OF MĀORI TERMS

Kupu	Definition
Hui	Meeting, *e.g.* as a process for deliberation or resolving disputes, sometimes where traditional protocol is followed
Iwi	Tribe
Kaitiakitanga	Guardianship, stewardship
Kaumatua	Elder
Mahinga kai	Food gathering sites, traditional food, the act of gathering food
Mana	Authority, respect
Marae	Māori meeting houses and associated grounds, the centre of Māori social and cultural activities
Mātauranga Māori	The body of knowledge originating from Māori ancestors, including the Māori world view and perspectives, Māori creativity and cultural practices[4]
Mauri	Life force, vital essence
Rohe	Territory
Tangata whenua	People of the land, the native people of an area
Taonga	Treasure, thing of value
Tauranga waka	Canoe landing sites
Tikanga	Principles and associated protocol and customs
Wāhi tapu	Sacred site
Wānanga	Place or activity of higher learning
Whakapapa	The connection between all things, genealogy, heritage, ancestry

[4] http://www.maoridictionary.co.nz/

1. INTRODUCTION

The National Policy Statement Freshwater Management 2014 (NPSFM 2014) directs New Zealand's regional councils to set objectives and limits in their regional plans for abstractions and discharges for all freshwater bodies by 2025 (New Zealand Government 2014).

The NPSFM 2014 and other recent documents indicate an expectation that freshwater management objectives will be based on both national and local 'freshwater values'. The Preamble to the NPSFM 2014 states:

> *Water quality and quantity limits must reflect local and national values (New Zealand Government 2014, p 4).*

To assist regional councils in the task of implementing the NPSFM 2014, the Ministry for the Environment contracted Cawthron Institute (Cawthron) to compile this summary of tools and methods for working with freshwater values. This report draws upon work conducted in the Integrated Valuation and Monitoring Framework for Improved Freshwater Outcomes (contract CO9X1003) research programme, led by Manaaki Whenua Landcare Research and funded by the Ministry of Business Innovation and Employment.

The next section considers the meaning of the terms *value* and *values*, and the remainder of the report consists of sections that describe tools and methods for working with freshwater values.

2. THE MULTIPLE MEANINGS OF VALUE AND VALUES

2.1. Values in the NPSFM 2014

In the NPSFM 2014, the terms *value* and *values* occur 69 times: 15 times in the Preamble, 14 times in the definitions, 23 times in the body of the policy statement, and 17 times in the appendices that specify numeric attributes for some 'national values'. Table 2 lists the national values identified in Appendix 1 of the NPSFM 2014.

Table 2. National values of fresh water, including secondary descriptors, identified in Appendix 1 of NPSFM 2014.

Compulsory national values	
Te Hauora o te Wai / the health and mauri of water	Ecosystem health
Te Hauora o te Tangata / the health and mauri of the people	Human health for recreation
Additional national values	
Te Hauora o te Taiao / the health and mauri of the environment	Natural form and character
Mahinga kai / food gathering, places of food	Mahinga kai Fishing
Mahi māra / cultivation	Irrigation and food production Animal drinking water
Wai tapu / Sacred waters	Wai tapu
Wai Māori / municipal and domestic water supply	Water supply
Āu Putea / economic or commercial development	Commercial and industrial use hydro-electric power generation
He ara haere / navigation	Transport and tauranga waka

The NPSFM 2014 states:

> *"Value" means:*
>
> *a) any national value; and*
>
> *b) includes any value in relation to fresh water, that is not a national value, which a regional council identifies as appropriate for regional or local circumstances (including any use value)* (p 8).

While this says what the term includes for the purposes of the policy statement, it is also helpful to look at the international literature, and at how the term is actually used in the NPSFM, for insights into how the concept of values is deployed in freshwater planning.

From the extensive international literature (for just a few examples, see Brown 1984; Dietz *et al.* 2005; O'Neill *et al.* 2008; Mattson *et al.* 2012; Ives & Kendal 2014) and from our own research (*e.g.* Sinner *et al.* 2012), and depending on the context, it is clear that the term *value* (as a noun[5]) can refer to any of the meanings in Table 3.

Table 3. Multiple meanings of the terms 'value' and 'values' (Tadaki & Sinner, 2014).

Meaning of value(s)	Definition	Example
Evaluative norms or principles	A belief or norm that guides human action	Water use efficiency is an important value to guide policy.
Contribution towards fulfilment of an objective	The extent to which a particular state contributes to a user-defined objective	What is the ecological value of this river, *i.e*. what is its value for ecology?
Magnitude of preference	The quantity or intensity of preference from a given state	How much value does the community put on a wetland in this state?
Ways of meaning or orienting oneself to the world	Ways in which environments matter to people	Why is this river of value to tangata whenua?
Things that have value or meaning	Things that are deemed worthy of protecting or enhancing	Swimming, fishing and irrigation are all values of this river.

These meanings are explained more fully elsewhere (*e.g.* see Tadaki & Sinner 2014 and Berkett *et al.* 2013), but briefly, as used in NPSFM 2014 including its Appendix 1, the term generally refers to *things that have value or meaning*, *i.e.* things that are worth protecting or enhancing.

In two instances in the Preamble to the NPSFM, the term is used in the sense employed in economics, as a particular magnitude of preference or contribution toward an objective (sometimes measured in monetary terms). That is, it sometimes refers to *how much* value something has, in some cases implying that these values can be compared to the value of something else (Brown 1984). This meaning is also employed in some tools described in this report, especially those from economics.

2.2. Considerations when working with values

Stakeholders can have constructive conversations about freshwater values without being precise about definitions, because the meaning can emerge from the context.

[5] When 'value' is used as a verb, it typically refers to a human act of assigning a degree of importance to something, in accordance with one of the meanings in Table 3.

However, if the term *value* or *values* is to be used in planning documents, it should be carefully defined to avoid unintended ambiguity.

Categories of values are simplifications that approximate the complexity of how people value water bodies, and such categories are often not discrete. Cultural values are not distinct from social values; social values can overlap with environmental values or economic values *etc*. For example, depending on one's perspective, swimming can be seen as an environmental, social and/or cultural value and swimming by tourists as an economic value. Categories such as environmental values and social values may be useful as prompts of the different aspects of how people value or find meaning in their environment. These, however, are not distinct enough to be used for planning purposes, if the intention is to define categories that do not overlap.

Documentation and measurement of values have other implications as well. The simple act of defining categories and documenting values can privilege some uses and values over others and thus provoke conflict (Sinner & Tadaki 2013). This conflict can perhaps be reduced if values are identified, assessed and documented as part of the same planning process that determines management objectives, policies and methods. Then the debate can appropriately focus on the latter, rather than on what values are worthy of documenting in a regional plan.

Decisions about freshwater management objectives inevitably involve some consideration of the relative significance or importance (or 'value') to be given to different aspects of freshwater systems. Furthermore, for purposes of policy analysis, it is generally the change in value arising from a policy intervention that is of interest, rather than the total value generated by an ecosystem or parcel of land. This is a fundamental consideration when using the tools described in this report, whether one is measuring values quantitatively using techniques from economics, using a multi-criteria methodology or describing values qualitatively.

Economics provides several methods for assessing the magnitude of values in monetary terms, but there have been numerous critiques of the economics approach to value (see *e.g.* Spash 2008; Gregory *et al.* 2012). Quite apart from fundamental debate about the human orientation of economics *vs* notions of intrinsic value, other issues have arisen from insights from human psychology.

Value as perceived by someone is not always well-defined, stable and hence measurable, as certain methods based in economics tend to assume. Rather, people often construct value in context. That is, how a person's feelings for a freshwater system or place manifest themselves depends not only on the person's experiences but also on other context-specific matters, such as how a question is asked and by whom (McNeil *et al.* 1982; Kahnemann & Tversky 2000). This suggests that care must be taken when comparing one value with another, especially when the thing being valued is not bought and sold in the economy.

The tools and practices that are used to elicit, categorise and assess values are all forms of what have been called ‘value-articulating institutions’ (Vatn 2005). The notion of value-articulating institutions serves to highlight that values are often defined and shaped by how they are being documented — just as, in quantum physics, the act of measuring an electron changes it.

These are some important considerations when working with freshwater values (Table 4) that are also relevant to many (if not most) of the tools described in this report. These considerations should be borne in mind by those who are working with freshwater values as part of a planning process such as implementation of the NPSFM.

2.3. Introduction to tools for working with values

There are undoubtedly numerous tools that have been, or could be used to identify, understand, assess or balance diverse values of freshwater systems. This report describes several of these tools, and this list is not exhaustive.
This report briefly describes each tool, its key features and steps, an example (if it has been used in New Zealand) and how it could be used for working with freshwater values. Uses of the tools are described as follows:

Identifying values – identifying ways that freshwater bodies matter, and where these values are located across an area of interest.

Understanding values – gaining a deeper appreciation for the meanings of values, *i.e.* why they are important, and improving knowledge about how a system works, *i.e.* how one part influences another.

Assessing values – evaluating the significance or magnitude of a value relative to the same value in other places or relative to other values, and how the value would change if management changes.

Balancing values – making decisions about how to accommodate multiple values or reconcile competing values, *e.g.* by comparing their respective magnitude or significance.

Bear in mind that these are somewhat arbitrary categories — sometimes the line between, say, assessing and balancing values, is a fine one.

Table 4. Considerations for working with freshwater values (Gregory *et al.* 2012, p 22).

Concept	What it is
Multi-attribute utility theory and analysis (MAUT)	MAUT is a prescriptive approach to multi-objective decision making, designed to help people make better decisions under uncertainty. It provides the analytical rigour that underlies Structured Decision Making (see section 10.2).
The integration of analysis and deliberation	Defensible environmental management and evaluation require 'an analytic deliberative process' – the effective and ongoing integration of systematic analysis and deliberation. Both require careful attention to best practice.
Constructed preferences	People often do not have fixed preferences for environmental-management actions. Instead, their preferences are constructed in response to information about both relevant facts (the consequences of proposed actions) and the values (preferences or priorities) held by themselves and others.
Separation of values and facts	It is possible and useful to distinguish, in practical terms, between values, which define what matters to people, and facts, which describe the likely effects of management actions. Both are fundamentally important to decision making, but they need to be treated differently in the decision process.
Value-focused thinking	Good decisions start by fully exploring what we want (our values or objectives) rather than what is typically available to do (alternatives). This shift has profound implications for how a decision process unfolds.
Two systems of thinking	People draw on two modes of thinking when they make choices: analytical (which is slower and thoughtful) and intuitive (which is fast and often automatic). Both have an important role to play in making good decisions.
Mental short-cuts and biases	All people, expert and non-expert, are influenced by predictable judgmental biases and cognitive short-cuts that can adversely affect decision quality. There are well-developed methods that can minimise the negative effects of these influences on the quality of environmental management choices.
Best available information	The information needed to understand likely consequences of actions comes from many sources, including (but not limited to) science. Information relevance and quality can only be determined in the context of the decision at hand, based on both analysis and deliberation.
Group wisdom and dysfunction	Groups are the source of both important insights and debilitating biases. Best practice involves an interplay between eliciting individual judgments and facilitating group dialogue.

2.4. Values in the planning process

The various tools for working with values described in this report are most useful at particular stages of the policy process. To help in choosing which tool to use and when, consider a hypothetical scenario in which regional council decides to initiate a plan change for a large catchment. It wants to establish objectives and limits for freshwater bodies and put in place policies to achieve these.

One of the first steps is to identify what the issues are — so this raises the question of values. What values are present, what has been lost, what do people want to protect, develop or restore? This requires the identification of values, and there are various tools and methods available for this.

Identifying the issues to be addressed in a plan change requires **identifying** the values that are in play and **understanding** these values – what do the values mean in this particular place, what is affecting them, what might be done to protect or promote them? This can involve tools such as scientific modelling and studies that aim to shed light on how the system works and how this affects various values. It also can involve more deliberative and qualitative methods that empower the community to explore and explain why and how freshwater bodies are important to them.

As the council and community explore management options, they will **assess** values, either explicitly or implicitly. This involves tools to determine the significance of values in specific places — what wetlands and estuaries are particularly important for certain native fish, and how do these compare nationally for these species? What reaches are especially important for mahinga kai and drinking water for marae? What aquifers are critical to the future economic well-being of the district, and how much do they contribute economically? Where do values conflict and where are they mutually compatible? How would these values change if management were different?

Finally, in making decisions, councils and communities need to **balance** values, especially where there are competing values for the same water body, *e.g.* natural flows to support native fish *vs* dams for hydro-electric power *vs* abstraction for irrigation *vs* runoff from urban or rural areas. Some tools are designed to balance diverse values explicitly by assessing them all using the same metric, *e.g.* dollars, while other approaches use more discursive and deliberative methods that aim to help all parties find mutually agreeable solutions. Some methods might be used by council staff or consultants to provide the basis for advice to a council committee or hearing commissioners, while others could be done with a collaborative stakeholder group that is formulating recommendations to the council.

3. PARTICIPATORY VALUES MAPPING

Participatory values mapping is a set of approaches and techniques that combine current cartography tools with participatory methods to elicit and display the values and spatial knowledge of local communities. This approach is holistic and place-based, and utilises qualitative methods to address issues embedded in context. It enables a better understanding of the personal and emotional bonds people ascribe to landscapes and natural and cultural features (Gunderson & Watson 2007).

Those involved in participatory values mapping, typically local residents or visitors to a region, are asked to identify sites on a map and to explain why those sites are valued. This may occur in workshops, focus groups, one-on-one interviews or online. Outputs of the exercise are maps displaying individual sites of importance, as well as density maps that show 'hot-spots' (Brown & Reed 2009).

Participatory values mapping has been used in a wide variety of environmental management settings. In a marine spatial planning study on northern Vancouver Island (Canada), Klain and Chan (2012) used participatory values mapping to include intangible cultural values alongside material values connected to ecosystems. Raymond *et al* (2009) quantified and mapped values and threats to natural capital assets and ecosystem services in the South Australian Murray–Darling Basin region. Beverly *et al* (2008) used online participatory mapping to collect data on the locations of forest landscape values across a 2.4 million hectare study area in Alberta (Canada). Brown and Weber (2011) elicited and mapped visitor perceptions of park experiences, environmental impacts, and facility needs via an internet-based mapping method for national park planning. Gunderson and Watson (2007) identified a range of personal and community values relating to a national forest in Montana, USA, using a rapid appraisal participatory mapping methodology.

The necessity of a small sample size requires purposeful (rather than random) sampling methods in interview, focus group and workshop settings. As explained by Gunderson and Watson —

> *'…the fundamental tension in sampling involves tradeoffs between depth of insight and specificity at an individual scale versus generalizability at a population scale* (Gunderson & Watson 2007).

An online public participation geographical information system (PPGIS) has been used by the Department of Conservation (DOC) to help develop a new conservation management strategy for the Otago and Southland regions (Hall *et al.* 2012). The PPGIS tool facilitates the identification of places of value to local people and people who visit public conservation land. The project utilises an interactive mapping system that allows participants to place a range of icons ('markers') on a map to show what they value in different places around Otago and Southland. Participants can identify, for example, important sites for recreation or native wildlife, or where they think there is overcrowding, poor information, or too much noise. They can even point out where they think development should or should not be encouraged (DOC 2011).

As part of the PPGIS project, Otago residents were recruited using a variety of methods to participate in the online exercise. In all, 412 people completed the exercise and placed 4,160 markers of various types (*e.g.* recreation, wilderness, historic, cultural). These were then used to create ‘hotspot maps’ showing areas favoured for particular values. Figure 1 for example, is a hotspot map of valued recreation areas in the Otago region. The map shows that the highest density of respondents’ recreation values are the Otago Peninsula and wider Dunedin area, Taieri River mouth and Papatowai, Oteake Conservation Park, Kopuwai Conservation Area and Alexandra surrounds, The Remarkables, Ben Lomond and Mount Crichton, Lake Wanaka shore and surrounds, Matukituki West Branch, and the Routeburn and Dart valleys (Hall *et al.* 2012).

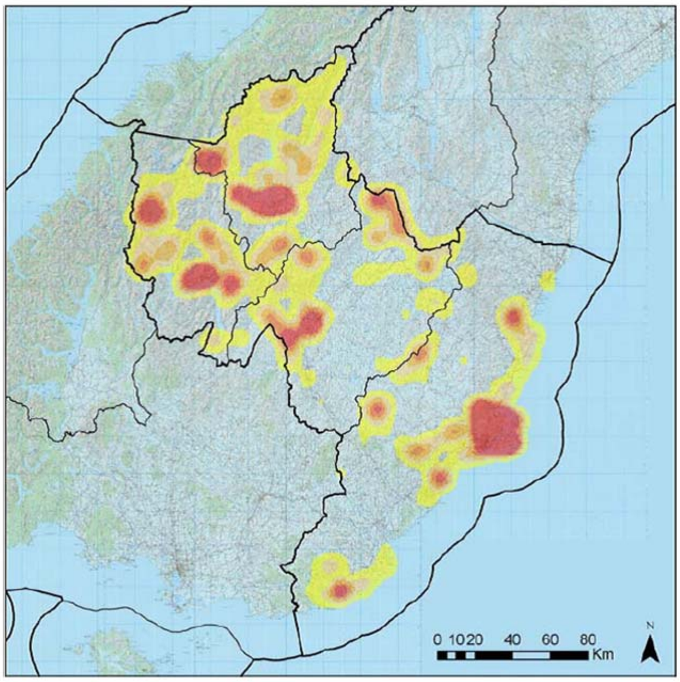

Figure 1. Hotspot analysis of valued recreation sites in Otago (Hall *et al.* 2012, p 13, Fig 2).

One weakness of participatory values mapping is that people may feel uncomfortable and refuse to divulge their values. This occurred during the study of Klain and Chan (2012), in which a minority of participants refused to participate on the bases of:

- a rejection of hard boundaries
- concern for sovereignty over local knowledge.
- a rejection of particular places being of greater value than others.

As explained by one interviewee,

> *"as soon as you start isolating things and say this is important to me, you lose the rest… that's the risk… we start drawing lines, suddenly what's outside of the line becomes available for development… the only way we have here to prevent open [environmental degradation]… is by … keeping your knowledge private…. [Sharing this knowledge] is like handing somebody a key to your food, to your house, to your front door"* (Klain and Chan 2012, p 5).

This point is particularly important in the context of New Zealand's unique governance landscape, where Māori are often wary of disclosing valuable intellectual and cultural information. Recognising this, in a participatory mapping project, Harmsworth (1999) stored layers of information on Māori environmental values in GIS, each with a different level of security. This ensured that information was only accessible to those who required it. For example, sites of tribal landmarks, sacred and ancestral sites, and medicinal plants were assigned different statuses according to the level of sensitivity of that information. Highly sensitive information was marked 'restricted access' and linked to an alternative source, for example, a kaumatua with traditional knowledge.

Uses of this tool

Participatory values mapping is a useful tool for ***identifying values***, *i.e.* the things about places that matter to people. Online tools make it feasible to collect and collate responses from large numbers of people, so this could be used to engage the wider public in the early stages of a freshwater planning process.

Because it has both qualitative and quantitative features, participatory mapping can also help with ***assessing values***, for example, understanding why a place is valued and how many people share certain values.

It can be difficult to obtain participation from a representative sample of the area of interest. Indeed, identifying whose values count is not a straightforward question — should all of New Zealand be surveyed for every catchment? Or, if all New Zealanders should be surveyed only where there are matters of national significance, how can this be determined *a priori* if the point is to assess significance? And if there are strongly competing values in a catchment and participatory mapping is used to assess as well as identify values, this creates an incentive for stakeholder groups to recruit as many respondents as possible from their own sectors. For these reasons, results from participatory values mapping should be seen as indicative rather than definitive.

More information

Landscape Values and PPGIS Institute http://www.landscapemap2.org/

Hall F, Oyston E, Lonie A, Grose M 2012. Identifying conservation values, park experiences, and development preferences in the Otago region of New Zealand. Department of Conservation. http://www.doc.govt.nz/Documents/getting-involved/consultations/current-consultations/otago/ppgis-final-public-report-otago.pdf

4. WATERSHED TALK

Watershed Talk is a "platform for social learning" (Kilvington *et al.* 2011, p 5) that uses interviews, photography and dialogue to elicit and share participants' values of water bodies. The Watershed Talk process (Atkinson *et al.* 2009) was designed to promote dialogue about catchment care, cultivate ideas and action for care, and develop community resilience. Watershed Talk was an initiative within the 10-year interdisciplinary Integrated Catchment Management (ICM) research programme, based in the Motueka catchment in the South Island of New Zealand. Watershed Talk spanned eight months, involved over 18 participants in individual interviews, and included two group meetings. Facilitation was carried out by a multi-disciplinary research team comprising a social scientist, catchment hydrologist and a landscape specialist.

The Watershed Talk process involves four stages: 1) engagement, 2) conversation, 3) evaluation, and 4) feedback. Interviews are conducted during the engagement phase, where people are asked to identify and reflect on their personal connection with the catchment, and then to take photographs of valued sites (Kilvington 2011). The method is based on the proposition that dialogue and deliberation processes, assisted by photographic images, can generate mutual understanding of diverse values by the participants. This can then establish the potential for reconciliation of competing values (Atkinson *et al.* 2009).

Watershed Talk builds on a long history of academic inquiry into the use of photography to elicit values. The photo elicitation technique was first documented by John Collier (1957). He used photo elicitation in anthropological studies and promoted the approach in subsequent decades (*e.g.* Collier 1986). The approach has since been used in visual sociology studies (Harper 1986, 1988, 1998, 2002), the health sector (Radley & Taylor 2003; Oliffe & Bottorff 2007; Lorenz & Kolb 2009), ethnography (Schwartz 1989), the use of public spaces (Haberl & Wortman 2012), the meanings of outdoor adventure experiences (Loeffler 2004), and perception of place (Garrod 2008) to name a few. Photo elicitation is also being applied in resource management and planning situations, for example, to balance conservation and agricultural production in Australia (Beilin 2005; Sherren *et al.* 2010), and for values-based planning of built environments (Alexander 2013), woodlands and forests (Dandy & Van Der Wal 2011), and rural landscapes (Stewart *et al.* 2004).

There are numerous benefits to photo elicitation, primarily relating to peoples' ability to express their practical knowledge through the attribution and association of meanings. As explained by Harper (2002),

> *"the parts of the brain that process visual information are evolutionarily older than the parts that process verbal information. Thus images evoke deeper elements of human consciousness than do words; exchanges*

> *based on words alone utilize less of the brain's capacity than do exchanges in which the brain is processing images as well as words"* (Harper 2002 p 13).

Photo elicitation, thus, can illuminate insights that would otherwise stay hidden (Clark-Ibanez 2004). Photo elicitation can also:

- help to breach a communication impasse between interviewee and interviewer
- stimulate the informants' ability to express their practical knowledge
- bridge geographical and cultural gaps between interviewee and interviewer
- collect more quantitatively and qualitatively complete data compared to that obtained by using 'words' only
- promote more relaxed and more aware participation in the research
- establish a dialogue in which to explore complementary and concurrent understandings of the physical, social and cultural milieu of the actors (Bignante 2010).

Uses of this tool

Watershed Talk, or similar methods of using photographs or other creative media to stimulate dialogue about the environment, can be a useful tool for ***identifying values***, *i.e.* the things about places that matter to people, and for ***understanding*** why a place is valued. Watershed Talk has been used successfully in New Zealand with a group of about 20 people, and as such might be suitable for collaborative stakeholder groups as a way to build understanding and appreciation of alternative values, perspectives and worldviews.

More information

Atkinson M, Kilvington M, Fenemor A 2009. Watershed talk: the cultivation of ideas and action. Lincoln, Manaaki Whenua Landcare Research. Available online at: http://icm.landcareresearch.co.nz/knowledgebase/publications/public/Watershed_Talk_Summary_2009.pdf

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Kilvington M, Atkinson M, Fenemor A 2011. Creative platforms for social learning in ICM: the Watershed Talk project. New Zealand Journal of Marine and Freshwater Research 45(3): 557-571.

5. VISIONING

5.1. About visioning

Planning has been described by Throgmorton (2003) as 'persuasive storytelling'. According to this perspective, as summarised by van Dijk (2011):

> *… we persuade one another about what the future should and can bring, as well as convince others to agree on and engage in a trajectory of actions. Decision-making is not about separate facts but concerns stories that strike a chord among those who can make things happen (p 124).*

Depending on the methodology and specific design, visioning may address values to a greater or lesser extent. It can be largely 'value-neutral' and aim to stimulate lateral thinking about possible future scenarios or it can be more explicitly values-based and designed to generate consensus on a desirable future.

As a values-based exercise, visioning is a process of engaging in a collective exercise to agree on a story about the future for a community or place. van Dijk (2011) explains why and how these visions (stories) influence decisions about the future, using mostly examples of urban spaces. van der Helm (2009) proposes a basic theoretical framework to underpin 'visionary' approaches, and explains that a vision is not the same as a goal or a plan:

> *A vision aims to direct through the creation of a tension between the 'what is' and 'what could be', and not by rationalised pathways which would make the vision become reality (what is expected from a plan). So a vision does not describe what to do, but it provides a mental framework by which potential actions can be (tacitly) evaluated, and hence accepted or rejected (ibid., p 102).*

But van der Helm also warns that:

> *More often than not, visions tend to become trivial, since we all want a better world, a more competitive company, a more rewarding career, etc. So visions have to go beyond the dreams we all foster for ourselves, our community, or for humanity as a whole… (ibid., p 103).*

To be an effective tool for working with values in freshwater planning, a vision needs to be sufficiently detailed to help people evaluate and choose between potential actions, while being broad enough to not unduly constrain the choice of pathways for getting there.

Essentially, adopting an agreed vision for the future is a way of identifying and reconciling different values at a high level. Defining specific goals, plans and actions for progressing towards an agreed vision is still likely to require reconciliation of values at a more detailed level.

The three sections that follow describe visioning tools that have been used in New Zealand.

5.2. The Natural Step's ABCD method[6]

The ABCD planning method of The Natural Step (TNS) is based on 'backcasting' from sustainability principles or conditions that describe what a sustainable organisation or system looks like. The method consists of four steps, starting with a visioning process (Figure 2). While designed primarily as a planning tool for businesses and other organisations, this method has also been used by the community of Whistler, Canada (Resort Municipality of Whistler 2007) and the Nelson City Council (Nelson City Council 2013) to develop long-term plans.

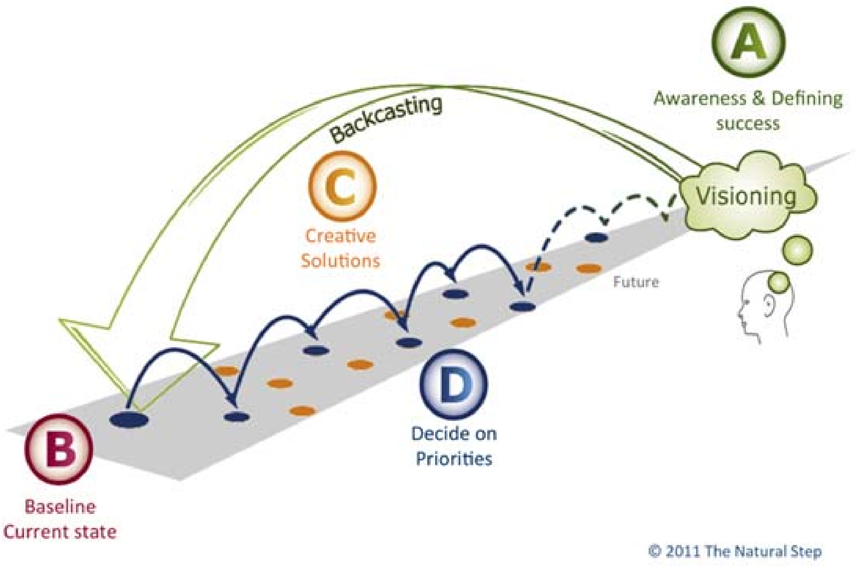

Figure 2. The Natural Step's ABCD method (http://www.naturalstep.org/en/abcd-process).

The first step, 'awareness and visioning', aligns the organisation around a common understanding of sustainability and identifies a 'whole-systems' context for that organisation. This builds a common language around sustainability and creates a vision of what that organisation would look like in a sustainable future.

[6] This section is a condensed version of the following web page: http://www.naturalstep.org/en/abcd-process

Participants review the state of the earth's systems, including the ecological, social and economic trends that are undermining our ability to create and manage healthy and prosperous ecosystems, businesses and communities. They then place their own organisation, community or project within that context. During the visioning process, people are encouraged to set ambitious goals. Some of these may require changes in how the organization operates and may take many years to achieve.

The second step, ‘baseline mapping’, conducts a ‘gap analysis’ of the organisation’s major flows and impacts to assess their compatibility with the sustainability principles of The Natural Step. The assessment also looks at the social context and organisational culture in order to understand how to positively introduce change.

In the third step, ‘creative solutions through backcasting’, people are asked to brainstorm potential solutions to the issues highlighted in the baseline analysis. Armed with their vision of success and potential actions, organisations look backwards from the vision to develop strategies toward sustainability. This is called backcasting and it prevents people from developing strategies that just solve the problems of today.

Finally, after identifying the opportunities and potential solutions, the group prioritises the fastest way to move the organisation toward sustainability. This step supports effective, step-by-step implementation and action planning. At this stage, organisations can pick the 'low-hanging fruit' — actions that are fairly easy to implement and offer a rapid return on investment in order to build internal support for the planning process.

Backcasting is used to continually assess decisions and actions to see whether they are moving the organisation toward the desired outcome identified in the vision.

Organisations are not expected to achieve long-term goals immediately. Rather they are encouraged to move systematically by making investments and take a series of steps that will provide benefits in the short-term and eventually lead to longer-term sustainability.

Uses of this tool

Visioning can be conducted as a values-based exercise for building consensus on a desirable future, which implicitly involves ***balancing values***. The Natural Step ABCD method is designed for the development of a vision and action plan based on four sustainability principles. It is likely to be most effective when all participants accept these principles and have common goals.

More information

The Natural Step http://www.naturalstep.org/en/abcd-process

Whistler 2020 http://www.whistler2020.ca/home

5.3. The Foresight Engine

The Foresight Engine is developed and directed by the Institute for the Future (IFTF), a non-profit futures-research group based in the United States. The Foresight Engine drives 'engaged forecasting' by creating a fast flow of micro-forecasts from hundreds or thousands of participants in just a day or two.

At the start of a foresight exercise, participants ('forecasters') from around the world watch a quick video briefing on a future scenario. Then they play cards: micro forecasts (140 characters or less) that represent their best thinking on events that will flow from the initial scenario. They can then build on cards that others play or try to start a new chain of cards by getting others to build on their forecast.

Participants earn forecasting points for ideas that inspire conversation and earn bonuses for moving the conversation in unexpected directions. Participants can track their favourite forecasters, watch the evolution of their ideas as others build on them, and monitor their standing in the leader board. They can create tags and follow forecasts that use those tags. In short, they can create their own personalised view on a fast-paced forecasting event.

Institute for the Future partners, with organisations and groups of all types, can create custom foresight engagements on their Foresight Engine platform. The Foresight Engine has been used in New Zealand to explore the future of post-earthquake Christchurch and to explore a more science-oriented future for the entire country.

In 2011, 'Magnetic South' was conducted following major earthquakes that affected Christchurch and Canterbury in 2010 and early 2011[7]. The game, set in 2021, focused on the challenge for small cities to attract skills and capital in a world of highly productive mega-cities. 'MagneticSouth' was developed by Landcare Research with Christchurch City Council, StratEDGY Strategic Foresight, and the IFTF to inform strategic planning for the future of the city. Nearly 9,000 micro-forecasts were posted by 850 players from across the world. This generated a wide array of ideas and possibilities for the future of Christchurch.

In 2012, Pounamu provided an opportunity for all New Zealanders to explore what we could do, for ourselves and others, if New Zealand was the most science literate country in the world. The exercise generated 4,688 micro-forecasts by 336 players.

Uses of this tool

Visioning can be used as a values-based exercise for building consensus on a desirable future, which implicitly involves ***balancing values***. The Foresight Engine applications in New Zealand have not had an explicit purpose of reaching an agreed

[7] See www.iftf.org/our-work/people-technology/games/magnetic-south/ and www.magneticsouth.net.nz/

vision, so some adaptation of the tool may be necessary for it to be suitable as a values-based visioning tool for freshwater planning.

More information
http://macdiarmid.ac.nz/pounamu
http://www.royalsociety.org.nz/2012/06/01/pounamu-what-if-new-zealanders-invited-to-join-online-game-to-create-a-better-future-for-this-country/
http://www.youtube.com/watch?v=KNGYLGwk2gE
http://foresight.breakthroughstocures.org/about (contact: info@iftf.org)

Dunagan, J. 2012. Massively Multiplayer Futuring: IFTF's Foresight Engine. Journal of Futures Studies 17(1): 141–150.

Gorbis, M. 2010. Foresight to insight to action: Imaginative forecasting helps shape a brighter future. Journal of the American Society on Aging 34(3): 12–13.

5.4. 100% Pure Conjecture

Landcare Research has been developing four contrasting future possibilities for NZ since 2004, to contribute to a future choices debate. These are presented in 100% Pure Conjecture, a game designed to help people explore the implications for their organisations of future scenarios for New Zealand.

The game has several suggested uses, including evaluation of long-term policy goals. It can be used to address questions such as: What circumstances could bring about our vision? What would help attain or hinder these policy goals? How sustainable are our policy goals? These questions help start dialogue that tests the plausibility of envisioned futures, or of distant policy goals. Backcasting from the goal towards the present day can reveal assumptions about change that were not originally explicit. This may lead either to changes in the policy or vision, or to variation in the methods being used to advance change into more-preferred directions. It can also help identify barriers to change that, unless they are known, can make policy solutions a mere token and thus ineffective.

The four scenarios presented in the game give a rich sense of how life could differ in the future: at work, at home, in politics and in business. With whom will we trade? How will we educate people? What may government priorities be? And what will all of this mean in terms of sustainable development?

The scenarios differ from each other on two primary dimensions:

1. Extent of social cohesion (from competitive individualism to social collaboration).
2. State of ecosystems and availability of natural resources (from conserved to depleted).

Each scenario diverges from today, so that 50 years from today they have the following characteristics (Figure 3):

A. **Fruits for a Few:** An open economy with protected ecosystems but unevenly-distributed benefits: Most (80%) of resources are in the hands of business-political elites and 20% with the rest.

B. **Independent Aotearoa:** A more closed economy and equitable society, with a Genuine Progress Index taking the place of GDP (Gross Domestic Product) as a measure of the national well-being.

C. **New Frontiers:** A globalised open economy where winners prosper, until New Zealand hits a wall of resource shortage and ecosystem pollution. This results in a severe economic crash and social conflict.

D. **Living on No.8 Wire:** After initial resource depletion (along the lines of C), strong social networks help to avoid the resource crash, creating a localised, inward-looking subsistence lifestyle.

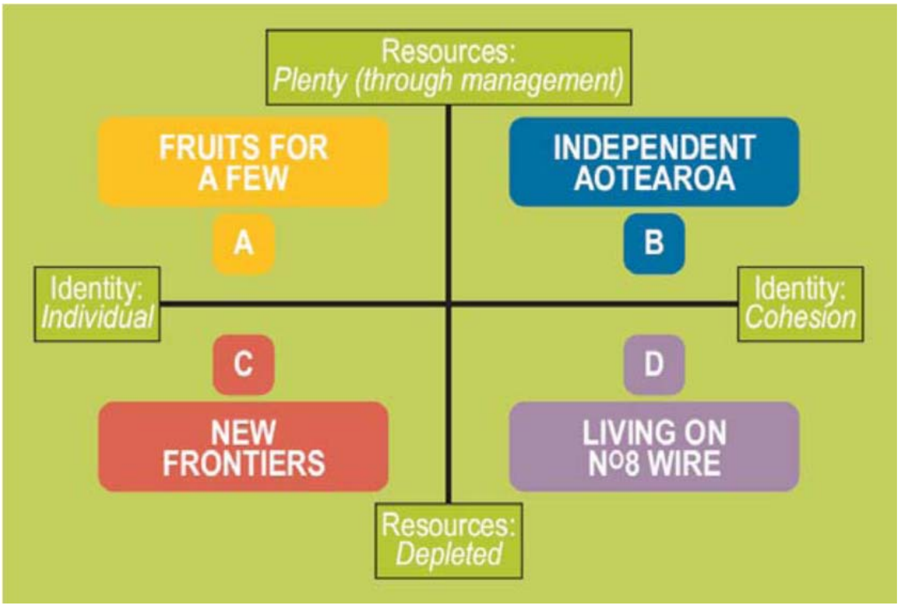

Figure 3. Four possible futures for New Zealand in 100% Pure Conjecture, Classic edition (https://www.landcareresearch.co.nz/science/living/sustainable-futures/future-scenarios/classic-edition).

The 100% Pure Conjecture Game is designed for groups of up to 16 people to stimulate strategic-thinking on sustainability and future directions for New Zealand. The game takes two to three hours and includes:

- a warm-up activity that looks back 20 years, using photos to show how much has changed in everyday life and inviting discussion of trends
- future possibility cards, to open discussion on new drivers of change
- role cards, for what a future grandchild might be doing in 50 years as an adult
- wildcards (*e.g.* earthquakes and technology shocks), to test the resilience of the scenarios.

The game has been run with various groups and has been modified and improved over this period using participant feedback. It has been used to stimulate creative thinking about sustainability by:

- public health staff within Canterbury and West Coast District Health Board
- urban and rural local government (including Christchurch City Council and Far North District Council)
- Auckland secondary schools and regional youth policy development
- national conferences on health, tourism, education and local government
- national meetings for transport and conservation with policy-makers.

Uses of this tool

For freshwater planning, the 100% Pure Conjecture Game is suitable as a tool for considering the feasibility of future visions, in particular, for ***understanding*** the events and trends that could make certain the realisation of values-based outcomes more or less likely. The game may also be useful as a precursor to developing an agreed vision that ***balances values***, in that it stimulates reconsideration of things about the future that people may take for granted.

More information

The materials and facilitator's guide are available free to download: https://www.landcareresearch.co.nz/science/living/sustainable-futures/future-scenarios

Frame R, Molisa P, Taylor RE, Toia H, Wong Liu Shueng 2005. 100% pure conjecture: Accounts of our future state(s). In: Liu JH *et al.* New Zealand identities—departures and destinations. Wellington, Victoria University Press.

Taylor R, Frame B, Delaney K, Brignall-Theyer M 2007. Work In Progress: Four Future Scenarios for New Zealand. 2nd ed. Manaaki Whenua Press, Lincoln, New Zealand.

http://www.landcareresearch.co.nz/publications/researchpubs/4_Futures_wholeEbook.pdf

6. EXPERT MODELLING AND DECISION SUPPORT SYSTEMS

6.1. Conservation modelling by Zonation

Over the years, numerous models and other expert tools have been developed in attempts to understand and, in some cases, predict how natural systems function. Many of these can be useful in freshwater planning but are beyond the scope of this report. This section describes one example that is explicitly designed as a tool for prioritising conservation effort by ranking sites for their significance for freshwater biodiversity.

Leathwick and others (Leathwick *et al.* 2010; Moilanen *et al.* 2011) have used the Freshwater Ecosystems of New Zealand[8] (FENZ) geo-database in conjunction with spatial prioritisation software, Zonation (Moilanen & Kujala 2008), to rank sub-catchments ('sites')[9] for their biodiversity value based on native fish and macroinvertebrate species. Stream reaches were classified based on environmental attributes to identify their biodiversity potential and then, using data on anthropogenic stressors and expert opinion on the impact of each stressor, the current condition of each site was assessed or estimated using statistical techniques and scored on a range of 0 (totally degraded) to 1 (pristine).

The Zonation software optimises for biodiversity outcomes across the entire network. It does this by identifying and then excluding the site that contributes least to existing aquatic biodiversity; this site is ranked last. The next lowest contributor site is identified, excluded, and ranked second to last, and so on until there is only one site left, for which protection is the highest priority. The ranking of a site is simply the percentage of sites remaining in the set at the point when the site is excluded.

The prioritisation can be done nationally or for a selected area, *e.g.* defined by local authority boundaries. It takes into account human pressures, complementarity with other sites, and upstream and downstream connectivity. The results can be displayed as a map showing, for example, the top 5% of sites within a given region for protection of native fish species.

[8] http://www.doc.govt.nz/conservation/land-and-freshwater/freshwater/freshwater-ecosystems-of-new-zealand/
[9] The analyses used planning units that break rivers of fourth or higher order into their third-or higher order sub-catchments and their main stem. Catchments of first- to third- order streams were treated as individual planning units.

With the benefit of extensive datasets and powerful statistical tools, FENZ and Zonation can prioritise sites for native fish and macroinvertebrates in a highly quantitative manner. However, the impact of a given stressor is still based on expert judgment and there are some manual steps in combining and prioritising sites into larger management units. Note also that the model gives each species equal weight, which is in itself a weighting.

Uses of this tool

Zonation is designed for ***assessing*** freshwater biodiversity values in the sense of prioritising which sites contribute most to biodiversity objectives and therefore most warrant protection for that purpose, but provides no guidance on balancing relative to other values. The underlying data in FENZ can be used also for ***identifying*** values and Zonation assists ***understanding*** how the system works. Expert assistance is required to operate the tool; enquiries should be directed to the Department of Conservation: fenz@doc.govt.nz.

More information

FENZ on the Department of Conservation website
http://www.doc.govt.nz/conservation/land-and-freshwater/freshwater/freshwater-ecosystems-of-new-zealand/

Leathwick J, Moilanen A, Ferrier S, Julian K 2010. Complementarity-based conservation prioritization using a community classification, and its application to riverine ecosystems. Biological Conservation 143: 984–991.

6.2. Bayesian networks[10]

How would different minimum river flow settings affect regional economic growth, trout fishing and suitability of the river for swimming? How certain are we of these outcomes?

What combinations of water allocation for irrigation, farming best practices and urban stormwater management can provide acceptable reliability of water supply and protect mahinga kai and river aesthetics, and at what cost to rate payers and land owners?

Such questions might arise when developing a catchment management plan. To develop an effective plan, decision-makers and those advising them need a tool to represent the community's key objectives for the water bodies in the catchment, the main components of the system that relate to those objectives, and the effects of

[10] This section was written by Richard Storey of NIWA, who is developing a Bayesian network model with Hawkes' Bay Regional Council and the TANK Group, as part of the Values Monitoring and Outcomes research programme http://www.landcareresearch.co.nz/science/portfolios/enhancing-policy-effectiveness/vmo.

different management actions or policies on achievement of the objectives. Ideally, this would use all relevant knowledge, which comes in a variety of different forms, while recognising degrees of uncertainty about different components of the system.

A Bayesian network is a tool designed to achieve this. It shows in an 'influence diagram' the key components of a system and the cause-effect relationships between them. Cause-effect relationships are quantified in terms of probabilities, with higher probabilities given to relationships we are more certain about. A completed Bayesian network could provide an output such as: if stock are excluded from more than 50% of streams in the Tutaekuri catchment, the probability of faecal coliforms exceeding contact recreation guidelines in a given year at site X is less than 25%.

Bayesian networks have a number of advantages for use in freshwater planning.

- All the relevant knowledge we have about freshwater systems are organised to focus on the effects of different policy options on stakeholder values.
- Different types of knowledge, including expert scientific judgment, numerical model output, monitoring data and stakeholder experience, are incorporated.
- The graphical layout makes them suitable for communicating among scientists, stakeholders, and decision makers.
- Scenarios can be run quickly so that the implications of different management options are rapidly understood.
- The probabilities of various outcomes give the stakeholders and decision makers a realistic appraisal of the chances of achieving desirable goals.

The primary sources of the information used to characterise probabilities are:

- observational and experimental evidence or data
- outputs of numerical models
- expert knowledge.

Although the influence diagrams that form the basis of Bayesian networks are very complex, the networks only require specification of the relationships between directly linked components (nodes). That is enough for the network to then estimate the interrelations among all nodes simultaneously.

Quinn *et al.* (2013) developed a Bayesian network to understand the implications of policy options for aquatic values in the Hurunui catchment in Canterbury, the results of which were considered by the Hurunui-Waiau Zone Committee of Environment Canterbury. Richard Storey of NIWA is now leading a project to develop a Bayesian network for a collaborative freshwater planning process in conjunction with the Hawke’s Bay Regional Council (see Figure 4 and TANK Group 2014).

Uses of this tool

Bayesian networks are primarily a tool for ***understanding*** how a system works and estimating the consequences of choosing one set of policy measures vs another set. The process of building a Bayesian network involves ***identifying*** values and its use can assist in the process of ***balancing*** values. A Bayesian network requires a considerable investment of resources, but if planned carefully this need not be a significant addition to the scientific investigations needed to inform a plan change and support the analysis required by Section 32 of the Resource Management Act 1991 (RMA).

More information

Sinner J, Greenhalgh S, Berkett N, Sharp T 2014. Structured Decision Making for Collaborative Planning. Policy Brief 9. http://www.landcareresearch.co.nz/__data/assets/pdf_file/0011/74765/Structured_Decision_Making_for_Collaborative_Planning_PB_9.pdf

TANK Group 2014. Collaborative decision making for freshwater resources in the Greater Heretaunga and Ahuriri Region: TANK Group Report 1 Interim Agreements. Napier, Hawke's Bay Regional Council. http://www.hbrc.govt.nz/Hawkes-Bay/Projects/Pages/tank.aspx

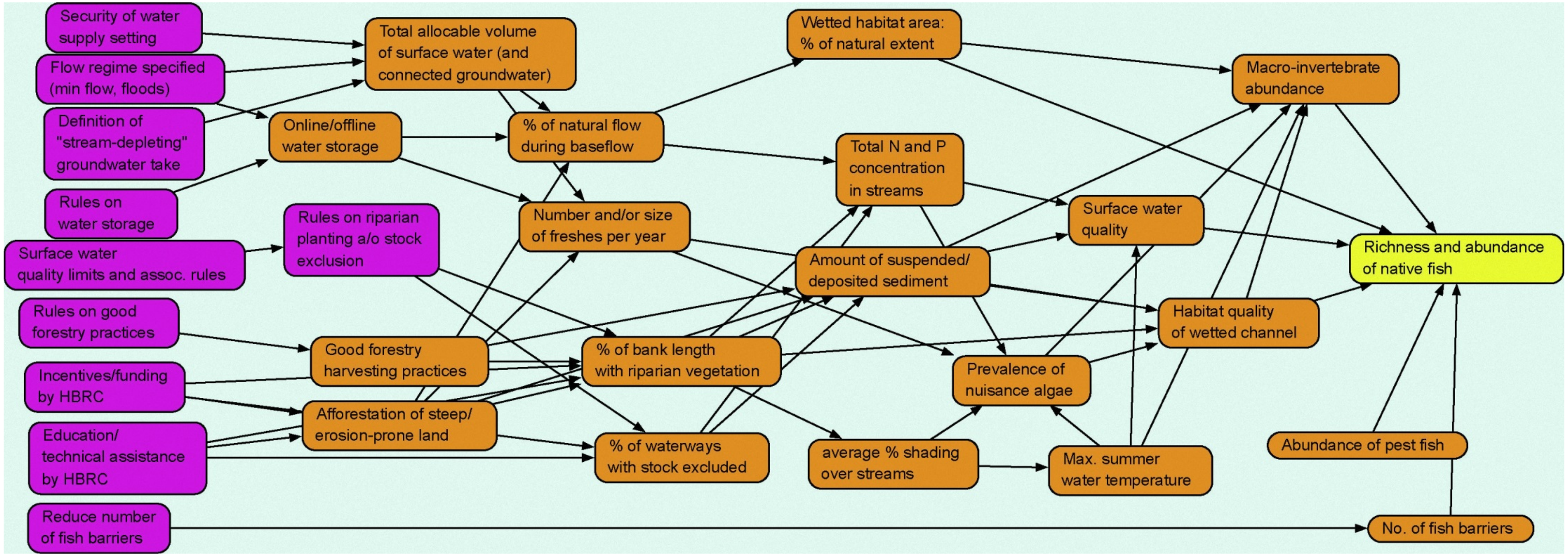

Figure 4. An influence diagram showing how management variables (pink, left side) influence the richness and abundance of native fish (yellow, right side) by affecting numerous intermediate variables (orange). This figure is part of a larger system diagram and associated model being developed by a collaborative stakeholder group in Hawke’s Bay (TANK Group 2014).

6.3. Decision support systems

A decision support system (DSS) has been defined in many different ways, but it can be regarded in general as an interactive, flexible, and adaptable (usually computer-based) information system developed to support decision-making regarding a complex problem (Matthies *et al.* 2007 p 123). Decision support systems originated as management and reporting tools in the mid-1960s and are now increasingly applied to complex environmental management challenges, for example in river rehabilitation (Reichert *et al.* 2007), biodiversity (Bell 2011), river basin management (van Delden *et al.* 2007), regional planning (Huser *et al.* 2009), and stormwater management (Moores *et al.* 2013).

The strength of DSSs in environmental decision-making contexts lies in their ability to simplify, structure, and present multiple information sources in a user-friendly graphical user interface. This information can be used to map, model, and value multiple ecosystem services provided by natural systems; estimate changes in the suite of services under different management scenarios; and to look at trade-offs among them (Guerry *et al.* 2012). The focus of DSSs is more to link together modelling components than to preserve scientific rigour, and they tend to show more breadth than depth (Liu *et al.* 2008). In doing so, a DSS simplifies the difficult task of assessing comprehensively how human activities in one sector affect a whole suite of environmental benefits that people want and need, and so provides an enhanced vehicle for communication among modellers, stakeholders and decision makers (Liu *et al.* 2008; Guerry *et al.* 2012).

With a DSS, end-users can compare and contrast alternative future scenarios to make decisions. These are based on a suite of system attributes (environmental, social, economic, and/or cultural) that are derived through transparent, logical, and participatory methods. End-user values are incorporated in both the settings of the DSS for a particular application (*e.g.* in weightings assigned to different attributes in models) and in preferences for different scenarios. An exemplary approach was employed by Huser *et al.* (2009), who used a participatory, deliberative approach so that stakeholders could evaluate scenarios iteratively (see Section 1.1).

Volk *et al.* (2010) analysed the benefits and shortcomings of four popular river management DSSs. They found that there were still challenges, despite the tools for landscape and river basin management ranging from good to excellent. Further attention is required for data availability and homogenisation, uncertainty analysis and uncertainty propagation and to address problems with model integration. All four DSSs lacked an appropriate stakeholder interaction process to identify end-user wants and needs. The authors proposed:

> *… an iterative development process that enables social learning of the different groups involved in the development process, because it is*

easier to design a DSS for a group of stakeholders who actively participate in an iterative process (ibid. p 834).

More information

A directory of DSSs developed in New Zealand for use in environmental management is available online at http://tools.envirolink.govt.nz/

6.3.1. Case Study: Decision support system for Urban Planning that Sustains Waterbodies

A DSS was developed in the NIWA-Cawthron Institute research partnership Urban Planning that Sustains Waterbodies (UPSW), funded by the Foundation for Research Science and Technology (Moores *et al.* 2013).

The Auckland Council, in response to demands for improved water quality, sought to achieve more compact urban design to minimise environmental impacts, including those associated with the discharge of stormwater (Auckland Council 2012). This was after a history of urban expansion that used freshwater bodies for stormwater disposal. The UPSW research team, with Auckland Council, developed the DSS to discriminate between alternative urban catchment development scenarios on the basis of effects (environmental, social, economic and cultural) of urban stormwater on the receiving waterbodies.

The DSS utilises a sustainability indexing system based on an OECD (Organisation for Economic Co-operation and Development) methodology that integrates indicators of the four well-beings (environmental, social, economic and cultural; see Batstone *et al.* 2008). The UPSW DSS uses inputs representing alternative catchment-scale stormwater management scenarios to drive models that predict changes in water and sediment quality and indicators of ecosystem health in streams and estuaries, providing a measure of environmental wellbeing. These environmental indicators are in turn used to evaluate effects on the ways in which people and communities interact with the waterbodies, expressed as indicators of social wellbeing and the economic benefits arising from a given stormwater management scenario. For example, increased sedimentation can affect social wellbeing by reducing the enjoyment of cultural ecosystem service activities such as swimming and snorkelling, and can also have impacts on provisioning ecosystem services such as fishing and shellfish gathering.

The DSS links a number of models and methods to make these predictions: deterministic models, a probabilistic model, non-market valuation methods, look-up tables populated through expert elicitation techniques and index construction. Catchment-scale cost estimates, a stream ecosystem health model and a method for predicting social wellbeing were also developed specifically for the DSS (Figure 5). MS Excel software is the platform for the DSS, and calls on each of the methods in a logical sequence. The inputs to the system are the characteristics of urban development options, specified for each planning unit within a study area.

To run the DSS, the end-user chooses a set of indicator targets to provide a benchmark against which results of each scenario will be assessed. Weights of social wellbeing indicators can also be assigned by the user. The user defines a development option in terms of time period, stormwater treatment characteristics, and the characteristics of riparian management. The DSS then generates output indicators of environmental, economic and social wellbeing for each reporting unit within the study area. The indicators are reported on a scale of one (low) to five (high), with a corresponding 'traffic light' colouring system (Figure 6).

The DSS is undergoing further development, with plans to include a cultural component, enhance the appearance of the system, and refine existing methods. In particular, under the Resilient Urban Futures program led by the University of Otago, work is underway (1) to investigate methods to extend the tool to other urban locations, and (2) to develop an indicator for the resilience of ecosystem service provision. This indicator reflects both vulnerabilities and the capacity of the urban socio-technical system (Moores *et al.* 2014) to maintain ecosystem services by urban waterbodies.

Uses of this tool

The UPSW DSS is designed primarily as an aid to ***understanding*** how a complex system works and, in particular, what outcomes are likely from different scenarios. It is also an aid to ***balancing*** values, to estimate the consequences of choosing one set of policy measures compared to another as seen through each of the indicator "lenses"—environmental, economic, social, cultural and resilience.

To use the UPSW DSS in a region other than Auckland, users can accept some or all of the default look-up tables or use local data to support estimation of indicator performance. Some local studies would probably be needed to support a plan change in any case. UPSW DSS is better suited to freshwater issues in urban environments, whereas the Waikato Integrated Scenario Explorer (see next section) was designed, at least initially, for a region where rural land use is a much stronger influence on all indicators sets.

More information

Auckland Council website
  http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/plansstrategies/unitaryplan/Documents/Section32report/Appendices/Appendix%203.2.16.pdf

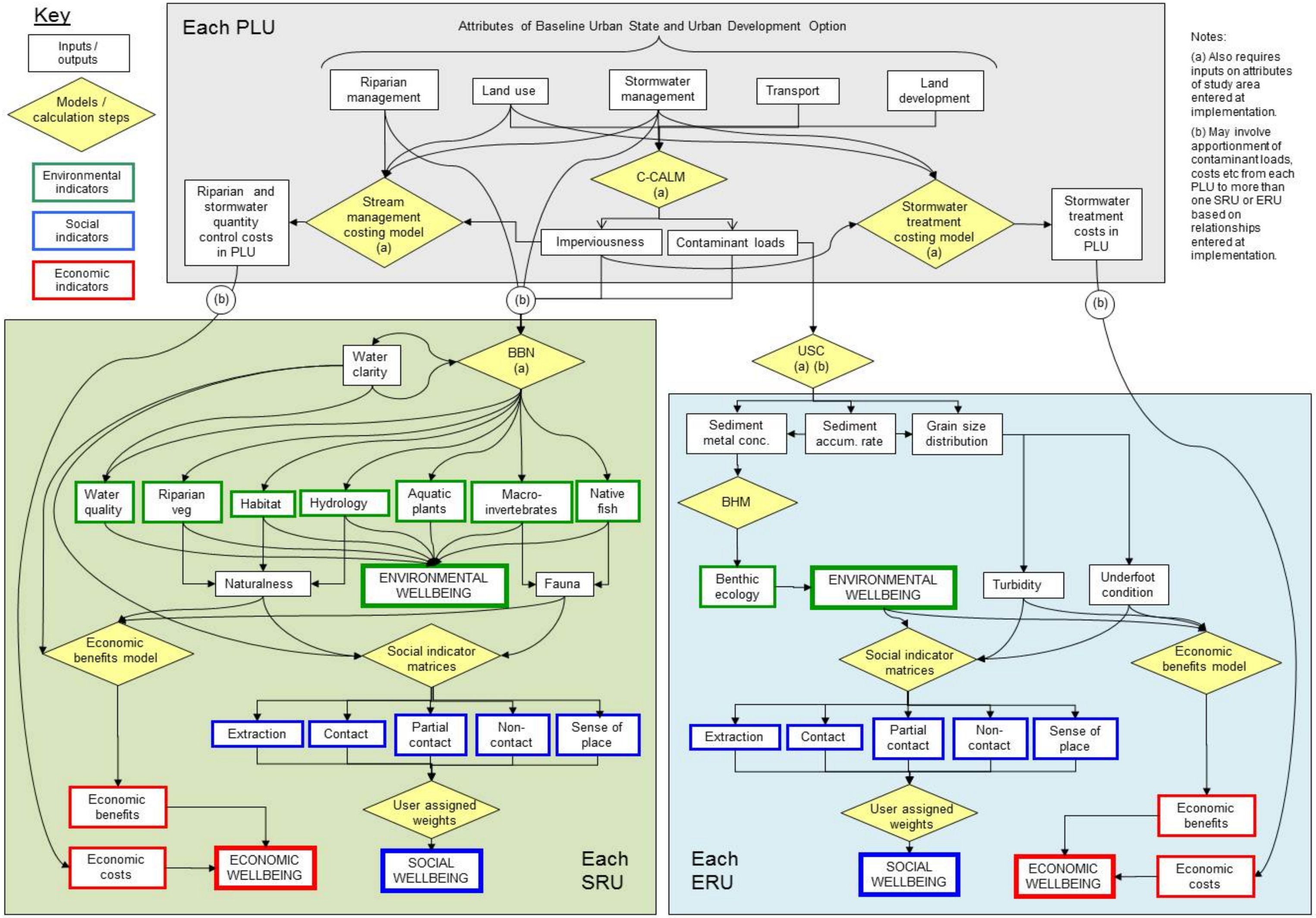

Figure 5. Structure of the pilot decision support system for Urban Planning that Sustains Waterbodies (Moores *et al.* 2013, p 7).

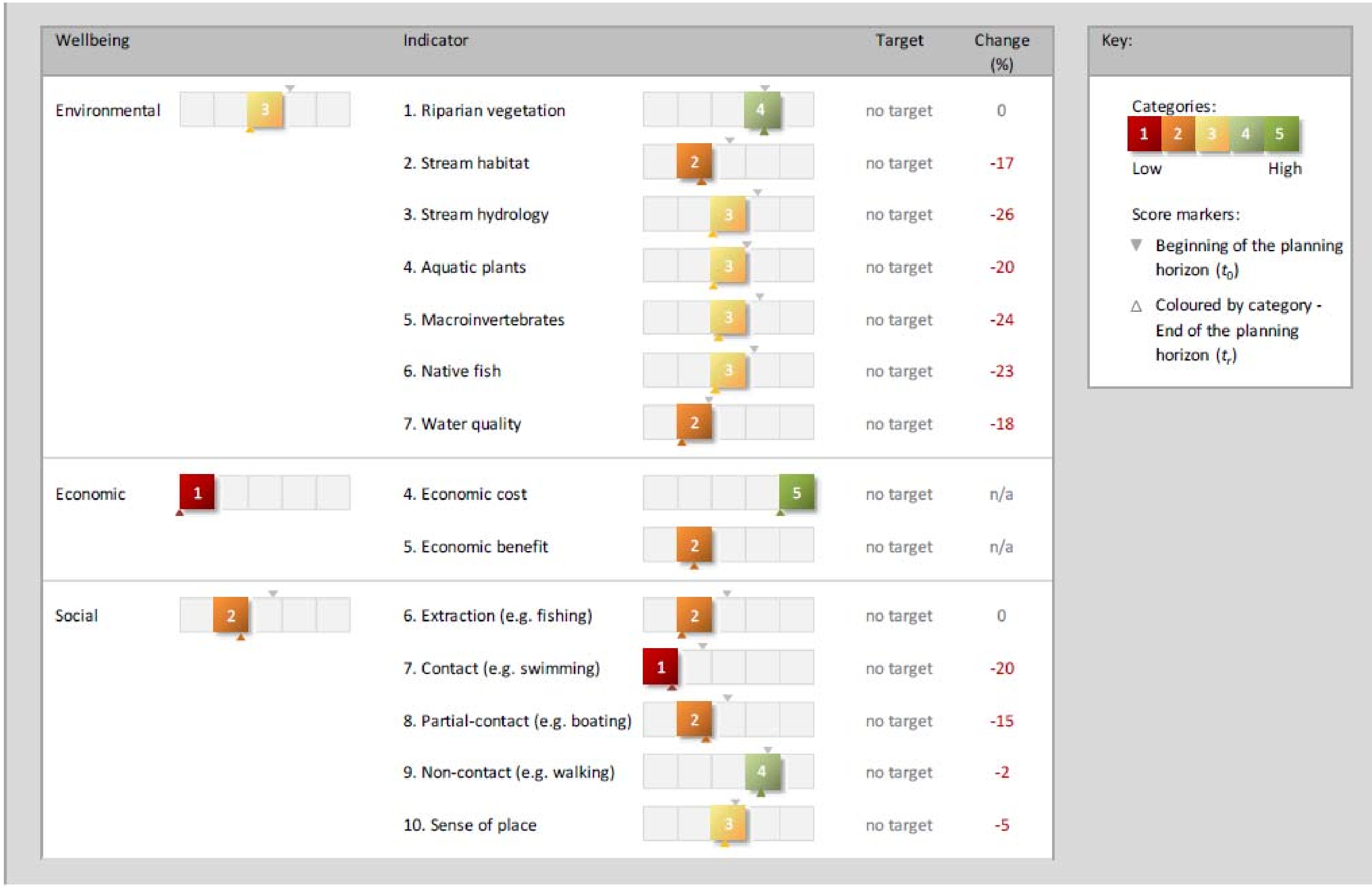

Figure 6. Example of predicted indicator levels for a stream reporting unit from the decision support system (DSS) for Urban Planning that Sustains Waterbodies (Moores *et al.* 2013, p 11).

6.4. WISE: Waikato Integrated Scenario Explorer

The Waikato Integrated Scenario Explorer (WISE) is another example of expert modelling specifically designed to assist decision-making by testing policy alternatives. WISE is a multi-scale, spatially explicit, dynamic systems model for the Waikato region linking components at four spatial scales: global to New Zealand, regional, district and local (*i.e.* 200 × 200 m grid cells). Figure 7 shows the various components of the model and how they are linked. According to the project website, version 1.4.0 is due for release in 2014.

Climate change scenarios and economic and population trends derived from global and national perspectives provide exogenous inputs into WISE, while policy alternatives include such things as zoning regulations, environmental standards and infrastructure developments. Simulations run for a 50-year period.

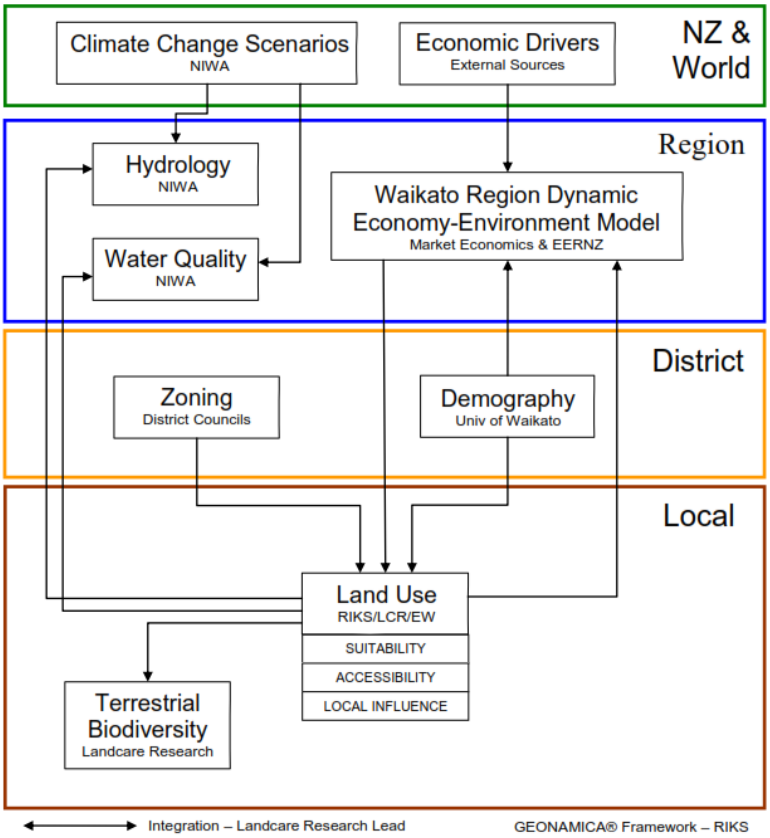

Figure 7. Waikato Integrated Scenario Explorer (WISE) Version 1.3 system design (Rutledge *et al.* 2010, p 5)

To help guide and organise thinking about the Waikato region's future, qualitative scenarios were developed in consultation with stakeholders to help identify and explore key drivers and challenges that the region will face. The deliberative process involved six stages:

1. Identify the problem
2. Organise the problem
    a. identify options and strategies to address the problem
    b. identify stakeholders and their values
3. Identify and mobilise tools for representation *e.g.* maps, conceptual system diagrams, models, indicators
4. Run model to assess consequences of the proposed strategy with regard to identified values
5. Prepare, validate and communicate the results and recommendations
6. Return to Step 1 and iterate to find a scenario with outcomes acceptable to all.

WISE was designed for use in a deliberative context to enable end users to evaluate policy options against a range of pre-determined values and associated indicators (Huser *et al.* 2009). The model has recently been used to assist Waikato Regional Council staff in their submission on the Auckland Unitary Plan by exploring the potential impacts of projected growth on the northern part of the Waikato Region.

Uses of this tool

Like Bayesian network models, WISE is designed to aid ***understanding*** of how a complex system works and estimating the consequences of choosing one set of policy measures vs another set, as an aid to ***balancing*** values. Significant resources would likely be required to adapt this to a different region, though some of the science would probably be needed to support a plan change in any case. Some work has already been done using the WISE platform to develop models for the Auckland and Wellington regions (see www.sp2.org.nz).

More information

http://www.creatingfutures.org.nz/
http://www.youtube.com/watch?v=RgEABCz1RrI
WISE Version 1.0.3 Technical Specifications Report

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7. PARTICIPATORY MODELLING

Participatory modelling refers to model building *with* (rather than *for*) people, and is intended to build a shared understanding among participants about how complex systems function. Vidiera *et al.* (2010) review the origins and logics of participatory modelling and provide an overview of the method. They identify some of the specific approaches used and list numerous examples from around the world where models have been built using participatory methods.

The following section describes a participatory modelling methodology that has been used in New Zealand.

It is worth noting that the WISE model described in Section 1.1 employed participatory techniques as a way to incorporate stakeholder information into the model and increase stakeholder acceptance of model outputs. Bayesian networks (see Section 6.1) and other models can also be developed in a participatory manner.

7.1. Mediated modelling

Mediated modelling (MM) uses computer model building as a tool for deliberation and mediation. Resulting recommendations can be in the form of proposed investigations, joint fact-finding or research, or initiation of a focused collaboration or policy advice (van den Belt 2004).

System dynamics is the underlying approach of MM. Facilitators use software (*e.g.* STELLA[11]) with a user-friendly graphical interface to describe elements of a complex system and how they are interconnected, as understood by the participants (see example in Figure 8). Participants decide the nature of effects between two elements, which can take a wide variety of functional forms, and they jointly scope for inter-connections, feedback loops and time lags that explain the behaviour of the system. Participants' perspectives are enhanced with available data that they determine to be relevant. Knowledge gaps become clear. In this way, MM assists in scoping for scenarios and pathways connecting the past, current actions and future outcomes.

[11] http://www.iseesystems.com/

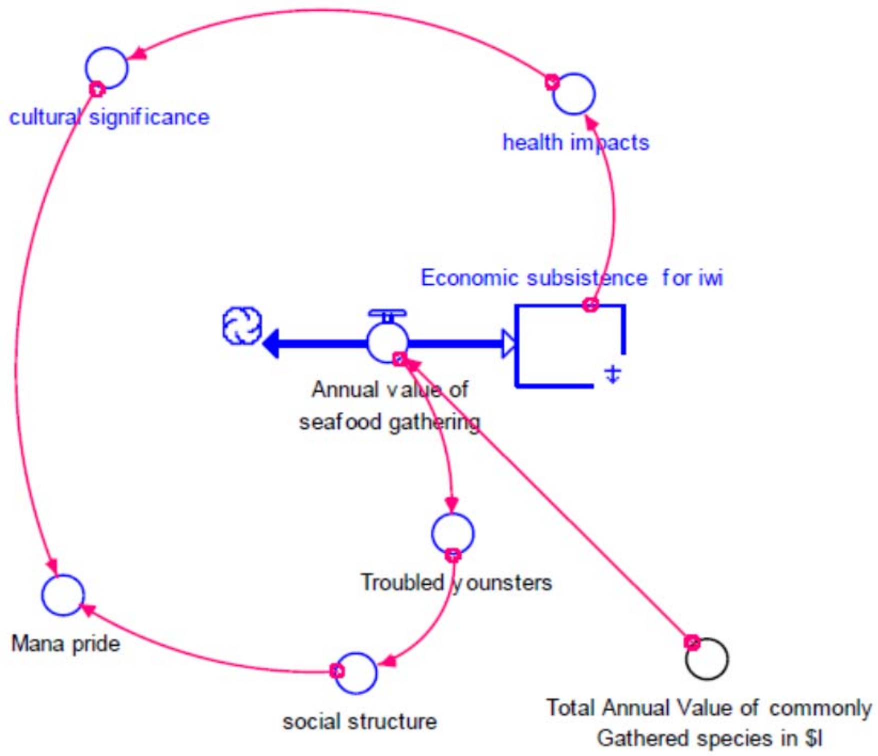

Figure 8. Causal diagram of effects of loss of kaimoana, part of a mediated model of Tauranga Harbour (van den Belt *et al.* 2012)

It was noted by van den Belt *et al* (2012):

> *No two MM processes are alike because the starting position and composition of each group are different. Before a MM process is undertaken, an initial stakeholder analysis is recommended to establish the level of contention, the level of past interaction of the members, how the group is perceived by non-participating stakeholders, and to search for people holding different perspectives (van den Belt et al. 2012, p 6).*

The main characteristics of a mediated model process include:

- Constructed by 10–30 stakeholders open to collaboration and mutual learning
- Employs software that is easy to understand
- Used for understanding rather than prediction
- Used early on in the process
- Flexible and easily adjustable over time
- Synthesises information to guide further analysis (van den Belt 2011).

An MM process conducted for Tauranga Harbour by the Manaaki Taha Moana research team has been described as follows:

> *…parts of participants' stories are interpreted by the facilitator and simultaneously reflected onto a projected computer screen for all to see and comment on. The summarised narratives are used as a guideline for model building between workshops. Over the course of four workshops, a simulation model evolved, and a final scoping model was presented and simulated at the fifth and final workshop in May 2011. Participants shared both facts and perspectives about their understanding of the factors at play in the Harbour. Both facts (when available we interpreted those facts) and perspectives (when facts were not available) were used to create a story with which participants could agree and in which they could recognise a value. The resulting model is not a predictive model, but rather it is a framework to help interpret diverse information and trends (van den Belt et al. 2012, p 10).*

Mediated modelling has also been utilised in the Manawatu as part of the Integrated Freshwater Solutions research programme (van den Belt *et al.* 2013b; van den Belt *et al.* 2013a).

Uses of this tool

Mediated modelling is designed primarily as an aid to ***understanding*** of how a complex system works and for participants to gain better appreciation for each other's values and perspectives. As with Bayesian network models, the construction of the model can help to ***identify*** values of participants and can provide a mechanism to facilitate discussion about ***balancing*** values.

More information

van den Belt M, Schiele H, Forgie V 2013a. Integrated Freshwater Solutions — A New Zealand Application of Mediated Modeling. JAWRA Journal of the American Water Resources Association 49(3): 669–680.

van den Belt M, Bowen T, Slee K, Forgie V 2013b. Flood Protection: Highlighting an Investment Trap Between Built and Natural Capital. JAWRA Journal of the American Water Resources Association 49(3): 681–692.

van den Belt M, McAllion A, Wairepo S, Hardy D, Hale L, Berry M 2012. Mediated Modelling of Coastal Ecosystem Services: A case study of Te Awanui Tauranga Harbour. Manaaki Taha Moana Report No. 4, Massey University, Palmerston North.

8. RIVER VALUES ASSESSMENT SYSTEM

Recognising that some values are difficult to convert to a single metric, especially monetary, some researchers have instead used multi-criteria methods to assess freshwater values. The River Values Assessment System, or RiVAS, is a multi-criteria tool developed for assessing the relative significance (*i.e.* contribution) of rivers for particular uses and values (Hughey & Baker 2010; Hughey & Booth 2012). This method has been applied at a regional scale to ten different river values thus far, and an extension known as RiVAS-plus has been developed to compare the restoration potential of rivers for a particular value (Hughey *et al.* 2011).

RiVAS involves the identification and assessment by experts of attributes, *e.g.* components or indicators of value. While questions have been raised about the inherent assumption of RiVAS, *i.e.* that the processes that produce the value are the same across space and time (Tadaki & Sinner 2014), the methodology has been utilised by a number of regional councils to aid in the identification of freshwater management priorities; see Table 5.

Using RiVAS, an expert group assesses rivers within a region or other geographic area for their significance for a particular value, which requires weighting the importance of the various attributes of that value as identified by the expert group (Hughey & Baker 2010). However, RiVAS does not provide for comparison between the significance of one value (*e.g.* native fish or natural character) with another (*e.g.* tangata whenua values or irrigation). If a river is assessed to have 'nationally significant' native fish and 'regionally significant' irrigation, it cannot be said that native fish should take priority as a management objective over irrigation, because these values are not cross-calibrated in any way.

Table 5. Applications of the River Values Assessment System (RiVAS) in regions of New Zealand.

RiVAS value	Region
Salmonid angling	Tasman, Hawke's Bay, Gisborne
Native fish	Gisborne, Hawke's Bay, Northland
Native birds	Canterbury, Hawke's Bay, Tasman, Gisborne
Natural character	Marlborough, Hawke's Bay, Tasman, Gisborne, Northland
Kayaking	West Coast, Tasman, Hawke's Bay
Irrigation	Canterbury, Tasman, Hawke's Bay, Gisborne
Swimming	Manawatu-Wanganui, Tasman, Gisborne, Hawke's Bay, Northland
Māori cultural values	Southland
Water for domestic purposes	Gisborne
Hydro-electric generation	Tasman — in draft

To enable comparison across values, some multi-criteria tools provide for explicit weighting of different objectives, so that an overall score can be calculated and a preferred option identified (Lennox *et al.* 2011). While intuitively appealing, this simply transfers a debate over competing values into a debate over weights, and does not actually provide a scientifically robust method of comparing values. It also reduces the complex and perhaps diverse notions of 'value' being measured into a single (and perhaps contestable) representation by a few indicators (Tadaki & Sinner 2014). For example, in discussing a RiVAS assessment of angling, some stakeholders contested the inclusion of the proportion of international anglers as relevant for assessing the angling value of a river (Sinner *et al.* 2012). Far from being technical decisions, the creation and choices of criteria and indicators are political in the sense that they promote certain ideas about what is desirable for a community.

Uses of this method

RiVAS is designed for ***identifying*** the location of and ***assessing*** the significance of specific uses and values of rivers. An assessment of one value can be done in a day by a group of experts. Experts who have participated report increased ***understanding*** of values. Some stakeholders challenge the definition of categories and others contest assumptions and weightings.

More information

Multiple examples on Lincoln University web page for RiVAS:
http://www.lincoln.ac.nz/Research-Centres/LEaP/Environmental-Management--Planning/projects/prioritising-river-values/

9. ECONOMIC VALUATION TECHNIQUES

9.1. Economic value frameworks

Total economic value (TEV) and cost benefit analysis (CBA) are not so much methods or tools as they are frameworks for assembling and comparing information in a logical and consistent way. Both rely on a range of methods from economics to estimate benefits and costs, which can be thought of as changes in value arising from an action, policy or externally driven event. The ecosystem services paradigm provides another way of categorising and compiling information about the total economic value (including costs and benefits) from natural systems. Kumar *et al.* (2010) provide a detailed discussion of the ecosystem services framework and considerations for applying economic valuation tools to it.

Economic tools can be useful for accounting for aspects of value that are well-bounded (and thus not prone to over-lapping definitions and double-counting) and reasonably stable (and thus not dependent on the policy context or how the question is asked). For example, the value of a horticultural crop in a specific area is well-defined and, while subject to market fluctuations, can be estimated with well accepted methods. In contested freshwater environments, however, we would not recommend attempting to account quantitatively for all aspects of total economic value because, for many of the things that are important to people, these two requirements are not met. For example, the importance to people of habitat that supports native fish populations cannot be captured by simply estimating a harvestable quantity of whitebait and assigning it a monetary value per kilogram.

9.2. Total economic value

The TEV framework (Figure 9) is a well-structured way to identify and categorise all aspects of value that a system provides (Pascual *et al.* 2010). This framework has two components: 'use value' and 'non-use value'. Use value is derived from direct and indirect use of resources (*e.g.* freshwater) as well as value derived from having the option to use the resources in the future. Use value derives from things that are bought and sold (and hence can be valued based on market prices) (see Section 9.2) and from things that are not, for which value can be estimated using non-market valuation methods (see Sections 9.6 and 9.7).

People derive non-use values from simply knowing that a resource exists (existence value[12]), or because they wish to leave it to future generations (bequest value) (ibid.). Non-use values can also be estimated using non-market valuation techniques.

[12] Although economics typically uses an anthropogenic frame of reference, existence value can also be interpreted as including the intrinsic value that something has irrespective of its utility to humans. Truly intrinsic values cannot be quantified in monetary terms, since that again implies utility to humans. It is sometimes

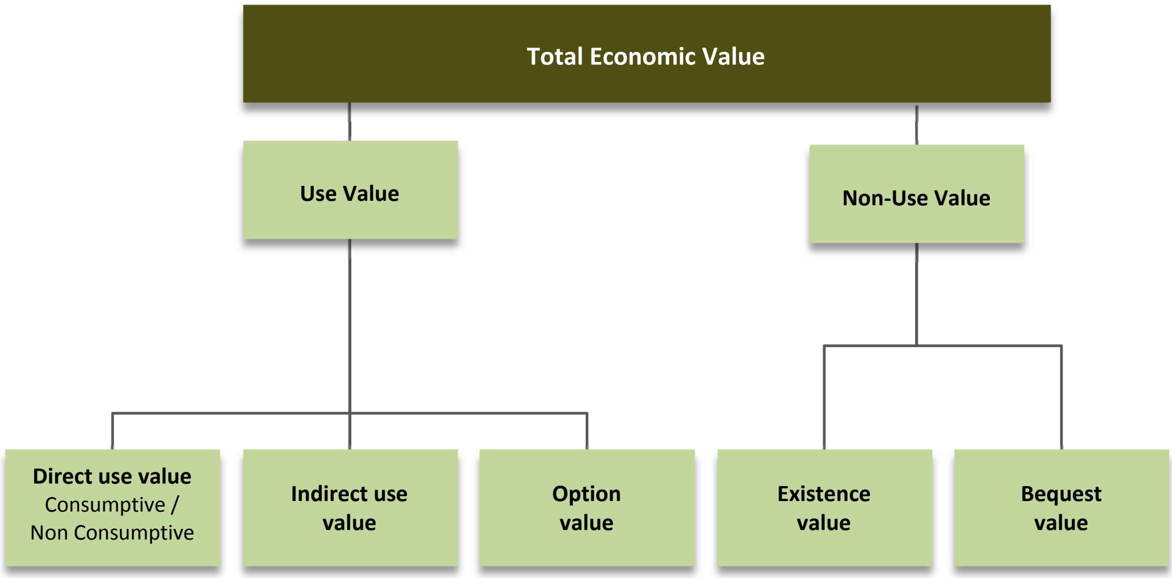

Figure 9. Components of total economic value (TEV) (adapted from Pascual *et al*. 2010).

In principle, the TEV framework offers a tidy, logically coherent approach to considering freshwater values and therefore choosing between alternative management objectives. Apart from the wider question of whether all values are reducible to commensurable quantification, the main challenge lies in estimating the different components and in avoiding double counting, as the real world does not always conform to the neat categories in TEV.

As noted above, it is generally the change in value arising from a policy intervention that is of interest, rather than any estimate of TEV. So, in applying the TEV or other framework such as ecosystem services, the analyst needs to estimate the likely change in each component value due to a policy alternative relative to a counterfactual, *e.g.* compared to what would happen in a 'do nothing' scenario.

Uses of this tool

The TEV framework can be used for categorising values as an aid to ***identifying*** and ***assessing*** them. It does not identify values per se, but prompts the user to consider what values need to be accounted for so that they can then be assessed using specific valuation methods.

argued that concept of intrinsic value still involves projection of value by humans onto another object (Brennan 2008, Dietz 2005). Nonetheless, whether such values are projections by humans or truly intrinsic, they can be recognised (if not necessarily quantified) in the TEV framework and included as existence values.

9.3. Ecosystem services framework

Ecosystem services are "the direct and indirect contributions of ecosystems to human well-being" (de Groot *et al.* 2010, p 25). Like Total Economic Value (TEV), the concept of ecosystem services offers a framework for identifying and classifying values. And like TEV, the ecosystem services framework is anthropocentric – it concerns benefits to humans. The ES framework aims to identify ecosystem functions that underpin human life, and our social and economic and cultural well-being, yet are often take for granted and overlooked.

The ES framework used by the Millennium Ecosystem Assessment (2003) is among the most commonly used, and has four categories of services:

1. Provisioning services: Products obtained from ecosystems, including food, fresh water, fuel wood, fibre, biochemicals and genetic resources.
2. Regulating services: Benefits gained from regulation of ecosystems processes, *e.g.* climate regulation, disease regulation, water regulation, and water purification.
3. Cultural services: Non-material benefits obtained from ecosystems.
4. Supporting services: Services necessary for the production of all other ecosystem services, *e.g.* soil formation, nutrient cycling, and primary production (*i.e.* photosynthesis) (MEA 2003, p.5).

The Millennium Ecosystem Assessment (2003, p. 38) cautions that "These categories overlap extensively, and the purpose is not to establish a taxonomy but rather to ensure that the analysis addresses the entire range of services." For instance, the category of cultural services has been the subject of some discussion in the literature, with some arguing that it is not well defined. Many cultural services, for example, are inextricably related to other services, such as 'provisioning'. A good example is *mahinga kai* — the significant cultural services provided by customary food gathering sites cannot be separated from the provisioning services that these ecosystems provide. Furthermore, if the intent is to measure and value the ES the services from a particular ecosystem, supporting services should be recognised but not separately valued, because their value would be included in the value of the other services. Thus, considerable care must be taken in defining, categorising, measuring and valuing ecosystem services.

A more recent work, The Economics of Ecosystems and Biodiversity (TEEB), adopts a similar classification system. However in this system 'supporting services', which are seen as a subset of ecological processes, are replaced with 'habitat services' such as maintenance of life cycles of migratory species and maintenance of genetic diversity (de Groot *et al.* 2010).

In New Zealand there have been few attempts to describe, measure and value freshwater systems in terms of their ecosystem services. Clarkson *et al.* (2013) describe the ecosystem services of wetlands and cite monetary values per hectare from other studies, following a slightly different classification proposed by de Groot *et al.* (2010). Schallenberg *et al.* (2013) describe some of the ecosystem services of lakes and trends in the ecological status of New Zealand lakes. Table 6 summarises the ecosystem services identified in these two studies, and shows that some things have been classified differently. For example, the wetlands study classifies recreation and tourism as cultural services, but the lakes study classifies them as both provisioning services and cultural services. Schallenberg *et al.* (2013) also present a case study of Lake Ōmāpere, a shallow lake in Northland, comparing the ecosystem services likely to be provided by the lake under different states of ecological impairment. Kumar *et al*. (2010, p 385) present a brief case study of the valuation of ecosystem services of the River Murray in Australia, in which recreation and tourism and food production dominate.

Table 6. Ecosystem services of wetlands and lakes.

ES category	Wetlands (Clarkson *et al.* 2013)	Lakes (Schallenberg *et al.* 2013)
Provisioning	Food, fresh water, raw materials, genetic resources, medicinal resources, ornamental resources	Drinking water, fisheries, waterfowl, recreation and tourism
Regulating*	Influence on air quality, climate regulation, moderation of extreme events, regulation of water flows, waste treatment, erosion prevention, maintenance of soil fertility, pollination, biological control	Nutrient and sediment processing (including filtering of water and sediment stabilisation), sequestration, and hydrological regulation
Habitat/Supporting	Life cycle maintenance, gene pool protection	
Cultural	Aesthetic, recreation/tourism, inspiration (for culture, art, design), spiritual experience, cognitive information	Recreation and tourism, fisheries, waterfowl

* Schallenberg *et al.* reported Regulating Services and Supporting Services together.

Uses of this tool

Like TEV, ES can be used as a prompt to help **identify** all of the important ways in which one or more ecosystems support human well-being, in order that these can all be taken into account when management options are formulated and considered. The ES framework also helps communities and decision-makers to **understand** how and why values are important and, in combination with other methods (*e.g.* economics) can assist in the **assessment** and **balancing** of values. While much of the ES literature is oriented towards economic valuation, ecosystem services can also be described, assessed and balanced using non-monetary methods described elsewhere in this report.

More information

Kumar P (Ed.) 2010. The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. London: Earthscan.

Millenium Ecosystem Assessment 2003. Ecosystems and Human Well-Being: A Framework For Assessment. Washington, DC: Island Press.

Clarkson BR, Ausseil A-GE, Gerbeaux P 2013. Wetland Ecosystem Services. In J. Dymond (Ed.), Ecosystem Services in New Zealand (pp. 192-202). Lincoln, NZ: Manaaki Whenua Press.

Schallenberg M, de Winton MD, Verbury P, Kelly DJ, Hamill KD, Hamilton DP 2013. Ecosystem Services of Lakes. In J. Dymond (Ed.), Ecosystem Services in New Zealand (pp. 203-225). Lincoln, NZ: Manaaki Whenua Press.

9.4. Cost benefit analysis

Methods for choosing between alternative management options vary in the extent to which all relevant costs and benefits are incorporated, the metric used for their measurement, and the way time is treated. Cost benefit analysis (CBA) is a systematic method for identifying, valuing, and comparing costs and benefits of alternative options (*e.g.* projects, policy) where benefits and costs are typically described in economic or financial terms (Buncle *et al.* 2013).

Costs and benefits are defined as changes in the value relative to a counterfactual situation. Thus, by definition, CBA considers marginal values rather than total value of a system. Cost benefit analysis is based on the fundamental principles of welfare economics and is comprehensive in the inclusion of costs and benefits. By quantifying costs and benefits in financial terms, and discounting, it is possible to estimate the net benefits (or costs) of a project or policy in today's dollars (NZ Treasury 2005). CBA follows a logical and systematic sequence but still allows for flexibility in choice of tools.

Methods for estimating the value of goods or services that are bought and sold in the economy are described briefly in Section 9.5, while the methods described in Sections 9.6 and 9.7 can be used for 'non-market' goods and services.

Where estimation of non-market goods and services is not appropriate or not feasible due to time or budget constraints, or due to philosophical objections, the relevant costs and benefits should be described as precisely as possible in other quantitative terms, *e.g.* how many people, hectares, kilometres of streams, animals, plants etc. would affected in a certain way. A decision-maker can then decide if the non-monetised costs and benefits are sufficiently large to outweigh any difference in the net benefits estimated in monetary terms.

For example, consider two options where the projected net benefits of Option A and Option B (relative to a 'do nothing' option) are $10 million and $15 million respectively. If Option A has a number of additional benefits that have not been monetised, the decision-maker can be advised to choose Option A if they consider the additional benefits worth at least $5 million.

9.4.1. Case study: Preliminary cost-benefit analysis of National Environmental Standard for on-site wastewater systems

Covec (2007) identifies the costs and benefits that would be likely to arise from the proposed National Environmental Standard (NES) for on-site wastewater systems. They assessed two options:

1. All on-site wastewater systems used by private domestic dwellings to be subject to warrant of fitness (WOF) inspections.
2. On-site wastewater systems require WOF inspections only for households within specific defined areas (hotspots).

The analysis concluded that, for the first option, the costs were likely to outweigh the benefits, while the reverse was true for the second.

Quantified costs included administrative costs, inspection costs, compliance costs (costs of bringing the septic systems up to requirement), and additional repair and maintenance costs. Benefits included reduced drinking water contamination, reduced contamination of shellfish, reduced contamination of ground surface or surface water above or adjacent to some on-site systems and reduced discomfort from gastro-intestinal and other diseases.

Benefits identified but not quantified in this study include greater use of recreational areas that are prone to contamination, such as some beaches, rivers and lakes, reduced impacts on New Zealand's international reputation for a clean environment and natural beauty, and reduced likelihood of harvesting bans for shellfish.

Uses of this tool

Cost-benefit analysis (CBA) is best used for ***assessing*** and ***balancing*** values when the values have been clearly identified and are not too numerous, there are a limited number of distinct alternatives, and most of the values can appropriately be quantified in financial terms.

More information

Buncle A, Daigneault A, Holland P, Fink A, Hook S, Manley M 2013. Cost-Benefit Analysis for Natural Resource Management in the Pacific: A Guide. Available online:

http://www.cepf.net/SiteCollectionDocuments/poly_micro/CostBenefitAnalysisNaturalResourceManagementPacific.pdf

Covec 2007. Preliminary cost-benefit analysis: National Environmental Standard for On-site Wastewater System. Prepared for Ministry for the Environment. Available online at: http://covec.co.nz/wp-content/uploads/NES-Preliminary-CBA.pdf

Moore D, Black M, Valji Y, and Tooth R. 2010. Cost benefit analysis of raising the quality of New Zealand networked drinking water. Available online at: http://www.srgexpert.com/cba-raising-quality-of-networked-drinking-water-jun2010[1].pdf

New Zealand Treasury 2005. Cost-Benefit Analysis Primer. Available online at: http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/primer

TEEB 2009. The Economics of Ecosystems and Biodiversity for National and International Policy Makers. Available online at: http://www.teebweb.org/wp-content/uploads/Study%20and%20Reports/Reports/National%20and%20International%20Policy%20Making/TEEB%20for%20National%20Policy%20Makers%20report/TEEB%20for%20National.pdf

9.5. Valuing market goods and services

Much of what people value is bought and sold in the economy, and the ongoing processes of supply and demand result in the prices that people pay for goods and services. This applies to food, fibre, fuel, housing and commercial tourism activities, to name just a few. Prices for these things can be used as indicative of their value in the economy.

However, despite the fact that prices are often readily available, estimating the change in market value in response to a change in policy is far from straight forward, for a number of reasons:

- Price multiplied by quantity equals revenue, but value is more accurately interpreted as profit, *i.e.* revenue less the cost of inputs. The total amount paid to labour and management is another way of defining economic value.
- Changes in water management can affect the production of many different goods and services in a given locality. Prices and quantities produced for all of these goods and services might not be readily available (*e.g.* there might be several varieties of apples and growers might get premiums or discounts for quality), and how these prices and quantities would change due to a change in policy can be difficult to predict.

- Different farms, even in the same sector, have different production and cost functions due to differences in soils, climate, levels of prior investment, skills and lifestyle objectives. The same change in output can thus have very different impacts on profits of two farms in the same sector.
- External factors such as global prices, climate and exchange rates can interact in unpredictable ways with the local effects of policy. How farms and businesses respond to global factors will have significant implications for the effects of local policies. The expansion in dairy farming in New Zealand over the past two decades is a prime example of this.

In a freshwater planning context, questions about economic effects of policy change usually concern the likely financial impacts on groups of businesses of a similar type (*e.g.* horticulturalists, dairy farmers, electricity generators, tourism operators, manufacturing plants) or on the economy as a whole (often in a defined region or district). Analysis typically involves identifying a representative enterprise for a given sector, developing an enterprise budget, and estimating the relationship between inputs, costs, output and discharges. Accessing financial records of individual enterprises can pose confidentiality issues; one solution is to use consultants who are familiar with a range of businesses in a sector and can describe 'representative' enterprises (Greenhalgh *et al.* 2013)[13], though this is not an option when there is only one large enterprise of a certain type in the district. Such firms will often provide their own estimates of how policy would affect them, although such estimates might well be questioned.

Scaling up estimated values to a catchment or district level poses other challenges. Catchments contain a mix of land uses, soil types, and climates. Each combination of these will have different practices with different implications for profitability, water quality and water use. Other types of enterprises will vary in other respects, such that a representative enterprise is not likely to be an accurate model of any particular business. The trick is to develop a set of representative enterprises to reflect as much diversity as possible (*e.g.* an apple orchard, a vineyard, a dairy farm, a sheep and beef farm, and a rafting business) within time and budget constraints.

A range of catchment economic land-use models can be useful to answer this question. Most models have been developed for specific catchments but are relatively easy to modify for other catchments. Some of the more common ones, NZFARM[14], N-Manager[15], ARLUNZ[16], and MAS[17], have been developed to answer different questions, to model different policies, and to work at different levels of detail. As a

[13] The remainder of this section draws extensively on Greenhalgh *et al.* 2013.
[14] http://www.landcareresearch.co.nz/science/soils-and-landscapes/ecosystem-services/nzfarm
[15] http://www.motu.org.nz/files/docs/resources/NManager_overview_final.pdf
[16] http://purl.umn.edu/124973
[17] Schilling, Chris; William Kaye-Blake; Elizabeth Post and Scott Rains. 2012. "The Important of Farmer Behaviour: An Application of Desktop MAS, a Multiagent System Mode for Rural New Zealand Communities," NZARES Annual Conference, New Zealand Agricultural & Resource Economics Society.

result these models include different assumptions, use different data, and apply different methodologies. The 'best' model will likely depend on the complexity of the policies being considered as well as the time and resources available.

One of the concerns of any policy is how it will affect the local economy. Policy not only has a direct impact on some enterprises but also has indirect effects on other businesses and households. For example, a policy may lead some farmers to convert land from pasture to forest. As a result, they produce fewer animals. This could reduce throughput at the local meat processing plant, leading to layoffs and possibly consolidation in the industry. Depending on how many people are employed in forestry and where they live, total employment could fall, fewer people might eat at local restaurants, school rolls could fall, and so on.

Analyses of these indirect effects typically use a multiplier approach to determine the estimated impact of policy. With water limits, for example, changes in land-use and/or input use resulting from a policy can be used to estimate the broader effects on employment and income. Ideally, land-use and input changes would be derived from catchment land-use analysis as suggested above. For example, a policy that induces a significant change in land use or land management may result in a large change in the quantities of farm outputs (*e.g.*, milk, meat, or timber), thereby affecting the number of personnel and skills required both on-farm and in the regional processing plants. The ARDEEM[18] input-output model of the Auckland regional economy was developed to estimate these kinds of effects.

Care should be taken in using estimated changes from input-output models, for several reasons. Input-output models are typically static in the sense that they assume fixed relationships between jobs and output in one sector with jobs and output in another sector. In reality, these relationships change, sometimes quite quickly, in response to changing prices or technology or the composition of the local economy. If the economy is strong and unemployment is low, indirect effects tend to be short-lived as people take up new jobs or move to other regions while others move in to take up new opportunities, but this will often not be picked up in input-output models. Furthermore, changes in revenue should not be equated with changes in value as experienced by the local community. Total output in a sector might fall by $1 million, but there may be a corresponding reduction of $800,000 in inputs purchased from outside the region (perhaps from outside New Zealand), so the reduction in value is really $200,000, not $1 million.

Uses of this tool

Market valuation is a broad term for a range of methods for ***assessing*** the economic value of goods and services that are bought and sold, *e.g.* as a component of cost benefit analysis.

[18] http://tools.envirolink.govt.nz/dsss/auckland-regional-dynamic-ecological-economic-model/

9.6. Revealed preference methods

9.6.1. Productivity Change Approach

The Productivity Change Approach (PCA) is a method that focuses on the relationship between a particular ecosystem service and the production (yield) of a marketed good where the ecosystem service in question is considered as an input to the production process of the good. This method can be used to measure actual change or, when coupled with production simulations, the likely impacts of possible interventions. It can be used to measure provisioning services (*e.g.* provision of freshwater for irrigation and some regulating services (*e.g.* water purification). This method assumes that the value of the ecosystem service (*e.g.* provision of water for irrigation) is equal to the change in revenue or profit of the marketed good caused by the change in that ecosystem service.

The PCA has been used to value the food provisioning and regulating services generated through soil organic matter recovery in three contrasting New Zealand soil orders (Sparling *et al.* 2006).

More information

Sparling G P, Wheeler D, Vesely E-T, Schipper LA 2006. What is soil organic matter worth? Journal of Environmental Quality 35: 548–557.

9.6.2. Travel Cost Method

The Travel Cost Method (TCM) uses the cost of traveling to and participating in an activity at a distant site to derive estimates of the value of the site. The key assumption is that people consider the money and time costs of travel to a site in the same way as an admission fee. The values of ecosystem services are captured by TCM to the extent they can be represented as factors that influence a person's decision about where to travel or how often to travel to a given site. For example, the quality of water and the state of river banks would influence a person's decisions about whether or how often to visit a river site for recreation.

This method has been used to value water-based recreation in New Zealand. Kerr *et al.* (2004) used TCM to value Rakaia River angling in Canterbury while McBeth (1997) used TCM to value the trout fishery in the Tongariro River.

More information

Kerr GN, Sharp BMH and Leathers KL 2004. Instream Water Values: Canterbury's Rakaia and Waimakariri Rivers. Research Report No. 272, Lincoln University. https://researcharchive.lincoln.ac.nz/bitstream/10182/734/1/aeru_rr_272.pdf

McBeth R 1997. The recreational value of angling on the Tongariro River. Non-market valuation using the travel cost method and contingent valuation method. Thesis submitted for Master of Arts, Department of Geography, University of Auckland.

9.6.3. Hedonic pricing

Hedonic pricing (Rosen 1974) uses property or land prices to estimate the economic value of associated attributes that affect property or land prices, *e.g.* size of the land area, distance to amenities, availability of water for irrigation. The sale price or value of land or property with different attribute qualities is assessed using statistical regression analysis. The basic assumption is that, all other attributes being equal, higher quality attributes translate into higher property values. For this to be true there needs to be an open and competitive market for property or land.

Hedonic pricing, for example, can be used to value water quality in a stream by analysing property price differences and controlling for all other property attributes. Grimes and Aitken (2008) used hedonic pricing method to value water consents for irrigation in drought prone Mackenzie District. Samarasinghe and Greenhalgh (2013) used the inherent characteristics of soil and land valuation data to examine the relationship between soil characteristics and rural farmland values in the Manawatu catchment.

More information

Grimes A, Aitken A 2008. Water, Water Somewhere: The Value of Water in a Drought-Prone Farming Region, Motu Working Paper 08-10.

Rosen S 1974. Hedonic prices and implicit markets: product differentiation in pure competition. Journal of Political Economy 82: 34–55.

Samarasinghe O, Greenhalgh S 2013. Valuing the soil natural capital – a New Zealand case study. Soil Research 51(4) 278-287. http://dx.doi.org/10.1071/SR12246.

9.6.4. Replacement Cost Approach

The Replacement Cost Approach estimates the monetary value of ecosystem services based on the costs of substitutes, *i.e.* market goods and services that can be used for replacing or restoring damaged ecosystem services to their original productivity levels. This is sometimes called the Provision Cost Approach. DOC (2006) used Replacement Cost Approach to value the provision of water in the Te Papanui catchment in the Otago region. The study found that the cost to provide water from somewhere else for drinking, hydro-electricity generation and irrigation would be substantial. The approach was also used to measure the value of clean drinking water provided by the Catskill watershed in New York City by estimating the cost to construct and maintain a water filtration plant (Chichilnisky & Heal 1998).

More information

Chichilnisky G, Heal G 1998. Economic returns from the biosphere. Nature 391: 629–630.

DOC (New Zealand Department of Conservation) 2006. The value of conservation: what does conservation contribute to the economy? URL: http://www.doc.govt.nz/upload/documents/conservation/value-of-conservation.pdf (accessed 9 June 2014).

Uses of these methods

Revealed preference methods (productivity change, travel cost, hedonic pricing and replacement cost) can be used for ***assessing*** values when features of a site strongly influence financial decisions by households or businesses, or provide ecosystem services that could be substituted by purchased services. Estimates can be included as a component of cost benefit analysis. Advice is required from experts trained in these methods.

9.7. Stated reference methods

9.7.1. Contingent Valuation Method

Contingent Valuation Method (CVM) can be used to estimate how people value changes in certain ecosystem services by directly questioning a sample of the population. These changes, and the markets in which they are to be valued, are based on hypothetical situations or scenarios. This method typically involves surveying a sample designed to be representative so that the results can be scaled to derive a value for the total population.

Creagh (2010) used a CVM survey of urban water consumers to elicit willingness to pay for water-related ecosystem goods and services in Auckland and Christchurch. To value the maintenance of Christchurch river flows, Kerr *et al.* (2003) conducted a survey of Christchurch householders. The study calculated people's willingness to pay to avoid reduced water flows and levels in rivers and wetlands and also to avoid the possibility of eventual restrictions on water use.

More information

Creagh K 2010. Value and price: A transdisciplinary approach to ecologically sustainable urban water management. Thesis, PhD, University of Auckland, January 2010 https://researchspace.auckland.ac.nz/bitstream/handle/2292/5886/whole.pdf?sequence=9

Kerr GN, Sharp BMH, White P 2003. The economics of augmenting Christchurch's water supply. Journal of Hydrology (New Zealand): 42(2). 113–124

9.7.2. Choice modelling

In choice modelling (or discrete choice experiments [DCE]), individuals are asked (via survey techniques) to choose from alternatives for a site or resource, based on a number of attributes. Attributes of most relevance are identified using focus groups and pilot studies, and a monetary attribute is generally added to enable estimates of economic value. Each respondent makes several choices and from the resulting data, statistical methods are used to estimate the monetary value of a change in each of the attributes.

Marsh and Phillips (2012) conducted a choice modelling survey of residents in the Canterbury region, to calculate the willingness to pay for improved water quality in the main rivers and tributaries. Kerr and Sharp (2003) applied this method and surveyed a sample of respondents to identify community willingness to trade-off stream attributes in Auckland. Stream attributes included in the study were water clarity, flow of water, quality of the stream bank, access, safety, surrounding land use, natural shape of the stream and habitat for wildlife. Batstone and Sinner (2010) used choice modelling to look at community preferences for the coastal marine environment, with a focus on effects of stormwater on ecological health, water clarity and underfoot conditions. Sinner *et al.* (in review) did a choice modelling study in the Tasman district in parallel with a collaborative stakeholder group process. However, as the group was not directly involved in the study, they questioned the validity of the results, which highlights the importance of involving end-users in design of such a study.

As noted in Section 2.2, values are often constructed in context rather than pre-formed and stable, calling into question the validity of survey-based techniques for eliciting values. In response to these issues, a number of practitioners have added a deliberative component to valuation studies, but these attempts at 'deliberative monetary valuation' (DMV) have lacked a consistent theoretical basis. Rather than resolving challenges to non-market valuation techniques, many DMV studies have seen practitioners using deliberative methods to manipulate responses to fit their models. Others suggest that a more appropriate conclusion from the difficulties encountered by these studies is that there are multiple ways that environmental values can be conceptualised and articulated, and not all can be summarised in a single monetary value (Spash 2008; Lo & Spash 2013).

This critique is not meant to invalidate a monetary construction of value, or more generally the concept of value as a magnitude of preference. Clearly, these are meanings of value that must be recognised in freshwater planning. Markets provide a robust mechanism for assigning a value to goods and services that are actively traded, and these are important considerations for decision-making about how we use and enjoy the natural environment. Likewise, some ecosystem services can be valued using techniques that are reasonably robust — such as estimating the marginal cost of substituting for a good or service that nature currently provides for free, *e.g.* treating drinking water if a natural water supply becomes contaminated. But even in this example, there are aspects of the value of an untreated water supply that exhibit the characteristics described above — not well defined, unstable, dependent upon context and therefore not amenable to quantification.

In some cases, accounting for the types of value that can be quantified in monetary terms will suggest a clear direction for decision-makers considering alternative management scenarios. We simply want to highlight here that a monetary or quantified construction of value must not be seen as the only way to understand what people mean by freshwater values.

Uses of these methods

Stated preference methods (contingent valuation and choice modelling) can be used for ***assessing*** the value of a site or resource when it has significant aspects of value that are not reflected in market behaviour. Stated preference methods are most suitable when values are clearly bounded, well-formed and stable, *i.e.* not likely to be influenced by how or by whom a question is asked. Estimates of value from these methods can be included as a component of cost benefit analysis.

More information

Batstone C, Sinner J 2010. Techniques for evaluating community preferences for managing coastal ecosystems. Auckland region stormwater case study, discrete choice model estimation. Prepared by Cawthron Institute for Auckland Regional Council. Auckland Regional Council technical report, TR2010/012. Available online: http://www.cawthron.org.nz/publication/science-reports/techniques-evaluating-community-preferences-managing-coastal-ecosystems/

Kerr GN, Sharp B 2003. Community mitigation preferences: A choice modelling study of Auckland streams. Lincoln University, research report no.256

Marsh D, Phillips Y 2012. Which Future for the Hurunui? Combining Choice Analysis with Stakeholder Consultation. Department of Economics Working Paper in Economics 17/12. University of Waikato, Hamilton.

9.8. Benefit transfer methods

Benefit transfer involves the application (or transfer) of values obtained by one or more previous studies (‘study sites’) to a similar context for the project / policy of interest (‘policy site’). In other words, it is the reuse of existing valuation estimates in another context. Benefit transfer is often used when budget and / or time constraints preclude an original valuation study. There are two main variants of benefits transfer.

Unit value transfer uses values for ecosystem services at a study site, expressed as a value per unit (usually per unit of area or per beneficiary). This is combined with information on the quantity of units at the policy site to estimate policy site values. Unit values can be adjusted to reflect differences between the study and policy sites (*e.g.* income and price levels).

Value function transfer uses a function estimated for a study site in conjunction with information on parameter values for the policy site to calculate the value of an ecosystem service at the policy site. This approach accounts for differences in characteristics of the two sites and their populations.

The use of benefit transfer is widespread but it requires careful application. Benefits transfer methods are subject to both measurement errors of the primary study and errors related to the transfer process. The acceptable level of error will depend on the risk aversion of those using the information (*i.e.* policy decision-makers), the relative uncertainty of other data used in the economic analysis, and the costs of conducting an original study (Johnston & Rosenberger 2010).

Bateman *et al.* (2010) suggests validation of the benefits transfer by ensuring:

- the source valuation studies are of sufficient quality
- similarity of good or service in the source studies to the new context (including the nature of the good or service and its quality and quantity)
- similarity of the contexts (*e.g.* characteristics of the site and the population, accessibility of the good or service, availability of substitutes and capacity, income constraints of the population)
- relevance of the source study explanatory variables and their value range to the new context
- the value function is consistent with economic theory.

In a recent study, researchers collected primary data in two sites in England using three different methods (travel cost and two types of contingent valuation) to estimate the benefits of water quality improvements that could be realised due to the European Water Framework Directive (Ferrini *et al.* 2014). They found that the results from contingent valuation were more suitable for benefit transfer than the travel cost method, with transfer errors less than 20% using both unit value transfer and function transfer.

Valuation databases can help to identify economic valuation studies suitable for the benefit transfer method. Examples include the New Zealand Non-Market Valuation Database (http://www2.lincoln.ac.nz/nonmarketvaluation/) and the Environmental Valuation Reference Inventory (www.evri.ca). The valuation database developed and maintained by Earth Economics (www.esvaluation.org/serves.php) contains over 44,000 papers and abstracts.

Danne *et al.* (2013) used benefit transfer method to analyse the impacts of possible changes to water quality on non-market water values in Southland. Baskaran *et al.* (2010) used estimated values of selected ecosystem services associated with wine-growing from a choice experiment in Marlborough and Hawke's Bay to test validity of benefit transfer method. Kerr and Woods (2010) applied value transfer method to estimate the magnitude of New Zealand recreational big game hunting benefits.

Uses of these methods

Like stated preference methods, benefit transfer can be used for ***assessing*** the value of a site or resource when it has significant aspects of value that are not reflected in market behaviour. Considerable care should be taken in transferring a value estimate from one site to another, as differences in the two sites are likely to mean the real value in the policy site (*i.e.* the site of policy interest) may vary considerably from the value in the study site.

More information

Baskaran R, Cullen R, Colombo S 2010. Testing different types of benefit transfer in valuation of ecosystem services: New Zealand winegrowing case studies. *Ecological Economics* 69(5): 1010–1022.

Bateman I, Brouwer R, Cranford M, Hime S, Ozdemiroglu E, Provins A 2010. Valuing environmental impacts: practical guidelines for the use of value transfer in policy and project appraisal. Available online at http://archive.defra.gov.uk/environment/policy/natural-environ/using/valuation/documents/technical-report.pdf

Brander LM 2013. Guidance manual on value transfer methods for ecosystem services. United Nations Environment Programme.

Denne T, Hoskins S, Webster G, Jowett I 2013. Non-Market Water Values in Southland. Prepared by Covec for Ministry for the Environment. http://www.mfe.govt.nz/issues/water/freshwater/supporting-papers/non-market-water-values-southland.pdf

Kerr GN, Woods A 2010. New Zealand Big Game Hunting Values: A benefit transfer study. Land Environment and People Research Report No. 23, Lincoln University. http://researcharchive.lincoln.ac.nz/bitstream/10182/2739/1/LEaP_rr_23.pdf

9.8.1. InVEST: Integrated Valuation of Ecosystem Services and Trade-offs

InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) is a specific tool for performing benefit transfer. It is a suite of ecosystem service models developed by the Natural Capital Project to map and value ecosystem services and it is most effectively used within a decision-making process that starts with stakeholder consultations.

InVEST models are based on production functions that define how an ecosystem's structure and function affect the flows and values of ecosystem services. The models account for both service supply (*e.g.* living habitats as buffers for storm waves) and the location and activities of people who benefit from services (*e.g.* location of people and infrastructure potentially affected by coastal storms). Economic values are derived from original studies in several locations (*i.e.* via benefit transfer).

InVEST models are spatially-explicit, using maps as information sources and producing maps as outputs. InVEST returns results in either biophysical terms (*e.g.* tons of carbon sequestered) or economic terms (*e.g.* net present value of that sequestered carbon). The spatial resolution of analyses is also flexible, allowing users to address questions at the local, regional or global scales.

The process of using InVEST begins by identifying critical management choices being considered by stakeholders. From these, alternative scenarios can then be developed to explore how the current delivery of services is likely to change under alternative decisions or conditions such as climate change. InVEST models how these alternative futures influence ecosystem processes, and how such changes affect biodiversity and the flows and values of ecosystem services. InVEST thus simultaneously quantifies and values multiple ecosystem services generated by a landscape and demonstrates the trade-offs in ecosystem services, biodiversity conservation, and other land-use objectives.

A subset of the simpler InVEST models was applied to three plausible land-use / land-cover (LU / LC) change scenarios in the Willamette Basin, Oregon, and focus largely on reporting ecosystem services in biophysical terms (Nelson *et al.* 2009). Stakeholders defined the scenarios of LU / LC change, from 1990 to 2050, which included spatially explicit LU / LC maps. The study showed how different land use scenarios affect hydrological services (water quality and storm peak mitigation), soil conservation, carbon sequestration, biodiversity conservation, and the value of several marketed commodities (agricultural crop products, timber harvest, and rural–residential housing).

Polasky *et al*. (2011) used InVEST to quantify the changes in ecosystem services, habitat for biodiversity, and returns to landowners from land-use change in Minnesota from 1992 to 2001. They evaluated the impact of actual land-use change and a suite of alternative land-use change scenarios. Results illustrate the importance of accounting for ecosystem services. The scenario that generated the highest private returns to landowners (agricultural expansion) had the lowest net social benefit due to loss of carbon storage, reduction in water quality and lower habitat quality for wildlife.

Uses of this method

InVEST is designed for ***assessing*** the value of ecosystem services that are otherwise difficult to define, quantify and value. Estimates are based on benefit transfer are should be seen as indicative rather than definitive, and care must be taken to avoid double-counting especially when used in conjunction with other methods. Expert advice is required.

More information

Natural capital project http://www.naturalcapitalproject.org/InVEST.html
InVEST: A Tool for Integrating Ecosystem Services into Policy and Decision-Making.

Nelson E, Mendoza G, Regetz J, Polasky S, Tallis H, Cameron R, Chan KM, Daily GC, Goldstein J, Kareiva PM, Lonsdorf E, Naidoo R, Ricketts TH, Shaw R 2009. Modelling multiple ecosystem services, biodiversity conservation, commodity production, and trade-offs at landscape scales. Frontiers in Ecology and the Environment **7**: 4–11.

Polasky S, Nelson E, Pennington D and Johnson K. 2011. The impact of land-use change on ecosystem services, biodiversity and returns to landowners: A case study in the State of Minnesota. Environment and Resource Economics. 48(2): 219–242.

10. DELIBERATIVE PROCESSES

10.1. Hui

Under the Treaty of Waitangi, Māori have a fundamental role in natural resource management in New Zealand. As such, Māori are vitally concerned with the identification and balancing of values to address complex environmental management challenges. To discuss important issues, Māori come together to participate in hui.

> "*Hui are open-ended meetings where there is no time constraint and no predetermined outcome. People talk about the issues for as long as it takes to reach understanding (and possibly agreement). If there is no agreement, then the meeting continues later.*" (Robinson & Robinson 2005).

While academic literature is scant, several studies present experiences of the hui as a means of communicating and discussing important issues with Māori. In a survey of local government, Local Government New Zealand (LGNZ 1997) presented the processes — of which hui is one of many — by which local government consults and undertakes liaison with tangata whenua. The Ministry of Justice (1997) presented guidelines for consulting with tangata whenua. The process of values elicitation facilitated by the Ministry for the Environment through a series of 13 hui about future climate change management is explained in *Consultation with Māori on Climate Change: Hui Report* (MfE 2007).

Hui have been employed by government departments with varying degrees of success. Those that have experienced greater success have generally closely followed hui protocols and have participated in the 'spirit' of hui — meaning a commitment to authentic dialogue — as opposed to 'shallower' forms of participation such as consultation or informing. As explained by Robinson and Robinson (2005),

> *[i]n its authentic form, the outcome of a hui is not referred elsewhere for a decision. It is not just a form of consultation for an outside body or external process; it is a self-contained activity.*

Robinson and Robinson (2005) also discussed the relative failure of the hui set up by the Government in 2004 to consider proposed legislation on ownership of the foreshore and seabed. In that instance, they said, symbolism of space provided by the marae and the ceremony of the powhiri could not obscure the fact that the issue to be discussed was pre-determined by government and the time allowed was determined by Ministers' schedules and the government's legislative programme. Furthermore, the hui were not empowered to make decisions but only to inform submissions to a formal legislative process.

The wananga (learning processes) inherent in hui have been likened to deliberative dialogue (Sinclair 2008). In that sense, it is akin to collaborative decision-making. While there are some government guidelines for consulting with tangata whenua (*e.g.* Ministry of Justice 1997), the protocol for hui is likely to vary from iwi to iwi and sometimes from marae to marae.

Regional councils considering using hui to identify, assess or balance values should therefore discuss the purpose and protocol for any such hui with the tangata whenua of the relevant area (rohe).

Uses of this method

Hui are a traditional form of deliberative decision-making. In their fullest form, they can be used for ***understanding, assessing and balancing*** issues and associated values. In the process, values may also be ***identified***.

More information

Ministry for the Environment 2007. Consultation with Māori on Climate Change: Hui Report. Wellington, Ministry for the Environment. http://www.mfe.govt.nz/publications/climate/consultation-maori-hui-report-nov07/

Robinson D, Robinson K 2005. "Pacific ways" of talk: Hui and talanoa. New Zealand Trade Consortium Working Paper, No. 36. https://www.econstor.eu/.

Sinclair MD 2008. The Complementarity of Wānanga and Deliberations in the Work of the Bioethics Council. In: Proceedings of the Traditional Knowledge Conference Te Tatau Pounamu: The Greenstone Door Traditional Knowledge and Gateways to Balanced Relationships 2008. http://www.maramatanga.ac.nz/sites/default/files/TC-2008.pdf

10.2. Structured decision making

Structured decision making (SDM) is a methodology for organising and analysing diverse information for decision making with multiple objectives (Gregory *et al.* 2012). It also provides a solid foundation for the consideration of alternatives, benefits and costs required by Section 32 of the RMA. It is, in effect, a distillation of the principles and practices that constitute sound policy analysis, drawing upon concepts and methods from psychology, economics, decision analysis, biology and ecology, engineering, management science, facilitation, and negotiation analysis.

The key elements of SDM, undertaken by a group that includes as many perspectives as possible, are as follows:

1. Specify the decision context — what is the problem and what are the constraints?
2. Identify values relevant to the decision at hand and, from these, a set of meaningful objectives that cover everything that is important to people that will be significantly affected by the decision.
3. Define a measurable performance indicator for each objective.
4. Identify management variables within the control of the relevant agency.
5. Develop policy alternatives to address the problem.
6. Assess each alternative against every objective using performance indicators.
7. Identify variations of the policy alternatives that better meet the full range of objectives and reassess, until all participants agree on the preferred alternative or no further improvements can be identified.

Table 7 gives a hypothetical example of the main components of SDM. Once these components are identified, management variables at specific settings (*e.g.* a minimum flow of 2,400 l/sec in a specified river, specific stock exclusion rules, and provisions for tangata whenua involvement in monitoring) are assembled into policy alternatives (*i.e.* options) and the consequences of each are assessed.

Table 7. The building blocks of structured decision making: a hypothetical example.

Values =>	Objectives =>	Performance Measures	Management Variables
Primary Production	Create new jobs in Hawke's Bay	New full-time jobs in horticulture & farming	Minimum flow; allocation regime & volume
Trout fishing	Improve river for trout fishing	Trout habitat as % of maximum	Minimum flow; nutrient levels; riparian vegetation
Mauri of river	Restore mauri of river	Cultural health index	Minimum flow; stock exclusion; nutrient levels

An SDM process treats all values as equally legitimate. There is no attempt to rank or prioritise values or seek agreement on an over-arching vision or set of objectives. As such, SDM is primarily a mechanism for developing clear criteria so that each participant can see how each alternative meets their objectives. This facilitates creative exploration of new alternatives in an attempt to find a solution that everyone can accept. Participants can and will implicitly prioritise some values and objectives over others as they consider which alternatives they prefer and what they can accept. Sinner *et al.* (2014) describe how SDM has been used in a collaborative freshwater planning process led by Hawke's Bay Regional Council, which is the basis for the following case study.

10.2.1. Case study: Structured decision making in Hawke's Bay

In 2012 the Hawke's Bay Regional Council (HBRC) convened a collaborative stakeholder group (known locally as the TANK group) to recommend policy settings for freshwater management, including allocation limits and water quality targets for a plan change for the Greater Heretaunga and Ahuriri zone. At the outset, a council resolution gave a 'good faith' undertaking to implement any consensus recommendations from the group provided they are consistent with the RMA and higher level council policies. As of July 2014, the TANK group has met thirteen times and tentatively reached a number of interim agreements, including values and other factors the group will use to assess policy options. More meetings are planned for 2014, with a goal of making recommendations for the plan change by mid-2015.

The TANK group is using SDM to identify and assess the issues and options for freshwater management in the Greater Heretaunga and Ahuriri catchments, with assistance from Cawthron Institute, Landcare Research and NIWA through a research grant. In this process, group members have identified their values and objectives, as well as performance measures and management variables, which are used to identify policy options and estimate the consequences of these options (Table 8). Hawke's Bay Regional Council, in conjunction with NIWA and the TANK group, is developing a Bayesian Network model to estimate the consequences of the policy options.

In the TANK process, the complexity of the social-ecological system associated with fresh water has led to a large number of performance measures. Gregory *et al.* (2012) recommend having no more than ten performance measures for a given decision. The TANK group could rationalise its 26 measures to a smaller number by grouping those that respond similarly to management decisions. For example, several in-stream performance measures have been tentatively grouped and assessed using simple qualitative descriptors such as 'improved', 'no significant change' and 'worse'.

The TANK group has also identified management variables that could be incorporated in policy options. Some of these are within the control of HBRC while others are steps that landowners, city and district councils, industry bodies and others could initiate themselves. After an initial set of policy options has been considered, the group refines the options and updates the consequences table. If the group is unable to reach consensus on a preferred alternative, it can report to the council on two or more options it considered, indicating its assessment of the likely consequences of each and the reasons it was unable to reach agreement.

Table 8. Values, objectives and performance measures of the TANK group (TANK Group 2014).

Values	Performance measures
Life-supporting capacity Mauri and taonga Habitat / indigenous biodiversity	• Macroinvertebrate assemblage including community index score • Mauri • Richness and abundance of native fish • Area of wetlands • Condition of wetlands • Mahinga kai quality and availability • Richness and abundance of native birds
Food gathering Household and urban water supply (for drinking and other uses) Human health and wellbeing	• Reported cases of water-borne disease / year • Potable water quality in groundwater • Potable water quantity (days of restrictions / year) • Potable water quantity (Number of people with vulnerable supplies)
Food and fibre production and processing Amenity & tourism Household and urban water supply (for drinking and other uses)	• Number of jobs in water-dependent sectors • Total profit in water-dependent sectors • Certainty of water supply for water-dependent sectors (Number of years with < 5 days full water restrictions) • Net benefit of policy measures
Food gathering Swimming and wading (primary contact recreation) Kayaking and boating (secondary contact recreation) Trout fishing Amenity & tourism	• Aggregate number of days per year sites are suitable for swimming • Water flows for whitewater boating • Water flows for flat-water boating • Aesthetics of waters • Angler days • Income from freshwater related tourism
Kaitiakitanga Mana Mauri and taonga	• Tangata whenua involvement in governance • Use of Mātauranga Māori in environmental monitoring and reporting • Māori water allocations
Whakapapa and wāhi tapu	• Wāhi tapu register • Tangata whenua involvement in governance

Uses of this method

SDM is a comprehensive framework for ***identifying, understanding, assessing and balancing*** values. A range of other methods can be used to perform any of these steps in more detail. In particular, with complex systems, expert knowledge or modelling is likely to be helpful in understanding how the system works and assessing alternative management options.

More information

Gregory R, Failing L, Harstone M, Long G, McDaniels T, Ohlson D 2012. Structured Decision Making: A Practical Guide to Environmental Management Choices. Chichester, West Sussex, UK, Wiley-Blackwell.

Sinner J, Greenhalgh S, Berkett N, Sharp T 2014. Structured Decision Making for Collaborative Planning. Policy Brief 9. Manaaki Whenua Landcare Research.

TANK Group 2014. Collaborative decision making for freshwater resources in the Greater Heretaunga and Ahuriri Region: TANK Group Report 1 Interim Agreements. Napier, Hawke's Bay Regional Council.

10.3. WaterWheel

The Wheel of Water is a government funded research programme on collaborative water resource governance and management. It has developed a graphical tool, the WaterWheel, to assist councils and their communities who are engaged in freshwater planning. During 2013-2014, the programme ran two case studies – one in the Mangatarere catchment in the Wairarapa, the other in the Wairau catchment in Marlborough — to pilot the development and use of the graphical tool in a collaborative process. Participants developed a common understanding of their catchment, the interconnections between their values, and the trade-offs between these values that might occur under different land and water management scenarios. The WaterWheel (Figure 10) was an integral part of this process (Fraser *et al.* 2014).

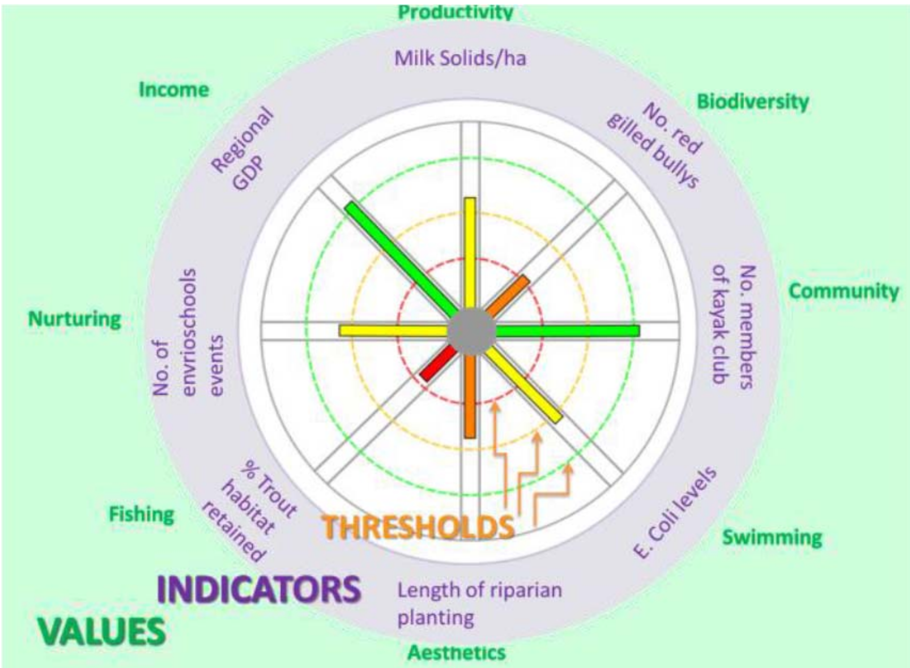

Figure 10. A WaterWheel (Fraser *et al.* 2014).

The collaborative process involved a series of facilitated workshops with stakeholders from multiple land-uses, urban and rural, recreational and conservation interests and technical experts. In the workshops, participants worked through values, indicators and scenarios to develop WaterWheel diagrams (Figure 11). The researchers concluded:

> *"Using processes and facilitation techniques that fostered safety and trust allowed the group to draw upon their collective knowledge, as well as other information sources. Participants also demonstrated an increased awareness of the complex interconnections among the values held in the stakeholder community. The WaterWheel diagrams made information more accessible and easier to understand, and the process used to develop them was inclusive such that the participants generally felt some level of ownership of the WaterWheel diagrams" (Fraser et al. 2014, p viii).*

The report also drew a number of conclusions about collaborative processes generally and the use of indicators more particularly. Observations concerning the process of translating values into indicators are shown in Box 1.

Figure 11. Discussion of the cardboard WaterWheel diagrams and hand drawn systems diagram in Workshop 4 in the Mangatarere catchment, Wairarapa (Fraser *et al.* 2014)

Box 1. Observations about values and indicators for a WaterWheel (Fraser *et al.* 2014).

From Values to WaterWheel Indicators

Define values clearly: Defining what is meant by a 'value' and defining each value unambiguously enables faster agreement on the values which are most important for future management.

Prioritising values: The process of prioritising stakeholders' values catalyses useful debate, but the lack of further consideration for lower priority values may cause concern among participants. It is important to use an iterative process and check that participants still feel that all important values have been taken into consideration in the process.

Uses of scenarios: Scenario development provides a grounded context for participants to evaluate impacts on their values of plausible future changes in their catchment. If the group is involved in helping to develop the scenarios, then it is more likely that those scenarios will incorporate their local knowledge and values. It will also help to develop catchment management objectives.

Exploring trends and drivers: Before developing scenarios, it can be useful to get participants to think about past trends and drivers. This helps draw out local knowledge and focus thinking about what might trigger future changes in the community, the economy, in or beyond the catchment and which of those changes is amenable to management.

Types of scenarios: The facilitation team need to consciously define and clarify with the group what types of scenarios will be useful to help with the task at hand. To stay focused try to include just enough detail to provide the direction, model the system appropriately, and to communicate the anticipated conditions and needs of the catchment and community.

Indicators should represent the important values most susceptible to change: The process of identifying important catchment values and then plausible long-term scenarios for change in the catchment assists groups to narrow their choice of suitable indicators to represent those values most vulnerable to change. Those values will be the ones which need to be addressed through policy or management actions.

Indicator complexity: Because indicators should meet certain criteria, and there are a large number of indicators possible, the collaborative process will need to provide a considerable amount of guidance and assistance with indicator selection. Without this guidance participants can easily struggle to settle on an appropriate package of indicators.

Tools exist to quantify complex indicators: Many values (*e.g.* "connected community") mean different things to different people. Rubrics are a tool that offers a collective process for measuring indicators of otherwise seemingly qualitative values.

Uses of this method

The WaterWheel is a method for ***identifying*** and ***assessing*** values, and contributes to both ***understanding*** and ***balancing*** of values. It would work well with other methods, for example, with complex systems, expert knowledge or modelling is likely to be helpful in understanding how alternative management options would perform against the chosen indicators. A WaterWheel could be used as a graphic illustration tool for a group using Structured Decision Making (section 10.2) to show how different options perform against multiple indicators.

More information

Fraser C, Fenemor A, Turner J, Allen W 2014. The Wheel of Water Research Programme: Designing collaborative catchment decision-making processes using a WaterWheel — reflections from two case studies.

10.3.1. Case study: Assessing scenarios for the Wairau Valley using the WaterWheel

The Wairau Valley in Marlborough was the location of a developmental case study for the Wheel of Water programme. Land use change has been a feature of the valley over the past two decades with conversion of dry land sheep and beef farming to viticulture, forestry and, in the lower reaches, lifestyle properties. A proposed hydroelectric scheme on the Wairau River in the 2000s divided the local community. Between June and December 2013, thirteen participants came together in four workshops with researchers and facilitators to test and refine the Wheel of Water methodology (pp 6–7)[19].

After exploring values and objectives for the future, participants were asked to develop two realistic 25-year scenarios. The final scenarios chosen were: i) 'urban'– unconstrained subdivision and population growth, and ii) 'full irrigation' – a mixture of dairying and viticulture on the valley floor, with the balance of hill country going into forestry (p 33).

Choosing relevant indicators

The group then had the task of selecting 12 indicators by which community well-being under these scenarios could be assessed. This raised a number of technical questions about exactly how, where and when the indicator would be measured. This specificity created some concerns about whether specific indicators would leave gaps in how well the resulting WaterWheel diagram represents the whole system. In some cases there were no indicators that the group felt would adequately capture their values. For two of these, *e.g.* 'connected community', they developed rubrics – qualitative indices with levels such as 'advanced',' intermediate', 'fair', and 'poor' where each level has clearly described attributes.

[19] This case study is drawn from Fraser *et al.* (2014), including numerous direct excerpts and paraphrasing. Page number references in this section refer to Fraser *et al.* (2014).

The group also had to determine thresholds for each indicator, the point at which a given indicator goes from ‘good’ to ‘excellent’. For example, category thresholds may reflect decisions about the acceptability of risk to human health or of levels of water supply reliability. These thresholds are socio-political decisions that reflect the acceptability of different outcomes, although experts can provide technical guidance. Because the category thresholds determine the length and colour of the spokes on a WaterWheel diagram, altering them can alter the appearance of the WaterWheel and influence the acceptability of the scenarios.

The case studies illustrated the importance of choosing indicators for the most sensitive or pressing issues in the catchment. The Wairau group required different indicators for the two scenarios. This is not ideal, if the main aim is to compare scenarios. The researchers acknowledged this as a drawback of using only 12 indicators in the WaterWheel (done mainly to aid graphical clarity). They suggested that an iterative approach between scenarios and indicators would help to develop more robust and versatile indicator sets. The indicators chosen by the Wairau group are shown in Table 9 alongside the indicators from the other case study group in the Mangatarere catchment in the Wairarapa (p35 ff).

In both case studies, indicators and thresholds were not completely defined by the groups within the workshop timeframes. Researchers said they under-estimated the complexity of this task and the group learning required. Overall, participants were positive about the WaterWheel and in particular about the process the group had undertaken, while highlighting the complexity. Participants said:

> *“the visual representation meant the values of all of the participants were put right in front of you, you could see the interconnectedness. If you move this one, it moves that one. No actions are independent of another action; the actual construct of the wheel makes that blatant in a way that a table or graph doesn’t.” (p 39)*

> *“Simplification of the catchment down to these indicators requires a lot of qualifiers. The product [the WaterWheel] and the process for getting there are both important.” (p 40)*

Table 9. Indicators chosen for the WaterWheels for Wairau Valley and Mangatarere catchments. Colours correspond to well-beings: yellow = socio-cultural; blue = economic; green = environmental). Source: Fraser *et al.* 2014 (p 38).

Wairau Valley indicators	**Mangatarere indicators**
Knowledge use in decision making (rubric)	Index of wellbeing (rubric)
Connected community (rubric)	Level of engagement for catchment improvement
Cultural health index	Cultural indicator (TBC)
River recreation index	Trout spawning for future angling (TBC)
Catchment earnings before interest & tax (EBIT)	Mean annual maximum periphyton at Belvedere Rd swimming site
% employment in catchment	*E.coli* at Belvedere Road swimming site
Reliability of water supply	Earnings before interest & tax (EBIT)
Terrestrial mitigation	Full time equivalent employment in catchment
Common bully habitat in Mill Creek	% time wastewater plant cannot discharge to river
Nitrate concentration in Mill Creek	% riparian planting in catchment
E. coli in Mill Creek	State of native fishery (expert opinion / TBC)
Mean river flow at the Narrows	Visual soil assessment index

10.4. Deliberative multi-criteria evaluation

Deliberative multi-criteria evaluation (DMCE) combines multi criteria analysis with a deliberative procedure — the citizen jury (Proctor & Drechsler 2006; Lennox *et al.* 2011). The objective is to provide a fair and equitable decision making framework that takes into account stakeholder preferences and priorities as well as factual information on the impacts and outcomes of different options. Another important outcome of DMCE is an increase in the understanding of the issues, trade-offs and different points of views.

This method is essentially a variant of structured decision making (SDM), in which explicit weightings are used to reveal and potentially resolve differences in values. Gregory *et al.* (2012) note that this is an option in SDM but suggest that it be used only as a last resort if consensus cannot be reached through other means.

Steps in DMCE process are as follows:

1. The sponsoring organisation chooses the stakeholders (jurors).
1. Stakeholders develop and agree on objectives, scenarios for evaluation and criteria to measure scenarios.
2. Stakeholders individually and independently assign weights to criteria in terms of how important they are to a particular goal or outcome.
3. Facilitator develops impact (evaluation) matrix to show scenarios, criteria, indicators and impacts.
4. Facilitator analyses weighting (using software) to identify those with large variation; invite experts to discuss and explain those criteria.
5. Facilitated process – display initial weightings and the MCA software results to all the participants. Participants with opposing priorities asked to defend. Experts answer questions. Weighting process is repeated. Deliberation and discussion continue to reach a final outcome.

The process has the following features:

- optimally, around 10 participants
- participants have specific decision making responsibilities
- the process is externally facilitated
- expert witnesses are used to provide information, as needed
- participants are given time to discuss, debate, and deliberate
- consensus is often reached but is not always necessary to achieve an outcome.

Deliberative multi-criteria evaluation was trialled in South Australia's Murray River catchment as part of the development of a new draft water-sharing plan. The new plan sought to provide a decision-making framework for the issuing of entitlements, allocations, site use approvals and other approvals, as well as monitoring and management requirements for water users. Protection of important environmental assets and water for the environment are also key components of the proposed draft plan. It was used as a means to identify and prioritise the community's preference environmental and public benefit outcomes from the allocation of environmental water. The outcomes from this provided policy-makers with a body of evidence to address questions about the way trade-offs should be made with the environmental water and the sites and values to which it should flow.

Deliberative multi-criteria evaluation was used for stakeholder engagement of the Hurunui Water Project (HWP), a proposed water storage and irrigation scheme in North Canterbury. It was also used at the start of a public process (Lennox *et al.* 2011). Evaluation criteria developed by the HWP were used to score various options.

An initial weighting exercise of criteria was also conducted at a public workshop, however, the next participatory workshop departed from this process due to time and external pressures.

Uses of this method

Deliberative multi-criteria evaluation is a comprehensive method for ***identifying, understanding, assessing and balancing*** values, and can be complemented by other methods to perform any of these in more detail. In particular, with complex systems, expert knowledge or modelling is likely to be helpful in understanding how the system works and in assessing alternative management options.

More information

http://waterwiki.net/index.php/Deliberative_Multi-Criteria_Evaluation

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11. CONCLUSIONS

A variety of frameworks, tools and methods are available to help councils and their communities identify, understand, assess and balance values of freshwater systems as they implement the National Policy Statement Freshwater Management 2014.

Each of these approaches has strengths and weaknesses and is suited to some circumstances more than others. When using any of them, there are a number of important considerations to bear in mind.

For example, categories of values are simplifications that approximate the complexity of how people value water bodies, and such categories are often not discrete. Another important consideration is that value and values are often constructed in context. How a person's feelings for a freshwater system or place manifest themselves depends not only on the person's experiences but also on context-specific matters, such as how a question is asked and by whom.

A number of methods have been developed for identifying values. These range from expert-based methods such as RiVAS to community-based methods such as participatory value mapping. Because values are often complex and defy simple categorisation and quantification, various methods have been developed for understanding values more fully, including understanding the linkages between biophysical and socio-cultural aspects of values.

Assessing values involves evaluating the significance, quantity or magnitude of the value of something. Goods and services that are bought and sold typically have values that are well-defined and reasonably stable and are amenable to economic valuation using market prices. Other methods from economics, such as hedonic pricing and choice modelling, are designed to estimate in monetary terms how much people would value changes in the environment. For a proposed policy change, if all relevant values, or at least most of them, can be quantified in monetary terms, cost benefit analysis can be used to compare management options. Total economic value and ecosystem services are two frameworks designed to help ensure that all values are accounted for.

There are many objections to expressing all values in monetary terms, especially when the values are strongly influenced by context. Deliberative methods such as structured decision making are designed to enable consideration of multiple and diverse objectives in a rigorous manner while promoting mutual understanding of values and creative solutions to complex problems.

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