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Topic of Research: Blue-Green Infrastructure for Sustainable Flood Management and Ecosystem Services

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Findings

This study examines sustainable strategies for Flood Risk Management (FRM) in India through a comprehensive investigation of nature-based solutions, especially Blue-Green Infrastructure (BGI) and ecosystem services. It focuses on FRM in Indian river basins, analyzing two distinct cases: the pluvial flood-prone Adyar River in Tamil Nadu and the fluvial flood-prone Kosi River in Bihar. This comparison aims to provide insights into BGI's effectiveness and adaptability across different geographic contexts settings.

The author has collected and analysed the data for Land Use Land Cover (LULC) using satellite imagery. Rainfall data was collected and analysed by developing Intensity-Duration-Frequency (IDF) curves to estimate storm rainfall depths for various return periods. Developing and analysing the Adyar basin LULC maps for 1994, 2014, 2024 and 2034 (predicted), a threefold increase in built-up area from 1994 to 2024 has been observed. The predicted 2034 - LULC map for the Adyar basin features a continued rising trend of built-up area, about a 23% rise as compared to the 2024 built-up area. In the Adyar basin, over 150 km² of vegetative cover has been converted into built-up areas in the last three decades. In contrast, the Kosi basin of Bihar, a predominant rural-agriculture region, experienced a 33% increase in the built-up area alongside a 29% decline in forest area over the last six years, from 2017 to 2023.

A review of various hydrological models has been carried out to assess the suitability of an appropriate hydrological model to assess the impact of watershed characteristics and BGI on flood peaks. The study evaluates the impact of LULC changes and rainfall on surface runoff, which leads to floods in the Adyar basin, using the InVEST-UFRM model. Additionally, it examines the role of BGI in reducing surface runoff peaks and mitigating flood risk in the rapidly urbanizing Adyar basin using the same model.

Due to limited data in the Adyar watershed, the model was utilized multiple times for scenario analysis involving three LULC scenarios: 2014 (past), 2024 (baseline), and 2034 (severe). It used storm rainfall depths by developing IDF curves for 2, 5, 10, 25, 50, and 100-year return periods. Analyses were conducted for the entire watershed and the sub-watersheds for each LULC scenario with the six rainfall scenarios. The results are presented as runoff retention index (RRI), flood volume (FV), and runoff retention volume (RRV). As urban areas expand and natural infrastructures decline, runoff retention capacity decreases from past to baseline and severe scenarios during a single precipitation event. At the sub-watershed level, the reduction in RRI values from the baseline to severe scenarios was observed, varying between 4% and 21%. Flood volume rises, and RRI drops as built-up areas expand in the sub-watershed under specific rainfall-LULC scenarios. These results highlight the watershed's hydrological response to LULC change, underscoring the need for sustainable nature-based solutions.

A BGI suitability map for the Adyar watershed has been developed, and BGI measures have been conceptualized and categorized as urban forest and rain gardens (UF), detention/retention basins (DB), green roofs and rainwater harvesting systems (GR). Furthermore, for the BGI impact analysis, six green scenarios (based on UF, DB & GR) were developed using the ‘*scenario generator*’ tool in the InVEST software. Two extreme rainfall depths (42.72 mm and 96.01 mm in the 2-hour storm of 2 years and 100 years return period) have been used to demonstrate the extent of flood risk mitigation. The critical analysis of green, baseline, and severe scenarios indicates that BGI enhances RRI and reduces FV, thereby improving flood mitigation in the watershed. The RRI increased by 19% to 35% from baseline to green scenarios, while severe scenarios exhibited an increase of 40% to 60%. Despite significant urbanization in sub-watershed 1, green scenarios improved RRI values by 1.3 to 2 times compared to baseline scenarios. Comparing the FV results of the green and baseline scenarios for 42.72 mm rainfall at the sub-watershed level, a decrease of about 37% to 54% was observed, even in sub-watershed 1 (higher built-up region). All green scenarios demonstrate a consistent trend: an increase in RRV and a decline in FV compared to both the baseline and severe scenarios.

BGI uses natural methods for flood risk management. To implement BGI effectively, it is essential to adopt eco-friendly policies, promote research, engage communities, and develop multi-benefit strategies. Integrating BGI into urban and rural development aims to transform flood-prone areas into resilient communities, reducing risks and enhancing ecosystem services for a sustainable future.