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Economic effects of a reservoir re-operation policy in the Rio Grande/Bravo for integrated human and environmental water management

J. Pablo Ortiz-Partida (Graduate Student Researcher)[1], B.A. Lane (Graduate Student Researcher)[1], S. Sandoval-Solis (Assistant Professor)*

Department of Land, Air and Water Resources, University of California, Davis, USA

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ABSTRACT

Study region: The study region is the Big Bend Reach of the Rio Grande/Bravo, from Luis L. Leon reservoir in the Rio Conchos to Amistad reservoir in the Rio Grande/Bravo mainstem. This reach is part of the Rio Grande trans-boundary river basin between United States and Mexico, an area of recognized environmental and socioeconomic significance by both countries.

Study focus: A central challenge of Integrated Water Resources Management is the design and implementation of policies to allocate water to both humans and the environment in a sustainable manner. This study uses the results from a water-planning model of the Big Bend Reach of the Rio Grande/Bravo to quantify and compare the economic benefits of two water management policies: business as usual (Baseline) policy and a proposed reservoir re-operation policy to provide environmental flows (EFs).

New hydrological insights: This study determines the economic feasibility of the EF policy. Results show that a proposed Environmental Flow policy would increase irrigated agriculture profit, slightly decrease recreational activities profit, and reduce costs from flood damage and environmental restoration compared to the baseline policy. In addition to supporting ecological objectives, the proposed EF policy would increase the economic benefits of water management objectives.

1. Introduction

Balancing trade-offs between environmental and human economic objectives for reservoirs has become a major goal for Integrated Water Resources Management (IWRM) (Palmer et al., 2008; Postel and Richter, 2003; Richter and Thomas, 2007). IWRM is "a process which promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Global Water Partnership, 2000). Traditionally, reservoirs have supported four primary objectives: water supply (for agriculture, industries, and households), flood management, energy production, and recreation activities (Loucks

* Corresponding author at: Department of Land, Air and Water Resources. University of California, 135 Veihmeyer Hall, One Shields Ave., Davis, CA 95616, USA.
E-mail addresses: joportiz@ucdavis.edu (J.P. Ortiz-Partida), baalane@ucdavis.edu (B.A. Lane), samsandoval@ucdavis.edu (S. Sandoval-Solis).
[1] Hydrologic Sciences Graduate Group, University of California, 138 Veihmeyer Hall, One Shields Ave., Davis, CA 95616, USA.

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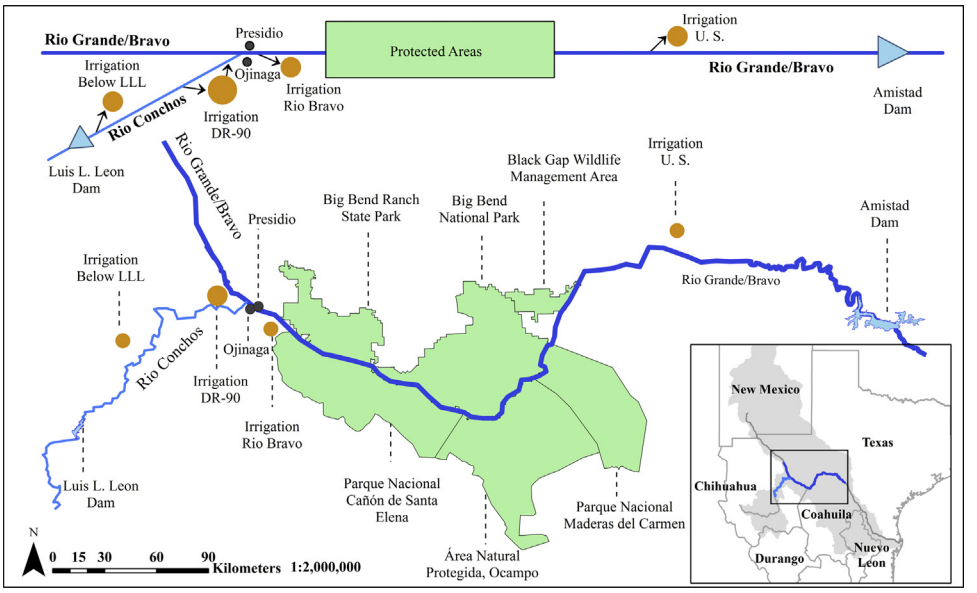

Fig. 1. Schematic of Big Bend Reach.

et al., 2005). The economic values and priorities associated with these objectives provide the basis for many reservoir operation policies. Recently, a fifth objective has emerged from the IWRM literature: water management for restoration or conservation of aquatic and riparian ecosystems. Understanding how this last objective fits within the economic framework is essential for balancing environmental and economic benefits.

There is a strong social and scientific impetus for *reservoir re-operation* (modification of a reservoir's operational method of storing and releasing water in time and volume) to balance the aforementioned objectives (Ai et al., 2013; Labadie, 2004; Lane et al., 2014; Sandoval-Solis and McKinney, 2014). Past studies have approached this problem by searching for trade-offs between reservoir environmental releases and hydropower production (Rheinheimer et al., 2016, 2013). Results from these studies show an overall reduction in hydropower gains as environmental releases increase, however, environmental and economic benefits were not quantified. For the reservoir in this study, hydropower is not an objective and therefore there are no economic losses related to energy production. The main concerns for environmental water releases in this study are instead related to irrigated agriculture and flood management.

This study is based on previous research by Lane et al. (2014). They demonstrated that, in the Big Bend Reach (BBR) of the Rio Grande/Bravo (RGB) (Fig. 1), there is sufficient water availability in time and volume to improve the health of aquatic and riparian ecosystems through reservoir re-operation (of Luis L. León reservoir). Reservoir re-operation is a commonly considered strategy for balancing human and environmental water management objectives, called *environmental flow* (*EF*) *policies*. EFs are important for maintaining the ecosystem functions and services provided by aquatic and riparian ecosystem in terms of provision of food and water supply, healthy floodplain maintenance for flood mitigation, provision of habitat, and better recreational opportunities, among others (Dyson et al., 2008; Postel and Richter, 2003). The current study expands on the previous body of research by performing a cost-benefit analysis of the current water management (baseline) policy and a proposed policy to provide EFs in the BBR.

The objective of this study is to estimate and compare the costs and benefits of key water-related economic drivers under a baseline and EFs policy. The four *key water-related economic drivers* in the BBR consist of irrigated agriculture, recreation, flood damage, and the environment. The main hypothesis is that the EF policy will provide greater economic benefits than the baseline policy in addition to supporting the BBR river ecosystem. If this assumption is true, then the EF policy is not only hydrologically feasible but also economically desirable. Such results would support a balanced water policy for what are often conflicting *water management objectives* in this basin: water supply (mostly for agriculture), flood management for Presidio-Ojinaga (P-O), and EFs for the BBR ecosystem. Specifically, this study aims to: estimate the economic value of water-related economic drivers (Table 1), integrate the economic value with the outputs of the existing BBR water allocation model, and compare the current and proposed water management policies using cost-benefit analysis (Fig. 2). This analysis builds upon the previously established hydrologic feasibility of implementing EFs in the BBR by quantifying the economic impacts of such a change in reservoir operational policy.

1.1. Big Bend Reach (BBR) of the Rio Grande/Bravo (RGB)

The RGB is a transboundary basin shared by the United States (U.S.) and Mexico. The BBR was selected for its bi-nationally recognized environmental and socioeconomic significance (Obama and Calderón-Hinojosa, 2010), its severe ecological