Freshwater Values Framework. A Review of Water Valuation Methods Utilised within Total Economic Valuation

February 2013

Working Report 2013/001

This report has been peer reviewed by the Peer Review Panel using the Panel's terms of reference

Submitted for review on 6 December 2012
Review completed on 31 January 2013
Reviewed by two reviewers

Approved for Auckland Council publication by:

Name: Eva McLaren

Position: Team Leader, Social and Economic Research
Research, Investigations and Monitoring Unit

Date: 18 February 2013

Recommended citation:
Rohani, M (2013). Freshwater Values Framework. A Review of Water Valuation Methods Utilised within Total Economic Valuation
Auckland Council working report, WR2013/001

Contents

Executive summary

The Unitary Plan requires a freshwater values framework as a part of implementing the National Policy Statement for Freshwater Management (NPS-FM). The purpose of this report is to identify what economists mean by water values and related issues on Cost Benefit Analysis (CBA) framework, Total Economic Values (TEV) framework and valuation tools and methods, and explore their potential application to informing water policy development.

As Auckland's population grows, freshwater resources will come under progressively increasing pressure. In economic terms, this means freshwater resources will become scarcer; with regards to both quality and quantity. Under conditions of scarcity and growing competition among water users, economic efficiency becomes an important social matter (Young 2005).

Evaluation of the trade-offs necessary to allocate resources between competing uses requires consideration of their economic, social, environmental and cultural values. In particular, efficient and sustainable resource allocation requires knowledge of the marginal value or benefits of the resource in its alternative uses, including non- consumptive uses, and non- use values. This is why water valuation is an important consideration for effective water management.

Different management options will yield different net benefits (or losses). A specific project or policy represents a welfare improvement if the net benefits are positive. The option with the highest net benefits is the preferred or optimal one. However, a cost benefit analysis of a policy or project with environmental impacts is complex because many environmental resources (including most water resources) are public goods and are therefore difficult to value.

Most resource allocation decisions produce a range of benefits and costs, many of which are not commonly expressed in dollar terms and therefore are not easily comparable. Non-market valuation is a term that describes a range of techniques (eg, Hedonic Price Method, Travel Cost Method, Contingent Value Method and Choice Modelling), which have been developed to meet the needs of decision makers trying to allocate scarce resources to their most valued uses, including non- consumptive uses. In many cases, it is desirable to compare social, economic and environmental values using a common indicator.

Young (2005) argues that environmental benefits and costs are typically measured by either willingness to accept (WTA) compensation or willingness to pay (WTP). WTP means the measurement of the maximum amount that an individual would be willing to pay to either receive a benefit, or avoid a cost of a worsening of a condition. WTA is the measurement of the minimum amount that an individual would be willing to accept to abandon a good or to put up with something negative, such as pollution. The fact that whether the person in question has an existing right to either receive a benefit or avoid a cost determines the selection of either WTA or WTP.

This review of the Total Economic Value (TEV) framework and the non-market valuation methods presented, shows that there are several methods and approaches appropriate to estimate WTP and WTA in monetary terms for freshwater, and that each method is suitable for a specific usage and service for which freshwater provides. Therefore, appropriate method for valuing a freshwater catchment would be a suite of various approaches depending on its freshwater services.

1.0 Introduction

The Research Investigations and Monitoring Unit (RIMU) has prepared a summary of economic valuation methods, to support the Unitary Plan Freshwater Values Framework project led by Environmental Strategy and Policy Unit. The information provided in this report could also be used in other environmental valuation projects.

The paper provides a summary of Total Economic Value (TEV) and economic valuation tools for monetary and non-monetary values associated in freshwater, to inform the preferred approach of an agreed value framework (AVF) using TEV. In preparation of this report, statutory and non-statutory documents were reviewed. The primary documents that were considered were the Resource Management Act 1991, the National Policy Statement for Freshwater Management 2011 and the Auckland Plan 2012.

According to State of the Auckland Region (2009), Auckland's freshwater body includes 16500km permanent rivers, 72 lakes and six major aquifer types. "Freshwater is a vital, but limited, resource that is essential to life. Without sufficient, clean freshwater, human health, cultural health, the economy and agricultural output would all decline. Freshwater features such as rivers and lakes also enhance the landscape, as well as providing an important resource for recreational activities such as swimming, freshwater fishing, and kayaking." (p. 140, State of the Auckland Region, 2009).

The 1992 International Conference on Water and Environment in Dublin, Ireland developed a set of four principles to guide management of freshwater that became known as the Dublin Principles. The principles are:

1. Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment. Since water sustains life, effective management of water resources demands a holistic approach, linking social and economic development with protection of natural ecosystems. Effective management links land and water uses across the whole of a catchment area or groundwater aquifer.
2. Water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels. The participatory approach involves raising awareness of the importance of water among policy-makers and the public. It means that decisions are taken at the lowest appropriate level, with full public consultation and involvement of users in the planning and implementation of water projects.
3. Women play a central part in the provision, management and safeguarding of water. This pivotal role of women as providers and users of water and guardians of the living environment has seldom been reflected in institutional arrangements for the development and management of water resources. Acceptance and implementation of this principle requires positive policies to address women's specific needs and to equip and empower women to participate at all levels in water resources programmes, including decision-making and implementation, in ways defined by them.
4. Water has economic value in all its competing uses and should be recognised as an economic good. Within this principle, it is vital to recognize first the basic right of all human beings to have access to clean water and sanitation at an affordable price. Past failure to recognize the economic value of water has led to wasteful and environmentally damaging uses of the resource. Managing water as an economic good is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources.

According to these principles, managing water well is about achieving efficient and equitable use, and encouraging conservation and protection of water resources. In order to allocate water efficiently, it is necessary to evaluate the trade-offs between competing demands through the consideration of economic values.

Although freshwater resources perform many functions and have important socio-economic values, water can be a classic non-market good. However, in situations where it is traded, water markets are often imperfect and its market price does not reflect the true value of the resource. Valuing water is by its nature contentious, and is about putting a price on something that is priceless. It is, however necessary if resources are going to be managed prudently. It is possible for policymakers to measure how much damage is being done to a resource and understand the economic consequences borne by current and future societies due to loosing the potential inherent in high quality freshwater networks.

Even when water is used as a tradable commodity, market prices are not generally available. The reasons why water has no price, relate to the historical, socio-cultural and institutional context in which water is used and managed. Another complicating factor is the continuity of water within the hydrological cycle. Water can be captured and shared, and water flows can be recycled. This complexity makes it difficult to break water down into clearly defined, marketable proportions (Smith *et al*., 2009).

Water also has many unique characteristics that make it difficult to trade within regular markets, reflecting in particular the absence of exclusive **property rights**[1], its **public good** characteristics, the presence of **externalities**, and frequently occurring monopoly conditions for by utility service operators. The reasons for these water-trading problems include the following:

First, the highly fluid and dynamic nature of the hydrological cycle, means that one persons use of water does not necessarily preclude another's use of the same resource, as is the case with non-use values like recreation and aesthetics. However, water is provided for the public by nature but it can be captured and used privately and property rights can be involved in its usage. For instance, if someone takes water from stream and precludes its use by downstream people.

Second, due to the large amount of interdependency with uses of water, such as hydroelectricity generation affecting recreation, externalities can occur. When externalities are present, the full cost of an activity may not be visible or taken into account by the producer or consumer that subsequently affects someone or something not party to the transaction.

Lastly, economies of scale in the supply of water lead to imperfect competition. Limited competition and monopoly suppliers can significantly influence the pricing of goods. A market relies on competition for the efficient pricing of goods.

Young (2005) suggests some questions that should be answered to determine the appropriate level to which resource managers should include the economic value of water:

- What type of goods and services are produced by water?
- Why are prices for water seldom observed in normal commodity markets?
- What do economists mean by value or benefits in relation to water resources?
- Is the economic benefit of an increase of water supply or quality the same at all times and places and for all purposes?
- Why are estimates of water related policy benefits important?
- What nonmarket valuation methods can be used to estimate economic benefits of water related policies?
- Which valuation methods are most appropriate for 'intermediate goods' and which for 'final goods' uses of water?
- How are the various valuation methods applied in practice?
- What are each method's advantages, limitations and appropriate roles?

The purpose of this report is to provide initial answers to these questions. A literature review has been undertaken to explore different methods for valuing water resources. Young (2005) and Birol *et al*., (2006) in an international context and Smith *et al*. (2009) in the New Zealand context

[1] The highlighted terms have been defined in the glossary.

are the main information sources that have been used for this report .They have introduced the conceptual framework and empirical tools needed for responding to the questions above.

Valuation methods of water resources are also summarised in this report, as freshwater valuation is a subset of water valuation. Table 1 illustrates an example of some potential freshwater services in a catchment that should be evaluated by an appropriate valuation method.

Table 1. Some potential freshwater services in a catchment

Catchment service	Description
Water quality improvement	Bioremediation, such as reducing phosphorus and nitrogen through biological processing
Biodiversity maintenance	Provide habitat for indigenous flora and fauna
Erosion control	Vegetation cover preventing soil erosion
Water supply	Supply water for industrial and agricultural usage
Recreational opportunity	Offer places for human enjoyment due to the natural and artificial scenes
Raw material supply	Supply fish for human and produce plants for livestock
Existence value	Maintain wetlands for future generations

The review is structured as follows. Section 2 briefly reviews the values attributed to freshwater resources according the most relevant statutory and non-statutory documents. Section 3 describes the causality of using economic evaluation methods through Total Economic Valuation (TEV) of freshwater and provides a summary of some popular market and non-market valuation methods, and their usage, advantages and shortcomings. Section 4 provides a detailed description of the valuation methods and provides some case studies. Conclusions and recommendations are provided in Section 5.

2.0 Values attributed to freshwater resources

There are many different meanings for 'value' from an economic perspective. The following definition from Webster's dictionary (1988) is a useful one for this analysis, namely, value as 'a fair or proper equivalent in money, commodities, etc'. The 'equivalent in money' represents the sum of money that would have an equivalent effect on the total economic, social, environmental and cultural wellbeing of individuals, or in economic terms the **utility** of an individual.

In this sense, the value of water arises from assessing the economic efficiency in the development, allocation and management of water resources, its supply (quantity) and quality.

Due to population growth, and increasing consumption, pressures are increasing on freshwater resources on global, national and regional scales. Water and intact water ecosystems are becoming scarcer, both in terms of quantity and in terms of quality. According to the Minister for environment, New Zealand does not have a water scarcity problem at the scale experienced elsewhere in the world although there are times and places where water is scarce. Under conditions of scarcity and growing competition among freshwater users (including non-use), economic efficiency becomes an increasingly important social matter, and efficiency values have viable meaning in resolving conflict (Young 2005).

There is no single correct answer for an economic valuation of a particular water resource, rather the final answer will reflect the methodologies used for the calculation and the inherent biases of the organisation making the calculation. This is due to the wide variety of economic, political and physical characteristics of water that affect policy decisions.

The appropriate measure of **welfare change** differs according to the specific attributes of the situation. Terms such as Long-Run versus Short-Run values, At-Site versus At-Source values (Young *et al*., 2005) and Total Economic Value (TEV) are examples of different approaches to measuring welfare.

The TEV framework is often overlooked in economic accounts. It is a concept that refers to the value derived by people from a natural resource, a man made heritage resource or an infrastructure system. TEV relates to a traditional cost benefit analysis in that it can facilitate comparison between the state of receiving or not receiving a benefit or cost from a resource use. In a TEV, economists assign several types of values to water according to the type of the usage (see section 3.5).

Total Economic Value = **Direct Use Value** + **Indirect Use Value** + **Option Value** + **Non-use Value**

<u>Direct Use Value</u>	<u>Indirect Use Value</u>	<u>Option Value</u>	<u>Non-Use Value</u>
-Irrigation -Industrial supply -Municipal supply -Energy resource -Transport and navigation -Recreation -Amenity	-Waste treatment -Wildlife harvesting -Nutrient cycling -Climate regulation -Ecosystem support	-Potential future uses (direct or in direct)	-Bequest values (natural heritage, cultural heritage, Māori value of water) -Existence values (intrinsic value of water) -Altruistic values

2.1 Māori values of water

The National Policy Statement for Freshwater under the Resource Management Act (RMA) requires regional councils to work with iwi and hapū to identify Māori values of water and, reflect these in the freshwater management.

Māori regard water as a **taonga** (treasure). Water remains an important political, economic and spiritual resource for Māori . Several iwi describe four central categories of water: wai Māori , waiora, waikino and waimate, meaning freshwater, pure water, polluted and dead water respectively. Many iwi have proverbs about the unity of people and water.

Māori have long expressed concerns about water quality (Bargh, 2006), and retaining indigenous ownership and rights to govern freshwater resources (Gibbs and Bennett, 2007). Smith *et al*. (2009), classified the Māori values of water as Mahinga Kai, Kaitiakitanga, Ki uta ki tai, Rahui, Taonga, as a result of literature review.

2.2. Statutory and non-statutory documents

This section provides some information from legislative and strategic documents related to freshwater management by local governments in New Zealand.

2.2.1. Resource Management Act 1991

The Resource Management Act 1991 (RMA) defines freshwater as all water (which is exclusive of water in any form while in any pipe, tank, or cistern) except coastal water and geothermal water. Regional policy statements, regional plans and resource consents are included in variety of tools that has been provided by RMA for regional councils to manage freshwater (Managing freshwater quality: challenging for regional councils, 2011).

The recently enacted National Policy Statement for Freshwater Management (NPS-FM) is an instrument under the RMA. According to NPS-FM implementation guide (2011), the NPS-FM must be interpreted and given effect to within the context of the RMA.

2.2.2. National Policy Statement for Freshwater Management

National Policy Statement for Freshwater Management (2011) (NPS-FM) took effect on 1 July 2011. "The purpose of a national policy statement is to state objectives and policies for matters of national significance that are relevant to achieving the purpose of the RMA". (RMA p.155)

The overarching objectives in NPS-FM, which describes the intended environmental outcome(s) relates to:

- Water quality
- Water quantity
- Integrated management
- Tāngata whenua roles and interests
- Progressive implementation programme.

A freshwater objective is the required environmental outcome for the water body.

The NPS-FM does not specify how to achieve the required outcomes. It is for local authorities to determine appropriate local objectives and methods.

In determining community objectives, the list of national values of freshwater is set out in the NPS-FM. These national values of freshwater are defined through the following usage and services:

- Domestic drinking and washing water
- Animal drinking water
- Community water supply
- Fire fighting
- Electricity generation
- Commercial and industrial processes
- Irrigation
- Recreational activities (including waka ama)
- Food production and harvesting, eg, fish farms and mahinga kai
- Transport and access (including tauranga waka)
- Cleaning, dilution and disposal of waste.

The NPS-FM also recognises non-use values. That is, those values that relate to recognising and respecting freshwater's intrinsic values for safeguarding the life-supporting capacity of ecosystems and sustaining the potential of freshwater to meet the reasonably foreseeable needs of future generations. Examples of these values include:

- The interdependency of the elements of the freshwater cycle
- The natural form, character, functioning and natural processes of water bodies and margins, including natural flows, velocities, levels, variability and connections
- The natural conditions of freshwater, free from biological or chemical alterations resulting from human activity, so that it is fit for all aspects of its intrinsic values
- Healthy ecosystem processes functioning naturally
- Healthy ecosystems supporting the diversity of indigenous species in sustainable populations
- Cultural and traditional relationships of Māori with freshwater
- Historic heritage associations with freshwater
- Providing a sense of place for people and communities.

In conclusion, the NPS-FM by itself, will not achieve local or national objectives for freshwater management; local government is responsible for catchment based freshwater management. "Because each water body is different – for example, flow rates differ in different rivers – the amount of water that can be taken and the amount of contaminants that can be discharged to achieve a particular objective will be specific to each system. Although a freshwater state objective may be applied across, a whole class of water bodies, the limit required to achieve that objective will depend on the individual characteristics of each system and its components."(LAWF2, p.23).

2.2.3. Land and Water Forum reports

Land and Water Forum (LAWF) came together because of the important role of water in national welfare and its neglected management. This forum has published three reports at the government's request.

The first report "A fresh start for freshwater" (September 2010), developed a blueprint for improved water management, with assistance from central and local government officials. This report paved the way for the government to publish a National Policy Statement on Freshwater Management.

The first report of the LAWF pointed out the multiple interests for water in New Zealand namely spiritual/traditional/identity interests, recreational/social/personal interests, ecological and environmental interests and economic interests. It noted that systems should be provided for these multiple values to be managed, and allow New Zealanders to implement water management regimes that will optimise all of these values. Water management regimes can not be optimal without full knowledge of values related to water services.

The second report of the forum “Setting limits for water quality and quantity freshwater policy and plan making through collaboration” (April 2012) provided the outline of a framework of national objectives within which catchment-specific limits would be set, a collaborative process for policy- and plan-making in regional and national level.

The latest report of the forum namely “Managing water quality and allocating water” (October 2012) presented the tools and approaches required to manage freshwater to meet limits and achieve freshwater objectives. The forum’s third report including the following key points:

- Comprehensive water management
- A freshwater management which support economically profitable and efficient operations for individuals and enterprises
- Clear objectives and limits for each catchment according to the NPS-FM requirements
- A freshwater management must be integrated with the wider public policy environment
- A fair transition to new way of water management
- Integrated land use, soil and freshwater management
- A permanent water management system must resolve the question of iwi rights and interests

This report has outlined an integrated catchment management approach to managing fresh water within quantitative and qualitative limits. . The first recommendation of the report is related to efficient allocation. The Forum believes that New Zealand’s economic welfare must be maximised through “technically efficient” outcomes[2], “allocatively efficient” patterns of water use[3] and a frame work that encourages “dynamic efficiency”[4]. To do so LAWF recommend “central government and regional council frameworks for allocating water and managing discharges of contaminants need to be accountable, efficient and fair. They should ensure that:

a. freshwater objectives are achieved and limits are met over the time period established by the regional planning process
b. water, land and related resource use is efficient, dynamic and maximises long-term economic welfare
c. social equity is considered in decision-making.” (LAWF3, 2012, p.10)

2.2.4. Coastal policy statement

The New Zealand Coastal Policy Statement 2010 (NZCPS) is another national policy statement under the RMA. The purpose of the New Zealand coastal policy statement is to state policies that will better achieve the purpose of the RMA in relation to the coastal environment of New Zealand.

The NZCPS and the NPS-FM are interrelated; ie, some objectives and policies of these two policy statements can be applied to the same water bodies. Therefore, they both need to be considered in freshwater management.

---

2 eg, allocating right amount of water in the right time for irrigation.
3 ie, allocating water to the highest valued use.
4 ie, adjustable patterns of water use need to be able to adjust efficiently to meet changing demands.

The objectives and policies of NZCPS listed below are those that are particularly relevant to the NPS-FM (NPS-FM, 2011, Implementation Guide).

- Objective 1: Ecosystems
- Objective 3: Treaty of Waitangi
- Policy 2: Tāngata whenua
- Policy 4: Integrated management
- Policy 21: Enhancement of water quality
- Policy 22: Sedimentation
- Policy 23: Discharge of contaminants.

2.2.5. The Auckland Plan

The Auckland Plan is a long-term strategy to guide Auckland's future over the next 30 years. It states, that 'environmental quality' is one of the seven challenges that Auckland will face. To achieve the desired outcome of high environmental quality, one of the six critical transformational shifts in this plan is to 'Strongly commit to environmental action and green growth'. Furthermore, the first priority within the strategic direction 7 (Acknowledge that nature and people are inseparable) is to 'value our natural heritage'.

Three other priorities ('sustainably manage natural resources', 'treasure our coastline, harbours, islands and marine areas' and 'build resilience to natural hazards') follow from the first priority.

The first directive (directive 7.1) of the first priority is to 'acknowledge and account for ecosystem services when making decisions for Auckland'. This directive is further explained as "our natural heritage contributes to our sense of place, and it benefits us in our daily lives. These benefits, termed ecosystem services include resources (such as soils for food production) and processes (such as filtering pollution). Ecosystem services provided by indigenous species underpin many recreational and eco-tourism opportunities. The challenge in managing ecosystem services is that we cannot manage well what we do not measure. Future decisions must account for the true value of nature and its benefits." (The Auckland Plan, p. 180).

In other words, the benefits/ that people obtain from ecosystem services related to freshwater resources, including goods (eg, drinking water) and services (eg, flood control), must be measured in order for good water management decisions to be made. Good decisions are focussed towards ensuring freshwater values are retained and not eroded, and that the needs of future generations are given due consideration.

3.0 Economic allocation of water and water valuation

Economics studies the allocation of resources in society as a means of satisfying human needs, wants or desires. In doing so, it takes into account the availability of resources, methods for the production of goods and services, their exchange, and the distribution of income within society (Turner *et al*., 2004). In this context, allocation is not confined to the allocation of water takes, but also to allocation between water use categories. For example, it includes the allocation of a water body or catchment for hydroelectricity generation, and catchments that should be left for their intrinsic value.

In an economically efficient resource allocation, the marginal benefit from the use of the resource should be equal across sectors (or uses) in order to maximize social welfare. To achieve the highest marginal satisfaction in society, the allocation needs to be efficient and equitable. Resource allocation may also be based on equity. Equity objectives are concerned with fairness of allocation across economically disparate groups, and may or may not be consistent with efficiency objectives. While economic efficiency is concerned with the amount of wealth that can be generated by a given resource base, equity deals with the distribution of the total wealth among the sectors and individuals of society (Dinar *et al*., 1997).

"Economic efficiency may be defined as an organisation of production and consumption such that all unambiguous possibilities for increasing economic wellbeing have been exhausted" (Young 2005). In other words, economic efficiency is an allocation of resources such that no further reallocation is possible which provides additional gains in production or customer satisfaction to some firms or individuals without imposing losses on others. This definition in economic theory is termed **Pareto optimisation**.

This theory is based on:

- individual wants assumed as what is good for individual,
- the economic welfare of society is based on the aggregate economic welfare of its individual citizens,
- a change that makes everyone better off with no person worse off equates with positive change in total welfare.

3.1 Economic criteria for water allocation

Water allocation models differ in the extent to which they address efficiency and equity objectives. The various systems can be compared according to a range of criteria (Dinar *et al*., 1997). These criteria include:

- *Flexibility in allocation of supplies:* allocation requires flexibility such that supplies can be shifted between uses and sectors, as demand changes, to achieve efficiency.
- *Security of tenure for users:* established users require security of tenure if they are to be expected to take the necessary measures to use the resource efficiently. Although this may conflict with flexibility, problems should not arise if sufficient water reserves are available to meet unexpected demands.
- *Payment of real opportunity costs of water by users:* users should pay the real opportunity costs of their use, so that other demand or external effects are internalised.
- *Predictability of the allocation outcome:* in order to achieve the best allocation and minimize uncertainty, the outcome of the allocation process needs to be predictable.

- *Equity in the allocation process:* users should perceive the allocation process to be equitable.
- *Political and public acceptability:* the allocation should meet the various political and public values and objectives, thereby making it acceptable to different groups in society.
- *Efficacy in achieving desired policy goals:* the form of allocation should change an existing undesirable situation towards one where the desired policy goals are achieved.
- *Administrative feasibility and sustainability:* the allocation mechanism must be practicable, adaptable and allow policy to be effective.

It should be noted that allocation for water takes is usually hierarchical (given priorities/ reserves). Auckland metropolitan use takes precedence over agriculture since much of the water supplied by Watercare is for the metropolitan area of Auckland. The non-metropolitan (rural) customers represent approximately 2% of the total water supplied in Auckland, with the majority of use for horticulture[5] (Auckland regional water demand management plan, 2011).

3.2 What connects water allocation and valuation?

Evaluation of the trade-offs necessary to allocate resources between competing demand requires consideration of their economic value. In particular, one of the main principles of efficient and sustainable resource allocation requires knowledge of the marginal value or benefits of the resource in its alternative uses (Turner *et al*., 2004). It is in this context that the importance of freshwater valuation for freshwater management arises.

Economics can contribute towards improved allocations by informing decision-makers of the full economic, social, environmental and cultural costs and benefits of water use and the goods and services that water provides.

Water resources provide important commodity and environmental benefits to society. Any particular use of water will be associated with opportunity costs, which are the benefits foregone from possible alternative uses of the resource. Decision-makers are faced with balancing, for example, water demands from agricultural irrigation for food production with the desire to preserve wetlands for fish and wildlife habitat. In reality, few policy changes or resource management practices would meet the strict Paretian standard of improving the welfare of many while making no person worse off.

To overcome this difficulty, welfare theorists apply the compensation test (Smith *et al*., 2009). Here, if beneficiaries could in principle compensate losers and still be better off, the change is considered acceptable, whether or not the compensation actually takes place (Young, 2005).

In relation to the Paretian standard, it should also be noted that applied cost benefit analysis typically examines large increments of change and assesses simply whether the movement is in the direction of Pareto improvement. Where an action generates incremental benefits in excess of costs, it is termed Pareto superior, as it is superior to the existing situation (Young, 2005).

Marginal Opportunity Cost (MOC) is an important and useful tool for conceptualising and measuring the physical effects of resource diminution and degradation in economic terms. The adoption of the opportunity cost analytical framework is implicit in most monetary valuation studies of ecological resources, which involves:

---

[5] Many other large agricultural organisations have their own water supplies and do not rely on Watercare's supply system.

- Developing ways of estimating in monetary terms the ‘opportunity cost’ associated with alternative uses of resources, which means assigning monetary values to ecological goods and services. This can be approached in two distinct ways:

  i) On the ‘supply side’ through estimates of economic costs, that is the reduction in welfare received as a result of a change in the quality or quantity of a good or service.

  ii) On the ‘demand side’ through estimates of economic benefits – that is, the change in welfare as a result of some improvement in the quality or quantity of a good or service.

- Choosing the course of action that is judged to be the ‘best’ for society based on this evaluation. Once benefits and costs categories have been decided and evaluated in monetary terms, the standard cost benefit analysis turns to principles of economic efficiency in order to evaluate the alternative courses of action. (O’Connor, 2002, 2007)

3.3 Market failure

According to OECD, Market failure is a general term describing situations in which market outcomes are not Pareto efficient. Market failures provide a rationale for government intervention. Causes of market failure include unrecognised **scarcity rent**, insufficient or non-existent property rights, externalities, the lack of perfect competition (eg, market power) and lack of perfect information.

Although water is increasingly allocated by market mechanisms, its unique attributes (for instance externalities and public goods characteristics) make it a classic example of the market’s potential failure to achieve an economically efficient allocation. (Young, 2005) To correct for market failures, the value of all the benefits provided by environmental resources need to be captured. Scarcity rent and externalities are two important components of freshwater related market failure.

When scarcity rents go unrecognised, this results in inefficiently high extraction or pollution rates over time and space (Koundouri, 2000). Efficiency in resource allocation is achieved when the resource price, the benefit society is willing to pay (forego) to access the resource today, is equal to the sum of marginal extraction cost plus scarcity rent. In general, both surface water and groundwater have public good characteristics in that people who extract them and use them are not paying their scarcity rents (both in terms of quality and quantity); they only pay the private extraction costs (Birol *et al.*, 2006).

An externality can be local, in which case it is confined to a specific location, or global, and it can be positive or negative. Where market failures exist, government intervention is required to allocate the resources efficiently.

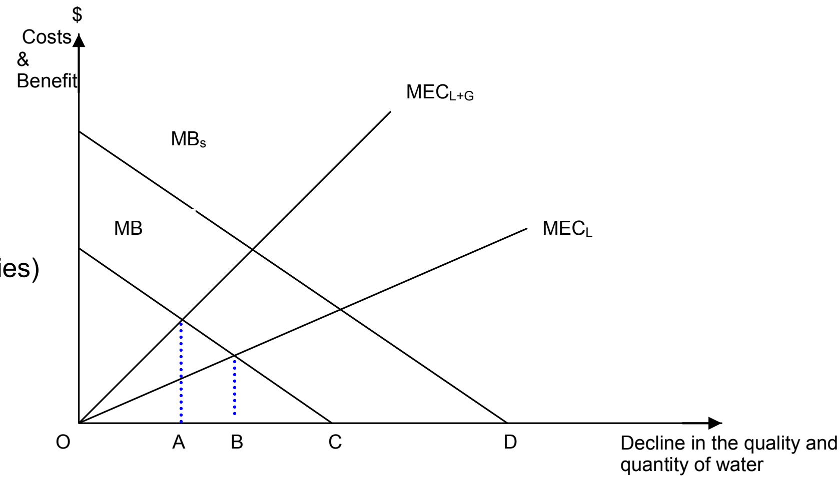
Figure 1 shows efficient and inefficient usage of water due to global and local market failure. The MB curve represents the Marginal Net Private Benefits of using water resources, where MB_S curve represents the Marginal Net Private Benefits of using water resources exacerbated by for example subsidies to their use.

The MEC_L is the Marginal External Costs borne locally from use of water resources and the MEC_{L+G} is the Local and Global Marginal External Costs from use of water resources, measured by the Total Economic Value (TEV) of the water resources.

These curves result in four distinct equilibrium, with four levels of water resource use. Point C is the local private optimum, where all externalities are disregarded and there are no subsidies to water use.

Point D is the local private optimum, where, again all externalities are disregarded and water use is subsidised. Point B is the local social optimum, where local externalities are internalised but global externalities are ignored, and Point A is the global social optimum, where all externalities are internalised in the analysis. When an externality is internalised, the market and government failures have been corrected to the point where economic efficiency has been attained (Pearce 2001).

OA= Efficient use of water
AB= Global market failure
BC= Local market failure
CD= Government failure
(as a result of government subsidies)
AD= Inefficiency



Adapted from: Birol *et al*., (2006), page 108.

Figure 1. Impact of market failure on the efficient use of water

3.4 From welfare theory to Cost Benefit Analysis

Water has economic value in all its competing uses and should be recognised as an economic good (The Dublin Principles, 1992). Therefore, managing water well is about achieving efficient and equitable use, and to encourage conservation and protection of water resources.

The most widely accepted and used framework for decision-making is Cost Benefit Analysis (CBA). CBA is an analytical tool based on welfare theory, which is conducted by aggregating the total costs and benefits of a project or policy over both space and time (Hanley and Spash, 1995).

Translating from the welfare economic theory to CBA requires some steps due to the complexity of modern societies. In reality, few policy changes would improve welfare for many while avoiding lower welfare of some individuals. So rather than evaluating all possible allocations in a continuous function framework, CBA typically examines large separate increments of change to assess whether the move is in the direction of Pareto efficiency, (Young, 2005).

A project or policy represents a welfare improvement only if the net benefits are positive. Different management options will yield different net benefits and the option with the highest net benefits is the preferred or optimal one. A CBA of a policy or project with environmental impacts is complicated because many environmental resources (including most water resources) are public goods.

A good is public to the extent that consumption of it is non-rival and non-excludable. It is non-rival if one person's consumption of the good does not reduce the amount available to others and non-excludable if it is not possible to supply the good only to those who choose to pay for it and exclude everyone else. Pure public goods (eg fresh air, flood control system and national defence) cannot be provided by the price mechanism because producers cannot stop providing the good for non-payment, and since there is no way of measuring how much a person consumes, there is no basis for establishing a market price (Birol *et al*., 2006).

To provide measures of value and scarcity for economic policy making related to freshwater non-market techniques are required (Young, 2005). Non-market valuation is a term describing a range of techniques, which have been developed to meet the needs of decision makers who try to allocate scarce resources to their most valued uses. Most resource allocations produce a range of benefits and costs, which are not easily comparable (Kerr, 1988).

Environmental benefits and costs are typically measured by either Willingness To Accept (WTA) compensation or Willingness To Pay (WTP). WTA is the measurement of the minimum amount that an individual would be willing to accept to abandon a good or to put up with something negative, such as pollution. WTP means the measurement of the maximum amount that an individual would be willing to pay to either receive a benefit or avoid a cost applicable to the condition. The fact that whether the person in question has an existing right to either receive a benefit or avoid a cost determines.

Table 2 sets out the framework for undertaking a cost benefit analysis on integrated catchment management projects.

Table 2. Framework for Developing Cost Benefit Analysis

Scenarios: course of action and likely effects	List of Costs and Benefits including who bears them and when	Methods: Valuation techniques (How to measure costs and benefits)	Assumptions (Method, limitations and caveats)	Measurement (Implementation)
What to measure? Scenarios – Envisioning the likely effects brought about by a change in freshwater management. Scientific expertise on each individual catchment/estuary basis required.	Economic Social Cultural Environmental	a) Is it possible to observe, infer causality and therefore measure the phenomena? b) Establish metrics - market valuation techniques? c) Non-market valuation (Willingness to pay, Willingness to accept) d) No feasible method for valuation (in this case use a qualitative assessment/ description of consequence)	- Assessment of data availability - Timeframes included - Social **discount rate** used - Environmental discount rate use	- Valuation - Check for double counting - Sensitivity analysis (Low/Medium/High) - Uncertainty in project effects

Adapted from: Murray (2012)

The application of cost benefit valuation techniques to ecological resources is to transpose traditional economic valuation methodology into a concept for which it was not originally devised. The following issues are major limitations that become apparent in the CBA approach:

1. For a variety of reasons, the equilibrium condition that is required for monetary commensurability cannot be satisfied because of market failures. Therefore, the comparison of costs and benefits that relies on this assumption cannot occur.
2. When systems under consideration are complex and environmental consequences are long-lived, scientific uncertainties are high. In these situations the evaluation of opportunity costs becomes difficult (O'Connor, 2001).
3. Water usage incorporates a number of dimensions, including quality, quantity, timing and location. Thus, costs and benefits that are identified may not be directly comparable. In regards to this issue, the concept of water quality is particularly challenging.
4. Water is not necessarily consumed in the process of being used, and can be in whole or in part reused (Gibbons, 1986).
5. Difference between average and marginal values give rise to a further complication. Although most valuation techniques focus on assessing changes in marginal value, in some situations average values are estimated.
6. Young (2005), distinguished between private and social prices in valuation estimates, with the difference between the measures relating to whether or not subsidies, taxes or other government influences are included in the price.
7. The ideal CBA that takes into account every positive and negative consequence of an action is impossible due to the complexity of the situation and limitations in the availability of resources for a study.
8. The results of any particular valuation exercise are highly dependent on the initial assumptions and parameters employed (O'Connor, 2002).
9. An individual's willingness to pay and willingness to accept[6] (demand and supply) is highly dependent on his or her income and thus existing property rights. Therefore, cost benefit analysis incorporates an assumption that individual preferences should be weighted according to the existing distribution of income and in turn implies acceptance of existing societal distribution of property rights (Wills, 1997).

O'Connor (1997) recommended an approach to sustainable water management that involved analysis of two or more scenarios (scenario modelling), on the basis that this provides a robust evaluation of water use benefits while taking account of fairness concerns in water distribution. In terms of the types of scenarios to be investigated he notes that one scenario, the reference scenario, could potentially be framed as a 'business-as-usual' scenario involving trends in water use that are potentially unsustainable. Another scenario could then be constructed as a comparison involving satisfaction of specific sustainable water management criteria (Smith *et al*., 2009).

There are different approaches to scenario modelling that involves stakeholders, including Bayesian belief network (probabilistic) and Mediated Modelling (non-probabilistic), (Barton *et al*. (2012) and Van Den Belt (2004)).

Mediated modelling brings together stakeholders and diverse interests to raise the level of shared understanding of how a system works and to develop a broad and deep consensus the consequence of interventions in this system. It provides a structured process based on system dynamics thinking in which community members, government officials, industry representatives, and other stakeholders can work together to produce a coherent, simple but elegant simulation model, which is then used to explore and communicate what-if scenarios (Van Den Belt 2004).

Environmental economists argue that individuals derive value from non-market goods, such as environmental resources, through many more sources than just direct consumption (Pearce and Turner, 1990). They refer to the importance of considering the Total Economic Value (TEV) of an environmental resource. TEV recognises two basic distinctions between the values that

[6] There are debates from some environmental economists (eg, Boven 2003) that the WTA is stronger than WTP for ecosystem services as individuals are willing to keep what they have rather than pay for some thing that they have not had before. For more information see Creagh (2010).

individuals derive from use the environmental resources (Ecosystem Services[7]), ie, use values, and the value that individuals derive from the environmental resource even if they themselves do not use it, ie, non-use values (Birol *et al*., 2006). These are discussed in greater depth in the next part of this section.

Depending on the values that are chosen for analysis, a valuation-assessment undertaken from the perspective of the current generation may entail, by default, consideration of benefits and costs for future generations. These considerations occur particularly in relation to the non-use categories of values as described above.

In addition, there is some attempt in established cost benefit methodologies to extend conventional cost benefit analysis across time by including costs and benefits that occur in the future, but at a 'discounted' value. **Discounting** costs and benefits is a way of describing the value in today's dollar term, taking into account discount rate, which reflects the opportunity cost of resources to be used elsewhere. This practice allows for consideration of future interests but assumes that these interests are of smaller weight to those of the present (Smith *et al,*. 2009).

It means that the current values are proportionally larger, while costs and benefits that occurring later in the evaluation period become less significant. For example using 4% discount rate implies that freshwater loss 50 years from now will be valued at only 14 percent of the same amount of freshwater loss today. Therefore, a lower discount rate for costs and benefits associated with freshwater, as a public good, should be applied compare to private and manufactured assets.

Social Return on Investment (SROI) and the New Zealand specific Mauri model are the other potential frameworks that can be used as an alternative for traditional CBA.

A guide to social return on investment (2012), defines SROI as a framework for understanding, managing and communicating the value of the triple bottom line – the social, economic and environmental outcomes created by an activity or organisation. The SROI approach aims to value of activities of material stakeholders, rather than focus on what can be easily measured and relies heavily on stakeholder engagement.

The New Zealand specific Mauri Model is a decision-making framework that provides a culturally based template within which indigenous values are explicitly empowered alongside Western knowledge (Morgan, 2006). According to Morgan (2004), the Mauri model is based on four circles that represent interactive aspects of ecosystem. "These have been redefined as the impacts on the Mauri of the family/whanau (economic), the community (social), the clan/hapu (cultural), and the ecosystem/taiao (environment) respectively." (p. 6).

For example the filling a lake with industrial waste there are components of biodiversity, leaching of contaminants, shocks to the habitants, etc. Each of these indicators can be rated on an integer scale from + 2 to - 2, where the high end of the scale represents full Mauri and the low end represents completely destroyed Mauri (Khan, 2012).

The Mauri Model and the Mauri-ometer function are two Decision Support Tools (DTS) that have been described by Morgan (2008). "The Mauri Model is the first DST and it has the primary function of enhancing the participants' understanding of sustainability while prioritising the mauri dimensions. The Mauri-ometer function is the second DST and has the function of determining absolute sustainability." (p.156).

[7] According to the ecosystem services definition by Millennium Assessment, ecosystem services are the benefits people obtain from ecosystems and include:

- Provisioning services such as food and water
- Regulatory services such as flood and disease control,
- Cultural services such as spiritual, recreation and cultural benefits
- Supporting services, such as nutrient cycling that maintain the conditions for life on earth

http://www.millenniumassessment.org/documents/document.300.aspx.pdf

3.5 Total Economic Value framework

While cost benefit analysis is a framework that links the values to the welfare theory and paretian optimisation, TEV is a convenient framework to organise the different classes of value that might be associated with water resource development in a catchment. Auckland Council could employ TEV framework as the preferred approach of an agreed value framework (AVF).

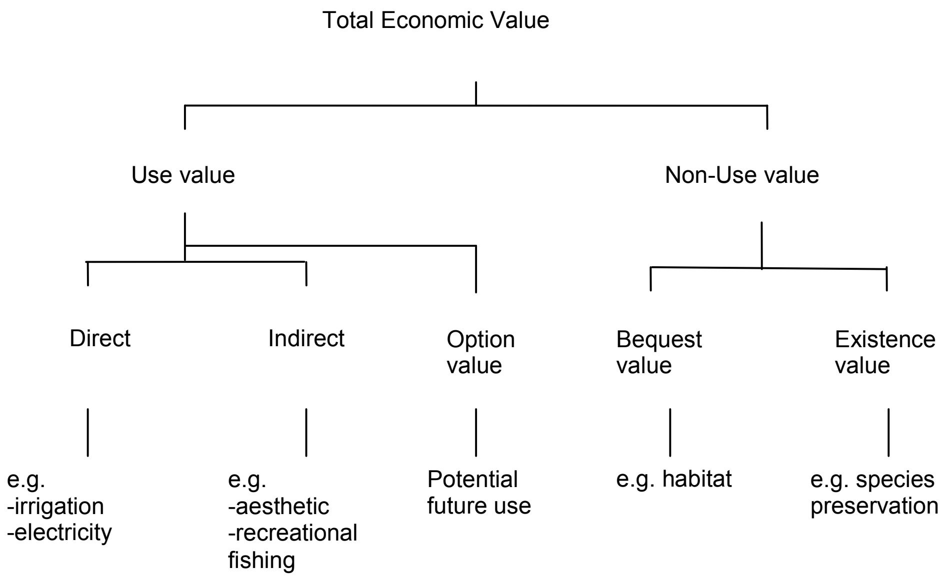


Figure 2. TEV components

Use value derives from actual use of the water resource. For example, water as an input into dairy production; the energy potential in water to generate electricity; angling and hunting. Use values can be further broken down into direct, Indirect and option values.

Option value, where, although individuals or firms are not using the resource, they might be prepared to pay for the right to use the services of the resource at some later date (Weisbrod, 1964; Freeman, 1993). Option value is not related to current use and is typically used to measure the value attached to future use opportunities.

Non-use values are independent of the individual's present use of the resource and are variously described as "existence value", the value from knowing that a particular environmental assets exists (eg, endangered species); and "bequest value", the value arising from the desire to bequeath certain resources to one's heirs or future generations (eg, habitat preservation) (Sharp and Kerr 2005).

For monetary valuation, some of these components are easier to measure than others. Direct use values are generally the most straightforward to measure because there are observable quantities of products consumed as well as market prices that can be used to determine economic value. Recreational use can also be measured by observing the number of visits and the characteristics of visitors and sites.

Indirect use values are more difficult to measure for two reasons. First, quantities are often a challenge to measure, eg, determining the flood control provided by a particular wetland. Second, the indirect uses are not usually traded in marketplaces and therefore have no associated prices. Hence, 'shadow values'[8] must be estimated in order to 'price' the produced services.

[8] A shadow price is any price that is not a market price, but the term usually also carries the connotation that it is an estimate of the economic value of the good or service in question.

Option values and non-use values are the most difficult to measure because these are not reflected in observable behaviour. These values are estimated by using surveys that ask people a series of questions about their willingness to pay for ecosystem services they value but do not use (Kramer, 2005). The environmental economic literature thus distinguishes between revealed preference (which can be observed) and stated preference.

Smith *et al*., (2009) provided a summary of values that are attributed to water resources according to a typology that is from the role of water in the complex ecological system. This summary is based on Young (2005) and Birol *et al*., (2006) definitions. A variety of methods are available for quantifying these values, which are discussed in section 4.

4.0 Water valuation techniques

Young (2005) divided valuation methods into two broad categories by quantification techniques

- Inductive methods use statistical techniques to infer economic values from data on observed human behaviour.
- Deductive approaches derive estimated willingness to pay from constructed models that hypothesise human motivations along with measured or predicted conditions of production or consumption.

A number of techniques, inductive and deductive approaches, are available to value environmental goods and services. The inductive approaches are the core of this summary where there are no market prices. These are categorised into Revealed Preference (RP) and Stated Preference (SP) techniques.

In RP methods, individuals indirectly reveal the willingness to pay for environmental goods through market and surrogate market prices (such as the hedonic pricing method). In SP methods, the individuals are asked directly what their willingness to pay is, for example via the contingent valuation method (Rohani 2012).

Although Freeman (2003) has mentioned using RP and SP as substitutes or alternative methods of estimating values for a given change in environmental condition, he has pointed out that some authors have used RP and SP methods as complements by combining RP and SP data to estimate a single valuation model (Cameron (1992), Adamowicz *et al*. (1994), McConnell *et al*. (1999)). Furthermore, Kling (1997) has shown that combining RP and SP data can reduce bias and improve the precision of welfare estimates.

Classification of the valuation methods in three water categories related to how the value of water is inferred, is presented in Figure 3, (Agudelo, 2001). He also categorised use values of water as agriculture, industry, hydropower, navigation and households, and non-use values of water as aesthetics, culture (religion), geomorphology and nature.

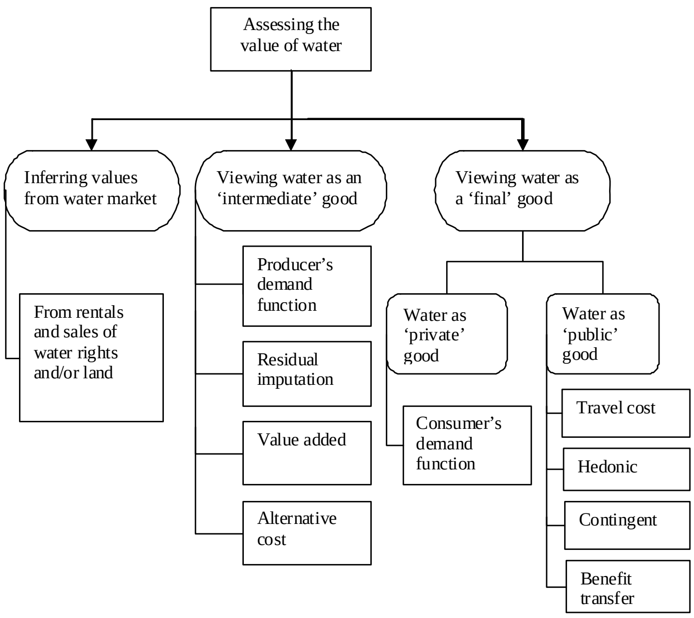


Figure 3. Methods to assess the value of water

Adapted from: Agudelo (2001), page 20

Young (2005) noted that valuation results depend on which water specific usages are being valued, as well as where and why the valuation exercise is being conducted. He categorised use and non-use consumption and related evaluation tools to determine the value of water.

In the New Zealand context, Smith *et al*. (2009) used the same principle in their literature review of water evaluation. They identified four main use categories: municipal, industrial, irrigation and water treatment.

Young (2005) also added three selected water related services:

- **Recreational and aesthetic:** An increasingly significant economic benefit from water is its value for recreation and aesthetics.
- **Water quality improvement:** Water quality is a significant component of recreational surrounding so measuring benefits of water quality improvement is also an important issue.
- **Flood risk reduction:** Floods cause property damage, economic disruption, disease, injuries and death. The property damage avoided method reflects the present value of real[9] expected property damage avoided by the project or policy, and has been the principal means of estimating urban flood risk reduction benefits (Young, 2005).

Birol *et al*. (2006) defined the appropriate economic valuation methods according to components of TEV of water resources with modification adapted from Barbier (1991), Barbier *et al*. (1997), Woodward and Wui (2001), Brouwer *et al*. (2003), and Brander *et al*. (2006). Table 3 summarises their key findings.

A summary of the most popular non-market valuation methods and their advantages and disadvantages is presented in Table 4 (refer to Young (2005), Kramer (2005), Birol (2006), Nijkamp *et al*. (2008) and Smith *et al*. (2009)). Each method is discussed in more detail further in this section.

[9] This is the value adjusted for inflation so that it represents the cost in current dollar.

Table 3. Components of TEV of water resources and appropriate economic valuation method

Water valuation methods

TEV component	Production Function	Net Factor Income	Replacement Cost	Market Prices	Cost-Of-Illness	Travel Cost Method	Hedonic Pricing Method	Contingent Valuation Method	Choice Experiment Method
Direct use values									
Irrigation for agriculture	✓	✓	✓	✓					
Domestic and industrial water supply	✓	✓	✓	✓					
Energy resources (hydro-electric, fuel wood, peat)				✓					
Transport and navigation				✓					
Recreation/amenity		✓				✓	✓	✓	✓
Wildlife harvesting				✓					
Indirect use values									
Nutrient retention			✓		✓				
Pollution abatement			✓		✓				
Flood control and protection			✓	✓					
Storm protection	✓		✓						
External eco-system support	✓		✓						
Reduced global warming			✓						
Micro-climatic stabilisation	✓								
Shoreline stabilisation			✓						
Soil erosion control	✓		✓						
Option values									
Potential future uses of direct and indirect uses								✓	✓
Future value of information of biodiversity								✓	✓
Non-use values									
Biodiversity								✓	✓
Cultural heritage								✓	✓
Bequest, existence and altruistic values								✓	✓

Table 4. Summary of non- market valuation methods

Valuation Method	Description of Method	Potentially useful for valuating		Data Sources	Main benefits	Main disadvantages
		Water usage	Water services[10]			
1. Hedonic Price Method (HPM) RP	Using econometric analysis of data on real property transactions with varying availability of water supply or quality	-Irrigation -Industrial water supply -Municipal water supply -Recreation and amenity	At-source demands for changes in water quantity or quality	Property values and characteristics including environmental quality.	Uses real market data	-Can estimate use values only -Requires extensive property market data -Cannot predict the changes in use values due to environmental changes without prior information -Current evidence suggests it is not suitable for use in benefits transfer
2. Travel Cost Method (TCM) RP	Using econometric analysis to infer the value of recreational site attributes from the varying expenditures incurred by consumers to travel to the site	Recreation and amenity	At-source valuations for changes in water supply	Survey on expenditures of time and money to travel to specific site.	Uses real market data	-Can estimate use values only -May have substantial data requirements -Requires estimates of value of travel / leisure time -Cannot predict the changes in use values due to environmental changes without prior information
3. Cost Methods (Damage, Replacement, Substitute) RP	Maximum willingness to pay for compensation, replacement or substitute of an ecosystem service	Waste treatment, potentially other indirect values	Valuation of reduced water pollution or flood damages	Cost of environmental services	Observable data, less data and resource intensive	-Assumes that costs = benefits. -Does not consider social preferences -Methods require good understanding of the dynamics of ecosystem services
4. Productivity Method (PM) (or Net Factor Income) RP	Estimates the economic value of ecosystem products or services that contribute to the production of commercially market goods	-Irrigation -Industrial water supply -Municipal water supply	Producers' (agricultural or industrial) at-site valuations Industrial or municipal water supply	Estimates of costs for factors of production and demand	Relatively straightforward estimate, inexpensive	-Limited to market resources -Externalities not captured in method -Relationships between resources may not be well understood
5. Market Price (MP) (or Water Demand Functions) RP	Observed prices from transactions for short-term leases or permanent sales of rights to water	-Irrigation -Industrial water supply -Municipal water supply	Actual at-source or at-site WTP manifested by transactions within or between agricultural, industrial, municipal and environmental uses	Data on market prices, as well as cost and demand functions	Reflects an individual willingness to pay for goods; price, quantity and cost data relatively easy to obtain	-Market data only available for a limited number of ecological resources -Market value may not reflect total cost due to market imperfections -Assumes perfectly competitive market
6. Contingent Valuation Method (CVM) SP	Using statistical techniques for analysing responses to survey questions asking for monetary valuation of proposed changes in environmental goods or services	-Recreation and amenity, -Non use values	At-source valuations of environmental water supplies. Also at-site valuations of changes in residential water supplies	Survey of willingness to pay for a specific ecosystem service	-Can estimate both use and non-use values -Suitable for valuing environmental changes irrespective of whether or not they have a precedence -Completed surveys give full profile of target population	-Relatively expensive -Complex and multidimensional scenarios may be too much of a cognitive burden for respondents -The concept of diversity may similarly be difficult to put across to the respondents -Imperfect information, improved with DMV methods
7. Choice Modelling (CM) SP	Using statistical techniques to infer WTP for goods or services from survey questions asking a sample of respondents to make choices among alternative proposed policies	-Recreation and amenity -Non use values	At-source valuations of environmental water supplies. Also at-site valuations of changes in residential water supplies	Data collected through a survey, that measures the ranking of various alternative choices	-Can estimate both use and non-use values - Suitable for valuing environmental changes irrespective of whether or not they have a precedence -Completed surveys give full	-Not yet as widely tested as CVM -Some techniques are not based on economic theory -The concept of 'diversity' may be difficult to put across to the respondents
8. Deliberative Monetary Valuation (DMV)	Combines stated preference methods with deliberative techniques known from political sciences. It is a two-step approach, with the first session dedicated to discussing the issues and deliberating, and the second session dedicated to monetary valuation.	-Recreation and amenity -Non use values	At-source valuations of environmental water supplies. Also at-site valuations of changes in residential water supplies	A panel of experts and scientists without conflict of interest.	-may increase the validity of stated preference methods. -time for reflection -the potential for information gathering and group deliberation	-Complex analysis -More expensive approach than CVM -More time and effort consumption
9. Benefit Transfer (BT) (or Meta-Analysis)	Statistical synthesis of the results of previously reported studies of the same phenomenon or relationship to distil generalisations	All use and non use values	A potential basis for benefit transfer in all producers and consumers' valuation contexts.	Extensive use of secondary data from other methods listed in the table	Useful as an initial investigation or when other data is too difficult or expensive to obtain	Not measuring the benefits within the context of the study
10. Averting Expenditure Method (AEV) RP	Using reductions in the costs of actions taken to mitigate or avoid incurring an external cost as a partial measure of the benefits of policies from reducing externality	Some indirect-use values	Valuation of reduced water pollution from biological or chemical contaminants	Primary and secondary data around private expenditure on mitigating/defensive behaviours	Provide good understanding of defensive behaviour of individuals	-Difficult to separate defensive behaviour from other spending -Defensive behaviour is not continuous and is often reactive

[10] At-source versus at-site: to ensure that the chosen measure of water valuation is commensurable in terms of a common denominator of place, form and time Young (2005) defined at- site and at- source values. At-site values will exceed the at-source values by whatever costs are incurred in capturing, storing, transporting, and treating the water.

4.1 Hedonic Pricing Method

The Hedonic Pricing Method (HPM) is a revealed preference technique. It is based on Lancaster's characteristics theory of value (Lancaster, 1966), which is based on the assumption that people value the characteristics of a good, or the services it provides, rather than the good itself. Therefore, prices will reflect the value of a set of characteristics, including environmental characteristics that people consider important when purchasing the good. Most applications use residential housing prices to estimate the value of environmental amenities.

Usage

The hedonic pricing method may be used to estimate economic benefits or costs associated with:

- Environmental quality, including air, water, or noise pollution
- Environmental amenities, such as aesthetic views or proximity to recreational sites

Data needed and approach

To apply the hedonic pricing method, the following information must be collected:

- A measure or index of the environmental amenity of interest.
- Cross-section and/or time-series data on property values and property and household characteristics for a well-defined market area, including homes with different levels of environmental quality, or different distances to an environmental amenity, such as open space or the coastline.

The data is analysed using multiple regression analysis, which relates the price of the property to its characteristics and the environmental characteristic(s) of interest. Thus, the effects of different characteristics on price can be estimated. The results indicate how much property values will change for a given change in each characteristic, holding all other characteristics constant.

Strengths and weaknesses

The main strength of this method is that it can be used to estimate values based on actual choices. The other positive points of HPM are:

- Property markets are relatively efficient in responding to information, so can be good indicators of value.
- Property records are typically very reliable.
- Data on property sales and characteristics are readily available through many sources, and can be related to other secondary data sources to obtain descriptive variables for the analysis.
- The method is versatile, and can be adapted to consider several possible interactions between market goods and environmental quality.

The major limitation of the HPM is that it only measures direct use values of water resources as perceived by the consumers' of the good in which it is implicitly traded. Services such as flood control, water quality improvement, habitat provision for species, and groundwater recharge may provide values that benefit individuals far away, beyond the consumers of the good, which the HPM is unable to capture (Boyer and Polasky, 2004). The HPM issues and limitations are listed in detail below:

- The scope of environmental benefits that can be measured is limited to things that are related to housing prices.

- The method will only capture people's willingness to pay for perceived differences in environmental attributes, and their direct consequences. Thus, if people are unaware of the linkages between the environmental attribute and benefits to them or their property, the value will not be reflected in property prices.
- The method assumes that people have the opportunity to select the combination of features they prefer, given their income. However, the housing market may be affected by outside influences, like taxes, interest rates, or other factors.
- The method is relatively complex to implement and interpret, requiring a high degree of statistical expertise.
- The results depend heavily on model specification.
- Large amounts of data must be gathered and manipulated.
- The time and expense to carry out an application depends on the availability and accessibility of data.

Alternative approaches

If the environmental quality of concern is open space used mainly for recreation, the travel cost method might be used. Alternatively, survey-based methods, like contingent valuation or contingent choice, might be used. However, these methods would generally be more difficult and expensive to apply.

Case studies

- HPM has been applied to wetland valuation. Mahan *et al*. (2000) used data on more than 14,000 home sales in the Portland, Oregon metropolitan area to estimate the effect of proximity to wetlands on property values. They found that a decrease in the distance to the nearest wetland by 1000 ft (304.8 m), from an initial distance of 1 mile (1.61 km) resulted in an increase in property values of €371.6.

- In the New Zealand context, Bourassa *et al*. (2004) provided a detailed literature review as well as an empirical analysis of the impact of a view on residential property values using a very rich database of nearly 5,000 house sales in Auckland. Several dimensions of a view were analysed (type of view, scope of view, distance to coast, and quality of surrounding improvements). They found that wide views of water add an average of 59 percent to the value of a waterfront property, but this effect decreases quite rapidly as the distance from the coast increases. Attractive landscaping and buildings in a property's neighbourhood on average add five and 37 percent to value, respectively. Particularly attractive improvements in the immediate surroundings of a property add a further 27 percent to value on average. Their results lead to the conclusion that aesthetic externalities are multi-dimensional and can have a substantial impact on residential property values.

- Rohani (2012) in a study of impact of the Hauraki Gulf amenity on land prices on Auckland's North shore, considered various view scopes as well as a vector of the network access distance to the nearest designated beach. Results show, keeping all other variables constant, the land value of a property 100 metres from the coastline is 41 and 47 percent less if it has moderate and slight scope views, respectively, compared to a similar property at the same location with wide views. Furthermore, a property with wide water views would cost on average, 32, 48 and 59 percent less if located 100, 500 and 2000 metres from the coast, respectively.

4.2 Travel Cost Method

The Travel Cost Method (TCM) is used to estimate the value of recreational benefits generated by a resource. It assumes that the value of the site or its recreational services is reflected in how much people are willing to pay to get there. It is referred to as a revealed preference method, because it uses actual behaviour and choices to infer values. Therefore, peoples' willingness to pay are revealed by their choices. The basic premise of the travel cost method is that the time and travel cost expenses that people incur to visit a site, for example to a river walking path, represent the price of access to the site. Thus, peoples' WTP to visit the site can be estimated based on the number of trips that people make at different travel costs. This is similar to estimating peoples' willingness to pay for a market good based on the quantity demanded at different prices.

Usage

The method can be used to estimate the economic benefits or costs resulting from:

- Changes in access costs for a recreational site
- Elimination of an existing recreational site
- Addition of a new recreational site and changes in environmental quality at a recreational site.

Data needed and approach

To apply the travel cost method, information must be collected about:

- Number of visits from each origin zone (usually defined by zip code/postcode)
- Demographic information about people from each zone
- Round-trip mileage from each zone
- Travel costs per mile
- The value of time spent travelling, or the opportunity cost of travel time

The TCM encompasses a variety of models, ranging from the simple single-site TCM to regional and generalised models that incorporate quality indices and account for substitute sites (Birol *et al*., 2006).

More complicated, and thorough, applications may also collect information about:

- Exact distance that each individual travelled to the site
- Exact travel expenses
- The length of the trip
- The amount of time spent at the site
- Other locations visited during the same trip, and amount of time spent at each
- Substitute sites that the person might visit instead of this site, and the travel distance to each
- Other reasons for the trip (is the trip only to visit the site, or for several purposes)
- Quality of the recreational experience at the site, and at other similar sites (eg, fishing success)
- Perceptions of environmental quality at the site
- Characteristics of the site and other, substitute, sites

This information is typically collected through surveys, on-site, telephone or mail surveys may be used.

Strengths and weaknesses

Advantages of the TCM can be summarised as below:

- The travel cost method closely mimics the more conventional empirical techniques used by economists to estimate economic values based on market prices.
- The method is based on actual behaviour (ie, what people actually do) rather than stated willingness to pay (ie, what people say they would do) in a hypothetical situation.
- The method is relatively inexpensive to apply.
- On-site surveys provide opportunities for large sample sizes, as visitors tend to be interested in participating.
- The results are relatively easy to interpret and explain.

Similar to HPM, this method cannot capture the non-use values of environmental resources; in addition, it has following limitations in use:

- In order to estimate the demand function, there needs to be sufficient difference between distances travelled to affect travel costs and for differences in travel costs to affect the number of trips made. Thus, it is not well suited for sites near major population centres where many visitations may be from "origin zones" that are quite close to one another.
- The travel cost method is limited in its scope of application because it requires user participation. It cannot be used to assign values to on-site environmental features and functions that users of the site do not find valuable. It cannot be used to value off-site values supported by the site. Most importantly, it cannot be used to measure non-use values. Thus, sites that have unique qualities that are valued by non-users will be undervalued.
- The travel cost method assumes that people perceive and respond to changes in travel costs the same way that they would respond to changes in admission price.
- The simplest models assume that individuals take a trip for a single purpose – to visit a specific recreational site. Therefore, if a trip has more than one purpose, the value of the site may be overestimated. It can be difficult to apportion the travel costs among the various purposes.
- Defining and measuring the opportunity cost of time, or the value of time spent travelling, can be problematic. Because the time spent travelling could have been used in other ways, it has an "opportunity cost." This should be added to the travel cost, or the value of the site will be underestimated. However, there is no strong consensus on the appropriate measure (the person’s wage rate, or some fraction of the wage rate) and the value chosen can have a large effect on benefit estimates. In addition, if people enjoy the travel itself, then travel time becomes a benefit, not a cost, and the value of the site will be overestimated.
- The availability of substitute sites will affect values. For example, if two people travel the same distance, they are assumed to have the same value. However, if one person has several substitutes available but travels to this site because it is preferred, this person’s value is actually higher. Some of the more complicated models account for the availability of substitutes.
- Those who value certain sites may choose to live nearby. If this is the case, they will have low travel costs, but high values for the site, that are not captured by the method.
- Interviewing visitors on site can introduce sampling biases to the analysis.
- Measuring recreational quality and relating recreational quality to environmental quality can be difficult.
- Standard travel cost approaches provides information about current conditions, but not about gains or losses from anticipated changes in resource conditions.

Alternative approaches

Contingent valuation or choice modelling could also be used in this case. While they might produce more precise estimates of values for specific characteristics of the site, and could capture non-use values, they would be considerably more complicated and expensive to apply.

Case studies

Loomis (2002) employed the TCM to estimate the recreation use values from hypothetically removing dams and restoring free-flowing rivers, with an application to the Lower Snake River in Washington, US. He found that removal of four dams and restoring 225km of river increased the value of river recreation to a high of €264.2 million. This exceeded the loss of reservoir recreation, but was about €51.1million less than the total costs of the dam removal alternative.

4.3 Damage Cost Avoided, Replacement Cost and Substitute Cost Method

The damage cost avoided, replacement cost, and substitute cost methods are related methods that estimate values of ecosystem services based on either the costs of avoiding damages due to lost services, the cost of replacing environmental assets, or the cost of providing substitute services, respectively. Since these methods are based on using costs to estimate benefits, they do not provide a technically correct measure of economic value, which is properly measured by the WTP to have a particular good, less the actual cost of the good.

The damage cost avoided method, uses either the value of property protected, or the cost of actions taken to avoid damages, as a measure of the benefits provided by ecosystems. For example, if a wetland protects adjacent property from flooding, the flood protection benefits may be estimated by the damages avoided if the flooding does not occur or by the expenditures property owners make to protect their property from flooding.

The cost of illness method (COI) is a subset of the damage cost avoided method. It uses data on costs of mediation; doctors visits, time lost from work etc to infer costs of damages to human health (Smith *et al*., 2009). Two important limitations of this approach are that it does not consider the actual disutility of those who are ill, nor does it account for the defensive or averting expenditures that individuals may have taken to protect themselves (Birol, 2006).

The replacement cost method uses the cost of replacing an ecosystem or its services as an estimate of the value of the ecosystem or its services. Similarly, the substitute cost method uses the cost of providing substitutes for an ecosystem or its services as an estimate of the value of the ecosystem or its services. For example, the flood protection services of a wetland might be replaced by a retaining wall or levee.

Usage

These methods are particularly applicable where there is a standard that must be met, such as a certain level of water quality (Markandya *et al*., 2002). They can also be used in valuing:

- Improved water quality by measuring the cost of controlling effluent emissions
- Erosion protection services of a forest or wetland by measuring the cost of removing eroded sediment from downstream areas
- The water purification services of a wetland by measuring the cost of filtering and chemically treating water
- Storm protection services of coastal wetlands by measuring the cost of building retaining walls
- Fish habitat and nursery services by measuring the cost of fish breeding and stocking programs

Data needed and approach

These methods require answers to the same initial questions. The first step is to assess the environmental services provided. This involves specifying the relevant services in terms of:

- How are they provided?
- To who are they provided?
- At what level are the services provided?

For example, in the case of flood protection, this would involve predictions of flooding occurrences and their levels, as well as the potential impacts on property.

The second and third steps for the damage cost avoided method are:

- Estimate the potential physical damage to property, either annually or over some discrete period.
- Calculate either the dollar value of potential property damage, or the amount that people spend to avoid such damage.

The second, third and fourth, steps for the replacement or substitute cost methods are:

- Identify the least costly alternative means of providing the services.
- Calculate the cost of the substitute or replacement services.
- Establish the public demand for this alternative. This requires gathering evidence that the public would be willing to accept the substitute or replacement services in place of the ecosystem services.

Strengths and weaknesses

Advantages of the Damage Cost Avoided, Replacement Cost, and Substitute Cost Methods can be defined as:

- The methods may provide a rough indicator of economic value, subject to data constraints and the degree of similarity or substitutability between related goods.
- It is easier to measure the costs of producing benefits, rather than the benefits themselves, when goods, services, and benefits are non-market. Thus, these approaches are less data and resource-intensive.
- The methods provide surrogate measures of value that are as consistent as possible with the economic concept of use value, for services which may be difficult to value by other means.

These methods have some issues and limitations in use:

- The replacement cost method requires information on the degree of substitution between the market good and the natural resource. Few environmental resources have such direct or indirect substitutes. Substitute goods are unlikely to provide the same types of benefits as the natural resource, eg, stocked salmon may not be valued as highly by anglers as wild salmon.
- The goods or services being replaced probably represent only a portion of the full range of services provided by the natural resource. Thus, the benefits of an action to protect or restore the ecological resource would be understated.
- These approaches assume that expenditures to repair damages or to replace ecosystem services are valid measures of the benefits provided. However, costs are usually not an accurate measure of benefits.
- These methods do not consider social preferences for ecosystem services, or individuals' behaviour in the absence of those services. Thus, they should be used as a last resort to value ecosystem services.
- The methods may be inconsistent because few environmental actions and regulations are based solely on benefit-cost comparisons, particularly at the national level. Therefore, the cost of a protective action may actually exceed the benefits to society. It is also likely that the cost of actions already taken to protect an ecological resource will underestimate the benefits of a new action to improve or protect the resource.
- These approaches should be used only after a project has been implemented or if society has demonstrated their willingness-to-pay for the project in some other way (eg, approved spending for the project). Otherwise, there is no indication that the value of the good or service provided by the ecological resource to the affected community is greater than the estimated cost of the project.
- Just because an ecosystem service is eliminated, there is no guarantee that the public would be willing to pay for the identified least cost alternative merely because it would supply the same benefit level as that service. Without evidence that the public would demand the alternative, this methodology is not an economically appropriate estimator of ecosystem service values.

Alternative approach

Dependent on the TEV component, there are several alternatives to using cost methods. For example for a flood control and protection valuation, market price is the alternative approach and for valuating a pollution control project, cost of illness could be the substitute approach.

Case studies

- Leschine *et al*. (1997) used a variant of the substitute cost method to estimate dollar-per-acre values of wetlands systems for flood protection in two Western Washington communities (Lynnwood and Renton). The proxy values they estimate are in the range of tens of thousands per acre in 1997 dollars.

- A practical example of damage cost avoided technique is the New York City (NYC) ecosystem services strategy to preserve the quality of its drinking water and saved millions of dollars (Appleton 2002).

NYC has historically expanded its water supply system by securing lands and water resources in its rural hinterland. This started with the acquisition of forestland in the Croton catchment and the construction of the Croton Aqueduct system in the mid-19th century. It continued with land acquisitions in the Catskill and Delaware catchments and construction of the 190 km Catskill Aqueduct, starting in the early 20th century (Appleton 2002).

According to Citizens network for sustainable development, due to population growth and increasing pressure on the water supplies, in the 1990's a decision had to be made between using lesser quality water for which a new water treatment plant needed to be built, or further securing the supplies of high quality water from the Catskill Ranges. The New York Water Strategy was developed based on a study comparing the cost of the two options, which found that freshwater released from an intact forested catchment would be fit to drink without further treatment, and that preventing harm to the catchment forests would best be achieved if the City has actual ownership (or other direct control) over activities within the catchment. Based on these findings, it was considered more cost effective to acquire control over catchment lands and protect their forests, than to invest in expensive water filtration or other treatment facilities.

By protecting the watershed at its source, NYC avoids spending the estimated $8 billion to $10 billion to build a filtration plant and the $400 million in annual maintenance and operation costs.

4.4 Productivity Method or Net Factor Income

The productivity method (PM), also referred to as the net factor income (NFI) or derived value method, is used to estimate the economic value of ecosystem products or services that contribute to the production of commercial market goods. It is applied in cases where the products or services of an ecosystem are used, along with other inputs, to produce a market good. The basic principle behind estimating the economic benefits or values of an un-priced producers' good entails isolating the portion contributed by the good (eg, environment) to the total output of the industrial process, from the contributions of all other inputs that go into the production process (Young, 2005).

In order to develop a theoretical measure of welfare changes for firms based on changes in the quantity or quality of a non-priced input (eg, water), economists typically derive what is termed a Value of Marginal Product (VMP) function. The method used to derive this function is complex and dependent on a number of assumptions (Smith *et al*., 2009).

For instance, water quality can affect the productivity of irrigated agricultural crops, or the costs of purifying municipal drinking water. Therefore, the economic benefits of improved water quality can be measured by the increased revenues from greater agricultural productivity, or the decreased costs of providing clean drinking water.

Usage

This method can be used in industrial and irrigation uses of water. Industrial water uses can be distinguished from municipal/residential water use in that the good is classified as an intermediate or producers' good, as opposed to a final consumption good (refer to Young (2005) and Smith *et al*. (2009).

The method is most easily applied in:

- Cases in which the resource in question is a perfect substitute for other inputs. For instance, increased water quality in a reservoir means that less chlorine is needed for treating the water. In this case, an increase in quality of the resource will result in decreased costs for the other inputs. Thus, in this example, the benefits of increased water quality can be directly measured by the decreased chlorination costs.
- Cases in which only producers of the final good benefit from changes in quantity or quality of the resource and consumers are not affected. For instance, improved quality of irrigation water may lead to greater agricultural productivity; more crops are produced on the same amount of land. If the market price of the crops to consumers does not change, benefits can be estimated from changes in producer surplus resulting from increased income from the other inputs. Thus, in this example, the profits per acre will increase, and this increase can be used to estimate the benefits of improved irrigation and water quality.

Data needed and approach

To apply the productivity method, data must be collected regarding how changes in the quantity or quality of the natural resource affect:

- Costs of production for the final good
- Supply and demand for the final good
- Supply and demand for other factors of production

This information is used to link the effects of changes in the quantity or quality of the resource to changes in consumer surplus and/or producer surplus, and therefore estimate the economic benefits.

Strengths and weaknesses

Key strengths of this approach include:

- In general, the methodology is straightforward.
- Data requirements are limited, and the relevant data may be readily available, so the method can be relatively inexpensive to apply.

PM has some limitations in application, including:

- The method is limited to valuing those resources that can be used as inputs in production of market goods.
- When valuing an ecosystem, not all services will be related to the production of market goods. Thus, the inferred value of that ecosystem component may understate its true value to society.
- Information is needed on the scientific relationships between actions to improve quality or quantity of the resource and the actual outcomes of those actions. In some cases, these relationships may not be well known or understood.
- If the changes in the natural resource affects the market price of the final good, or the prices of other production inputs, the method becomes much more complicated and difficult to apply.

Alternative approaches

Production function, market price and cost methods could also be used in this case.

Case studies

An example of this method is provided by Acharya and Barbier (2002), who use the production function approach to estimate the value of groundwater recharge in the Hadeja-Jama'Are floodplain, Northern Nigeria. They found the value of the recharge function is €11104 per day for the wetlands and the average welfare change for a one metre change in water levels is approximately €0.1 per household (refer to Birol *et al*., 2006).

4.5 Market Price Method or Water Demand Function

The market price method (MPM) estimates economic values for ecosystem products or services that are bought and sold in commercial markets. The standard method for measuring the use value of resources traded in the marketplace is the estimation of consumer surplus and producer surplus using market price and quantity data. The total net economic benefit, or economic surplus, is the sum of consumer surplus and producer surplus.

This method is generally used with other revealed preference methods (eg, cost-of-illness approach and replacement costs approach), which assume that market prices represent the opportunity cost of water resources.

Usage

The MPM uses prevailing prices for goods and services traded in markets, such as fish sold commercially. The market price represents the value of an additional unit of that good or service, assuming the good is sold through a perfectly competitive market (that is, a market where there is full information, identical products being sold and no taxes or subsidies, which in reality, rarely exist). Smith *et al*. (2009) have defined this method as an approach of municipal water supply valuation.

Data needed and approach

Application of the market price method requires the following data to estimate consumer and producer surplus:

- Data on variable costs of production and revenues received from the good.
- Time series data on the quantity demanded at different prices, plus data on other factors that might affect demand, such as income or other demographic data.

The data is used to estimate a demand function, from which consumer and producer surplus is derived.

Strengths and weaknesses

Key strengths of the MPM are listed below:

- The market price method reflects an individual's willingness to pay for costs and benefits of goods that are bought and sold in markets, such as fish, timber, or fuel wood. Thus, people's values are likely to be well defined. Price, quantity and cost data are relatively easy to obtain for established markets.
- The method uses observed data of actual consumer preferences.
- The method uses standard, accepted economic techniques

In terms of limitations, one of the major difficulties in applying the demand function approach is that sufficient data on prices and water use for developing reliable water demand function is difficult to obtain (Smith *et al*., 2009). The other main weaknesses of this method are listed as below:

- Market data may only be available for a limited number of goods and services provided by an ecological resource and may not reflect the value of all productive uses of a resource.
- The true economic value of goods or services may not be fully reflected in market transactions, due to market imperfections and/or policy failures.
- Seasonal variations and other effects on price must be considered.
- The method cannot be easily used to measure the value of larger scale changes that are likely to affect the supply of or demand for a good or service.
- Usually, the market price method does not deduct the market value of other resources used to bring ecosystem products to market, and thus may overstate benefits (for example the time value of fisherman).

Alternative approaches

The market price method can be selected in those cases where the primary resource affected has available market data. In these cases, it is the most straightforward approach, but other approaches such as cost methods and the productivity method could also be used.

Case studies

Watercare Services is Auckland City's water and wastewater utility, 100% owned by the Council. The company is a Council Controlled Organisation (CCO), that is tasked with operating an efficient and effective water and wastewater business.

It is driven by a statutory requirement to be a least-cost provider, promote water demand management to reduce use and delay expenditure to extend supplies, and to ensure intergenerational equity. Watercare's pricing strategy for water and wastewater is based on a user-pays model. The price per cubic metre is then set by a demand function accounting for demand elasticity.

The water and wastewater (calculated at 78.5 % of the water volume) charges have been set for July 2012 to June 2013 period, for residential customers that have water meters, as below:

- Water volumetric charges: $1.343 per 1000 litres
- Wastewater Fixed annual charge: $190
- Wastewater volumetric charge per water meter: $2.281 per 1000 litres

In 2005, one of Watercare's predecessors Metrowater carried out a tariff review to understand the impact of usage-based charges fully. The company's view on user-pays as the fairest and most sustainable system of charging was reinforced by the results of the review. A pricing structure including a low fixed charge was introduced when it became evident that a higher fixed charge and lower variable pricing structure introduced in 1997 did not provide sufficient incentives for customers to conserve water (Jaine and Ladd 2005).

4.6 Contingent Valuation Method

The purpose of the contingent valuation method (CVM) is to elicit individuals' preferences, in monetary terms, for changes in the quantity or quality of nonmarket environmental resources. With CVM, valuation is dependent or 'contingent' upon a hypothetical situation or scenario whereby a sample of the population is interviewed and individuals are asked to state their maximum WTP (or minimum willingness to accept (WTA) compensation) for an increase, or decrease, in the level of environmental quantity or quality (Birol *et al.*, 2006).

CVM is used to estimate economic values for all kinds of ecosystem and environmental services. The contingent valuation method is referred to as a stated preference method, because it asks people to directly state their values, rather than inferring values from actual choices, as the "revealed preference" methods do.

Usage

CVM can be used to estimate both use and non- use values, and it is the most widely used method for estimating non-use values. It is also the most controversial of the non-market valuation methods (eg, there are debates on the appropriate questionnaires).

Data needed and approach

The contingent valuation method involves directly asking people, in a survey, how much they would be willing to pay for specific environmental services. In some cases, people are asked for the amount of compensation they would be willing to accept to give up specific environmental services.

Strengths and weaknesses

Contingent valuation is enormously flexible, and it can be used to estimate the economic value of virtually anything. However, it is best able to estimate values for goods and services that are easily identified and understood by users and that are consumed in discrete units (eg, user days of recreation), even if there is no observable behaviour available to deduce values through other means.

The method's other strengths are listed below:

- CVM is the most widely accepted method for estimating TEV, including all types of non-use values, use values, existence values, option values and bequest values.
- Though the technique requires competent survey analysts to achieve defensible estimates, the nature of CVM studies and the results of CVM studies are not difficult to analyze and describe. Dollar values can be presented in terms of a mean or median value per capita or per household, or as an aggregate value for the affected population.
- CVM has been widely used, and a great deal of research is being conducted to improve the methodology, make results more valid and reliable, and better understand its strengths and limitations.

There are many weaknesses around CVM usage including:

- Although the contingent valuation method has been widely used for the past two decades, there is considerable controversy over whether it adequately measures people's willingness to pay for environmental quality.
- People have practice making choices with market goods, so their purchasing decisions in markets are likely to reflect their true willingness to pay. CVM assumes that people understand the good in question and will reveal their preferences in the contingent market just as they would in a real market. However, most people are unfamiliar with placing dollar values on environmental goods and services. Therefore, they may not have an adequate basis for stating their true value.
- The expressed answers to a willingness to pay question in a contingent valuation format may be biased because the respondent is actually answering a different question than the surveyor had intended. Rather than expressing value for the good, the respondent might actually be expressing their feelings about the scenario or the valuation exercise itself. For example, respondents may express a positive willingness to pay because they feel good about the act of giving for a social good (referred to as the "warm glow" effect), although they believe that the good itself is unimportant. Respondents may state a positive willingness to pay in order to signal that they place importance on improved environmental quality in general. Alternatively, some respondents may value the good, but state that they are not willing to pay for it, because they are protesting some aspect of the scenario, such as increased taxes or the means of providing the good.
- Respondents may make associations among environmental goods that the researcher had not intended. For example, if asked for willingness to pay for improved visibility (through reduced pollution), the respondent may actually answer based on the health risks that he or she associates with dirty air.

- Some researchers argue that there is a fundamental difference in the way that people make hypothetical decisions relative to the way they make actual decisions. For example, respondents may fail to take questions seriously because they will not actually be required to pay the stated amount. Responses may be unrealistically high if respondents believe they will not have to pay for the good or service and that their answer may influence the resulting supply of the good. Conversely, responses may be unrealistically low if respondents believe they will have to pay.
- The payment question can either be phrased as the conventional 'What are you willing to pay (WTP) to receive this environmental asset?', or in the less usual form, 'What are you willing to accept (WTA) in compensation for giving up this environmental asset?' In theory, the results should be very close. However, when the two formats have been compared, WTA very significantly exceeds WTP. Critics have claimed that this result invalidates the CVM approach, showing responses to be expressions of what individuals would like to have happen rather than true valuations.
- If people are first asked for their willingness to pay for one part of an environmental asset (eg, one lake in an entire system of lakes) and then asked to value the whole asset (eg, the whole lake system), the amounts stated may be similar. This is referred to as the "embedding effect."
- In some cases, people's expressed willingness to pay for something has been found to depend on where it is placed on a list of things being valued. This is referred to as the "ordering problem."
- Respondents may give different willingness to pay amounts, depending on the specific payment vehicle chosen. For example, some payment vehicles, such as taxes, may lead to protest responses from people who do not want increased taxes. Others, such as a contribution or donation, may lead people to answer in terms of how much they think their "fair share" contribution is, rather than expressing their actual value for the good.
- Many early studies attempted to prompt respondents by suggesting a starting bid and then increasing or decreasing this bid based upon whether the respondent agreed or refused to pay a such sum. However, it has been shown that the choice of starting bid affects respondents' final willingness to pay response.
- Strategic bias arises when the respondent provides a biased answer in order to influence a particular outcome. If a decision to preserve a stretch of river for fishing, for example, depends on whether or not the survey produces a sufficiently large value for fishing, the respondents who enjoy fishing may be tempted to provide an answer that ensures a high value, rather than a lower value that reflects their true valuation.
- Information bias may arise whenever respondents are forced to value attributes with which they have little or no experience. In such cases, the amount and type of information presented to respondents may affect their answers
- Non-response bias is a concern when sampling respondents, since individuals who do not respond are likely to have, on average, different values than individuals who do respond.
- Estimates of non-use values are difficult to validate externally.
- When conducted to the exacting standards of the profession, contingent valuation methods can be very expensive and time-consuming, because of the extensive pre-testing and survey work.
- Many people, including jurists, policy-makers, economists, and others, may not believe or accept the results of the CV method.
- The results of contingent valuation surveys are often highly sensitive to what people believe they are being asked to value, as well as the context that is described in the survey.

Alternative approaches

Since non-use values in relation to natural resources are significant and few people actually visit the site, other methods, such as the travel cost method, will underestimate the benefits of preserving the site. In this case, contingent choice methods might also be used, depending on the questions that must be answered, and whether contingent choice question formats are more effective than standard contingent valuation questions. This would be decided in the survey development stage of the application. Deliberative monetary valuation method is the other alternative approach for CVM.

Case studies

- Creagh (2010) used a CVM survey of urban water consumers in two cities in New Zealand to investigate the WTP for maintaining ecosystem services of local catchments to ensure high quality freshwater resources. A systems- approach extended the traditional CVM so the WTP related to a "bundle" of services that combined ensures healthy water catchments. "The aggregated mean welfare estimates for Auckland range from $15-27 million per annum, with the majority on average accepting a minimum of $12 million to be directed to maintaining and restoring the catchments' capacity to provide water related ecosystem services every year." (p. 152-153)

- The economic values of the groundwater resource in Waimea Plains was estimated by White *et al*. (2001) using CVM. Three sectors (agricultural, irrigation, and the commercial/industrial) represented the majority of groundwater users for productive uses. The results show that if all extractive users had their allocations reduced by 100 percent, the total cost was estimated at $244 million to $248 million; comprising $38 million to $42 million (260 irrigators), $173 million (15 commercial users) and $33 million (the bulk water supplier).

- Lommis *et al*. (1999) studied five ecosystem services that could be restored along a 45-mile section of the Platte river (Colorado, US) using CVM. They described the project to respondents using a building block approach developed by an interdisciplinary team. The ecosystem services examined, included the dilution of wastewater, natural purification of water, erosion control, habitat for fish and wildlife, and recreation.

Households were asked a dichotomous choice willingness to pay question regarding purchasing the increase in ecosystem services through a higher water bill. Results from nearly 100 in-person interviews indicated that households would pay an average of $21 per month or $252 annually for the additional ecosystem services.

The mean WTP ($21) to increase five ecosystem services, dilution of wastewater, natural purification of water, erosion control, habitat for fish and wildlife and recreation, along 45 miles of the South Platte river was generalized to all households living along the river. Since it is sufficient to pay for the conservation easements on agricultural land along the river and the leasing of water for in stream flow, the policy to increase ecosystem services through restoration efforts meets the economic efficiency criteria.

4.7 Choice Modelling or Choice Experiment Method

The choice model (CM), contingent choice method (CCM) (Birol *et al*., 2006) or choice experiment method (CEM) is similar to contingent valuation. It can be used to estimate economic values for virtually any ecosystem or environmental service, and can be used to estimate non-use as well as use values. Like contingent valuation, it is a hypothetical method and asks people to make choices based on a hypothetical scenario. However, it differs from contingent valuation because it does not directly ask people to state their values in dollars. Instead, values are inferred from the hypothetical choices or tradeoffs that people make.

The contingent choice method asks the respondent to state a preference between one group of environmental services or characteristics, at a given price or cost to the individual, and another group of environmental characteristics at a different price or cost. Because it focuses on tradeoffs among scenarios with different characteristics, contingent choice is especially suited to policy decisions where a set of possible actions might result in different impacts on natural resources or environmental services. For example, improved water quality in a lake will improve the quality of several services provided by the lake, such as drinking water supply, fishing, swimming, and biodiversity. In addition, while contingent choice can be used to estimate dollar values, the results may also be used to rank options, without focusing on dollar values.

Usage

Contingent choice is especially suited to policy decisions where a set of possible actions might result in different impacts on natural resources or environmental services.

Data needed and approach

The data required for CM are collected through survey. These surveys can be classified into three types:

- Contingent Ranking: Contingent ranking surveys ask individuals to compare and rank alternate program outcomes with various characteristics, including costs.
- Discrete Choice: In the discrete choice approach, respondents are simultaneously shown two or more different alternatives and their characteristics, and asked to identify the most preferred alternative in the choice.
- Paired Rating: This is a variation on the discrete choice format, where respondents are asked to compare two alternate situations and are asked to rate them in terms of strength of preference.

Strengths and weaknesses

Advantages of the choice modelling are listed below:

- The contingent choice method can be used to value the outcomes of an action as a whole, as well as the various attributes or effects of the action.
- The method allows respondents to think in terms of tradeoffs, which may be easier than directly expressing dollar values. The trade-off process may encourage respondent introspection and make it easier to check for consistency of responses. In addition, respondents may be able to give more meaningful answers to questions about their behaviour (ie, they prefer one alternative over another), than to questions that ask them directly about the dollar value of a good or service or the value of changes in environmental quality. Thus, an advantage of this method over the contingent valuation method is that it does not ask the respondent to make a trade-off directly between environmental quality and money.
- Respondents are generally more comfortable providing qualitative rankings or ratings of attribute bundles that include prices, rather than dollar valuation of the same bundles without prices, by de-emphasising price as simply another attribute.
- Survey methods may be better at estimating relative values than absolute values. Thus, even if the absolute dollar values estimated are not precise, the relative values or priorities elicited by a contingent choice survey are likely to be valid and useful for policy decisions.
- The method minimises many of the biases that can arise in open-ended contingent valuation studies where respondents are presented with the unfamiliar and often unrealistic task of putting prices on non-market amenities.
- The method has the potential to reduce problems such as expressions of symbolic values, protest bids, and some of the other sources of potential bias associated with contingent valuation.

Although contingent choice has been widely used in the field of market research, its validity and reliability for valuing non-market commodities is largely untested. There are some issues and limitations that apply to CM usage:

- Respondents may find some tradeoffs difficult to evaluate, because they are unfamiliar.
- The respondents' behaviour underlying the results of a contingent choice study is not well understood. Respondents may resort to simplified decision rules if the choices are too complicated, which can bias the results of the statistical analysis.
- If the number of attributes or levels of attributes are increased, the sample size and/or number of comparisons each respondent makes must be increased.
- When presented with a large number of trade-off questions, respondents may lose interest or become frustrated.
- Contingent choice may extract preferences in the form of attitudes instead of behaviour intentions.
- By only providing a limited number of options, it may force respondents to make choices that they would not voluntarily make.
- Contingent ranking requires more sophisticated statistical techniques to estimate willingness to pay.
- Translating the answers into dollar values, may lead to greater uncertainty in the actual value that is placed on the good or service of interest.

Alternative approaches

Contingent valuation method and deliberative monetary valuation method are the best alternative for this approach.

Case studies

- Kerr and Sharp (2002) used a choice modelling method to study the value of Auckland streams. The Auckland Regional Council funded this study and it was the first of its type in New Zealand.

Two focus groups were shown photographic images of thirteen streams in the Auckland region. Participants were then asked to comment on the "good things about this stream", and the "bad things about this stream", and to score the stream on a 10-point scale (where 1 = terrible, 10 = outstanding). In general, the average and median scores across the two focus groups were not dissimilar (Kerr and Sharp, 2003). The stream attributes in this study are listed below:

- Water clarity
- Flow of water
- Quality of the stream bank
- Access
- Safety
- Surrounding land use
- Natural shape of the stream
- Habitat for wildlife

- A case study by Stewart (2010), the estimation of the Discrete Choice Model DCM, produces mathematical expressions that summarise how human welfare changes when environmental quality attributes are changed. This study has been done for the project that was intended to inform policy development for the management of the Auckland coastal environment.

This report, detailed the outcomes of the final phase of a three-year project to investigate techniques to inform coastal management decisions. Previous reports in this series have reviewed prior research into benefit estimation for storm water remedial works (Batstone *et al*., 2008) and developed the design for a choice experiment and associated analytical discrete choice model (Batstone 2009). The study's aim has been providing a vehicle to understand Aucklander's coastal preferences and the economic benefits that flow from mitigation expenditure.

To address the choice experiment format, respondents were offered three options reflecting aspects of coastal use experience impacted by the constituents of storm water: water quality, underfoot conditions, and ecological health. Each of these options were differentiated at three broad location categories: outer harbour (beaches), middle harbour and upper harbour environments. For each location/environmental quality combination, three levels were specified: low, medium and high. In the estimation process, the model base case was low levels of each of the environmental quality attributes. The model coefficients were interpreted as the change in utility associated with a change in environmental quality from low to medium or from low to high, depending on the variable label.

The application involved a hypothetical project consisting of policy and engineering components delivers changes in water quality and underfoot conditions in the upper harbour areas of the Auckland region (no noticeable change to other locations). The result shows that in a 95 percent confidence estimate of the monetary value of welfare change ranges from $783 million to $1.122 billion.

4.8 Deliberative Monetary Valuation

Deliberative monetary valuation (DMV) uses formal methods of deliberation to express values for environmental change in monetary terms (Spash, 2008).

Deliberative methods for environmental decision making is based in discussion and consensus-building and can give stakeholders a wide range of information, provide a structure for evaluating and discussing complex information, incorporate a range of ethical, moral and monetary values and use methods for reaching consensus (Rodriguez-Vargas *et al*., 2011).

Usage

Deliberative monetary valuation (DMV) has become an increasingly popular area of research in recent years. This aims to combine stated-preference methods with elements of deliberative processes from political science (Spash, 2001). Contingent valuation has suffered many philosophical and methodological criticisms. One of the main criticisms is that its results only reflect an aggregate of individual value (Spash, 2007). Both contingent valuation method (CVM) and choice experiment approaches to valuing environmental change have been employed in DMV studies.

Data needed and approach

Deliberative monetary valuation can be described as a two step approach,

i) first session dedicated to discussing the issues and deliberating
ii) second session dedicated to monetary valuation.

In the first session, participants are free to discuss the issue (biodiversity, ecosystem services). Valuation (monetary) aspects enter only during the second session.

Discussions are not confined to the first session, but also the period which elapses between the two sessions (which may be 1 week or several weeks). This process contributes to reducing the uncertainty about the meaning of the good and thereby leads to a more robust preference formation. This cognitive process is ensured by instructing participants to keep a diary between the two sessions to record their thoughts, questions, etc. Rather than discussing the valuation scenario, the provision of a discussion forum primarily serves the aim of tackling unformed preferences as well as addressing problematic methodological areas; ie, discussing the issues (eg, biodiversity as a good, forms of contributing) leading up to the valuation task (Szabo 2011).

Strengths and weaknesses

Advantages of the DMV are listed below:

- This method may increase the validity of stated preference methods.
- Since it is a two step approach, it gives time interviewers for reflection.
- It give the opportunity to information gathering and group deliberation

Although DMV is supposed to be a used as a stated preference method which could be more robust than two other methods, using it has some weaknesses as below:

- DMV requires more comprehensive preparation and analysis and is more complicated than other stated preference methods
- It can be more expensive compared to CVM and choice modelling
- DMV practice requires longer time period and consumes more effort

Alternative approaches

Contingent valuation method and choice modelling could be alternative approaches for DMV.

Case studies

This method has elements of deliberative processes from political science and is a relatively new methodology that has been used in the environmental valuation. Therefore, there are not many case studies related to environmental valuation and particularly water valuation in the literature, for more information about this method's case studies see Spash (2008).

4.9 Benefit Transfer Method

The benefit transfer method (BMT) is used to estimate economic values for ecosystem services by transferring available information from studies already completed in another location and/or context.

Thus, the basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from another context. Benefit transfer is often used when it is too expensive and/or there is too little time available to conduct an extensive valuation study, yet some measure of benefits is required. It is important to note that benefit transfers can only be as accurate as the initial study.

Usage

The benefit transfer method is selected in cases for two main reasons. First, the agency does not have a large budget for site-specific benefits studies. Second, values for the specific uses are relatively easy to transfer.

Data needed and Approach

Application of the benefit transfer method involves four main steps. First: Identify existing studies or values that can be used for the transfer. Second: Evaluate the existing values to determine whether they are appropriately transferable, considering whether:

- The service being valued is comparable to the service valued in the existing studies. This includes determining whether the features and qualities of sites or ecosystems are similar, including the availability of substitutes.
- The characteristics of the relevant population are comparable. This includes determining whether the demographics, and peoples' preferences, are similar between the area where the existing study was conducted and the area being valued.

Third: Evaluate the quality of studies to be transferred. The better the quality of the initial study is derived the more accurate and useful the transferred value. This step requires professional judgment of the researcher.

Fourth: Adjust the existing values to better reflect the values for the site under consideration, using whatever information is available and relevant. The researcher may need to collect supplemental data in order to do this well.

For instance, the researcher might survey key informants, talk to the investigators of the original studies, get the original data sets, or collect some primary data at the study site to use to make adjustments. Finally, estimate the total value by multiplying the transferred values by the number of affected people.

Strengths and weaknesses

The most significant benefit of using this method is saving time and budget.

It is important to note that benefit transfers method is not reliable when the original the site and the study site are not similar or comparable in terms of factors such as quality, location, and population characteristics. It is also not reliable when the environmental change is not similar for the two sites or when the original valuation study was not carefully conducted and used sound valuation techniques.

Alternative approaches

This approach is an alternative approach for most of the other methods.

Case studies

Sharp and Kerr. (2005) have used the benefit transfer method to estimate the option and existence values for the Waitaki Catchment. As they defined existence value as changes in natural character, these affect the values that citizens perceive to be embodied in the environment. These changes are independent of use of that environment and are commonly termed “existence values”, “passive use values”, or “non-use values”.

They reviewed more than ten existence value studies in national, regional and local level. They found that New Zealand studies have not attempted to isolate and measure option values, although this value has been estimated indirectly through TEV process.

Their study results indicate that New Zealand residents can place high value on protection of the natural environment. Study design limitations ensure that it is not always possible to separate use and non-use values, but mean TEV changes estimated for various management interventions for braided Canterbury rivers falls in the order of $60 per household per year. Where separate values have been obtained, non-use values appear to be substantial. If recreational use values are in the order of $2 million per annum, this capitalises into $20 million (at a 10% discount rate) or $40 million (at a 5% discount rate) (Kerr, 2004). The relative magnitude of upper catchment recreational benefits is not known, principally because of the absence of information on recreational activity levels. The complete loss of all recreational opportunities on the lower Waitaki would result in costs of about $2 million per annum from reduced use values.

4.10 Averting Expenditure Method

Averting expenditure methods are sometimes used to estimate the benefits of the human health effects of certain policies. The averting expenditure method simply measures the costs incurred by individuals to protect themselves from human health risks.

This method is based on the household production function theory of consumer behaviour. The household produces consumption goods using various inputs, some of which are subject to degradation by pollution (Birol, 2006). For example, if drinking water were contaminated, individuals would turn to drinking bottled water. The cost of bottled water is thus used to measure the benefits of eliminating pollution in the drinking water.

Usage

In the context of water resources, households may respond to increased degradation of inputs in various ways that are generally referred to as averting or defensive behaviours to avoid the adverse impacts of water contaminants.

Data needed and Approach

The summation of documented expenditures incurred to engage in the averting behaviour.

Strengths and weaknesses

The main strength of this method is that:

- It is based on observed behaviours and market data.

There are some important limitations to this method:

- Individuals may undertake more than one form of averting behaviour in response to an environmental change and the averting behaviour may have other beneficial effects that are not considered explicitly (eg, the purchase of bottled water to avoid the risk of consuming polluted supplies may also provide added taste benefits).
- Averting behaviour is often not a continuous decision but a discrete one, eg, a water filter is either purchased or not.
- The averting expenditures does not measure all the costs related to pollution that affect household utility and are therefore only able to provide a lower bound estimate of the true cost of increased pollution.

Alternative approaches

Alternative approaches are other non-market valuation methods.

Case studies

Um *et al*. (2002) estimated improved drinking water quality in Pusan, Korea and found that marginal WTP estimation results for a small reduction, 10mgl−1 of suspended solid concentration in tap water from 335mgl−1 range from €0.60–1.50 per month per house.

5.0 Conclusions and recommendations

The national policy statement for freshwater management (2011), gives local government the responsibility for managing freshwater on a catchment basis. The third report of Land and Water Forum (2012) clarify that central government and regional council frameworks for allocating water and managing discharges of contaminants need to set a more accountable, efficient and fair approach to the management and use of freshwater. According to the first recommendation of this report, New Zealand's economic welfare must be maximised through "technically efficient" outcomes, "allocatively efficient" patterns of water use and a framework that encourages "dynamic efficiency".

Efficient allocation of scarce freshwater will not be achieved without knowing water values to the society related to the four well-beings (economic, social, environmental and cultural), for its different services and usage.

Cost benefit analysis is a framework that links these water values to economic concepts/ models of welfare theory and paretian optimisation. The Total Economic Value is a convenient framework to organise the different classes of value that might be associated with water resource development in a catchment.

As water is a "priceless good", its valuation is not straightforward. This is not only because many of the water resources are public goods in nature, and hence do not have readily available monetary values attached to them, but also because their value is more complex compared to private goods. This complexity arises from the fact that the value of water resources are composed of both use and non-use values (Birol *et al*., 2006).

There are several methods and approaches to estimate a monetary term of water benefits to allocate it efficiently and support policy makers. Each method is more appropriate for a specific usage and service for which freshwater is provided.

Some values, particularly non-use values, will still fall outside of the economic analysis, but these values should be acknowledged and captured within the same framework. It is recommended that Auckland Council progress work on establishing this as the Agreed Values Framework (Creagh and Scarfe, 2011).

It is considered appropriate to use a combination of methods to estimate water value in a catchment, or for a particular water body, wetland or water catchment. The appropriate combination of methods is chosen depending on the water services received and the significance of the usage.

Table 5 provided appropriate valuation methods for each of the catchment services that represented in table 1 in introduction.

Table 5. Potential freshwater services in a catchment and their related valuation methods.

Catchment service	Description	Evaluation method
Water quality improvement	Bioremediation, such as self-purification removing phosphorus and nitrogen	Replacement cost method
Biodiversity maintenance	Provide habitat for precious birds	Market price method
Erosion control	Vegetation cover preventing soil erosion	Avoid cost method
Water supply	Supply water for industrial and agricultural usage	Market price method
Recreational opportunity	Offer places for human enjoyment due to the natural and artificial scenes	Travel cost method
Raw material supply	Supply fish for human and produce plants for livestock	Market price method
Existence value	Maintain wetlands for future generations	Contingent valuation method

5.1 Recommendations for further work and research

- It is recommended that Auckland Council establish an accounting framework for water resources and other environmental goods and services that includes use and non-use values.
- Based on its widespread use in the field of natural resource valuation the Total Economic Values Framework is recommended as the starting point for assessing where and what to measure, to become the Agreed Values Framework AVF for Auckland.
- It is recommended that all values (qualitative/quantitative and monetary/non-monetary) are included in the assessment.
- It is recommended to undertake an investigation of compatibility of using TEV within process methodologies such as SROI or the New Zealand specific Mauri model.

To further the freshwater values work, the next objective is to use the frameworks described in this report to recognise and measure the value of significant freshwater services in Auckland.

This will entail the following steps:

- Review Auckland's freshwater literature.
- Identify the freshwater resources in Auckland wide, including various types of freshwater bodies (eg, rivers, lakes, wetlands) and with this inventory choose a subset or catchment as a case study.
- Recognise freshwater services in the chosen catchments.
- Define the most appropriate approach for valuating each freshwater service in catchments using the current report.
- Complete freshwater values framework by generalising the result of the catchment studies.

6.0 Glossary

Direct Use Value is a term to describe the value (monetary or otherwise) obtained from consumption of a good or service. The good is used in one or more production processes. It is usually captured in market processes, or can be calculated in monetary terms by assessing how much people would have to pay to buy an equivalent product (eg, what would a person have to pay for the products they harvested from the wild).

Discounting process refers to quantifying value of any benefits and costs that occur later in time and convert them into present values (typically in today's dollars).The estimated benefits and costs associated with a proposal are likely to occur at various points in time over the life of the proposal. This allows projects to be quantified in today's dollars and projects with different life spans to be compared.

Discount rate is effectively a desired rate of return. It includes two components, the time value of money and risk, as mirrored in the rationale for discounting.

Externalities are defined as the benefits or costs that are generated as a by-product of an economic activity and that do not accrue to the parties involved in the activity.

Indirect Use Value is a term used in ecological economics, implicitly recognising that there are dependencies in any system. Many natural resources provide beneficial services through ecological processes and functions, for example trees and vegetation convert carbon dioxide into oxygen, which is the basis for human life.

Market Failure occurs when the mechanism to determine prices in economic theory – the interaction of demand and supply - does not lead to the best or most efficient outcome (Pareto optimal). This occurs for a number of reasons, sometimes the size and structure of the industry, incomplete information, agency problems such as the costs of transacting and the existence of externalities.

Non-Use Value of a good describes the value derived not from directly consuming that good, but from the existence of the good. Non-use includes bequest values, option values and the continued availability of the good. The value is not captured in direct market processes (eg, use of water for watering sheep, in the production of meat), which are 'counted' in production based GDP figures. There is value in the good – through happiness or satisfaction derived from the existence of the good and the potential to use the good in the future, for some unspecified (perhaps unknown) use.

Option value in environmental literature is defined as the value of preserving threatened natural resources that they might be available for use in the future.

Pareto optimisation is a concept within welfare economics and is said to occur when a change to a different allocation makes at least one individual better off, without making any other individual worse off.

Property rights are a set of rules and obligations associated with ownership of land, resource or good.

A Public Good is a good that is non-rival and non-excludable, for example national defence or knowledge. Non-rivalry means that consumption of the good by one individual does not reduce availability of the good for consumption by others; and non-excludability that no one can be effectively excluded from using the good.

Scarcity rent is the marginal opportunity cost imposed on future generations by extracting one more unit of a resource today.

A Taonga in a Māori culture is a treasured thing, whether tangible or intangible.

Utility is an economic term referring to the total satisfaction received from consuming a good or service. It is what individuals are attempting to maximise through the economic choices they make.

Welfare changes are the changes in the net benefits of individuals. It is based on economic, social, environmental and cultural wellbeing changes. Based on welfare theory in microeconomics, individuals maximise their utility subject to an income constraint or minimise their expenditure subject to a utility constraint.

7.0 Acknowledgements

I would like to thank everyone who provided support and assistance during the preparation of this report, including my colleagues at the Research Investigations and Monitoring Unit (RIMU), the Auckland Council Peer Review Panel and staff from the Air Land Water Coastal Unit (CLAW).

In particular, I would like to thank Dr Karen Creagh, Specialist Water, from CLAW, Dr Martin Neale, Senior Scientist (freshwater), from RIMU and Dr Catherine Murray, Consultant (economist), from Market Economics Ltd for their very helpful reviews of the technical aspects.

8.0 References

Acharya, G and Barbier, E. (2002). Using domestic water to value groundwater recharge in Northern Nigeria. *American Journal of Agricultural Economics,* 84(2), 26, 415-426

Agudelo, J. I. (2001). The economic valuation of water, principles and methods. *Value of water report research series,* Netherlands: IHE, Delft

Appleton, Albert F. (2002). How New York City used an ecosystem services strategy carried out through an urban-rural partnership to preserve the pristine quality of its drinking water and save billions of dollars. A paper for forest trends – Tokyo, November2002

Auckland Council (2012). *The Auckland Plan*. Available on the Auckland Council website at: http://theplan.theaucklandplan.govt.nz/pdfs-and-maps/#downloads

Barbier, E. (1991). An approach to economic valuation of tropical wetlands: with examples from Guatemalea and Nicaragua. In: N P Girvan and D A. Simons (Eds.), *Caribbean ecology and economics*. St. Michael, Barbados: Caribbean Conservation Association

Barbier, E. B., Acreman, M and Knowler, D. (1991). *Economic valuation of tropical wetlands: a guide for policy makers and planners.* Paper presented at the Ramsar Convention Bureau

Bargh, M. (2006). *Freshwater: issues for Māori .* Paper presented at the New Zealand Political Science Association Conference

Batstone, C. (2009). *Methods for evaluating coastal receiving environments and the effects of storm water - report to 30 April 2009,* Auckland Regional Council internal report IR2010/001

Batstone, C., Roberts B and Sharp B. (2008). *Evaluating coastal receiving environments and the effects of storm water – phase 1 interim report*. Auckland Regional Council working report, WR137

Benson, E. D., Hansen, J. L., Schwartz, A. L and Smersh, G. T. (1998). Pricing residential amenities: The value of a view. *Journal of Real Estate Finance and Economics,* 16, 55-73

Birol, E., Karousakis, K and Koundouri, P. (2006). Using economic valuation techniques to inform water resources management: A survey and critical appraisal of available techniques and an application. *Science of the Total Environment*, 105-122

Bourassa, S. C., Hoesli, M and Sun, J. (2004). What's in a view? *Environment and Planning Association*, 36(8), 1427-50

Bourassa, S. C., Hoesli, M and Sun, J. (2005). The price of aesthetic externalities. *Journal of Real Estate Literature,* 13, 167-187

Boyer T and Polasky S (2004). *Valuing urban wetlands: a review of non-market valuation studies.* Department of Applied Economics, University of Minnesota

Brander, L. M., Florax, R. J and Vernaat, J. E. (2006). The empirics of wetland valuation: a comprehensive summary and a meta-analysis of the literature. *Environmental Resource Economics,* 33, 223-250

Brouwer, R., Lanford, I., Bateman, I and Turner, R. K. (2003). *A meta-analysis of wetland ecosystem valuation studies*. In: R K Turner, C J van den Bergh Jeroen and R. Brouwer, *Managing wetlands: an ecological economics approach*. Cheltenham, UK: Edward Elgar

Citizens Network for Sustainable Development (2008). New York City's watershed protection praised by the UN Environment Programme. Available: http://www.unep.org/delc/Portals/119/Green_Breakthroughs.pdf p 54 http://www.citnet.org/New%20York%20Citys%20watershed%20protection%20praised%20UN%20Environment%20Programme (accessed 18 February 2013)

Creagh, K. (2010). *Value and price: A transdisciplinary approach to ecologically sustainable urban water management*. Thesis, PhD, University of Auckland, January 2010

Creagh, K and Scarfe, B. (2011). Personal communications, Auckland Council Environmental Policy and Strategy Department*, Agreed values framework*, draft concept paper 2011

Dinar, A., Moigne, G. L and Giltner, S. (1997). Principles and examples for the allocation of scarce water resources among economic sectors. *CIHEAM - Options Mediterraneennes Sér. A /n031, 1997 Séminaires Méditerranéens*

Faux, J and Perry, G. M. (1999). Estimating irrigation water value using hedonic price analysis: a case study in Malheur County, Oregon. *Land* 1999, 75, 440-452

Filippova, O. (2008). The influence of submarkets on water view house price premiums in New Zealand. *International Journal of Housing Markets and Analysis, 2*, 91-105

Freeman, A. M. (1993). *The Measurement of Environmental and Resource Values.* Washington D.C, Resources for the Future

Gibbons, D. C. (1986). *The economic valuation of water.* Washington D.C, Resources for the Future

Gibbs, M and Bennett, M. (2007). Māori claims to ownership of fresh water. *Resource Management Journal,* August 2007, 13-18

Hanley, N and Spash C. (1995). *Cost benefit analysis and the environment.* Edward Elgar Publishing

International Conference on Water and the Environment (ICWE), (1992). *The Dublin statement on water and sustainable development*, 26-31 January. Available: http://docs.watsan.net/Scanned_PDF_Files/Class_Code_7_Conference/71-ICWE92-9739.pdf http://www.wmo.int/pages/prog/hwrp/documents/english/icwedece.html

Jaine, L and Ladd, R. (2005). *Metrowater's user pays pricing model*, Metro Water Limited

Kerr, G.N. (1988). *Non-market valuation in New Zealand*. Information Paper 11, Centre for Resource Management Lincoln College and University of Canterbury

Kerr, G. N. (2004). *Lower Waitaki river recreation use values*. Report to Anderson Lioyd Caudwell, Lincoln University.

Kerr, G. N and Sharp, B. (2002). *Community perceptions of stream attributes: focus group results.* Report to Auckland Regional Council. Canterbury: Agribusiness and Research Unit, Lincoln University

Kerr, G. N and Sharp, B. (2003). C*ommunity mitigation preferences: A choice modelling study of Auckland streams. Lincoln University,* research report no.256

Khan, R. (2012). A Mauri model analysis of remediation methods of industrial waste from the Tasman pulp and paper mill in Kawerau, Bay of Plenty, New Zealand. University of Auckland, June 2012

Kling, C. L. (1997). The gains from combining travel cost and contingent valuation data to value nonmarket goods. *Land Economics,* 73, 428-439

Koundouri, P. (2000). *Three approaches to measuring natural resource scarcity: theory and application to groundwater.* Unpublished PhD, University of Cambridge, UK

Kramer, R. A. (2005). *Economic tools for valuating freshwater and estuarine ecosystem services.* Nicholas School of the Environmental and Earth Sciences. Durham, USA: Duke University

Lancaster, K. (1966). A new approach to consumer theory. *The Journal of Political Economy,* 84, 132-157

Land and water Forum, (2010). *Report of the Land and Water Forum: A fresh start for freshwater*

Land and water Forum, (2012). *Second report of the Land and Water Forum: Setting limits for water quality and quantity, and freshwater policy- and plan- making through collaboration*

Land and water Forum, (2012). *Third report of the Land and Water Forum: Managing water quality and allocating water*

Leschine, T.M., Wellman, K. F and Green, T. H. (1997). The Economic value of wetland, wetlands' role in flood protection in western Washington. Washington State Department of Ecology. Ecology publication no. 97-100, October 1997

Lin, Z., Yun, C and Huili, G., *et al*,. (2011). Economic value evaluation of wetland services in Yeyahu Wetland nature reserve, Beijing. *Geogra. Sci.,* 21, 744-752

Loomis, J. (2002). Quantifying recreation use values from removing dams and restoring free-flowing rivers: A contingent behavior travel cost demand model for the Lower Snake River. *Water Resources Research, 38*

Loomis, J., Kent, P and Strange, L., *et al*. (1999). Measuring the total economic value of restoring ecosystem services in an impaired river basin: results from a contingent valuation survey. *Ecological Economics,* 33, 103-117

Mahan, B., Polasky, S and Adams, R. (2000). Valuing urban wetlands: a property price approach. *Land Economics,* 76, 100-113

Markandya, A., Harou, P., Bellu, L and Cistulli, V. (2002). *Environmental economics for sustainable growth: a handbook for practitioners.* Cheltenham: Edward Elgar

Minister for the Environment (2004). Water allocation and use: 7- Specific problems identified in current water allocation and use systems. Available: http://www.mfe.govt.nz/publications/water/water-allocation-use-jun04/html/page7.html

Morgan, K.B. (2004). *Tangata whenua perspective on sustainability using the mauri model*. Paper presented at the International Conference on Sustainability Engineering and Science 7 – 9 July 2004, Auckland, New Zealand

Morgan, O. A and Hamilton, S. E. (2011). Disentangling access and view amenities in access-restricted coastal residential communities. *Journal of Agricultural and Applied Economics,* 43, 157-166

Morgan, T. K. K. B. (2006). Decision-support tools and the indigenous paradigm. *Engineering Sustainability, 159*(ES4)*,* 169–177

Morgan, T.K.K.B. (2008). *The Value of a Hapū Perspective to Municipal Water Management Practice: Mauri and potential contribution to Sustainability Decision Making in Aotearoa New Zealand*, University of Auckland.

Murray, C. (2013). As assessment of cost benefit analysis approaches to mangrove management. Auckland Council technical report TR2013/006. (In preparation)

National Policy Statement for Freshwater Management 2011. Available: http://www.mfe.govt.nz/publications/rma/nps-freshwater-management-2011/docs/nps-freshwater-mgnt-2011.pdf

National Policy Statement for Freshwater Management 2011: Implementation Guide. Available: http://www.mfe.govt.nz/publications/rma/nps-freshwater-guide-2011/nps-freshwater-management-guide.pdf

New Zealand Government (2011). *National Policy Statement - Freshwater Management,* Wellington, New Zealand

Nijkamp, P., Vindigni, G and Nunes, P. A. (2008). Economic valuation of biodiversity: A comparative study. *Ecological Economics*, 217-231

O'Connor, M. (2001). Towards a typology of 'environmentally adjusted' national sustainability indicators: key concepts and their policy applications. *Eurostat Working Paper* No 2/2001/B/4. Belgium: European Commission

O'Connor, M. (2002). Reframing environmental valuation: reasoning about resource use and the re-distribution of sustainability. In: H Abaza and A Baranzini (Eds.), *Implementing Sustainable Development*. Cheltenham, UK and Northampton, MA, USA: Edward Elgar

O'Connor, M. (2007). Paradigms for sustainability assessment: inventory of costs and benefits versus representative diversity of indicators. Background Paper in Support of the SEEA 2010 Reform Process. Paris: Centre d'Economie et d'Ethique pour l'Environnment et le Developppment, Universite de Versailles Saint-Quentin-en-Yvelines

OECD (2006). Glossary of statistical terms. Available: http://stats.oecd.org/glossary/detail.asp?ID=3254 (accessed February 2013)

Office of the Auditor-General, (2011), *Managing freshwater quality: Challenging for regional councils*, September 2011

Pearce D.W. (2001). *Lecture notes*. London, UK: University College London

Pearce, D. W and Turner, K. (1990). *Economics of natural resources and the environment*, Harvester Wheatsheaf

Resource Management Act 1991. Available: http://www.legislation.govt.nz/act/public/1991/0069/latest/DLM230265.html

Rodríguez-Vargas, A and Marburg, P. (2011). A Deliberative Economics of Ecosystems and Biodiversity. 9th Conference of European Society for Ecological Economics "Advancing Ecological Economics: Theory and Practice" Istanbul, Jun 14-17, 2011

Rohani, M. (2012). *Impact of Hauraki Gulf amenity on the land price of neighbourhood properties. An empirical hedonic pricing method case study North Shore, Auckland,* Auckland Council Working Paper, WP2012/001

Samarasinghe, O. E and Sharp, B. (2008). The value of a view: a spatial hedonic analysis. *New Zealand Economic Papers,* 42, 59-78

Sharp, B and Kerr, G. (2005). *Option and existence values for the Waitaki catchment.* Retrieved. from

Smith, N., Mcdonald, G and Trinh, S. (2009). *A framework for valuating water demand management: Literature review*. Beacon Pathway Limited

Spash, C.L. (2001). Deliberative Monetary Valuation. Department of Land Economy University of Cambridge. Paper for presentation at 5th Nordic Environmental Research Conference Aarhus, Denmark 14th - 16th June, 2001

Spash, C.L. (2007).Deliberative monetary valuation (DMV): Issues in combining economic and political processes to value environmental change. *Ecological Economics*, 63, 690-699

Spash, C.L. (2008). Deliberative monetary valuation and the evidence for a New Value Theory. *Land Economics,* 84(3), 469–488

The SROI network (2012), *A guide to social return on investment*, January 2012

Szabó, Z. (2011). Reducing protest responses by deliberative monetary valuation: Improving the validity of biodiversity valuation. *Ecological Economics*, 72, 37–44

Stewart, M. (2010). *Techniques for evaluating community preferences for managing coastal ecosystems, Auckland region stormwater case study, discrete choice model estimation*. Auckland Regional Council, technical report TR2010/012

Um, M. J., Kwak, S. J and Kim, T. Y. (2002). Estimating willingness to pay for improved drinking water quality using averting behavior method with perception measure. *Environmental and Resource Economics,* 21, 287-302

Watercare services limited (2011), *Auckland regional water demand management plan*, June 2011

White, P., Sharp, B and Kerr, G. (2001). Economic value of the Waimea Plains groundwater system. *Journal of Hydrology (NZ),* 40, 59-76

Wills, I. (1997). *Economics and the Environment: A signalling and incentives approach.* St. Leonards, NSW, Australia: Allen and Unwin

Woodward, R. T and Wui, Y. S. (2001). The economic value of wetland services: a meta-analysis. *Ecological Economics*, *37,* 257-270

Young, R. A. (2005). *Determining the economic value of water concepts and methods.* Resource for the future, Washington, DC, USA