

HYDROLOGICAL AND HYDRAULIC STUDY OF NATURE-BASED FLOOD MANAGEMENT PRACTICES IN THE ATTANAGALU OYA BASIN, SRI LANKA

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Floods are among the frequent and destructive natural disasters in Sri Lanka, often resulting in significant social and economic consequences, such as loss of life, displacement of communities, and extensive damage to property and infrastructure. The Attanagalu Oya Basin, situated in the Western Province and wet zone of the country, is one of the country's most flood-prone areas due to rapid urbanisation, land-use changes, and climate-driven hydrological variability. Traditional flood control methods, such as levees and drainage canals, have been proven insufficient in addressing the increasing flood risks and often result in undesirable adverse downstream impacts. In this context, the integration of Nature-Based Solutions (NBS) into flood management frameworks based on source control has emerged as a sustainable and cost-effective approach. This study investigates the hydrological and hydraulic effectiveness of selected NBS interventions in mitigating flood hazards in the Attanagalu Oya Basin.

The methodology combined the public domain Hydrologic Modelling System (HEC-HMS) and the Hydraulic Modelling System (HEC-RAS) developed by the U.S. Army Corps of Engineers to simulate rainfall–runoff processes and flood inundation patterns, respectively. Rainfall and streamflow data from 1990 to 2020 were collected and rigorously validated, while Intensity–Duration–Frequency (IDF) curves were derived using a Log–Weibull frequency analysis. The HEC-HMS model was calibrated and validated for the Dunamale sub-basin, achieving Nash–Sutcliffe Efficiency (NSE) values of 0.779 and 0.775, indicating high model reliability. In the absence of observed flood depth records, the HEC-RAS model was validated using the flood extent shapefile of the 2010 flood event through spatial comparison with simulated inundation maps. This ensured model robustness prior to scenario analysis. Three NBS strategies, such as rainwater harvesting systems, leaky dams, and permeable pavements, were incorporated in the modelling framework. These scenario interventions were represented through adjustments in curve numbers and impervious surface percentages to reflect enhanced infiltration and reduced runoff. Results indicated that NBS significantly attenuated peak discharges and flood extents. Peak flow reductions were quantified at 21%, 14%, 13%, and 10% for the 5-, 10-, 25-, and 50-year return periods, respectively. Moreover, under the 50-year scenario, the flood inundation extent decreased by 32.5%, reducing from 40 km² to 27 km². These outcomes demonstrate that NBS interventions effectively enhance infiltration, delay flood peaks, and reduce surface runoff, thereby alleviating flood risk in both rural and urbanised floodplains.

The findings position NBS not as replacements but as vital complements to traditional flood control infrastructure, offering integrated, adaptive, and climate-resilient solutions for flood-prone regions of Sri Lanka. In conclusion, the study establishes that implementing NBS within the Attanagalu Oya Basin can play a transformative role in strengthening disaster resilience, guiding future flood risk management, and informing sustainable urban planning practices. The results highlight the urgent need for policymakers, engineers, and urban planners to mainstream NBS into Sri Lanka's national flood management strategies.

Keywords: HEC-HMS, HEC-RAS, Leaky Dams, Permeable Pavements, Rainwater Harvesting

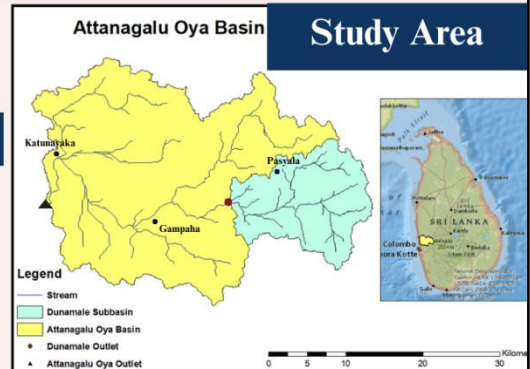
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Background

Main Factors Affecting for Flood in Study Area

- Rapid Urbanization
- Inadequate Drainage Systems
- Land Use Changes
- Monsoonal Climate



Methodology

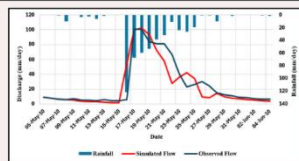
Data Collection and Processing

Hydrological Modeling

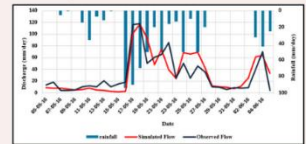
Hydraulic Modeling

Implementation of NBS

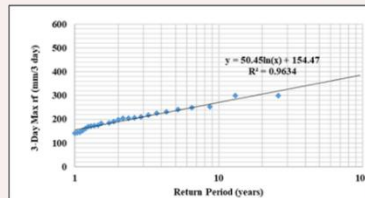
Results



Calibration Event (NSE - 0.779)



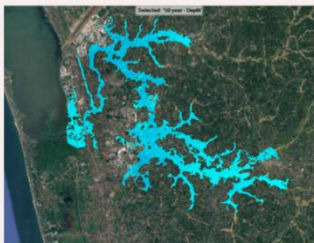
Validation Event (NSE - 0.775)



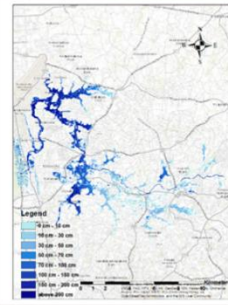
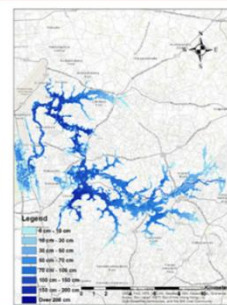
Log-Weibull Extreme Value Distributions for 3-Day Cumulative Rainfall



25-year return period inundation map



50-year return period inundation map



Flood inundation for a 50-year event for Before NBS and After NBS

- Flood inundation Area = 40 km² (Before NBS)
- Flood inundation Area = 27 km² (After Implementation of NBS)

**Inundation Area
Reduction = 32.5%**

- ### Solutions
- Leaky Dams
 - Rain Water Harvesting
 - Permeable Pavements

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