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Editorial: Water and ecological systems: responses, management, and restoration, volume II

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Editorial on the Research Topic
Water and ecological systems: responses, management, and restoration, volume II

1 Introduction

Climate change and the intensification of human activities can induce unprecedented alterations in global hydrological and ecological systems. These disruptions manifest in altered river flows, degraded water quality, biodiversity loss, and compromised ecosystem services. In a warming world, ecological systems have different hydrological responses to changes in climate and human activities and have different water demands in different basins or regions. However, the hydrological and ecological system response remains uncertain. Water resources management and ecological restoration in a changing world need to elucidate its hydrological and ecological response and then provide a suitable way to adapt to global change. Understanding the interactions between water cycles and ecological processes is critical for devising adaptive management strategies that reconcile socioeconomic development with environmental sustainability.

This Research Topic "Water and Ecological System: Response, Management, and Restoration-Volume II" aims to collect and present the latest research developments in hydrological and ecological response in different basins or regions and its implication for water resources management and ecological restoration. Articles published in this Research Topic would shed light on divergent evidence in hydrological and ecological response, explain it with new and deeper insight, and interpret its implication for ecological water demand, water resources management and planning, and ecological restoration. These articles are expected to benefit communities, basins, and government agencies in water and ecosystem management that deal with hydrological and ecological responses in a changing world.

This Research Topic collects 14 manuscripts that explore these interactions across varied geographic and climatic contexts. From the cascade reservoirs of the Yellow River to the coal mining regions of Huainan and the Karst landscapes of Guizhou, the articles investigate hydrological responses to environmental stressors, evaluate ecosystem health, and propose frameworks for r This synthesis consolidates their findings, identifies cross-cutting themes, and outlines future research priorities.

2 Main researches and contributions

2.1 Hydrological responses to climate change and human activities

Climate change including global warming and other related Research Topic profoundly affects hydrological processes such as precipitation and evaporation. Li et al. attribute streamflow reductions in the Daqing River Basin in the North China Plain, to a combination of climate change (35% contribution) and human activities (65%), notably afforestation and water conservancy projects. Hydrological simulations and elasticity coefficient analyses highlight the vulnerability of semi-arid regions to compounding stressors, urging adaptive strategies to mitigate water scarcity.

Human activity and climate change have significantly modified the hydrological processes of groundwater. In coal mining areas, dewatering operations have become more influential than climate change, making human activity the primary factor impacting groundwater systems. Zhou et al. investigate groundwater level fluctuations in the Pansan Coal Mine in Huainan, China, demonstrating that El Niño-Southern Oscillation (ENSO) signals persist despite over-exploitation. Wavelet analysis reveals interannual resonance between groundwater levels and precipitation, underscoring the dual pressures of climate variability and mining. The study highlights the need to integrate climate teleconnections into groundwater management, particularly in regions reliant on fossil fuel extraction. Quaternary aquifers showed 80 m declines in water tables, underscoring the need for managed aquifer recharge.

Cascade hydropower development significantly alters the structure and function of river ecosystems. Phytoplankton, as primary producers, are highly sensitive to environmental changes, and their diversity and community structure reflect the state of the water environment. Luo et al. examine the role of hydraulic residence time (HRT) in shaping phytoplankton communities in the Upper Yellow River cascade reservoirs. Their study reveals that HRT positively correlates with phytoplankton abundance and diversity, with deterministic processes (e.g., water temperature, nutrient availability) dominating community assembly. Annual regulation reservoirs (e.g., Liujiaxia) exhibited 30% higher species richness than runoff-dominated systems. Annual regulation hydropower stations, characterized by longer HRT, support higher species richness compared to runoff stations. These findings emphasize HRT as a critical factor in reservoir management to balance hydropower generation and aquatic ecosystem health. However, prolonged HRT amplified cyanobacterial dominance, raising concerns about eutrophication risks.

Rivers are critical to ecological and societal sustainability, yet human activities like urbanization, industrialization, and agricultural runoff increasingly threaten their ecological health. Bu et al. apply set pair analysis to assess Dalian's rivers, identifying S12 and S15 as healthy (Grade II) due to restored connectivity. In contrast, S7 (near a steel mill) ranked as severely polluted (Grade V), with macroinvertebrate assemblages dominated by pollution-tolerant Chironomidae.

2.2 Water resources, ecological system and environmental carrying capacity assessment

The agricultural water footprint (WF) is essential for understanding environmental impacts and managing water resources, especially in waterscarce regions. Wei et al. develop an integrated framework to assess agricultural water footprints (WF) in Beijing, combining blue, green, and grey water metrics with reliability-resilience-vulnerability (RRV) indices. WF were analysed using STIRPAT model. The overall WF decreased from 22.0×10^8 m^3 to 3.9×10^7 m^3, showing a significant downward trend from 1978 to 2018, and 25 out of 35 years exceed the water stress thresholds (WSI >1), They were driven by improved irrigation efficiency and crop restructuring. However, water stress indices (WSI >1) persist, underscoring the need for policies that enhance water-use efficiency and reduce nitrogen pollution.

Evaluating resource and environmental carrying capacity (RECC) within the framework of ecological civilization is essential for reconciling development with ecological preservation and optimizing land-use patterns. Yang et al. evaluate resource and environmental carrying capacity (RECC) in Guizhou's Karst regions using an obstacle degree model and Pearson's correlation analysis. They find significant medium-to-high positive correlations: resource carrying capacity with environmental capacity (0.61) and overall capacity (0.74). The environmental capacity correlates with the overall capacity (0.80). Conversely, the socioeconomic carrying capacity shows no significant correlations with the resource carrying capacity (−0.21), environmental capacity (−0.32), or overall capacity (0.23). These results indicate that resource and environmental capacities have a significantly greater influence on the overall carrying capacity than socioeconomic indicators. They identify delayed socioeconomic development and inadequate infrastructure as key constraints, advocating for industrial modernization and market-driven resource allocation to enhance RECC.

For urban river ecological health, Bu et al. and Zhang et al. advance bioassessment protocols for urban and undammed rivers. Bu's entropy-weighted set pair analysis identifies pH, dissolved oxygen, and ammonium nitrogen as critical determinants of river health in Dalian, while Zhang's multimetric index (MMI) for the Zaogang River integrates hydrologic, chemical, and biological indicators to guide restoration.

The Chishui River, as an important tributary of the upper Yangtze River without dams, the macroinvertebrate community structure and habitat suitability conditions holds significant implications for water ecological conservation and restoration. Li et al. identify taxa of *Ephemeroptera, Plecoptera*, and *Trichoptera* as key bio-indicators in the pristine Chishui River. ANOSIM analysis revealed seasonal shifts in community composition, with dry-season dominance by *Baetis* and *Heptagenia*. Habitat suitability modeling prioritized riffle habitats with moderate flow velocities (0.3–0.6 m/s) and gravel substrates (D50 = 100–300 mm).

Liu et al. quantify the gross ecosystem product (GEP) of Shandong Mata Lake National Wetland Park, valuing its regulatory and cultural services at CNY 74.8 million annually. Regulation services (78.5% of total) dominated, with water purification (CNY 480,000) and flood regulation (CNY 220,000) as primary contributors. Scenario modeling suggests carbon sequestration could increase by 25% under afforestation.

2.3 Innovations in monitoring and modeling

In order to explore the relationship between groundwater levels and hydrometeorological factors in Fengnan District. Zhang et al. employ a PCA-CIWOABP neural network to predict groundwater levels in Fengnan District, achieving mean absolute errors (MAE) of 0.19–0.23. Their model, which integrates hydrological and meteorological data, demonstrates the potential of machine learning for real-time groundwater management in the North China Plain.

Large-scale afforestation projects on the Loess Plateau have resulted in significant vegetation greening, contributing to ecosystem restoration and enhanced soil conservation. Tan et al. identify the drivers of evapotranspiration (ET) changes, attributing long-term increases (80%) to vegetation greening and interannual variability to climate fluctuations. Their findings caution against afforestation in arid zones, where ET amplification exacerbates water deficits.

3 Other cross-cutting insights

Multiple studies highlight the growing frequency of droughts and floods under climate change. For instance, Li et al. note a 1.09–1.32 mm/year decline in precipitation across the Daqing River Basin, while Tan et al. report rising temperatures as a key driver of increasing ET on the Loess Plateau. These trends necessitate adaptive infrastructure, such as sponge cities and managed aquifer recharge, to buffer against hydrological extremes.

Anthropogenic pressures—overfishing, mining, urbanization—emerge as primary drivers of ecosystem decline. Du et al. document the recovery of fish populations in the Yangtze River following a 10-year fishing ban, noting a 91% increase in average body length for nine species (e.g., *Hemiculter leucisculus*). However, piscivores like *Pseudobagrus crassilabris* declined due to trophic cascades. Spatial heterogeneity was evident: Huangshi showed improved Margalef richness (from 4.55 to 4.78), while Jingzhou stagnated. yet stress that full biodiversity restoration requires decades. Similarly, Zhou et al. link groundwater depletion in Huainan to coal mining, advocating for stricter regulations on dewatering.

The studies collectively advocate for holistic approaches that bridge hydrology, ecology, and socioeconomics. Wei et al. and Yang et al. demonstrate how water footprint analysis and RECC evaluations can align agricultural practices and land-use planning with ecological limits. Meanwhile, Liu et al. and Bu et al. showcase the policy relevance of ecosystem service valuation and bioassessment.

4 Challenges and future directions

4.1 Data gaps and methodological limitations

Several studies identify limitations in data resolution and model accuracy. For example, Zhang et al. note the scarcity of long-term groundwater monitoring data, while Li et al. emphasize the need for high-temporal-resolution biodiversity surveys. Future research should leverage emerging technologies—remote sensing, IoT sensors, eDNA—to enhance data Research Topic.

4.2 Scaling local findings to regional policies

While case studies provide valuable insights, scaling local solutions (e.g., the Chishui River's undammed management) to regional or national levels remains challenging (Li et al.). Participatory modeling and decision-support systems could facilitate knowledge transfer, as demonstrated by Cui et al. in optimizing crop structures for water-energy-food nexus sustainability.

4.3 Balancing ecological and socioeconomic goals

The tension between conservation and development persists, particularly in rapidly urbanizing regions. Zhang et al. and Li et al. propose "happy river" frameworks that integrate ecological health with human wellbeing metrics (e.g., flood safety, cultural value). Such frameworks require robust stakeholder engagement and adaptive governance.

The studies in this Research Topic collectively advance our understanding of water-ecosystem interactions in a changing climate. Moving forward, interdisciplinary collaboration, technological innovation, and adaptive governance will be essential to navigate the complexities of water and ecosystem management. This synthesis underscores the urgency of translating scientific insights into actionable policies to safeguard water resources and ecological resilience for future generations.

Author contributions

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