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Nature-based solutions for mitigating multi-hazard flood and temperature extremes in coastal and deltaic regions

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ABSTRACT

Coastal, deltaic, and estuarine regions are increasingly exposed to compound multi-hazard events, particularly the interaction of coastal and riverine flooding with extreme temperatures. These hazards interact across spatial and temporal scales, generating complex events that challenge conventional single-hazard risk reduction approaches. Despite growing interest in Nature-based Solutions (NbS), quantitative evidence on multi-hazard interactions and NbS effectiveness remains limited. This study addresses these gaps through a two-fold approach: (i) detecting and characterizing multi-hazard flood–temperature events across five representative deltaic and estuarine regions in Bangladesh, India, Ghana, the United Kingdom, and the Netherlands, and (ii) evaluating the potential of NbS interventions to mitigate their impacts. Multi-hazard interactions are quantified using a nonparametric copula framework to estimate joint probabilities, combined with cross-correlation analysis to identify precursor relationships and optimal time lags. A systematic literature review and meta-analysis is conducted to assess NbS performance across different hazard indicators and regions. Results reveal strong spatial variability in compound hazard dynamics. Riverine–coastal flooding is the most frequent compound event, often occurring simultaneously in several regions (e.g., Bangladesh, the United Kingdom, and the Netherlands). In contrast, flood–heat interactions exhibit distinct lead–lag relationships, with extreme heat often preceding flooding. The meta-analysis indicates that NbS can reduce key hydrodynamic hazard indicators by over 50% on average, although effectiveness is highly context-dependent and evidence gaps persist, particularly in West Africa. Overall, this study advances the understanding of compound hazard processes in coastal and deltaic systems and provides quantitative evidence on the role of NbS in mitigating interacting climate risks.

Keywords: *Multi-hazard interactions, nature-based solutions, flood, temperature extremes.*

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