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Editorial: Watershed environmental changes and adaptive management for sustainability

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Editorial on the Research Topic
Watershed environmental changes and adaptive management for sustainability

Water and environmental sustainability in watersheds are challenged by climate change and human interference, which presents a global issue that concerns scientists, policymakers, and the public. Climate and land use changes significantly affect hydrological processes and water resources within watersheds. Increasing demands for human water usage exacerbate stress on water resources, heightening competition between human needs and ecosystem requirements in heavily managed watersheds. Meanwhile, water and environmental sustainability in watersheds are threatened by eutrophication and emerging pollutants. Altered hydrological and hydrodynamic processes complicate pollutant dynamics, which further lead to risks in water quality and ecosystem health. Understanding the feedback of watershed ecosystem to environmental changes is significant for ensuring ecological security.

This research topic aims to address watershed environmental changes under multiple disturbances and adaptive management for watershed sustainability. Specifically, interdisciplinary research is needed to analyze the dynamics and underlying mechanisms of watershed hydrology, water quality, and ecology. Interactions and feedbacks of processes within the natural system (i.e., interactions among hydrological, environmental, and ecological processes) and among the natural and social systems further complicate the water problems in a watershed and require further investigations. As a result, the complexity and uncertainty associated with climatic change and human activities call for adaptive management approaches that can be used to adapt watershed management actions over time in response to changes in system drivers. Moreover, it is significant to manage watersheds from a system's perspective and promote integrated watershed management in the context of environmental change.

This research topic collects eight original research papers. These papers explore watershed environmental changes and sustainable management worldwide by investigating the impact of climate and land use changes on watershed hydrological and pollutant transport processes and overall watershed sustainability. Jarrin-Perez et al. enhanced the Soil and Water Assessment Tool (SWAT) model to simulate runoff as saturation-excess overland flow in neotropical alpine catchments with conductive soils. The model can be adapted to paramo catchments to explore the hydrological variations caused by climate and land use changes. Chen et al. investigated the impact of land use modes on nitrogen (N) and phosphorus (P) contents in soil and water in an agricultural basin in China. Nutrients in two sub-catchments with different land use compositions and spatial layouts were compared. It was found that the interplanted mulberry and paddy fields effectively reduced the N and P outputs of surface runoff. Li et al. adopted an epsilon-based measure model to analyze the spatio-temporal evolution of the eco-efficiency in cultivated land use in the region around Beijing–Tianjin, China, providing fresh insights for the sustainable use of arable land to enhance food and ecological security. In addition, Meng et al. conducted a global-scale study that clarified the zoning and evolution of various environmentally oriented watershed sustainable development issues, offering a new perspective on the interplay between watershed sustainability, environmental change, and human impacts.

To pursue watershed sustainability, it is significant to assess the adaptability of watershed management strategies to environmental changes and implement adaptive management. Huang and Chen developed a machine learning prediction model for the hourly scale water temperature of reservoir discharge, which can support short-term water temperature forecasting and reservoir operation to manage discharge water temperature under climate change. Kim et al. employed the SWAT model to analyze the efficiency of two best management practices in reducing nutrients in a watershed under future climate scenarios. The study emphasized the adaptability and reliability of nature-based solutions in nutrient pollution control under a changing climate. Liu et al. constructed the ecological security pattern in the Songnen Plain of China and proposed multiple spatial pattern optimization strategies, which are helpful in coordinating the relationship between socioeconomic development and environmental protection. McLellan et al. proposed a generalized framework for assessing and improving ecosystem health in highly altered watersheds. This approach helps identify and reduce ecosystem stressors, thereby improving ecosystem functions and resilience to disturbances.

In summary, this research topic presents the most recent progress on watershed environmental changes and management worldwide. Given the dynamics and uncertain nature of the environment, we call for increased efforts in watershed monitoring, assessment, and adaptation under environmental changes. These studies are crucial for addressing and downscaling United Nations (UN)' sustainable development goals (SDGs) at the watershed scale, ensuring long-term sustainability via practical approaches. Such studies could leverage advanced data and artificial intelligence (AI) techniques to facilitate the mapping, understanding, and modeling of watershed responses to environmental change, using data not only from traditional gauging and measurement methods but also from alternative data sources such as social media and crowdsourcing participants.

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