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Bringing ecosystem services into integrated water resources management

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ABSTRACT

In this paper we propose an ecosystem service framework to support integrated water resource management and apply it to the Murray-Darling Basin in Australia. Water resources in the Murray-Darling Basin have been over-allocated for irrigation use with the consequent degradation of freshwater ecosystems. In line with integrated water resource management principles, Australian Government reforms are reducing the amount of water diverted for irrigation to improve ecosystem health. However, limited understanding of the broader benefits and trade-offs associated with reducing irrigation diversions has hampered the planning process supporting this reform. Ecosystem services offer an integrative framework to identify the broader benefits associated with integrated water resource management in the Murray-Darling Basin, thereby providing support for the Government to reform decision-making. We conducted a multi-criteria decision analysis for ranking regional potentials to provide ecosystem services at river basin scale. We surveyed the wider public about their understanding of, and priorities for, managing ecosystem services and then integrated the results with spatially explicit indicators of ecosystem service provision. The preliminary results of this work identified the sub-catchments with the greatest potential synergies and trade-offs of ecosystem service provision under the integrated water resources management reform process. With future development, our framework could be used as a decision support tool by those grappling with the challenge of the sustainable allocation of water between irrigation and the environment.

1. Introduction

Achieving an effective and sustainable balance between human and ecological needs for freshwater is a substantial challenge (Poff et al., 2003). Population growth and climate change impose constraints on both the spatial and temporal distribution of water, resulting in increased competition for declining water resources (UNEP, 2012). Integrated Water Resource Management (IWRM) has been developed to "promote the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Lenton and Muller, 2009; The Global Water Partnership, 2012). Since the concept was formally shaped in 1992 (Snellen and Schrevel, 2004), 80% of countries have embarked on reforms to improve the enabling environment for water resources management based on the application of integrated approaches, and 65% have developed IWRM plans (UNEP, 2012).

The success of IWRM depends on striking a balance between ecosystem health and human demand (Bakker, 2012). Managing ecosystems for both goals depends on the effective integration of scientific information with an understanding of how ecosystems affect the welfare of the society, and ecosystem services addresses this integration (Granek et al., 2010). The concept of ecosystem services has shifted the paradigm of how nature matters to human societies (Liu et al., 2010). Instead of viewing the preservation of nature as something for which human society has to sacrifice its well-being, we now perceive of the environment as natural capital, one of society's critical assets (Costanza and Daly, 1992; Millennium Ecosystem Assessment, 2005).

IWRM and ecosystem services both emphasize the critical role of integrating competing interests in environmental decision-making, and this similarity suggests an opportunity for adopting ecosystem service-based IWRM schemes (Cook and Spray, 2012). Yet, to our knowledge, there is no existing study that has developed an *operational* ecosystem services framework to support IWRM.

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In this paper, we attempt to fill this gap in the literature by developing an ecosystem services framework to support IWRM. We apply the framework to the Murray-Darling Basin (MDB) in Australia, which is typical of many large river basins where the integrity of ecosystems is threatened by over allocating water resources to irrigation (Özerol et al., 2012). Using multi-criteria decision analysis (MCDA), we combined scientific information on regional potentials in supplying ecosystem services with stakeholders' preferences towards these services. The MCDA results rank the 19 sub-catchments at the basin scale to identify which sub-catchments are the top suppliers of ecosystem services.

MCDA has been widely used in the area of water resources management (Bryan and Crossman, 2008; Bryan et al., 2010; Gurocak and Whittlesey, 1998; Hajkowicz and Collins, 2007; Silva et al., 2010), and it was applied to support IWRM for the purpose of regional delineation (Coelho et al., 2012), identifying water management strategies (Calizaya et al., 2010), and ranking the desirability of different farming systems (Prato and Herath, 2007). In this paper, we contribute to the emerging MCDA literature that attempts to integrate the concept of ecosystem services and visualization maps (via Geographic Information Systems, GIS) (Jackson et al., 2013; Labiosa et al., 2013). This integration allows us to explore spatially explicit synergies and trade-offs amongst ecosystem services to support IWRM. To our knowledge, this is the first case study to apply the integrated framework in facilitating water resources management.

The framework developed in this paper can be used for at least two purposes: to communicate the importance of ecosystem services and spatial heterogeneity of ecosystem services supply to a broader audience; and to be used as a screening tool for the next level of analysis or to be further developed to support decisions in prioritizing water management and investment across MDB sub-catchments for supplying ecosystem services.

2. Methods

2.1. Study area and current IWRM management

Extending over 1 million km^2, the MDB (Fig. 1) is defined by the 19 sub-catchments of the Murray and Darling rivers and their many

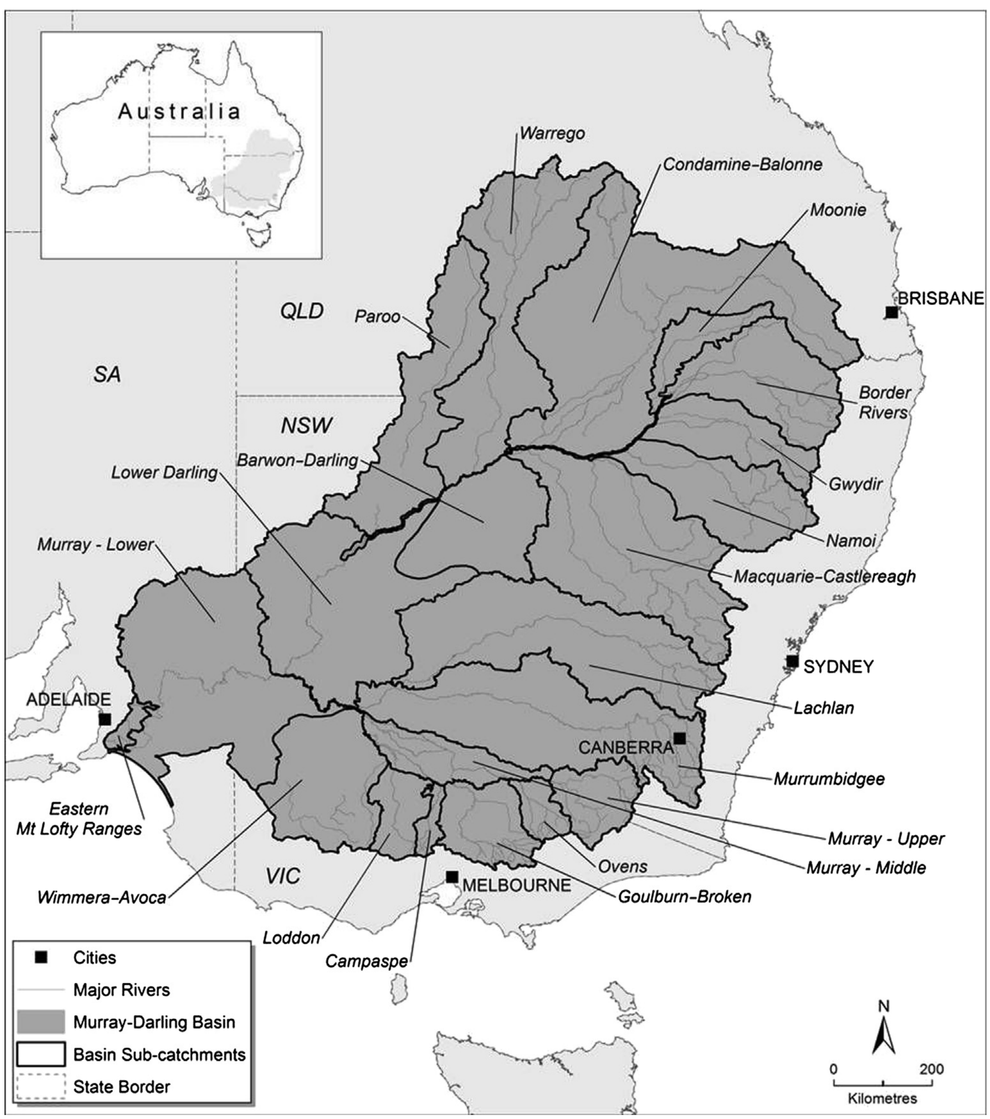

Fig. 1. The sub-catchments in the Murray-Darling Basin (In our analysis, the original Murray was divided into the three sub-catchments of Murray-Lower, Murray-mid and Murray-upper because of its diverse biogeography, giving a total of 21 sub-catchments).