Title: Living on the flood line: Constructing and validating a combined multidimensional resilience index for rural riverine floodplain communities

Author names: Abu Reza Md. Towfiqul Islam , Md. Abdullah-Al Mamun , Anjum Tasnuva , Mst. Nazneen Aktar , Manoranjan Mishra , Abdullah Al Mamun , Md. Julfiker Moin

Abstract: Resilience analysis is crucial for developing interventions that mitigate riverine flood risk in the context of global environmental change and sustainable development. Index-based assessment remains the dominant methodological approach for operationalizing and evaluating resilience. Nevertheless, current frameworks often rely on subjective indicators, lack statistical validation, and exhibit limited utility for environmental planning. This study proposes an integrated methodology that combines expert-based multi-criteria decision analysis, data-driven principal axis factoring, and Monte Carlo–based index construction with deep learning–enabled predictive validation, supported by spatially explicit, explainable artificial intelligence (XAI). Using 1000 georeferenced observations and 56 indicators spanning socio-cultural, economic, physical-infrastructural, organizational-institutional, hydraulic, and ecological domains for 49 unions in the Brahmaputra River Basin (Bangladesh), the triadic framework yields a fully validated Combined Multidimensional Resilience Index (CMRI) that offers a transparent, rigorous, and statistically robust characterization of community-level resilience. The CMRI reveals significant spatial differences: low-resilience conditions are heavily concentrated in northern floodplains (70% of low-resilience locations), whereas higher resilience is predominantly observed in central and southern unions (56%). The deep learning model (DR-DNN) demonstrates excellent predictive skill (AUC = 0.989; 87.8% accuracy), confirming the internal coherence and predictive learnability of resilience structures. SHAP-based explanations highlight hydraulic deficits, ecological degradation, and institutional weaknesses as primary drivers of vulnerability. In contrast, ecological integrity, institutional capacity, financial inclusion, and reduced social vulnerability emerge as key determinants of high resilience. The asymmetric vulnerability–resilience pathways indicate that addressing deficits alone is insufficient; targeted ecological restoration and institutional strengthening are required to raise resilience levels. By integrating rigorous quantitative modeling with interpretable XAI, this study advances flood-resilience assessment from a static diagnostic exercise to a dynamic, actionable, and context-sensitive decision-support framework, providing a scalable model for rural and transboundary riverine floodplain systems.

Keywords: Flood resilience, Multicriteria decision analysis, Explainable artificial intelligence, Deep learning model, Climate adaptation

10.1016/j.scitotenv.2026.181581