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Editorial: Enhancing coastal resilience through nature-based solutions: bridging fluvial and marine ecosystems

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Editorial on the Research Topic

[Enhancing coastal resilience through nature-based solutions: bridging
fluvial and marine ecosystems](#)

Rivers and estuaries play a crucial role in shaping coastal and marine ecosystems, where land-based activities alter the flow of sediment, organic carbon, and nutrients, thereby reshaping biodiversity. Increasing anthropogenic pressures intensify these impacts, which highlights the need to better understand the biotic and abiotic interplay across the land-sea continuum. Nature-based solutions (NbS) such as wetland restoration, riparian buffers, and green-blue infrastructure may offer cost-effective and sustainable ways to mitigate these pressures while enhancing ecosystem resilience.

This Research Topic highlights recent advances in monitoring, modeling, and implementing such solutions to foster innovative strategies for the sustainable management of interconnected fluvial and marine environments. For instance, the beneficial use of dredged sediments for habitat restoration is gaining attention as a way to support ecosystem resilience while maintaining navigable waterways. Unlike static hard infrastructure, NbS is dynamic and may be adapted to changing conditions, such as sea level rise and storms. However, the thresholds governing its performance under these dynamic environmental conditions are still not fully understood. Despite these advantages, hard infrastructure remains the default option due to established engineering criteria and longstanding reliance.

Within this context, articles featured in this Research Topic discuss ongoing efforts regarding NbS and other related topics. For instance, [Davis et al.](#) provide a compelling example of NbS implementation through the restoration of Swan Island, Maryland. The project aimed to enhance resilience to sea-level rise, maintain the island's wave-breaking function, and increase habitat diversity by using dredged sediments to build elevation gradients to support local vegetation. A comprehensive monitoring program

assessed vegetation dynamics, sediment properties, topography, and hydrodynamics to evaluate restoration success. However, the containment barrier failed due to design limitations based on outdated hydrodynamic data, emphasizing the need for site-specific environmental characterization and continuous monitoring. Ongoing erosion further demonstrated the importance of hybrid (green-gray) approaches that combine ecological restoration with engineering measures when natural resilience is already compromised. Vegetation monitoring revealed strong species-specific responses to elevation and burial, highlighting the need to select stress-tolerant species for successful restoration. However, biodiversity assessments were limited, excluding broader ecosystem components such as phytoplankton and benthic communities, underscoring the importance of multi-trophic monitoring. Finally, the absence of detailed sediment composition data constrained our understanding of biotic–abiotic interactions, demonstrating that future NbS efforts must integrate comprehensive sediment characterization, adaptive design, and ecosystem-scale evaluation to ensure sustainable outcomes.

Another interesting topic addressed in this Research Topic is the intermittent rivers and ephemeral streams (IRES), which occur in regions with low precipitation. These are important for providing ecosystem services along the fluvial perimeter and for coastal systems that depend on them. [da Silva et al.](#) demonstrated the fate of nutrients (such as phosphorus, P), which are vital to several ecosystems, in an intermittent river in a semi-arid region of Brazil (the state of Ceará). The authors sampled sediments and water to investigate seasonality in these drylands across the following hydroperiods: dry, rewetting, and flow. They found changes in P content in sediments and water across the different hydroperiods, in addition to a close correlation between P and organic matter in sediments. Additionally, IRES has been poorly investigated, primarily concerning sediments, soils, and water. However, they play an important role in draining or sourcing nutrients for downstream ecosystems, which impacts the land–sea continuum.

Groundwater is important for the functioning of several ecosystems, impacting the fluvial and estuarine ecosystems. Models that can predict, understand, and prevail in future scenarios of groundwater pumping (GWP) and water table depth (WTD) are still challenging and are being developed. The article by [Kim et al.](#) presents models, including a regression-enhanced random forest (RERF), which are aimed at forecasting WTD changes related to GWP in New Jersey State (United States), a state that contains both terrestrial and coastal areas. This study provides insights into water resources from land to sea. The authors demonstrate that the best variables for model predictions included the following: the average of the long-term WTD, the water balance of precipitation minus evapotranspiration (PME), and variations in the slope of the landscape. This study provides decision-makers with important information regarding the management of continental and coastal areas subject to GWP and WTD fluctuations and their impact on fluvial and marine systems.

Complementing these biophysical perspectives, the study by [Islam et al.](#) addresses the social dimensions of coastal transformations by linking physical shoreline changes to the resilience of human livelihoods. Focusing on the

Ganga–Brahmaputra–Meghna (GBM) delta in Bangladesh, the authors combine long-term geospatial analyses of shoreline migration—spanning the past 9,000 years—with satellite imagery from 1972 to 2020 and interviews with local experts to assess the impacts of climate-driven erosion, sediment deposition, and salinity intrusion on coastal communities. The study highlights that the combined influence of the major river systems, the Ganga/Padma, the Brahmaputra/Jamuna, and the Meghna, particularly at the mouth of the Padma River, plays a key role in shaping the coastline and driving its continuous migration. This dynamic shoreline shift and land loss have intensified community vulnerability, prompting migration, livelihood diversification, and the adoption of community-led adaptation practices such as mangrove restoration and integrated water management. The study emphasizes that strengthening the resilience of deltaic and coastal regions requires not only engineering or ecological interventions but also policies that integrate local knowledge, cultural values, and participatory governance to ensure equitable adaptation in the face of accelerating climate change.

Together, the four studies show that the sustainable management of fluvial, estuarine, and coastal systems requires the integration of biophysical and social perspectives. From sediment-based restoration ([Davis et al.](#)), nutrient cycling in intermittent rivers ([da Silva et al.](#)), and groundwater modeling ([Kim et al.](#)) to socio-environmental adaptation in deltaic regions ([Islam et al.](#)), all these contributions emphasize the interdependence of land–sea processes and the need for continuous monitoring, adaptive design, and predictive tools in the context of climate change. They also highlight that technological and ecological solutions must be complemented with community participation and local knowledge to enhance resilience. Collectively, these articles reinforce that cross-disciplinary approaches and Nature-based Solutions are essential to achieve ecological sustainability and social equity across interconnected riverine, estuarine, and coastal environments.

Author contributions

CG: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. KO: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. DB: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Conflict of interest

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