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Editorial: Advancement in hydrological modeling and water resources management for achieving Sustainable Development Goals (SDGs)

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Editorial on the Research Topic
Advancement in hydrological modeling and water resources management for achieving Sustainable Development Goals (SDGs)

The sustainable management of our existing water resources is of utmost importance as water is a fundamental resource for life and critical for food security, sanitation, and human wellbeing. At the global scale, the United Nations Sustainable Development Goals (SDGs), particularly SDG 6 (Clean Water and Sanitation), SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land), directly needs a serious effort toward effective management of water resources. This Research Topic titled "*Advancement in Hydrological Modeling and Water Resources Management for Achieving Sustainable Development Goals (SDGs)*" explores the crucial role that hydrological monitoring and modeling along with the innovative water resources management practices play in achieving these SDGs. The integration of advance hydrological tools and models with water resources planning and management strategies is crucial for decision maker to and minimize the impacts of climate change which is a global issue. In this Research Topic, emerging challenges, and its solutions has been showcasing from different region which are as follows:

Hydrological modeling: the foundation of effective water resources management

Hydrological models have long been instrumental in predicting and developing an understanding of the distribution of water and water quality challenges within the environment. Several articles in Research Topic brings advancement in hydrological modeling which offers better simulations, thereby improving predictions of hydrological behavior under various scenarios. Integrating hydrological models with climate models

permits more accurate predictions of future water availability in the face of climate change, helping policymakers design more effective strategies for water management and climate resilient infrastructure. Such models provide an understanding of how a minor shift in temperature, precipitation patterns, and extreme weather events can affect local and regional water resources planning. For instance, a study featured in Research Topic utilizes advanced downscaling techniques to improve climate projections, particularly in regions susceptible to water stress. By using bias-corrected regional climate model (RCM) data, the study offers valuable insights into how climate change may influence water availability, highlighting at-risk areas and providing decision-makers with the tools to anticipate challenges and plan accordingly aligning with SDG 13–15.

Groundwater resources: vulnerability assessment and protection

To date, groundwater remains one of the most important sources of freshwater, facilitating water for domestic purpose, agriculture use, and industrial use, especially in regions with limited surface water. However, groundwater resources are dwindling due to over-extraction, pollution, and climate change. Several articles in Research Topic highlight the need for improved methods to assess and protect groundwater resources. For example, one study discusses the use of Geographic Information Systems (GIS) and the DRASTIC model to assess groundwater vulnerability to contamination. This approach helps identify areas where groundwater is at risk, allowing for targeted protection measures, such as land-use regulations or establishing buffer zones around vulnerable aquifers. Such innovative approaches to groundwater management may prove vital to ensure that groundwater resources remain available for future generations aligning with SDG6 and SDG13.

Streamflow and sediment transport modeling for flood control and ecosystem health

Streamflow and sediment transport models are crucial for predicting flooding events, managing river systems, and conserving a healthy aquatic ecosystem. Accurate simulation of water flow through catchments and movement of sediments through rivers can help reduce the impacts of floods, prevent soil erosion, and preserve water quality. In this Research Topic, several articles explore the application of the Soil and Water Assessment Tool (SWAT) to simulate streamflow and sediment transport. One such case study in the Song River basin, using the SWAT model to predict how land use and climate changes will affect water and sediment dynamics in the region. This type of understanding is crucial for developing flood control strategies, as it helps identify areas at risk, which may be of high importance for designing flood protection infrastructure. The study further elucidates the need for integrated land and water management approaches, considering the complex interactions between hydrological systems and human activities. Such study also helps in ensuring that river ecosystems remain resilient, supporting biodiversity, and providing ecosystem services like water purification and carbon sequestration aligning with SDG 3,11–13, and SDG15.

Nature-based solutions and ecosystem services for resilient urban water systems

With the growth in urban population, the need for a sustainable and climate resilient water system is becoming more pressing. Traditional approaches for water management, such as dams and pipelines, are observed to be less effective in addressing the multifaceted challenges of modern cities. In response, the concept of nature-based solutions (NbS) is gradually gaining momentum. These solutions utilize natural resources associated with often biologically mediated processes, such as wetlands, forests, and green infrastructure, to manage water resources and enhance resilience to climate change. An article in Research Topic explores the role of NbS in urban water management, specifically focusing on their ability to provide multiple ecosystem services, including flood regulation, water quality enhancement, and temperature moderation. The study integrates NbS into urban planning to create more cost-effective, resilient, and sustainable cities, aligning with SDG 11.

Addressing droughts in a changing climate

Droughts represent themselves as a threat to water security, agriculture, and the ecosystem. With climate change's influence on the frequency and intensity of drought events, our ability to predict and manage drought conditions becomes imperative. A study featured in this Research Topic explains the use of drought models for the prediction of drought conditions in semi-arid regions. Through the analysis of historical data and advanced modeling techniques, this research facilitates early warning signals, allowing communities and governments to take proactive measures, such as water rationing or the implementation of drought-resistant crop varieties. Such efforts contribute toward SDG 2 (Zero Hunger) and SDG 6 (Clean Water and Sanitation) by ensuring food and water security.

Advancements in wastewater treatment and water reuse technologies

Innovative technologies promoting the reuse of water are pivotal to addressing the challenge of water scarcity. Several articles in this Research Topic discuss advancements in wastewater treatment processes, focusing on development of efficient and affordable technologies for treatment of wastewater to meet with the water demand and water quality standards for reuse. Such innovations are crucial for reduced burden on freshwater

resources, particularly in regions facing water scarcity. Reusing treated wastewater for non-potable purposes, such as irrigation, industrial use, or landscape irrigation, can help conserve valuable freshwater resources and contribute to the achievement of SDG 12 (Responsible Consumption and Production) and SDG 6 (Clean Water and Sanitation).

Gender equality and inclusive water management

Women are often most disproportionately affected by water scarcity and water-related challenges. However, their involvement in water management decision-making processes has often been limited. An article from this Research Topic emphasizes the importance of integrating gender considerations into water management practices, ensuring that women have equal opportunities to participate in water governance and decision-making. Through gender equality in water management, the policies and interventions can become more inclusive, effective, and sustainable, supporting SDG 5 (Gender Equality) and SDG 6 (Clean Water and Sanitation).

Conclusion: bridging science, policy, and practice for sustainable water management

The articles in this Research Topic underscore the transformative potential of advanced hydrological modeling and innovative water management techniques toward achieving the SDGs the United Nations (UN) set up. By incorporating climate change projections, improving groundwater vulnerability assessments, utilizing nature-based solutions, and enhancing water reuse technologies, the world would be better equipped to address the challenges of water scarcity, pollution, and extreme weather events. Moreover, these advancements are not solely the domain of scientists and engineers as, policymakers and communities should also work together to translate these scientific insights into effective, actionable strategies. The synergy between science, policy, and practice is imperative for a sustainable and resilient water future. As we look toward the future, it is evident that achieving the SDGs will need more ongoing innovation, collaboration, and commitment. Through continued research, the adoption of best practices, and the integration of science into policy and governance, we can move toward a world where water resources are managed sustainably, equitably, and effectively.

Author contributions

VK: Writing – review & editing, Formal analysis, Writing – original draft, Visualization. JJ: Writing – original draft, Formal analysis, Writing – review & editing, Visualization. RS: Writing – review & editing, Formal analysis, Writing – original draft, Visualization. PD: Writing – review & editing.

Conflict of interest

The 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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