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Editorial: River and watershed restoration, rehabilitation, and conservation: Challenges, actions, and perspectives

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Editorial on the Research Topic
River and watershed restoration, rehabilitation and conservation: Challenges, actions, and perspectives

River and watershed (i.e., rehabilitation) are increasing environmental challenges, due to the increasing anthropogenic pressures that are degrading water body quality worldwide. Human technical and engineering capacity increased dramatically in the last century, allowing us to modify rivers to meet demands for waterways, electricity generation, and human safety. As a consequence, rivers became strongly regulated and damaged. Watersheds and rivers were highly affected by these actions, having more negative consequences than were ever anticipated.

Unfortunately, human activities have negatively altered watersheds worldwide, meaning countless rivers are polluted and many coastal oceans have degraded habitat or reduced fisheries (Bernhardt et al., 2005). The altered flow regimes of almost all world rivers constrain (i.e., rehabilitation) of riparian and estuarine habitats that rely on annual flood cycles. Man-made dams, which can cause this alteration, are considered permanent landscape features, however dams should not be considered immutable constraints, as exemplified by successful dam removal that has been occurring as part of rehabilitation actions around the world (Chenoweth et al., 2022).

One of the worst socioenvironmental disasters of modern history occurred in November 2015 in Brazil. This involved an iron mining tailings dam rupture that resulted in the contamination of water, soil, and sediment along the entire 600 km course of the Doce River.

The subsequent rupture of a second iron mining tailings dam at the neighboring watershed of the Paraopeba River, 4 years later, is considered the largest work accident in Brazil so far. This reveals the urgency, high risk, and lack of effective measures to avoid such disasters. Unfortunately, these events are not restricted to Brazil, but have been occurring worldwide. Examples include the dam rupture of Banqiao e Shimatan, in 1975 in China, or the Machchu-2 dam rupture in India, in 1979, or at the Stava river in Italy, in 1985. Dam ruptures are only one of several consequences of anthropogenic intervention that have strong impacts on both biodiversity and human populations (Bain et al., 2008). This special issue on river and watershed restoration, rehabilitation, and conservation is dedicated to providing an international platform for generating an integrated systems perspective on this complex, multidimensional, and socially constructed environmental hazard. We invited studies on recent advances in the current and future challenges and perspectives of river and watershed rehabilitation, and conservation; approaches to water river quality monitoring; perceptions and social understanding of environmental disasters, along with case-study-based learning from specific events; use of the state-of-the-art knowledge and methods for dealing with uncertainty, i.e. predictive frameworks as a scientific tool in repairing damaged ecosystems; studies that encompass bodies of ecological knowledge pivotal to successful restoration; system dynamics, scale and context-dependency, and diversity; treatment of fisheries' considering principles of harvest management and stock assessment with ecosystem restoration; interactions of physical processes (hydrological and geomorphic) with ecological processes and players and, forestry activities; and impacts and restoration efforts of changing flood characteristics, managing sediment delivery, altering riparian vegetation, and managing channel integrity.

In total, 15 manuscripts were submitted to our special issue, and after a rigorous peer review process by 32 anonymous reviewers, six high-quality papers based on cutting-edge, international research on river and watershed restoration, rehabilitation, and conservation were finally selected for publication by a total of 41 authors.

Published papers cover a wide range of topics with these six papers dealing with the evaluation of ongoing watershed restoration programs (Flitcroft et al.; Macedo et al.; Neeson et al.), and proposition of new effective approaches to restoration (Kaushal et al., 2022; Pennock et al.). It is symptomatic that two papers dealt with watershed sediments, linking watershed restoration with controlling erosion and silting (Karami et al.; Kaushal et al., 2022), a major issue in watershed restoration.

A paper contributed by Macedo et al. presents evaluation of the rehabilitation experience carried out in three urban stream sites in the third-largest Brazilian metropolis (c. 5.5 million inhabitants) that was and continues to be effective in terms of socio-environmental improvement after 10 years of intervention. The authors compared water quality, physical habitat structure, and benthic macroinvertebrate assemblages in three test sites in three sampling periods: pre-intervention (2004–2007), early post-intervention (2008–2011), and late post-intervention (2018–2019). They also added three reference-stream sites (2018–2019) and discussed the social perceptions concerning the interventions. There was a significant improvement in most water quality parameters, moderate improvement in the physical habitat and macroinvertebrate indicators, and the residents' social perceptions indicated increased appreciation of the environmental improvements over 10 years

Currently, 41% of global irrigation water use occurs at the expense of the maintenance of ecological integrity requirements (Grill et al., 2015), which is defined by Arthington et al. (2018) as "the quantity, timing, and quality of freshwater flows and levels necessary to sustain aquatic ecosystems which, in turn, support human cultures, economies, sustainable livelihoods, and well-being". In this special issue, a contribution by Kaushal et al. (2022) evaluated the experience of securing flows in river systems through irrigation water use efficiency, in a case study from the Karula River in the Ganga. To deal with the diminishing flows in critical river systems, due to water use for irrigation (80%) and domestic and industrial use, a joint initiative involving farmers, the Irrigation and Water Resources Department, local administration, and a conservation organization aimed to enhance flows in the Karula River in the Ganga by routing the saved water from irrigation supplies in a canal commanded area.

Flitcroft et al. proposed a new type of rehabilitation, "restoration to a Stage 0 condition", shifting the rehabilitation goals to process-based restoration, such as reconnecting rivers to their floodplains by slowing down flows of sediment, water, and nutrients to encourage lateral and vertical connectivity at base flows. This approach to rehabilitation is at a valley scale, rendering traditional monitoring strategies that target single-thread channels inadequate to capture pre- and post-project site conditions, thus motivating the development of novel monitoring approaches.

Neeson et al. analyzed the patterns of participation and spending across five freshwater conservation programs in the United States. The authors highlight fundamental differences between emerging programs, which may experience exponential or logistic growth, and mature programs with slower growth, in which changes in participation may be driven by a number of internal and exogenous factors, such as changes in legislation that open new funding streams; shifting priorities of actors; changes in the policies or management of a program that align it with new funding streams; and increases in individuals' willingness to participate in a program as it grows. The authors propose that programmatic shifts represent windows of opportunity for strategically reorienting conservation programs to leverage newly-available resources.

Pennock et al. evaluated the requirements for effective conservation of desert riverscapes. Such landscapes must deal with simultaneous diverse effects of increasing human water demand, persistent drought, non-native species establishment, and climate change. The authors stress the importance of natural flows and large floods for successful conservation and

rehabilitation of riverscapes. Based on their experience with rehabilitation projects, the authors propose spatially extensive measures such as protection of in-stream flows, rehabilitation to available annual water availability, and working with nature using low-tech process-based techniques, such as flow reduction and vegetation-induced channel narrowing. The authors oppose the traditional rehabilitation efforts at small spatial extents, largely focused on reducing non-native plant and fish species, to spatially broader approaches, crucial to long-term success of management efforts for both in-stream and riparian communities.

Karami et al. proposed a novel approach for estimating sediment loads in dam reservoirs, using different models of intelligent algorithms. As input data the authors used data on river flow, sediment concentration, and temperature, whereas sediment load was considered as output data. Their results show high correlation of sediment concentration and discharge with sediment rate and low correlation with temperature. The modeling included sensitivity analysis, classical Adaptive Neuro-Fuzzy Inference System (ANFIS), and evolutionary algorithms. Karami et al. showed that the use of intelligent algorithms in ANFIS training has been able to improve its performance in predicting the amount of sediment in the catchment area. This saving of water is being achieved due to 'supply-side' and 'demand-side' measures that are being adopted in the project area. With the objective of ensuring the sustainability of the initiative, efforts are made for an institutional arrangement (Water Users Association), through which this initiative can be sustained beyond the project support.

Although there is much work to be done on the topic of this special issue, we hope that readers can benefit from the insights provided by these papers and that the highlights presented in this Special Issue can attract attention to pursue further investigations and meaningful developments in river and watershed restoration, rehabilitation, and conservation area.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

RH is employed by Amnis Opes Institute.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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