Estimating the Total Economic Value of Water in the Millstream Aquifer of the Pilbara

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Abstract

Water provides a number of different benefits to society, many of which are not traded in markets. This makes it difficult to determine exactly what the Total Economic Value of water is to society, and how the water should be allocated between different uses. This paper represents the first attempt to value the water in the Millstream aquifer of the Pilbara region, using a variety of techniques including Benefit Transfer. This first estimate will allow WorleyParsons to work with its key clients on improving water management in the region.

1. Introduction

Water provides a range of goods and services to society. As well as being critical to human health, water is a vital input into agriculture and many industrial processes. It also supports the ecosystems that provide benefits such as recreational opportunities, visual amenity and biodiversity values. The purpose of this project was to estimate the value of all these benefits and derive the Total Economic Value (TEV) of water in the Millstream aquifer in the Pilbara.

1.1 Background

In the Pilbara region of Western Australia, water is used by towns and communities, as well as by agriculture and manufacturing. The mining sector has grown rapidly, and in 2006 was the biggest user of water in the region. Demand for water by most of these sectors is projected to increase (Economics Consulting Services 2007), potentially placing pressure on certain groundwater aquifers. One of these aquifers is the Millstream aquifer, which supplies the West Pilbara Water Supply Scheme.

Many uses of water from the Millstream aquifer are rival, in that they compete for the same water resource. Water consumed in mining processes may reduce the amount available to support native ecosystems in the Pilbara such as the wetlands of Millstream-Chichester National Park. Recreational opportunities for swimming and camping may be affected. Because these benefits of water are not quantified in markets, demand for water for these purposes is often unrecognised and undervalued.

Historically, water has been allocated on a first-come, first-served basis throughout much of Australia. Given that water is scarce in many sections of the Pilbara, this is an inadequate solution, as it fails to recognise the value that water provides to different sectors of the community, and to different locations. For the social benefits of water to be maximised, a new concept of value is required.

Total Economic Value (TEV) is a simple formula that acknowledges the benefits, both priced and unpriced, of a resource, in this case, water. TEV is equal to the benefits from using the water plus the benefits not associated with use, as shown in Figure 1.

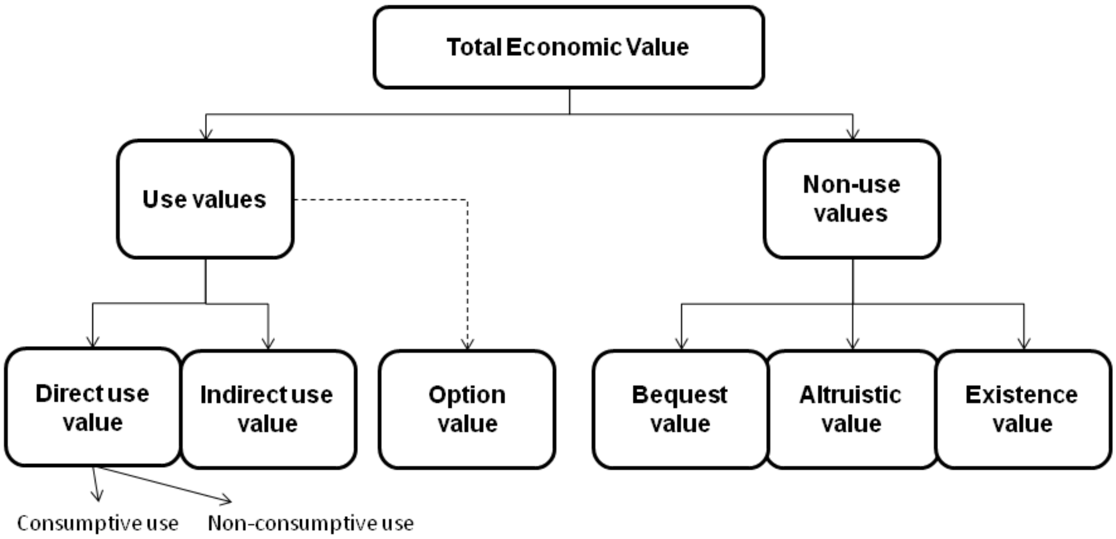

Figure 1: The components of Total Economic Value (Pascual and Muradian 2010)

TEV is comprised of use and non-use values. The use values can be direct (such as water use by industry, or recreational use) or indirect (such as water's contribution to ecosystem maintenance). Option value refers to the value associated with leaving water for future uses (keeping the option open). The non-use values include bequest value (the value associated with being able to 'bequest' the resource to future generations), altruistic value (the value in knowing that others in the current generation are benefiting from the resource) and existence value (the value of knowing that the resource exists, without actually seeing or using it).

Understanding the TEV of water in the Millstream aquifer of the Pilbara, and the individual components of value, allows for better allocation decisions to be made about how water should be used and supplied. For Worley Parsons and its key mining clients, it allows for better long term water management strategies, and a stronger foundation for considering any transfer of water between Pilbara sites.

1.2. Key findings of the literature review

The TEV model has been in existence for some time but few actual applications exist. The majority of studies focus on only one or two individual value components, such as recreation and existence values. Bringing together individual values estimated using different methodologies into a TEV estimate therefore has a particular complication. There is a significant risk that due to the different methodologies used, some of the value components actually incorporate elements of other values – Lazo, McClelland and Schultz for instance argue that people may feel guilty about their generation's treatment of a resource, and increase their existence value estimates to accommodate a transfer to future generations for restoration (Lazo, McClelland et al. 1997). This leads to double counting, if bequest value estimates are derived from the same motive. Hanley and Spash (1993) recommend using only existence value as a blanket value for all non-use values, to avoid this.

The majority of applied TEV studies relate to forestry, and situations where the different demands for the forest resource can all be met (i.e. they are non-rival). In this situation, it is appropriate to simply sum the different values together to obtain TEV. For water, this is generally not appropriate, as not all demands may be met from the limited resource, and summing will overstate TEV. A number of guides for TEV estimation for water exist (see, for instance WorleyParsons Canada Ltd and Economics for the Environment Consultancy Ltd 2010) but these focus on individual value components and not the aggregation process.

River Basin Hydro-Economic (RBHE) models offer another approach to the value aggregation problem. These combine a hydrologic model of the catchment with an economic model incorporating the different demands for water at different locations within the catchment. Water is allocated to different uses via the equi-marginal principle, which states that total value is maximised when the marginal value of water to each use is equal. This is indicated in Figure 2. The marginal benefit (MB) curves reflect the marginal value of each additional megalitre (ML) of water to either extractive use (such as mining) or in situ uses (such as recreation and existence values).

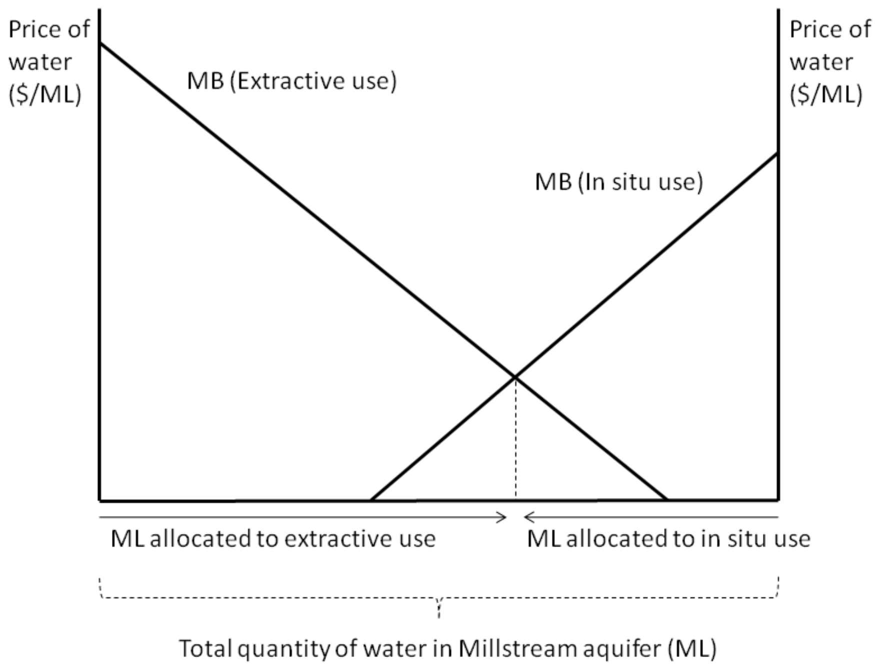

Figure 2: the equi-marginal principle

The total quantity of water to be allocated represents the total amount in the Millstream aquifer. In this diagram, the marginal cost (MC) of supplying each additional megalitre of water is assumed to be zero. As the quantity of water increases, the MB associated with each additional megalitre of water decreases. Water is initially valued more highly for extractive uses than for in situ uses, so initially water is allocated to extractive uses. But eventually there reaches a point where the MB of extractive uses is less than the MB of in situ use. Total value is maximised by switching the allocation from that point onwards to in situ use.

A RBHE model is essentially what is required for each of the Pilbara aquifers, however these models commonly focus only on the benefits associated with consumptive water use, and are highly complex to develop. For this project, a very simplified version will be developed, which will include not only use benefits, but also the benefits associated with unpriced uses and non-use values. This will be one of the first studies in Australia to attempt to identify the TEV of water in a specific region.

2. Development of the model

As previously mentioned, the water resource of interest in this study is the Millstream aquifer. This aquifer is an important part of the West Pilbara Water Supply Scheme, and also supports a Wetland of National Significance, the Millstream-Chichester wetland. This aquifer was chosen because information exists on aquifer inflows, storage capacity and environmental flow requirements. This information meant that a rudimentary hydrologic model could be developed, which linked together aquifer inflows, outflows, abstraction and aquifer levels.

The TEV model was modified to account for the specific nature of water. In particular, values for water can be largely considered *instrumental values*, in that water is valued for the goods and services it helps to provide, and not so much as a good in itself. People value not so much the existence of groundwater in the Millstream aquifer, but the existence of the environments and ecosystem functions that water supports. The existence value of water, and the indirect use value of water both then are valuing the contribution water makes to the ongoing existence of ecosystems, and indirect use value was excluded to avoid double counting. Based on suggestions from the literature (Hanley and Spash 1993), existence value, bequest value and altruistic value were reduced to existence value only, as the distinction between these values is too fine to allow for accurate measurement (in fact, very few studies identifying these values separately exist in the literature). Option value was also excluded due to measurement difficulties. The model applied in this study therefore became:

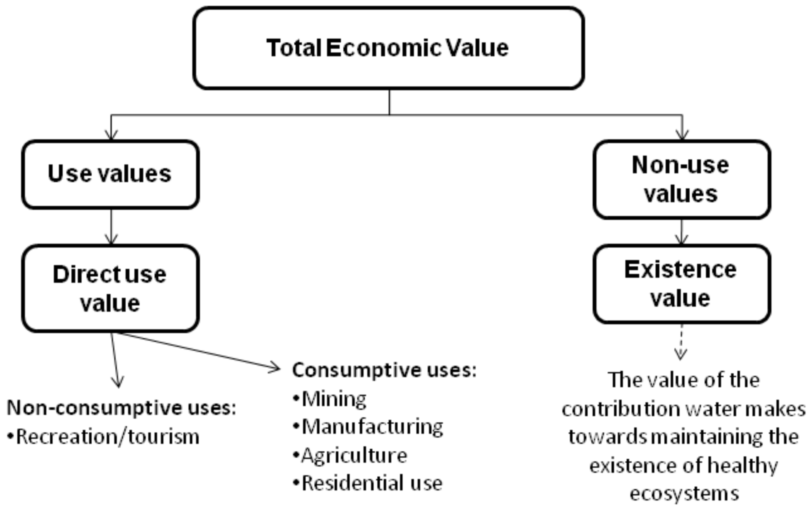

Figure 3: TEV of water model

Estimates of the different non-market values were obtained using Benefits Transfer. This technique applies the values obtained in similar studies to the specific circumstances of the Pilbara. Benefits Transfer was used because no relevant valuation studies have been conducted in the Pilbara region.

The difficulty with many of the studies found is that they do not tend to measure the same welfare change, or they use an inappropriate methodology to measure value. When measuring the welfare gain to consumers, the appropriate measure is consumer surplus, which in a market situation is simply the amount the consumer is willing to pay (WTP) less the amount they actually pay (the market equilibrium price). WTP is determined by the Marginal Benefit (MB) the consumer expects to derive from the good.

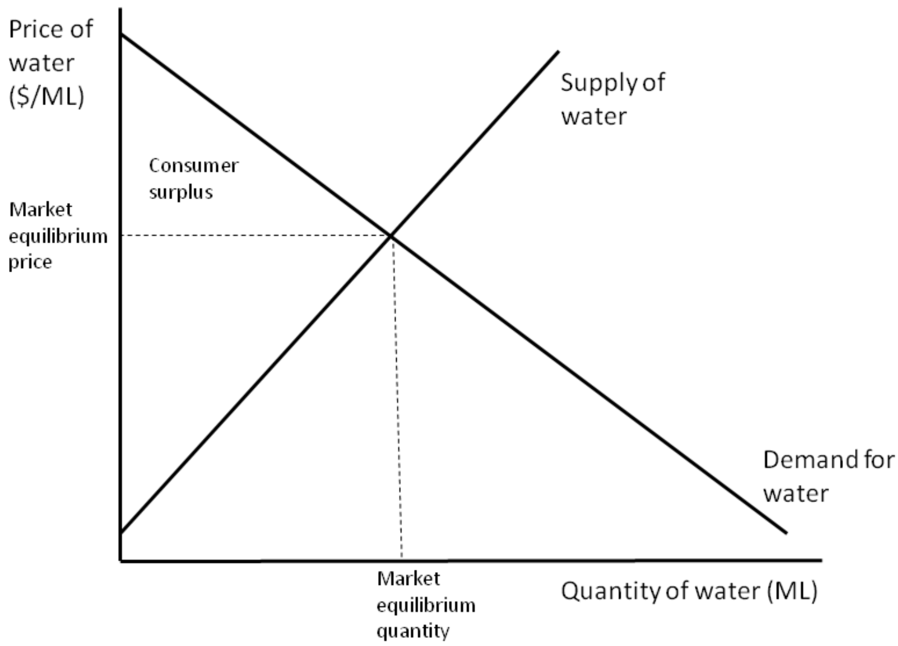

Figure 4: Consumer surplus and market equilibrium

For goods with no market price, such as recreation and existence value, non-market valuation studies estimate the consumer's WTP. This could lie anywhere along the demand curve (MB curve) shown in the above diagram. The problem therefore is how to accurately compare the value of market and non-market goods.

A market price reflects not only the demand for the good, but also the marginal cost of supply (the supply curve) – in a perfectly competitive market, firms maximise profit by producing at the point where marginal revenue (market price) equals marginal cost. So the difference between market and non-market goods is the marginal cost of supply multiplied by the quantity (as indicated by the dashed rectangle in the above diagram).

One option therefore is to include supply and treatment costs for all non-market goods – either the cost of getting the water to the user, or the user to the water (for recreational uses). This will give the Marginal Net Benefit (MB less MC) of the water at point of use. The alternative is to exclude all supply costs from market goods, which will give MB of the water in situ at the point of abstraction. This was the process followed in this study, as only two of the water uses actually incurred a market price.

4. Results

At this stage, only some values have been calculated. Recreational value estimates were derived from a study of the Barmah forest floodplains (Dyack, Rolfe et al. 2007) and adjusted for visitor numbers to the Millstream-Chichester National Park. Existence value estimates were obtained from a choice modelling study of two Australian wetlands (Whitten and Bennett 2005) and also adjusted to local Pilbara characteristics, assuming a direct link betweeen wetland area and water supply. The preliminary values are given in Table 1.

Use	Average value per gigalitre, 2010	Quantity demanded (gigalitres), 2010	Value being measured
Recreation	$83,968	11.6	Consumer surplus (cost of supply assumed negligible)
Existence	$40,753	11.6	Consumer surplus (no cost of supply)

Table 1: Existence and recreation value results

What these values indicate is that the importance of water in recreation is potentially substantial, as is its existence value. These values are traditionally not considered in water allocation planning, but are increasingly considered when setting aquifer allocation limits. They should not be compared with the price of water (paid by residential users, for instance), as this represents supply cost, not value as measured by consumer surplus. Consumer surplus estimates of residential and alternative water uses will be estimated as part of this study.

Because recreation and existence values are non-rival (both can be realised from the same water supply), they can be summed together to arrrive at the MB of in situ use as indicated in Figure 2. The next stage is to determine the slope of this curve and to repeat the process for the MB curve for extractive uses.

5. Conclusions and Future Work

Work on this project is still ongoing, and will lead to the calculation of values for all of the value components mentioned above. Results so far indicate an absence of suitable data that accurately measures the marginal value of water. They also indicate that the traditionally unpriced benefits of water, such as recreation and existence value, are substantial, and allocation planning may need to consider improved methods of allocating water between the different values.

6. References

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