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ABSTRACT

Climate variability has greatly impacted the riparian functionalities of diverse ecosystems; recent increases in flooding are linked to this phenomenon. Hence, the devastating floods and associated risks can only be managed holistically through a wide spectrum of engineering, societal, and institutional measures. Against this backdrop, this study evaluates and models the effects of climate change on the flood dynamics of the River Niger and explores adaptation strategies in Lokoja and Niamey, West Africa. To achieve this, the study analyses land use and land cover (LULC) patterns and their associated impacts, flood vulnerability, and risk distribution. It also develops flood profiles or scenarios under varying climate change projections, coupled with the proposition of flood risk management and adaptation strategies. The results reveal that between 1991 and 2021, Lokoja experienced significant urban expansion, with a 21.0% increase in built up areas. Conversely, vegetation cover exhibited contrasting dynamics: shrubs and grasslands declined by 0.3%, and dense vegetation decreased by 0.6%. Simultaneously, agricultural land expanded by 8.0%. In Niamey (1991–2021), water bodies expanded by 14.66%, and agricultural lands grew by 18%. This pattern suggests a shift in land use toward intensive cultivation, leading to enhanced water retention. Human settlements increased by 312.88%, highlighting extensive urban development and a surge in urbanisation. Similarly, bare lands expanded by 21%, indicating significant soil exposure, partly due to vegetation loss and extensive land clearing. The findings further indicate that Niamey Metropolis is vulnerable to varying degrees of flood risk, with 26% of low-lying areas classified as high risk and 31% of the city center classified as moderate risk. In contrast, the scenario for Lokoja revealed that 41% of the city is at very high flood risk, with high-risk areas concentrated along the river. Analysis of extreme rainfall indices showed varying trends; however, no statistically significant changes were observed overall, except for the years 2011 and 2003 in Boubon, Niamey City, and Lokoja, respectively. Breakpoints were identified based on the RX1DAY statistic, indicating a short cycle of two years. In this context, the findings also reveal that flood risk management and adaptation through preventive measures both structural and non-structural achieved a high overall mean score of 3.32 in Lokoja. Education, awareness, and institutional policies also scored a mean of 3.32, while infrastructure restoration scored 3.30. For Niamey, infrastructure (notably the use of dykes) recorded a mean score of 2.03, and wetland restoration scored 2.02. Based on the overall findings, it suffices to conclude that a surge in urbanisation and increased human settlement in recent times has significantly amplified flood risks in both cities; flood risk in both cities can be classified as moderate (32%) spatially, while in Lokoja, the city center has an overall moderate risk (15%), with low-risk zones in the north and very high-risk pockets in the south; extreme rainfall patterns exhibit sporadic breakpoints, signaling high vulnerability induced by climate change; and infrastructure-based interventions, wetland restoration, and education/awareness programs emerge as the most viable frameworks for flood risk management and adaptation strategies. However, to avoid overgeneralisation, it is imperative to recommend the implementation of holistic catchment management planning for the

transboundary River Niger. In addition to structural interventions, the development of an integrated flood-drought early warning system for flood defense has become necessary, given the complexities of climate variability. Thus, to complement these efforts, future studies should focus on the reliability-based design of flood defenses, optimisation of flood defense strategies, habitat or nature-based rehabilitation, development of integrated flood damage mitigation plans, and the advancement of flood simulation and risk analysis frameworks.