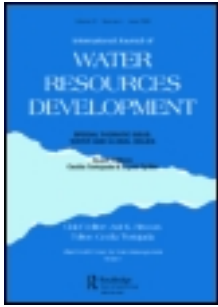


This article was downloaded by: [CSIRO Library Services]

On: 05 March 2013, At: 15:47

Publisher: Routledge

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



## International Journal of Water Resources Development

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/cijw20>

### Incentives for ecosystem service supply in Australia's Murray-Darling Basin

Onil Banerjee <sup>a</sup> & Rosalind Bark <sup>b</sup>

<sup>a</sup> CSIRO, Environment and Development, Dutton Park, Australia

<sup>b</sup> CSIRO, Natural Resource Economics and Decision Science, Dutton Park, Australia

Version of record first published: 05 Mar 2013.

To cite this article: Onil Banerjee & Rosalind Bark (2013): Incentives for ecosystem service supply in Australia's Murray-Darling Basin, International Journal of Water Resources Development, DOI:10.1080/07900627.2013.769489

To link to this article: <http://dx.doi.org/10.1080/07900627.2013.769489>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.tandfonline.com/page/terms-and-conditions>

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae, and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

## Incentives for ecosystem service supply in Australia's Murray–Darling Basin

Onil Banerjee<sup>a\*</sup> and Rosalind Bark<sup>b</sup>

<sup>a</sup>CSIRO, Environment and Development, Dutton Park, Australia; <sup>b</sup>CSIRO, Natural Resource Economics and Decision Science, Dutton Park, Australia

(Received 7 March 2012; final version received 20 January 2013)

For Australia, the Murray–Darling Basin is a significant ecological and socioeconomic asset. During the Millennium Drought (1997 – 2010), severe ecosystem service losses provided impetus for water policy reform. With around \$8.9 billion committed, the Commonwealth's two-pronged water recovery strategy is to purchase water entitlements for the environment and support investment in improving irrigation infrastructure efficiency. In this paper, we consider the design of a complementary payment for ecosystem services pathway which using water as payment can provide incentives for local ecosystem service supply.

**Keywords:** Payment for ecosystem services; market-based instruments; sustainable diversion limits; the Murray–Darling Basin; Basin plan

### Introduction

The Millennium Drought (1997–2010) in Australia's Murray–Darling Basin (MDB) was the most severe in recorded history, revealing a suite of ecological thresholds and socioeconomic and political tipping points (Banerjee, Bark, Connor, & Crossman, in review; CSIRO, 2011, 2012). The integrity of many ecosystems in the basin and their capacity to deliver the full range of ecosystem services was compromised. In response, decision makers were faced with stark trade-offs in the way water was allocated between different uses including ecosystems. The severity of the drought and its socioeconomic and environmental impacts provided a political impetus for Australia's Commonwealth Government to pursue an ambitious agenda of water policy reform. This agenda seeks to maximize multiple objectives including maintaining adequate water flows for the basin's ecosystems to ensure the supply of freshwater ecosystem services while sustaining the communities that depend on basin water resources for their livelihoods.

Ecosystem services are the benefits nature provides that contribute to human well-being (Costanza et al., 1997; Daily, 1997; MEA, 2005, 2003; Perrings, 2006; TEEB, 2010b). An environmental economics definition of a payment for ecosystem services (PES) programme is a programme that involves a voluntary transaction where a well defined ecosystem service is purchased from a service provider and is delivered as agreed (Wunder, 2005). This form of PES programme is sometimes referred to as a Coasean PES programme. In actuality, there are few PES programmes that meet the strict definition of a Coasean PES programme due to issues around who pays for the services, the spatial and temporal complexity of ecosystem functions and the delineation of the ecosystems supplied (Farley & Costanza, 2010; Kemkes, Farley, & Koliba, 2010; Muradian, Corbera,

---

\* Corresponding author. Email: onil.banerjee@csiro.au

Pascual, Kosoy, & May, 2010). A broader ecological economics definition of a PES programme is a programme that involves a transfer of resources, monetary or otherwise, which creates incentives for the alignment of individual and social welfare (Muradian et al., 2010).

PES is a market-based instrument that has emerged as a promising option for creating incentives for restoring or enhancing ecosystem service supply by internalizing environmental externalities (Coase, 1960; Engel, Pagiola, & Wunder, 2008; Gómez-Baggethun, de Groot, Lomas, & Montes, 2010). Norgaard (2010) summarizes the restructuring of incentives thus: “By paying for the services...those who manage ecosystems will have an incentive to protect the ecological capital... that generates the services. Doing this entails combating or counteracting the direct drivers of changes to the ecosystems” (Norgaard, 2010: 1220).

There are a handful of active PES programmes in Australia. At the national level, the Caring for our Country initiative aims to improve environmental management for the enhanced supply of ecosystem services. This initiative provides funding to land managers, communities, industries and non-governmental organizations (NGOs) in priority areas to adopt sustainable farm practices, increase protected areas, and engage in conservation activities in critical aquatic habitats such as Ramsar sanctioned wetlands (Commonwealth of Australia, 2011). Embedded in the Caring for our Country initiative is the Working on Country programme that provides payments for improving natural resources management on Indigenous land (May, 2010). The Carbon Farming Initiative is another nation-wide programme which establishes a PES programme framework for farmers to be compensated for storing carbon on farm land (e.g. in soils or biomass) and to reduce farm-related greenhouse gas emissions (Commonwealth of Australia, 2012). At the state level, the State of Victoria has a number of active PES programmes, for example BushTender and BushBroker are auction-based programmes designed to improve native vegetation management on private land (Department of Sustainability & the Environment, 2011).

At the basin scale, the Basin Salinity Management Strategy 2001–2015 establishes a PES framework for improved salinity management to enhance ecosystem service supply (Garrick, Bark, Connor, & Banerjee, 2012). The proposed Murray–Darling Basin Plan which among other things will reduce water diverted for irrigation, aims to restore ecosystem integrity and increase ecosystem service supply. The Plan involves explicit trade-offs between the supply of food and fibre provisioning ecosystem services and the restoration of freshwater ecosystems and the regulating and habitat services they provide (Gordon, Finlayson, & Falkenmark, 2010). Central to the Commonwealth Government’s water reform agenda is a water recovery strategy which seeks to reduce the opportunity cost of trade-offs between provisioning ecosystem services and other ecosystem services by investing \$8.9 billion in buying water entitlements from willing sellers and in improving irrigation efficiency both on and off-farm. At the sub-basin scale, The Living Murray initiative is designed to restore wetland habitat at six iconic sites along the River Murray.

In this paper we demonstrate how a PES programme could complement the Commonwealth’s water recovery strategy through targeted objectives that water buybacks and irrigation efficiency investments alone may be unable to meet. This paper is organized as follows: the second section provides a brief description of the MDB system, its natural resources and importance to multiple users, and highlights current water policy and management challenges. The third section offers an overview of the basic design principles of a PES programme. The fourth section discusses how a PES programme might

be developed in the MDB. The paper concludes with a discussion of the need for a suite of policy and market-based instruments to meet multiple objectives and maximize basin-wide benefits.

**Australia’s Murray–Darling Basin**

Australia’s MDB is a 1 million km<sup>2</sup>, multi-jurisdictional basin, occupying portions of the States of Queensland, New South Wales, Victoria and South Australia, and the Australian Capital Territory (Figure 1). The MDB comprises the Murray, Darling and Murrumbidgee rivers, three of Australia’s longest rivers, and their tributaries. The MDB is a semi-arid river system with highly variable stream flow (Peel, McMahon, & Finlayson, 2004), one of the most variable in the world (Kirby et al., 2006). The basin is mostly low-lying and



Figure 1. Map of Australia’s Murray–Darling Basin.

supports extensive floodplains as well as over 30,000 wetlands, 220 of which are listed in the Directory of Important Wetlands in Australia (CSIRO, 2008). Sixteen of these wetlands are of international importance and are protected under the Ramsar Convention (MDBA, 2010; Ramsar Convention, 1971). The MDB supports large floodplain forests such as the Barmah-Millewa and Gunbower-Koondrook-Perricoota forests which provide critical wildlife habitat. The basin is home to approximately 45 species of native fish, 35 endangered bird species and 16 endangered mammals (Department of the Environment, Water, Heritage and the Arts, 2010).

At the river terminus are the Coorong, Lower Lakes, Murray Mouth and a complex and internationally important series of wetlands and lagoons which serve as crucial refuge for international migratory wading birds and waterfowl. The Barmah-Millewa forest, the Coorong lagoon and the main stem of the River Murray are also key recreational hotspots for boating, fishing, camping and bird watching (Hatton MacDonald, Tapsuwan, Albouy, & Rimbaud, 2011; MDBA, 2010; Rolfe & Dyack, 2011).

The MDB's water resources support an important irrigated agricultural industry: two-thirds of the nation's irrigated agricultural area is located in the basin (ABS, 2008), generating 10% of basin employment in 2008–09 (ABS, 2010). The agricultural sector is the largest water user in the basin accounting for 85% of consumptive use in 2004–05 (ABS, 2008). The basin also supplies water to over 2 million urban and rural consumers.

There have been 3 severe droughts in the 117-year stream flow records, the latest of which, the Millennium Drought, was the most severe. During the drought, the MDB experienced 10%–30% less rainfall than the long run average, and although allocations to irrigators were reduced (Kirby, 2011), basin ecosystems bore a disproportionate reduction in water availability (WGCS, 2010). State Water Sharing Plans were suspended (National Water Commission, 2011) which greatly reduced downstream flows, and in 2002, flows out of the mouth of the River Murray ceased. The reduced water flows resulted in heavy degradation of basin riverine, wetland and estuarine ecosystems (Crossman et al., 2011; Kingsford et al., 2011). In South Australia alone, the downstream state in the MDB system, the Commonwealth and State governments, communities and individuals incurred expenditures of between \$790 and \$810 million in drought-related mitigation and adaptation measures (Banerjee et al., in review; CSIRO, 2011).

The Millennium Drought subjected water management and water sharing arrangements to a harsh test (Chiew, Young, Cai, & Teng, 2011). In response, the Parliament passed The Water Act of 2007 (Commonwealth of Australia, 2007), Australia's legal framework for water resource management and ecosystem restoration. The Act created the Murray–Darling Basin Authority (MDBA) which is charged with developing a Basin Plan and an Environmental Watering Plan, and the Commonwealth Environmental Water Holder to manage Commonwealth environmental water (Department of the Environment, Water, Heritage & the Arts, 2009). The water reform agenda seeks to balance ecosystem service supply and the maintenance of the livelihoods of those that depend on basin water resources. The volume of water to be reallocated in the Draft Basin Plan is based on proposed sustainable diversion limits which will reduce water diversions by 2,750 gegaliters (GL) per year. On average, this implies that surface water extraction will be capped at 10,873 GL/yr, reducing basin-wide consumptive use by 24% (MDBA, 2012).

There are political concerns that the costs to the irrigator communities will be high (The Parliament of the Commonwealth of Australia, 2011). Recent economic analysis, however, suggests that adjustment costs to new sustainable diversion limits may be less than anticipated, though some communities could be more vulnerable than others

(ABARES, 2011; Dixon, Rimmer, & Wittwer, 2010, 2011). The Commonwealth's water recovery strategy does not contemplate a PES programme, though it has features that could underpin a PES programme where sustainable diversion limits are based on the ecological needs of freshwater ecosystems (Acreman & Dunbar, 2004).

### **Design principles of a payment for ecosystem services programme**

The purpose of a PES programme is to correct a market failure by providing incentives for communities or individuals to undertake management interventions that enhance the supply of ecosystem services (Dunn, 2011; Muradian et al., 2010). There are three main design principles for developing a PES programme: 1) catalogue the range of ecosystem services to be supplied and identify the beneficiaries; 2) determine the price to be paid, and; 3) design a policy, subsidy or market to finance the programme and develop a regulatory framework to manage the programme (BioClimate Research & Development, 2010). There is much complexity, associated research and transaction costs embedded in each principle which is one reason PES arrangements have been slow to develop (WBCSD, 2010). These three PES programme design principles are discussed in turn.

The Economics of Ecosystems and Biodiversity (TEEB) ecosystem services framework provides a standardized approach to classifying and comparing ecosystem services in a rigorous, systematic and transparent accounting system (de Groot, Wilson, & Boumans, 2002; MEA, 2005, 2003; TEEB, 2010b). This framework specifies the relationship between ecosystem structure and function and how ecosystem functions produce services which contribute to human well-being. TEEB identifies 4 classes of ecosystem services (provisioning, regulating, habitat, and cultural and amenity services) and 22 services. This framework can be applied to cataloguing the ecosystem services that will be supplied and sold in a PES programme.

Once the ecosystem services are catalogued, biophysical metrics are developed to measure ecological responses and resulting changes in ecosystem service supply that are attributable to management interventions. Since this process requires understanding of ecological responses to management interventions and their impact on human well-being, a multidisciplinary approach is appropriate (Dunn, 2011; Pagiola & Platais, 2005). Management interventions funded under a PES programme should represent an increase in ecosystem service supply compared with the business as usual or baseline scenario (Forest Trends, 2008; Kinzig et al., 2011; TEEB, 2010a), while eliminating potential leakages where harmful management practices are relocated as a result of the PES programme (Arriagada & Perrings, 2009).

Linking ecological response to management interventions is complex because ecosystems are dynamic and exhibit thresholds and keystone processes (Kelsey, Kousky, & Sims, 2008; Landell-Mills & Porras, 2002). Ecological responses are the product of complementary relationships where ecosystem service supply often depends on the integrity of the whole functioning system. In some cases, ecosystems may respond to change in irreversible and unexpected ways (Turner, Georgiou, & Fisher, 2008). Because of these intrinsic characteristics of ecosystems, bundling ecosystem services sold in a PES programme may maximize ecological integrity and social welfare as opposed to the sale of discrete ecosystem services (Farley & Costanza, 2010).

The nature of the ecosystem services supplied provides guidance in the identification of beneficiaries (i.e. who pays). Public goods (e.g. fish habitat or maintenance of water quality) are open access and non-rival in use which means that in practice, these goods are costless in their supply, free-riding is often an issue, and they are frequently supplied

below socially optimal levels in the absence of incentives or government regulation (Kelsey et al., 2008). In these cases where user groups are not easily identified, property rights are less well-defined and the service is not tradable in the market place, mandatory mechanisms or third-party financing, where an institution such as a government or an NGO purchases the service on the beneficiaries' behalf, may be appropriate (Dunn, 2011; Farley & Costanza, 2010; Kelsey et al., 2008).

In the case of club goods which are excludable and non-rival (e.g. a national park), Coasean or user-funded PES programmes may emerge where beneficiaries are easily identified and organized, transaction costs are low and property rights are well defined. This form of PES may be financed through direct payments or service fees levied on beneficiaries and are often efficient since beneficiaries have a direct stake in ensuring that the services are supplied as contracted (Arriagada & Perrings, 2009; Engel et al., 2008; Wunder, Engel, & Pagiola, 2008).

The second principle in PES programme design involves assigning a price to the ecosystem services supplied. There are two primary approaches to assigning a price: an opportunity cost approach and an ecosystem service valuation approach. In the former, landowners supplying ecosystem services are paid the recurring value of the foregone land use resulting from a change in management practices (Pagiola & Platais, 2005). For example, if a farmer plants a riparian buffer, reducing pesticide run-off into a stream, the opportunity cost of this change in management would be the forgone value of not cropping in the riparian area, net of PES programme transaction costs. This conservation opportunity cost approach is the basis of Costa Rica's well established PES programme (Pagiola, 2008).

The more complex ecosystem service valuation approach involves estimating the marginal economic value associated with an increase in ecosystem service supply. Stated preference, revealed preference and direct market-based methods may be used to estimate marginal value (Farber et al., 2006; Liu, Costanza, Farber, & Troy, 2010; TEEB, 2010b). To avoid double-counting ecosystem service values, valuation methods emphasize transparency and replicability (Johnston & Russell, 2011). Recent studies in the MDB have utilized all three valuation approaches to estimate marginal values for changes in ecosystem service supply (Banerjee et al., in review; CSIRO, 2011, 2012).

The third PES programme design principle involves developing a framework for financing, payment and programme regulation. The financing mechanism collects payments from beneficiaries and manages these funds. The payment mechanism promotes the PES programme, establishes contracts with ecosystem service suppliers and implements a monitoring and compliance programme. Regular auditing assures beneficiaries that their payments are used appropriately and helps maintain their confidence in the system (Dunn, 2011). The supervisory component negotiates agreements and resolves disputes (Pagiola & Platais, 2005).

## Discussion

Do the foundational elements exist to implement complementary PES programmes in the MDB? In Australia's overarching water reform legislation, the Water Act, the importance of ecosystem services is highlighted: one of the Act's objectives is to restore "ecological values and ecosystem services of the Murray–Darling Basin" (Water Act 2007, Section 3dii). Although the final sustainable diversion limits and the Basin Plan are not yet approved, early implementation outcomes utilizing environmental water acquired by the office responsible for environmental watering, the Commonwealth Environmental Water

Office (CEWO), are reported in terms of ecosystem responses (Watts et al., 2012). Given the large investment in the MDB's water recovery strategy, this emphasis on ecological response is unsurprising: value for money and ecological outcomes are key indicators of performance (CEWO, 2012).

The Commonwealth's water recovery strategy has relied on the purchase of water entitlements from willing sellers and to a lesser degree, investment in enhancing irrigation efficiency, both on and off-farm. As of October 2012, 1,433 GL were purchased with an average long-term yield of 1,040 GL/year. These water entitlements will support a stream of ecosystem service benefits in the implementation stage of water reform through the CEWO's Environmental Watering Plan. The Commonwealth's water recovery strategy does not, however, constitute a PES programme in a strict sense since it does not change the incentive structure for communities and individuals to change management practices to enhance ecosystem service supply (Kelsey et al., 2008). Instead, the strategy is a Commonwealth-funded reallocation of water resources from irrigated agriculture to environmental flows (Gordon et al., 2010).

Facing a large implementation, monitoring and verification challenge in managing environmental water, there may be opportunities for the MDBA and CEWO to complement their water recovery strategy with a PES programme. In such a programme, the Commonwealth could provide water as a form of payment to landholders, Indigenous groups and environmental NGOs, to enhance the supply of a bundle of ecosystem services. The CEWO's business plan allows for such shared stewardship, working with the MDBA, States, communities and industry, toward the goal of maximizing environmental outcomes that increase ecosystem service supply and improve community well-being. In fact, the activities detailed in the CEWO's business plan closely follow the PES programme design principles outlined in Section 3, by emphasizing the importance of environmental outcomes, institutional arrangements, and financing and accountability (CEWO, 2012). Through a PES programme, the Commonwealth government has the opportunity to more confidently deliver on the expected benefits from implementation of the Basin Plan and can share the onerous of monitoring and verification (Dunn, 2011).

The MDBA-commissioned CSIRO (2012) study could underpin the development of a PES programme as it addresses some of the challenges associated with the first and second PES programme design principles, including the notion of additionality and establishing clear links between environmental flows and ecosystem service supply. The CSIRO study catalogues changes in ecosystem service supply in the MDB by catchment which are attributable to changes in water management. The study also estimates the monetary value of incremental ecosystem services supply. The study does not, however, identify the beneficiaries of enhanced ecosystem service supply. In this instance we presuppose that the beneficiary is the Australian public.

By making payment to communities, landholders, Indigenous groups and NGOs in the form of water, these groups and the Commonwealth would share in the stewardship of water and other natural resources. The buyer, the Commonwealth on behalf of the Australian public, is likely to receive multiple ecosystem service benefits, including many cultural and community engagement benefits. A distinct advantage of this form of PES programme is that the Commonwealth can share the implementation, monitoring and verification challenges inherent in the Basin Plan, benefit from local knowledge (Garrick et al., 2012), and can experiment and adaptively learn from different approaches to enhancing ecosystem service supply (Lee, 1997). Furthermore, such a PES programme fulfils the MDBA's agenda of localism by reinforcing partnerships and collaboration with local and regional communities (MDBA, 2011). This form of PES programme adheres to

principles of subsidiarity, where tasks are decentralized to the lowest level at which capacity and authority exists to implement the task (Garrick et al., 2012).

The notion of using water as a PES payment is being trialled in the MDB and there is significant opportunity to scale up and extend this PES programme approach in a strategic way. For example, in 2012, the CEWO donated 10 GL, valued at between \$16.7 million and \$20.5 million, to the Nature Foundation South Australia (NFSA) for local environmental watering projects (NFSA, 2012). This approach has advantages associated with the subsidiarity principle. Since the NFSA has an established presence in the local community, this familiarity reduces the transaction costs involved in negotiating environmental watering events with local landholders. In cooperation with landholders, water can be delivered using private infrastructure and with the help of volunteers. This environmental water can be targeted to maximize ecosystem service supply outcomes that are informed by local ecological knowledge. Furthermore, the NFSA is responsible for developing frameworks for local environmental watering prioritisation, which may include more cultural and community criteria and metrics, as well as monitoring and verification activities which are critical for ensuring PES programme success. The development of cultural and community value metrics specific to the MDB would be a significant advance in ecosystem service valuation (Chan, Satterfield, & Goldstein, 2012) which may be used to underpin a PES programme.

There are likely other groups in the MDB that would participate in a PES programme. For instance, there are 35 Indigenous groups residing in the MDB (Mooney, 2011). In practice, limited land rights (Taylor & Biddle, 2004) have meant that Indigenous communities have had limited access to water entitlements (Bark, Garrick, Robinson, & Jackson, 2012; Jackson, 2011). Although environmental flows sometimes align with the concept of cultural flows, this alignment is not perfect (CSIRO, 2012; Jackson & Langton, 2012) which presents significant opportunities for the MDBA and CEWO to partner with Indigenous communities to achieve a raft of additional cultural and environmental benefits from the Basin Plan. There would also be opportunity to improve ecosystem service supply outcomes through the application of Indigenous local water and natural resource management knowledge (Jackson, Tan, Mooney, Hoverman, & White, 2011).

There is evidence that the Australian community is willing to contribute to a conservation fund to pay Indigenous communities for conservation activities such as feral animal control, coastal surveillance, weed control and fire management. These activities are equated with biodiversity, aesthetic, recreational, cultural and carbon sequestration ecosystem services (Zander & Garnett, 2011). Muller (2008) outlines the numerous ecosystem services that the Australian public receive from Indigenous land managers in Australia's northern region. This cataloguing of services follows the first PES programme design principle and provides a basis for advancing new PES programme initiatives to compensate Indigenous communities for their management interventions. Such programmes may also yield additional social co-benefits to the communities involved in ecosystem service supply (Garnett & Sithole, 2007; Muller, 2008; Zander & Garnett, 2011).

A PES programme approach is not without its risks, however. Garrick et al. (2012) note that a keystone of the Commonwealth water reform agenda is to manage the MDB as an ecologically important system at the basin-scale. Conforming to this principle necessitates that PES programmes that provide greater local control be balanced with overall basin-wide objectives, and limited to those things that can be managed at the local level. Furthermore, there may be capacity, resourcing, administrative, governance and leadership challenges (May, 2010) with delegating environmental watering activities. The volume of water that

could be set aside for PES programmes without undermining basin-scale ecological objectives would have to be determined by the best available scientific evidence generated by modellers, hydrologists and ecologists. Nevertheless, the advantages of a PES programme in terms of local ecological outcomes, stakeholder engagement, cultural and community benefits, community and NGO capacity building, learning from adaptive management, and the sharing of monitoring and verification activities will in many instances outweigh the risks.

## **Conclusions**

A few PES programmes are already in operation including Caring for our Country, the Carbon Farming Initiative and the Basin Salinity Management Strategy. Local PES programmes are also emerging, such as the NFSA initiative which is designed to enhance freshwater ecosystem service supply. In this programme, beneficiaries are local landowners and communities and payment is made in the form of water. Aligned with the subsidiarity principle, this type of arrangement can meet multiple policy objectives including the MDBA's aim of greater localism and the application of local ecological knowledge, adaptive management and the enhancement of ecosystem service supply. By engaging local stakeholders, PES programme transaction costs can be reduced.

The MDBA and CEWO face a large implementation, monitoring and verification challenge, managing recovered water to balance ecosystem service supply and community wellbeing. The core elements of the CEWO's business plan, with an emphasis on environmental outcomes, institutional arrangements, and financing and accountability, aligns closely with the basic design principles of a PES programme. Levels of payment for such a PES programme may be underpinned by recent valuation studies in the MDB or could follow an opportunity cost approach.

The Millennium Drought provided a strong impetus for water reform. The Basin Plan will establish sustainable diversion limits with the water recovered allocated to enhancing ecosystem service supply. Water buyback revenues represent a transfer of public resources from outside the MDB, with water reallocation involving significant opportunity costs. The development of a complementary PES programme is another instrument that may be used to reduce opportunity costs, help achieve the multiple objectives of the basin plan, maximize basin-wide benefits and supply ecosystem services at levels that approximate a social optimum.

## **Acknowledgements**

We thank Cathy Robinson, CSIRO for her advice on Indigenous PES programmes. Thanks go to Peter Wallbrink and Jeff Connor, CSIRO, and two reviewers for their constructive and insightful comments and recommendations which have greatly enriched this work. Thanks to Martin Nolan, CSIRO for producing the map of the MDB.

## **References**

- Acreman, M. C., & Dunbar, M. J. (2004). Methods for defining environmental flow requirements – a review. *Hydrology and Earth System Sciences*, 8(5), 861–876.
- Australian Bureau of Agricultural and Resource Economics and Sciences (2011). *Modelling the economic effects of the Murray-Darling Basin Plan*. Canberra: ABARES. Retrieved from <http://www.mdba.gov.au/files/bp-kid/1716-ModellingTheEconomicEffectsOfTheMDBPlan.pdf>
- Australian Bureau of Statistics (2008). *Water and the Murray-Darling Basin – a statistical profile, 2000–01 to 2005–06*. Retrieved from <http://www.abs.gov.au/ausstats/abs@.nsf/mf/4610.0.55.007>

- Australian Bureau of Statistics (2010). *Experimental estimates of the gross value of irrigated agricultural production, 2000–01 – 2008–09*.
- Arriagada, R., & Perrings, C. (2009). *Making payments for ecosystem services work*. Retrieved from [http://bioecon-network.org/pages/UNEP\\_publications/02%20PES.pdf](http://bioecon-network.org/pages/UNEP_publications/02%20PES.pdf)
- Banerjee, O., Bark, R., Connor, J., & Crossman, N. (in review). *An ecosystem services approach to estimating economic losses associated with drought*.
- Bark, R. H., Garrick, D. E., Robinson, C. J., & Jackson, S. (2012). Adaptive basin governance and the prospects for meeting Indigenous water claims. *Environmental Science & Policy, 19–20*, 169–177. doi: 10.1016/j.envsci.2012.03.005.
- BioClimate Research and Development (2010). Payments for ecosystem services – literature review. A review of lessons learned and a framework for assessing PES feasibility. Retrieved from [http://www.planvivo.org/wp-content/uploads/Framework-for-PES-feasibility\\_WWF\\_MorrisonAubrey\\_2010.pdf](http://www.planvivo.org/wp-content/uploads/Framework-for-PES-feasibility_WWF_MorrisonAubrey_2010.pdf)
- Commonwealth Environmental Water Office (2012). *Commonwealth Environmental Water Office business plan 2012–2013*. Canberra.
- Chan, K. M. A., Satterfield, T., & Goldstein, J. (2012). Rethinking ecosystem services to better address and navigate cultural values. *Ecological Economics, 74(0)*, 8–18. doi: 10.1016/j.ecolecon.2011.11.011.
- Chiew, F., Young, W., Cai, W., & Teng, J. (2011). Current drought and future hydroclimate projections in southeast Australia and implications for water resources management. *Stochastic Environmental Research and Risk Assessment, 25(4)*, 601–612. doi: 10.1007/s00477-010-0424-x.
- Coase, R. H. (1960). The problem of social cost. *Journal of Law & Economics, 3*, 1–44.
- Commonwealth of Australia (2007). Water Act 2007.
- Commonwealth of Australia (2011). *Caring for our country business plan 2012–2013*. Canberra: Commonwealth of Australia.
- Commonwealth of Australia (2012). *Carbon farming initiative handbook*. Canberra: Commonwealth of Australia.
- Costanza, R., D'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., & ... van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Nature, 387*, 253–260.
- Crossman, N., Rustomji, P., Brown, A., Pollino, C., Colloff, M., Lester, R., & ... Schmidt, R. K. (2011). Status of the aquatic ecosystems of the Murray-Darling Basin and a framework for assessing the ecosystem services they provide. *An interim report to the Murray-Darling Basin Authority from the CSIRO multiple benefits of the basin plan project*.
- Commonwealth Scientific and Industrial Research Organization (2008). *Water availability in the Murray-Darling Basin. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project*. Canberra: CSIRO. Retrieved from <http://www.csiro.au/files/files/po0n.pdf>
- Commonwealth Scientific and Industrial Research Organization (2011). *A science review of the implications for South Australia of the Guide to the Proposed Basin Plan: synthesis*. Adelaide: Goyder Institute. Retrieved from <http://www.goyderinstitute.org/uploads/documents/publications/2011/synthesis-science-review-Basin-plan.pdf>
- Commonwealth Scientific and Industrial Research Organization (2012). *Assessment of the ecological and economic benefits of environmental water in the Murray-Darling Basin*. Canberra: CSIRO. Retrieved from <http://www.csiro.au/en/Organisation-Structure/Flagships/Water-for-a-Healthy-Country-Flagship/MDB-Multiple-Benefits-Project.aspx>
- Daily, G. C. (Ed.). (1997). *Nature's services: societal dependence on natural ecosystems*. Washington, D.C. Island Press.
- de Groot, R. S., Wilson, M. A., & Boumans, R. M. J. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics, 41(3)*, 393–408.
- Department of Sustainability and the Environment (2011). *BushTender northern plains report*. Retrieved from [http://www.dse.vic.gov.au/\\_data/assets/pdf\\_file/0008/119276/Project-report\\_BTNP.pdf](http://www.dse.vic.gov.au/_data/assets/pdf_file/0008/119276/Project-report_BTNP.pdf)
- Department of the Environment, Water, Heritage and the Arts (2009). *A framework for determining Commonwealth environmental watering actions*. Canberra: Department of the Environment, Heritage and the Arts.
- Department of the Environment, Water, Heritage and the Arts (2010). *The Macquarie Marshes, Australian Ramsar Wetlands*. Canberra: Department of the Environment, Heritage and the Arts.

- Dixon, P. B., Rimmer, M. T., & Wittwer, G. (2010). *Modelling the Australian Government's buyback scheme with a dynamic multi-regional CGE model*. Retrieved from [www.monash.edu.au/policy/ftp/workpapt/g-186.pdf](http://www.monash.edu.au/policy/ftp/workpapt/g-186.pdf)
- Dixon, P. B., Rimmer, M. T., & Wittwer, G. (2011). Saving the Southern Murray-Darling Basin: the economic effects of a buyback of irrigation water. *Economic Record*, 87(276), 153–168. doi: DOI 10.1111/j.1475-4932.2010.00691.x.
- Dunn, H. (2011). *Payments for Ecosystem Services*. London: DEFRA. Retrieved from <http://www.defra.gov.uk/publications/files/ecosystem-payment-services-pb13658a.pdf>
- Engel, S., Pagiola, S., & Wunder, S. (2008). Designing payments for environmental services in theory and practice: an overview of the issues. *Ecological Economics*, 65(4), 663–674.
- Farber, S., Costanza, R., Childers, D. L., Erickson, J., Gross, K., Grove, M., . . . Wilson, M. (2006). Linking ecology and economics for ecosystem management. *BioScience*, 56(2), 121–133. doi: citeulike-article-id:2979606.
- Farley, J., & Costanza, R. (2010). Payments for ecosystem services: from local to global. *Ecological Economics*, 69(11), 2060–2068. doi: 10.1016/j.ecolecon.2010.06.010.
- Forest Trends, T. K. G. a. U. (2008). *Payment for ecosystem services, getting started: a primer*. Retrieved from <http://www.katoombagroup.org/documents/publications/GettingStarted.pdf>
- Garnett, S., & Sithole, B. (2007). *Sustainable northern landscapes and the nexus with indigenous health: healthy country, healthy people*. Canberra: Land and Water Australia.
- Garrick, D., Bark, R., Connor, J., & Banerjee, O. (2012). doi: 10.2166/wp.2012.120 Environmental water governance in federal rivers: opportunities and limits of the subsidiarity principle in Australia's Murray–Darling River. *Water Policy*.
- Gordon, L. J., Finlayson, C. M., & Falkenmark, M. (2010). Managing water in agriculture for food production and other ecosystem services. *Agricultural Water Management*, 97(4), 512–519. doi: 10.1016/j.agwat.2009.03.017.
- Gómez-Baggethun, E., de Groot, R., Lomas, P. L., & Montes, C. (2010). The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. *Ecological Economics*, 69(6), 1209–1218.
- Hatton MacDonald, D., Tapsuwan, S., Albouy, S., & Rimbaud, A. (2011). Challenges of estimating the value of tourism and recreation in the Murray-Darling Basin. In L. Crase & S. O'Keefe (Eds.), *Water Policy, Tourism and Recreation* (pp. 33–51): Earthscan LLC.
- Jackson, S. (2011). Aboriginal access to water in Australia: opportunities and constraints. In Q. Grafton & K. Hussey (Eds.), *Water resources, planning and management* (pp. 601–627). Cambridge: Cambridge University Press.
- Jackson, S., & Langton, M. (2012). Trends in the recognition of indigenous water needs in Australian water reform: the limitations of 'cultural' entitlements in achieving water equity. *Journal of Water Law*, 22(2/3), 109–123.
- Jackson, S., Tan, P., Mooney, C., Hoverman, S., & White, I. (2011). Principles and guidelines for good practice in indigenous engagement in water planning. *Journal of Hydrology*, 474(12), 57–65. doi: 10.1016/j.jhydrol.2011.12.015.
- Johnston, R. J., & Russell, M. (2011). An operational structure for clarity in ecosystem service values. *Ecological Economics*, 70(12), 2243–2249.
- Kelsey, J. B., Kousky, C., & Sims, K. R. E. (2008). Designing payments for ecosystem services: lessons from previous experience with incentive-based mechanisms. *Proceedings of the National Academy of Sciences*, 105(28), 9465–9470. doi: 10.1073/pnas.0705503104.
- Kemkes, R. J., Farley, J., & Koliba, C. J. (2010). Determining when payments are an effective policy approach to ecosystem service provision. *Ecological Economics*, 69(11), 2069–2074. doi: 10.1016/j.ecolecon.2009.11.032.
- Kingsford, R. T., Walker, K. F., Lester, R. E., Young, W. J., Fairweather, P. G., Sammut, J., & Geddes, M. C. (2011). A Ramsar wetland in crisis - the Coorong, Lower Lakes and Murray Mouth, Australia. *Marine and Freshwater Research*, 62(3), 255–265. doi: 10.1071/Mf09315.
- Kinzig, A. P., Perrings, C., Chapin, F. S., Polasky, S., Smith, V. K., Tilman, D., & Turner, B. L. (2011). Paying for ecosystem services - promise and peril. *Science*, 334(6056), 603–604. doi: 10.1126/science.1210297.
- Kirby, M. (2011). Irrigation. In I. Prosser (Ed.), *Science and solutions for Australia: Water*. Canberra: CSIRO.

- Kirby, M., Evans, R., Walker, G., Cresswell, R., Coram, J., Khan, S., & Ryan, S. (2006). *The shared water resources of the Murray-Darling Basin*. Canberra: Murray-Darling Basin Commission. Retrieved from <http://www.csiro.au/files/files/p7g9.pdf>
- Landell-Mills, N., & Porras, I. T. (2002). *Silver bullet or fools' gold? a global review of markets for forest environmental services and their impact on the poor*. London: IIED.
- Lee, K. N. (1997). Compass and gyroscope: integrating science and politics for the environment. *Environment and Planning A*, 29(6).
- Liu, S., Costanza, R., Farber, S., & Troy, A. (2010). Valuing ecosystem services. *Annals of the New York Academy of Sciences*, 1185(1), 54–78. doi: 10.1111/j.1749-6632.2009.05167.x.
- May, K. (2010). Indigenous cultural and natural resource management and the emerging role of the Working on Country Program. *The Australia National University CAEPR Working Paper No. 65*. Canberra.
- Millennium Ecosystem Assessment (2003). *Ecosystems and Human Well-being: A Framework for Assessment*. Washington, D.C. Island Press.
- Millennium Ecosystem Assessment (2005). Ecosystems and human well-being: wetlands and water synthesis. Retrieved from <http://www.millenniumassessment.org/documents/document.358.aspx.pdf>
- Mooney, C. (2011). Murray River country: an ecological dialogue with traditional owners. *Australasian Journal of Environmental Management*, 18(2), 123–124.
- Muller, S. (2008). Indigenous payment for environmental service (PES) opportunities in the Northern Territory: negotiating with customs. *Australian Geographer*, 39(2), 149–170. doi: 10.1080/00049180802056831.
- Muradian, R., Corbera, E., Pascual, U., Kosoy, N., & May, P. H. (2010). Reconciling theory and practice: an alternative conceptual framework for understanding payments for environmental services. *Ecological Economics*, 69(6), 1202–1208. doi: 10.1016/j.ecolecon.2009.11.006.
- Murray-Darling Basin Authority (2010). *Guide to the Proposed Basin Plan: overview*. Canberra: MDBA. Retrieved from [http://download.mdba.gov.au/proposed/social\\_economic\\_analysis\\_part\\_a.pdf](http://download.mdba.gov.au/proposed/social_economic_analysis_part_a.pdf)
- Murray-Darling Basin Authority (2011). *Delivering a healthy working basin – about the Draft Basin Plan*. Canberra: MDBA.
- Murray-Darling Basin Authority (2012). *Proposed Basin Plan – a revised draft*. Canberra: MDBA. Retrieved from [http://download.mdba.gov.au/revised-BP/PBP\\_reviseddraft.pdf](http://download.mdba.gov.au/revised-BP/PBP_reviseddraft.pdf)
- National Water Commission (2011). *Strengthening Australia's water markets*. Canberra: National Water Commission. Retrieved from [http://nwc.gov.au/\\_data/assets/pdf\\_file/0008/11240/StrengtheningAustraliasWaterMarketsReport.pdf](http://nwc.gov.au/_data/assets/pdf_file/0008/11240/StrengtheningAustraliasWaterMarketsReport.pdf)
- Nature Foundation South Australia (2012). *Nature Matters. A newsletter of Nature Foundation SA Inc.*
- Norgaard, R. B. (2010). Ecosystem services: from eye-opening metaphor to complexity blinder. *Ecological Economics*, 69(6), 1219–1227. doi: 10.1016/j.ecolecon.2009.11.009.
- Pagiola, S. (2008). Payments for environmental services in Costa Rica. *Ecological Economics*, 65(4), 712–724.
- Pagiola, S., & Platais, G. (2005). *Payments for environmental services for dummies, a quick reference for the rest of us*. Retrieved from [siteresources.worldbank.org/INTEEEI/214584.../IntrotoPES.ppt](http://siteresources.worldbank.org/INTEEEI/214584.../IntrotoPES.ppt)
- Peel, M. C., McMahon, T. A., & Finlayson, B. L. (2004). Continental differences in the variability of annual runoff-update and reassessment. *Journal of Hydrology*, 295(1–4), 185–197.
- Perrings, C. (2006). Ecological economics after the Millennium Assessment. *International Journal of Ecological Economics & Statistics*, 6(F06), 8–22.
- Ramsar Convention (1971). *The Convention on Wetlands of International Importance, Especially as Waterfowl Habitat*. Ramsar UN Treaty Series No. 14583.
- Rolfe, J., & Dyack, B. (2011). Valuing recreation in the Coorong, Australia, with travel cost and contingent behaviour models. *Economic Record*, 87(277), 282–293. doi: 10.1111/j.1475-4932.2010.00683.x.
- Taylor, J., & Biddle, N. (2004). *Indigenous people in the Murray-Darling Basin- a statistical profile*. Discussion Paper No. 264. Centre for Aboriginal Economic Policy Research. Canberra: ANU.
- TEEB (2010a). *The economics of ecosystems and biodiversity for local and regional policy makers*. Retrieved from <http://www.teebweb.org/ForLocalandRegionalPolicy/LocalandRegionalPolicyMakersChapterDrafts/tabid/29433/Default.aspx>

- TEEB (2010b). *The economics of ecosystems and biodiversity: ecological and economic foundations*. London: Earthscan.
- The Parliament of the Commonwealth of Australia (2011). *Of drought and flooding rains- inquiry into the impact of the Guide to the Murray-Darling Basin Plan*. Canberra: Commonwealth of Australia. Retrieved from <http://www.aph.gov.au/house/committee/ra/murraydarling/report.htm>
- Turner, R. K., Georgiou, S., & Fisher, B. (2008). *Valuing ecosystem services: the case of multi-functional wetlands*. London: Earthscan.
- Watts, R. J., Kopf, R. K., Hladyz, S., Grace, M., Thompson, R., McCasker, N., ... Conallin, J. (2012). Monitoring of ecosystem responses to the delivery of environmental water in the Edward-Wakool River System, 2011 – 2012. Institute for Land, Water and Society, Charles Sturt University, Report 1.
- World Business Council for Sustainable Development (2010). Effective biodiversity and ecosystem policy and regulation: business input to the COP10 of the Convention on Biological Diversity. World Business Council for Sustainable Development.
- Wentworth Group of Concerned Scientists (2010). *Sustainable diversions in the Murray-Darling Basin. An analysis of options for achieving a sustainable diversion limit in the Murray-Darling Basin*. Sydney: Wentworth Group of Concerned Scientists.
- Wunder, S. (2005). *Payments for environmental services: some nuts and bolts*. Jakarta: Center for International Forestry Research. Retrieved from [http://www.cifor.org/publications/pdf\\_files/OccPapers/OP-42.pdf](http://www.cifor.org/publications/pdf_files/OccPapers/OP-42.pdf)
- Wunder, S., Engel, S., & Pagiola, S. (2008). Taking stock: A comparative analysis of payments for environmental services programmes in developed and developing countries. *Ecological Economics*, 65(4), 834–852.
- Zander, K. K., & Garnett, S. T. (2011). The economic value of environmental services on indigenous-held lands in Australia. *Plos One*, 6(8), e23154. doi: 10.1371/journal.pone.0023154.