

## ***Extended Abstract***

### **Estimating the Value of River Flow Related Ecosystem Services- the Case of the South Australian Murray-Darling Basin**

Onil Banerjee, Jeff Connor and Neville Crossman

CSIRO Natural Resource Economics and Decision Science

***[Please note that this paper will be published in a journal elsewhere and therefore we are unable to provide the full version. The presentation at the World Water Congress, however, will include all dimensions of the full paper including all of the key findings.]***

#### **Key words:**

Ecosystem services, environmental valuation, drought mitigation and adaptation.

#### **Introduction**

The Intergovernmental Panel on Climate Change (IPCC) predicts that arid and semi-arid regions will experience increased temperature, reduced rainfall and less snowmelt runoff as a result of climate change. The intensity and frequency of droughts is also expected to increase. Droughts are anticipated to be the most costly consequence of climate change. Estimating the economic value of ecosystem service loss arising from drought is critical for informing drought mitigation policy and vulnerability assessments. Furthermore, assigning economic value to ecosystem services not traded in the market place provides an economic basis for formulating sustainable water diversion policy thereby insuring adequate base and environmental river flows in times of drought. A consistent methodology for such estimation has, however, been elusive. In this paper, we develop an ecosystem service approach to estimating the value of ecosystem service loss resulting from drought. With South Australia's Murray-Darling Basin recently emerging from the most severe drought in recorded history, this natural experiment is used to estimate the value of river-flow related ecosystem services. What follows is a brief overview of the ecosystem service approach, a synopsis of key results and concluding commentary.

#### **Methods**

##### ***The ecosystem services framework***

The ecosystem service framework offers a standardized approach to classifying river flow related ecosystem services. In the advent of drought, classification of river flow related ecosystem services facilitates the enumeration and valuation of those services compromised by drought. Such a standardized approach enables the comparison of drought impacts both spatially and temporally. This categorization provides a transparent accounting system that aids in avoiding the double counting of ecosystem service losses. Furthermore, this classification and the ability to compare drought impacts are useful for identifying critical ecosystem thresholds and drought-induced trends in ecosystem service loss which may be used to inform drought response and mitigation measures.

The ecosystem service framework was developed with the aim of linking human well-being and ecosystem function (de Groot in Kumar, 2010). The Millennium Ecosystem Assessment (MA) was established in 2001 to "...assess the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being" (MA, 2005). Based on a large body of literature, the MA specified four categories of ecosystem services, namely provisioning, regulating, habitat and cultural and amenity services.

Estimating the Value of River Flow Related Ecosystem Services. DRAFT- PLEASE DO NOT CITE.

Considering river flow related ecosystem services, provisioning services include the production of clean water for agricultural production and municipal and industrial consumption. Regulatory services play an important role in the movement of water, sediment, solutes, biota and energy. Conveyance and environmental river flows are critical in maintaining connectivity between river, estuarial and marine environments. River systems regulate water flow and runoff, contribute to floodplain interactions, prevent erosion and mitigate natural hazards. Habitat services produced by riparian and wetland systems are largely related to the maintenance of lifecycles of migratory species, nursery services and their contribution to biological and genetic diversity. Finally, these freshwater systems provide cultural and amenity services including recreational opportunities such as boating and fishing, as well as other services that are inspirational, educational and historical in nature.

Once categorized in this way, there are three main classes of methods that may be used in estimating the value of provisioning, regulating, habitat and cultural and amenity services. They are: survey-based methods, indirect market methods and direct market based methods. Stated preference or survey-based methods include contingent valuation and choice modelling techniques. The contingent valuation approach involves surveying an individual's willingness to pay to enhance or protect an ecosystem service. Choice modelling techniques add a layer of complexity to contingent valuation in enabling the valuation of multiple attributes of an ecosystem. In choice modelling, an individual's decision process is modelled to ascertain how they value a bundle of ecosystem services. These stated preference methods are often the only way to capture option, bequest and existence values.

Of the indirect market methods, the travel cost and hedonic pricing methods are the most frequently applied. The travel cost method has been used extensively in estimating cultural and amenity ecosystem service values. These values are estimated as the costs users incur to visit a particular location, often a recreational site. The hedonic pricing method is used to estimate ecosystem service values based on the assumption that environmental attributes are embedded in the price of marketed commodities. Direct market methods consist of the market price approach, the production function approach and cost and expenditure-based methods. Often used to value some ecosystem provisioning services, market price methods assume that individual preferences and the real marginal costs of production are reflected in a good or service's market price. The ecosystem production function approach may be used to estimate the value of an ecosystem service through the added value it contributes to the market price of a good or service.

There are various cost and expenditure-based estimation methods, all of which are closely related. These estimation approaches are: avoided and defensive expenditures, replacement cost, mitigation and adaptation cost, and damage cost. Avoided and defensive expenditure based methods estimate value as the cost required to avoid or defend against an environmental bad previously mitigated by ecosystem functions. Replacement cost estimation techniques use the cost of replacing an ecosystem service with a technological alternative. Mitigation measures use data on what consumers may be willing to pay for a good or service that reduces a negative environmental externality. Adaptation cost methods reflect the costs that are or would be associated with adjusting to a new ecosystem state. Damage cost methods estimate ecosystem service value with the cost of the damage that would be caused in the absence of the service.

There are a number of advantages to cost-based approaches. Some people are more inclined to believe cost-based estimates since they are based on either expenditures consumers have actually incurred or on real market prices. Cost-based estimators are also easy to replicate as data in most cases are readily available. Cost-based methods are particularly effective where the technological alternative provides the same services as the ecosystem in question, the expenditure undertaken or cost estimation used is the least cost alternative, and there is evidence that where expenditures were undertaken on an individual or group's behalf, the beneficiary would demand the expenditure in the absence of institutionalized action (Barbier, 2007; Shabman & Batie, 1978).

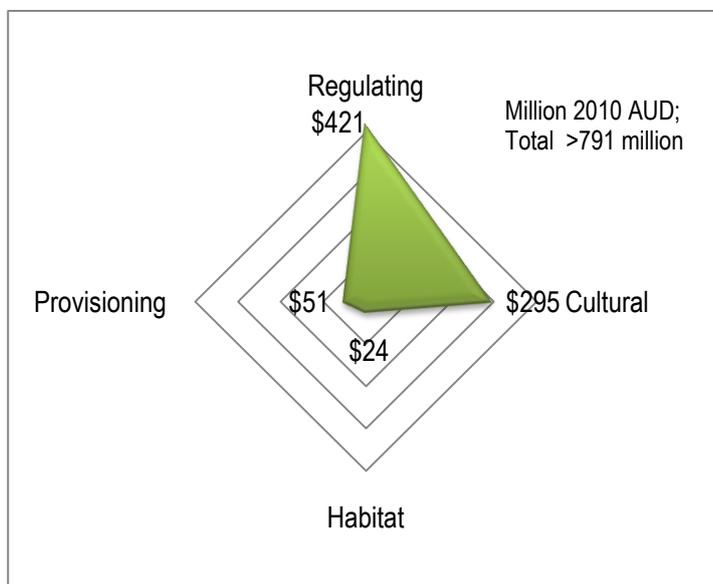
The case study presented here applies expenditure and cost based ecosystem service valuation approaches. With the South Australian Murray-Darling Basin recently emerging from the most severe drought in recorded history, a rare natural experiment has been provided which enables the piloting of an

ecosystem service approach to estimating ecosystem service loss. During this ten year drought, low water inflows into the system coupled with unsustainable water diversions for consumptive uses have exacerbated the damage caused to riparian and wetland ecosystems. Some ecosystems breached critical thresholds and were no longer able to provide the same range and level of services as they did in average inflow periods. As a result of this deteriorating condition, the Australian Commonwealth and South Australian state governments incurred costly expenditures to repair the damage caused in the absence of these services being provided as well expenditures related to mitigation of further damage and adaptation to a new ecosystem dynamics. Through in person and telephone interviews, a review of the literature and damage cost assessment, the value of river flow related ecosystem services was estimated.

## Results

Chart 1 provides an overview of the distribution of ecosystem services losses between provisioning, regulating, habitat and cultural and amenity services for the period 1999 to 2011. The provisioning services most affected by the drought and exacerbated by water diversions were those produced by the dairying industry in the lower section of the South Australian Murray-Darling Basin system. These provisioning service losses were estimated at close to \$51 million.

Regulating ecosystem service loss represented the greatest mitigation and adaptation expense. The cost of



**Figure 1. Mitigation and Adaptation Expenditures to Ecosystem Services Loss (1999-2011)**

regulating the river to maintain connectivity between the freshwater, estuarial and marine environment was conservatively estimated at \$32 million (Kingsford et al., 2010). Emergency levee repairs amounted to \$1.38 million. Repairs to bridge footings, ferry landings and pipelines were costed at \$1 million. Investment lost in updating irrigation infrastructure was estimated as \$22 million while the lost expenditure on the laser levelling of farm plots was estimated at \$60 million. Some infrastructure works including the construction of bunds, pipelines and standpipes exceeded \$160 million. Property damage due to riverbank collapse was estimated at \$1.9 million. Costs incurred by landowners, the Department for the Environment and Natural Resources and local Councils for riverbank collapse mitigation and monitoring was estimated at \$1 million while

the South Australian Department for Water's Riverbank Collapse Hazard Program has cost over \$1.5 million (DFW, 2010). Damage costs resulting from higher levels of salinity affected both households and industry; this damage was estimated at upwards of \$122 million.

Significant loss of habitat services was drought and unsustainable diversion-induced. Low water levels in the Lower Lakes of the system and its tributaries resulted in the generation of large areas of acid sulphate soils. Acid sulphate soils are problematic since they reduce water quality and agricultural productivity as well as negatively impact infrastructure works. Low water levels around the Lower Lakes, where much of the region's biodiversity is located, has contributed significantly to habitat loss (Department for Environment and Heritage, 2010). To deal with this loss of ecosystem services, various replacement and mitigation measures have been taken. These measures include the establishment of vegetation plots, aerial and machine seeding, tree planting, the application of limestone and the pumping of water to maintain lake levels. These measures represented a cost of over \$24 million. Finally, cultural and amenity ecosystem service losses, primarily quantified as lost tourism opportunities, were estimated at close to \$140 million.

## **Conclusions**

The estimated value of river flow related ecosystem service loss associated with drought and unsustainable water diversions for the South Australian Murray-Darling Basin was over \$791 million. The ecosystem service approach to valuing this loss provides a standardized and transparent approach to valuing ecosystem services. Knowledge of the value of ecosystem service loss that may result from drought and unsustainable diversions can inform drought mitigation and vulnerability policy and planning as well as water diversion policy.

There is significant scope to develop more comprehensive value estimates. Methods such as benefits transfer may be applied to transfer ecosystem service values for services where cost and expenditure data were unavailable. Use of survey-based stated preference techniques could also be employed to capture some of the less tangible of the ecosystem services such as those embodied in cultural and amenity as well as habitat services. The approach presented here is a fundamental point of departure for a more robust quantification of river flow related ecosystem service values and their application. With climate change anticipated to increase the frequency and duration of droughts, exacerbated by ever increasing municipal and industrial consumption, further refinement of such a framework is critical.

## References

Barbier, E.B. 2007. Valuing Ecosystem Services as Productive Inputs. *Economic Policy*, 22: 177–229.

de Groot, R. 2010. Integrating the Ecological and Economic Dimensions in Biodiversity and Ecosystem Service Valuation. In P. Kumar (Ed.), *The Economics of Ecosystems and Biodiversity* (pp. 9-147).

Department for Water [DFW]. 2010. Riverbank Collapse- Costing Estimate Breakdown. Unpublished data.

Department for Environment and Heritage. 2010. Securing the Future, Long-Term Plan for the Coorong, Lower Lakes and Murray Mouth. Department for Environment and Heritage: Adelaide, South Australia.

Kingsford, R.T., Walker, K.F., Lester, R.E., Young, W.J., Fairweather, P.G., Sammut, J. and Geddes, M.C. 2010. A Ramsar Wetland in Crisis- the Coorong, Lower Lakes and Murray Mouth, Australia. *Marine and Freshwater Research*.

Millennium Ecosystem Assessment. 2005. Overview of the Millennium Ecosystem Assessment. Retrieved March 15, 2011, from: <http://www.maweb.org/en/About.aspx#>

Shabman, L.A. and Batie, S.S. 1978. Economic Value of Natural Coastal Wetlands: A Critique. *Coastal Zone Management Journal*, 4(3): 231-247.