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Editorial: Adapting water management to climate change: challenges for vulnerable regions and extreme events

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Editorial on the Research Topic
Adapting water management to climate change: challenges for vulnerable regions and extreme events

The impact of Global Change on water resources constitutes a critical area of scientific inquiry. Global Change refers to large-scale environmental transformations driven by anthropogenic activities that contribute to Climate Change and necessitate substantial societal adaptation and ecological safeguarding. This dual challenge requires not only a rigorous assessment of Climate Change impacts but also a comprehensive evaluation of the environmental and socio-economic consequences associated with human adaptive responses, particularly in the management of water resources and water-dependent ecosystems (Pulido-Velazquez et al., 2023).

Climate Change perturbs the hydrosphere by altering the spatiotemporal distribution of key atmospheric variables, thereby increasing the frequency, intensity, and duration of extreme events. Along with demographic growth and escalating freshwater demands, these pressures threaten the sustainability of water bodies and the resilience of dependent ecosystems. Research has advanced projections of Climate and Global Change impacts on surface water and groundwater systems, typically focusing on variables such as river discharge, evapotranspiration, soil moisture, aquifer recharge, and snow water equivalent (Collados-Lara et al., 2021). However, gaps remain in integrating heterogeneous datasets and modeling frameworks to represent system dynamics and assess future water quantity. Water quality projections under similar uncertain conditions also pose a global challenge.

This Research Topic brings together contributions that advance our knowledge on Climate and Global Change impacts on surface and groundwater systems, including responses in quantity and quality. It also includes reviews of challenges and management strategies in vulnerable regions. Emphasis is placed on the socio-economic ramifications of Climate and Global Change in threatened socio-ecological systems in coastal zones (Baena-Ruiz et al., 2020), dryland regions (Alcalá et al., 2018), alpine environments

(Jimeno-Sáez et al., 2020), and wetlands (Collados-Lara et al., 2021). This Research Topic also addresses hydrological extremes, such as floods and droughts, supporting the development of robust decision-making frameworks for adaptation in the face of increasing scarcity and risk. These dynamics affect social conflicts, climate migration (driven by climate-related pressures—such as extreme weather or gradual environmental degradation; Yang et al., 2025), and the water–energy–food nexus.

The Research Topic includes studies examining climatic drivers and adaptive measures.

For example, Yin et al. compared five methods for estimating potential evapotranspiration in Nanjing, China, from 1961 to 2021, using the Penman model as a reference. The differences among the models showed that no single approach is universally applicable, although the trends were similar. The refinement of these models improves the prediction of greenhouse water demand.

Tezcan and Garcia developed a hidden Markov model that uses drought indices and temperature to generate climate-informed scenarios for the Colorado River basin. The purpose was to understand the impact of Climate Change on spatiotemporal hydroclimatic patterns to develop adaptation strategies in large watersheds where interbasin transfers and shared demand nodes link different watersheds. These ensembles can be used to generate streamflow ensembles, which, in turn, will be used to study the impact of Climate Change on regional Hydrology.

Odunola et al. assessed the willingness-to-pay for adaptation in water projects, using the Lesotho irrigation project as a case study. By extending cost–benefit analysis with a Climate-informed Robustness Index, the authors identified vulnerable conditions and supported measures like integrated catchment management to improve resilience.

Prasad et al. explored irrigation development under uncertainty in Kenya and Zimbabwe. The researchers argued that large infrastructure lacks flexibility, whereas small-scale farm investments enhance adaptability and reduce lock-in risks, reflecting farmer responses to opportunities and threats.

In conclusion, exploring adaptive water management strategies in response to Climate and Global Change, along with the challenges faced by regions vulnerable to extreme climate events, provides a crucial dimension to understanding the environmental and socioeconomic consequences and adaptive responses. The authors contributing to this Research Topic employed cutting-edge methodologies to gain unique perspectives on the effects of Climate and Global Change. This in-depth exploration not only enhances our ability to identify human, environmental, and climatic interactions that underlie the dynamics of water systems to design mitigation and adaptation strategies to Climate and Global Change, but it also lays the groundwork for more effective interventions in the realm of socio-economic adaptation and environmental protection interventions.

Author contributions

DP-V: Conceptualization, Formal analysis, Funding acquisition, Supervision, Writing – original draft, Writing – review & editing, Visualization. FA: Conceptualization, Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Funding acquisition. MCP: Conceptualization, Formal analysis, Funding acquisition, Visualization, Writing – original draft, Writing – review & editing. AC-L: Conceptualization, Formal analysis, Funding acquisition, Writing – original draft, Writing – review & editing.

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