River Economics – problems, progress and potential

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Abstract
Rivers have enormous value to society. To make the most of rivers, we need to recognise that tradeoffs need to be made between competing uses and values, and recognise that some of the competition is between present and future generations. Economics can help us to understand the dynamics of markets for river use, so that market failure can be identified and adjustments may be made where necessary. Economics can help us to provide accurate information on market values and estimates of non-market values, including ecosystem services – for decision making about allocation and limits. Market-based instruments such as taxes, subsidies and tradable permits can help us manage river use for more efficient outcomes. Examples of studies that support the arguments are included.

Keywords
Economics, rivers, ecosystem services, market-based instruments, nutrient trading

INTRODUCTION

Rivers have a broad range of values, including:

- water for extraction – for drinking, growing crops and animals, industrial processes, households and gardens,
- food and other resources,
- recreational resources– clean water is good for swimming, fishing, and boating,
- biodiversity values – for aquatic ecosystems and significant animals (including totemic species) such as turtles, dolphins and lungfish,
- cultural and historical values for Indigenous groups and other members of society,
- aesthetic values – people want to enjoy river views and live by the river, and
- assimilative capacity – rivers provide waste disposal services for all manner of inputs – an important ecosystem service.

Can everyone enjoy all these values at once? Will our level of river use be sustainable for future generations? How do we make tradeoffs amongst the demands for river use?

Economics is sometimes called the science of the allocation of scarce resources. It provides concepts and tools to help find a balance between competing demands. This can be easy where all uses have a dollar value and we can find the combination of uses that provide the highest dollar value. But natural resources like rivers are more challenging, as not all uses have dollar values, and society is also concerned with the long-term sustainability of the resource. Nevertheless, economics concepts and tools can be used effectively to help allocate resource use and to help manage uses of the resource. This includes protecting and enhancing environmental values.

In this paper, I will touch on:

- Economics and a sustainability approach
- How economics can help us understand the drivers of patterns of river use
- How economics can help to determine society's preferred pattern of river use
- Economic valuation of uses and values that do not generally have dollar values
- How market based instruments can be used to set up new markets and correct existing markets

ECONOMICS AND A SUSTAINABILITY APPROACH

Economics is built on a set of assumptions about human behaviour as exercised in markets. It assumes that individuals have good information on the consequences of their choices. However, this information is often lacking in respect to complex natural systems such as rivers.

There is increasing acknowledgement amongst economists, and it is the personal view of the authors, that economics cannot be relied on alone to address the challenge of sustainability. If society wants rivers to be clean and flowing and provide environmental, social and economic values on a long term basis, then sustainability limits need to be set using scientific, cultural, social and economic information.

Economics though, as a discipline, can assist in setting these limits, by providing decision making frameworks, accurate information about market values and estimates of dollar values for 'non-market' goods and services. These two points – the application and limits of economics – is currently widely misunderstood. A key premise of this paper is that the economics discipline can vastly assist in setting up efficient ways to allocate and use resources within the limits that we set.

HOW ECONOMICS CAN HELP US UNDERSTAND THE DRIVERS OF PATTERNS OF RIVER USE.

Economic systems are dynamic and are driven by people making choices on a daily basis. We rely on markets to get the allocation of many goods and services right for society. However, according to the economic model, there are properties of economic systems, which may lead to the overuse, or undersupply of goods and services. If we understand how uses of rivers function in terms of the economic model, this may explain what is driving either overuse or undersupply of different values from rivers. This understanding is useful because it guides intervention to improve the outcomes.

There are mixed approaches to river use and management. In Australia, there is now a market to buy and sell water. Users of water extracted from rivers must pay for water. In many examples, there is a partial market, for example the capacity of rivers to assimilate waste is an important resource value of rivers. In most places major industry and wastewater treatment plants have restrictions on their discharge to rivers, yet what goes down the stormwater drains in urban areas or runoff from rural areas is generally not so restricted. There is no market and often little protection for the cultural value of rivers to Indigenous people, or for the biodiversity of a healthy river system. As a basic step, economics can help identify where markets exist and where there are no markets.

Where there is no market value, or where the value is low, resources tend to be overused or undersupplied. So an initial scoping of where markets exist and where they don't, can give an idea of how the patterns of use are being driven.

In economics, there is a concept of public and private goods. Briefly, private goods are those that can be identified and awarded exclusively to an individual. Public goods are non-excludable and non-rival. A common example is clean air. It is impracticable to exclude individuals from consuming clean air. The consumption by one person does not reduce the amount available to others. In fact there are few pure public goods; they often lie on a continuum. It is difficult to set up markets for public goods, so they are often overused or undersupplied. Uses of rivers such as biodiversity, beautiful views and cultural values, are at the public good end of the scale and usually not represented in markets.

Externalities are the impacts of uses that do not fall upon the participants in the market. The classic example of a negative externality is discharges of pollutants into a river negatively affecting people downstream. A classic example of a positive externality is where a dam is created and provides a recreational resource. As the externalities do not affect those who generate them, there are no market signals to encourage more or less of the externalities to be produced.

An important issue in relation to resource use is the recognition of property rights. The ‘rights’ to use property, such as water can be defined in legislation or rights can grow as a matter of practice over time. Water allocation is a good example. Historically in Australia, people who extracted water for rural and urban use over time came to expect that they had a right to extract. In many cases, this was supported by licensing regimes. In the recent years, the water reform agenda has included redefining property rights to water. It is no longer linked to land and is being defined as a separate right, which in many cases is tradable. The reform process has caused some people to feel they are worse off than previously. However, it is important when setting up workable markets that property rights are clearly defined.

Of course, existing regulatory and planing settings are a fundamental part of determining the pattern of use at any time. These are usually put in place in response to how the system is moving, for example, planning to protect the views and access to rivers in some places, regulation to prevent overuse of the assimilative capacity of rivers. However the drivers generally come from the ‘whole’ economic system that is made up of people exercising choices within the markets, prices, public and private goods, and property rights as they exist.

For each of the river values listed above, we can analyse the performance of the current economic system in terms of a number of concepts. Does a market exist? Does the market achieve an efficient price? Are the values public goods or private goods? Are there externalities (that is positive or negative effects on people who are not participants in the market)? Who are the winners and losers? Are property rights clearly defined?

All the above questions help us examine if there is ‘market failure’. To overcome market failure, we can:

- set up markets where they do not exist
- adjust markets to provide a more efficient price or to internalise externalities
- recognise non-market values in dollar terms, and

- use policy tools such as education and regulation to complement economic approaches.

All approaches need to recognise the underlying dynamics of the economic system in order to be effective.

HOW ECONOMICS CAN HELP TO DETERMINE SOCIETY'S PREFERRED PATTERN OF RIVER USE

Given the broad range of potential uses and values of rivers, how can we possibly get the best mix of these, and a mix that is beneficial for the long term? There are several economic evaluation methods that attempt to organise information on the costs and benefits of different options, for use by decision makers. These include cost benefit analysis, cost effectiveness analysis, multi criteria analysis and linear programming approaches. All have in common that they are a way of presenting information to identify tradeoffs (see Environmental Protection Agency 2002, for more information on these evaluation frameworks).

Rather than go into these approaches in this paper, we will illustrate the challenge of providing information to decision makers by way of a study that was recently done in Queensland for the EPA by the Institute for Sustainable Regional Development, Central Queensland University (Rolfe et al 2005), assisted by the Economics Branch of the EPA, and with some further interpretation of results by the Economics Branch of the EPA (Environmental Protection Agency 2005).

The EPA wishes to set Environmental Values and Water Quality Objectives for the long term for waters in regions of Queensland. Environmental values (EVs) for water are a statement of the importance, or worth, placed on the qualities of a waterway that make it suitable to support healthy aquatic ecosystems, and in turn, support the livelihoods and lifestyles of the community. The government and community jointly develop EVs that reflect the ecological, social and economic values and uses of the waterway indicating their importance to the community and a need to protect them. Examples of EVs include aquatic ecosystems; urban and industrial water supply; recreation swimming and fishing; and aesthetic qualities that require water to be free from aquatic weeds, and unsightly and odorous algal growths.

Water quality objectives (WQOs) form measurable targets of specific water quality indicators at the whole-of-catchment level that protect the EVs of the water. They are mostly numerical, scientifically based targets for water bodies. For example, the WQOs to maintain seagrass depth range to at least 5 metres; and limit algal blooms to no more than one occurrence within five years would achieve the EV for aquatic ecosystems.

The environmental benefits of setting long term EVs and WQOs are to maintain and/or improve water quality. The EPA was asked to examine the economic and social implications of meeting these targets. We will focus on the study results for South East Queensland (SEQ), an area of high population growth and conversion of land use.

Scientific modelling shows that without further management intervention, loads of nutrients and sediment in rivers in SEQ, will increase over time and will threaten the maintenance of existing water quality or will reduce quality. There are clear environmental advantages in setting the WQOs as targets to aspire to over a 20 year time frame.

The study aimed to identify the economic and social implications of setting these EVS and WQOs – to assist decision makers in knowing whether there would be positive or negative economic or social impacts in adopting them. This is not an easy question as there are hundreds of EVS and WQOs for the study areas. Economics deals best with measurable marginal changes – that is, what are the marginal benefits and costs of moving from one water quality standard to a higher or lower one. It was scientifically difficult to identify the impacts on ecosystems and economic resources of these marginal changes, let alone make the connection to potential economic (and social) changes.

The following approach was adopted. The **economic costs** of undertaking the interventions are quantifiable as they mainly refer to works to upgrade sewage treatment plants, manage urban runoff and revegetate rural riverbanks. We needed to distinguish the marginal cost of what was likely to happen anyway to meet population increase and what extra may be required to meet EVs and WQOs. The latter was called the 'interventions strategy'. These costs were projected over 20 years, with a discount rate of 6% to get a 'Present Value'. For SEQ (population estimated to reach approximately 3.7 million by 2026), these costs are considerable at around $500 million over 20 years.

Table 1 South East Queensland - Costs of the 'interventions' strategy.

Intervention type	**Time period for program**	**20 year Present Value**
Upgrade sewage treatment Plants/wastewater reuse	5 years	$272 million
Urban stormwater management	20 years	$115 million
Rural diffuse runoff Management	20 years	$95 million
Total		**$482 million**

The **economic benefit** of the interventions were defined as:

- avoiding potential costs of declines in water quality
- additional economic benefits of improving and/or better protecting water quality.

A list was developed of industries dependant on water quality, along with other values that may be at risk from reduced water quality, or that may benefit from improved water quality.

Table 2 South East Queensland, Values 'at risk' or with potential to increase.

Identified Value	**'At risk' from declining water quality**	**Would benefit from improved water quality**
Direct recreation	✓✓	✓
Recreational fishing	✓✓	✓
Commercial fishing	✓✓	✓

Aquaculture	✓	?
Urban water treatment costs	✓	?
Industry water treatment costs	✓	?
Agricultural water treatment costs	✓	?
Property values	✓✓	✓
Aesthetics	✓	✓
Tourism	✓✓	✓
Biodiversity in waterways	✓✓	✓
Biodiversity – esturay & coastal	✓✓	✓
Protection of cultural heritage	✓	✓
Protection of Indigenous cultural heritage	✓✓	✓

The gross dollar values of the industries 'at risk' were identified, based on annual turnover, and projected over 20 years. Note that this is the gross value of the industry, and not all that amount will be at risk from declining water quality.

Table 3 South East Queensland - Gross dollar values of industries at risk.

Industry	Annual value	Present Value 20 years
Recreational fishing	$217 m	$2,993 m
Commercial fishing	$60 m	$729 m
Aquaculture	$14 m	$512 m
Tourism	$10,683 million	$228,887 m
Total	**$10,974**	**$293,121 m**

In a benefit cost analysis framework, the relevant benefit value to compare with the cost of works noted above is the potential 'producer surplus' at risk if the industry declines due to declining water quality (or which may increase if the industry grows with water quality improvements). Producer surplus is the net value of the industry once costs of production and wages are deducted from gross turnover. It has been estimated here using a well-known 'rule of thumb' at 10% of gross turnover.

The major challenge of this study was that we did not have information on the marginal benefits of the interventions, that is the quantitative link between maintaining water quality and avoiding costs to these industries. In this case, the hypothetical scenario of avoiding just a 2% decline in the value of the industries justifies the expenditure on the works. The potential cost of a 2% decline in the value of the industries (measured as producer surplus) is around $600 million, while the works would cost $500 million. This gives a benefit to cost ratio of greater than 1 to 1. Thus, it is an economic net benefit in avoiding even small declines in the industries at risk.

Table 4 'What if' the value of industries at risk declined.

Hypothetical Decline in industry Value	Present Value of industry decline avoided (benefits)	Present Value of costs	Benefit: Cost ratio
2%	$586 m	$482 m	1.2:1
5%	$1,465 m	$482 m	3:1
10%	$2,931 m	$482 m	6:1

The largest potential social impact identified was the loss of jobs if industry declines. In this case, the economic and social arguments support the environmental argument for maintaining and/or improving water quality. It is important to remember this impact independent from impacts to non-market values or 'at risk' values additional to the above industry values such as risks to beneficial services from ecosystems. Full consideration of these would of course make the benefit-cost ratio larger.

This example illustrates how providing information on the relative magnitude of benefits and costs can help decision-makers understand tradeoffs.

ECONOMIC VALUATION OF USES AND VALUES THAT DO NOT GENERALLY HAVE DOLLAR VALUES

Not all cases are so clear as the one described above, and it is often necessary to try to place dollar estimates on values not generally traded in markets, in order to get a full picture of the tradeoffs. In the study just described, dollar values were also placed on biodiversity protection, drawn from a number of studies that had found 'willingness to pay' for protection or improvement in the extent and health of wetlands, waterways and estuaries.

'Willingness to pay' survey results (all per household per year) included $11 for non-use values and $19 for use values for protection of Moreton Bay wetlands (Clouston 2002), $3.17 for a one percent improvement in river estuary health and two cents per kilometre for waterway improvement (Windle and Rolfe 2004). When these results were extrapolated to all waterways and households in SEQ, the values are considerable – at around $200 million per annum ($2,300 million over 20 years). This certainly adds to the argument for the interventions to maintain and/or improve water quality.

A number of non-market valuation techniques are now widely used in economics. These include methods based on:

- estimating market prices, for example for infrastructure that would be required to replace ecosystem services
- methods which set up proxy markets for closely related goods, and
- survey based methods that examine willingness to pay (or accept compensation) for a proposed outcome.

There is more information on these methods in *'Environmental Economic Valuation, an Introductory Guide for Policy Makers*, Environmental Protection Agency (2002). There are several on line databases that compile references to studies with non-market values.[1]

[1] See for example Envalue, searchable environmental valuation database at http://www.epa.nsw.gov.au/envalue/

It is now recognised that natural environments provide 'ecosystem services', that is services that benefit people, which would need to be replaced by artificial infrastructure if no longer viable. A good example in the case of rivers is the value of natural watersheds. In a well-quoted case, New York City authorities have chosen to improve New York's drinking water quality through catchment or 'watershed' protection rather than upgrading sewage treatment plants and filtration systems creating savings in the billions of dollars (US EPA 1996).

A particular point we would like to note here is that Indigenous values are usually thought of as non-market values related to spiritual and cultural use, and usually given little recognition in economic studies. In fact, colleagues in the EPA are mapping Indigenous values for rivers against a conventional economics framework and have identified that the full range of values, from market to non-market values, exist for Indigenous people in Australia. A key point to note is that many values such as 'existence' or 'bequest' values in biodiversity and recreational amenities, and a corresponding system of measurement, has existed in Australian communities for millennia. This work will be developed further in the near future.

HOW MARKET BASED INSTRUMENTS CAN BE USED TO SET UP NEW MARKETS AND CORRECT EXISTING MARKETS

The other main use of economics is to set up and adjust markets to provide better outcomes. Market based instruments are a complement to command and control regulation and to the softer approach of education.

Market based instruments include:

1. **Price-based** systems that lever behavioural change by changing prices in existing markets. Examples include taxes, levies, charges and subsidies.
2. **Tradeable permits** are quantity-based schemes that lever behavioural change by specifying the 'amount' of rights/obligations. Examples include emissions trading and offsetting damage to wetlands.
3. **Market friction** tools lower market barriers by levering behavioural change by making existing private markets work better. Examples include eco-labelling or accreditation of good farm management.

The advantages of market based instruments are that they can be flexible, provide incentives to reduce impacts or use resources more efficiently, and promote the lowest cost approaches to meeting a defined outcome.

A significant topic for economics is the price of water, and whether it reflects the true cost of production, scarcity and environmental impacts. The program of water reform in Australia utilises market based instruments to: construct a well defined market where one previously did not exist, make water pricing more reflective of costs of production, attempt to capture the scarcity value of water through trading, and account for some environmental externalities through defining environmental flows. The aim of reform is a market in which the price of water facilitates it going to the highest value use and promotes efficiency in use of this precious commodity.

Significant steps have been made in most States and Territories, but the full effect of reform will not occur until trading is common, and it is probable that some catchments will not be suitable for efficient trading.

At the EPA, we are exploring the opportunity to use the market-based instrument of nutrient trading to address water quality. The point of considering a market based instruments trading instrument is that we are trying to find the least cost way of meeting a target, or even better, whether we can move to lower emissions while still making savings for emitters.

In NSW, there are two ground-breaking emissions trading schemes, the Hunter River Salinity Scheme and South Creek Nutrient Trading. We will focus on South Creek, as it is similar to the issue EPA is looking at.

The South Creek Scheme involves the major discharger of nitrogen and phosphorous, Sydney Water, having a 'bubble licence' that allows them to meet a discharge target collectively across a number of their sewage treatment plants. Under traditional command and control regulation, each sewage treatment plant would need to meet an individual target. Each plant would need to upgrade to meet population and development growth. By allowing trade between these plants, the most cost effective solution for upgrades can be found. Gains from this change are estimated to be $45 million in savings on infrastructure.

In addition, the effectiveness of voluntary offsets of works to reduce runoff on rural properties is being trialed as part of the scheme. Addressing diffuse-source pollution is often cheaper than further reducing point-source pollution. For example, the cost of upgrading a modern STP to reduce phosphorus discharge can be as high as $10,000 per kilogram saved per year. In contrast, the cost of reducing phosphorus from some diffuse sources in the South Creek catchment has been estimated at $10–$200 per kilogram, although this cost varies between catchments and land uses. Having such wide differences in costs may seriously influence where and how to direct efforts to reduce pollution (NSW EPA 2003). In addition, diffuse actions can have spin-off effects addressing sediment discharge problems and improving vegetation.

The approaches described above could be expanded to a wider trading scheme with more players. The benefits of a trading scheme is that the market can find the least cost way of meeting an emissions target or cap.[2]

In Queensland, we are undertaking a feasibility study of nutrient trading for catchments discharging into Moreton Bay. It appears that some of these catchments have characteristics that would allow development of a trading approach, although further scientific and other feasibility work is required. We would like to acknowledge funding contribution from the Commonwealth Government's Coastal Catchment Initiative, as well as the EPA.

The EPA has also tested a price based market based instrument called the *Queensland Ecosystem Services Tender,* in an effort to improve water quality outcomes in the waterways adjacent to the Douglas Shire. This project offered incentives to encourage canegrowers in the Douglas region to implement management regimes on their land that would have a direct and positive relationship to improving water

[2] For more detail on such approaches see a paper at last year's Riversymposium, O'Sullivan D, 'The grip of the 'invisible hand' on water pollution', International Riversymposium 2004, Brisbane.

quality. There are many government programs where financial incentives are made available to landholders for delivering environmental improvements. An auction or tender creates a competitive process that can assist the government to discover where limited investment dollars will achieve the 'best value for money', that is the highest return to water quality at the most reasonable price. Therefore, in the case of the Douglas project, those canefarmers who were willing to provide a high level of service to improving water quality at a reasonable price were successful. The tenders or bids submitted by canefarmers to provide water quality services were ranked and compared on a financial and water quality outcomes basis. Evaluation of the project found that the *Queensland Ecosystem Services Tender* provided a true incentive as it rewarded landholders for good past environmental performance; and achieved value for money by targeting canefarmers who were able to provide good returns to water quality, cost effectively. The project also managed to secure enduring water quality improvements by formalising a deed of agreement and River Improvement Trust notices with successful bidders.

It is worth mentioning here the developments in 'experimental economics'. This involves simulating new markets and trading situations and experimenting with different rules and approaches to find those that are likely to be successful. This is especially useful in situations where a new market is being considered and where the participants are not accustomed to trading. Good design of a system is critical in order to avoid counter productive outcomes.

CONCLUSION

Rivers have enormous value to society. To make the most of rivers, we need to recognise that tradeoffs need to be made between competing values, and recognise that some of the competition is between present and future generations. Economics can help us to understand the dynamics of river use, so that adjustments may be made where necessary. Economics can help us to provide accurate information on market values and estimates of non-market values, including ecosystem services – this allows for improved decision making about allocation and limits. Market-based instruments can also help us achieve desired river use outcomes, in more cost-effective and equitable ways.

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