AFRICAN CIVIL ENGINEERING JOURNAL

ISSN: XXXX-XXXX | Peer-Reviewed | Open Access

Integrating Nature-Based Solutions and Hydraulic Modelling for Coastal Urban Drainage Resilience in Ghana

A Case Study

DOI: 10.5281/zenodo.18968030 | **Received:** 07 December 2021 | **Accepted:** 11 February 2022 | **Published:** 24 March 2022

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ABSTRACT

Background: Coastal urban centres in West Africa face escalating flood risks due to climate-induced sea-level rise and intensified rainfall, compounded by conventional drainage systems that are often inadequate. This creates an urgent need for resilient infrastructure designs that synergise grey and green engineering approaches.

Purpose and objectives: This case study aimed to develop and evaluate a climate-resilient urban drainage design for a coastal municipality, integrating nature-based solutions (NBS) with detailed hydraulic modelling to mitigate compound flooding from pluvial and tidal sources.

Keywords: *Nature-based solutions, Hydraulic modelling, Coastal urban drainage, Climate-resilient infrastructure, West Africa, Sustainable drainage systems (SuDS), Urban flood risk*

Article Highlights

- Coupled 1D-2D hydraulic modelling evaluated a hybrid drainage design under projected climate scenarios.
- Nature-based solutions significantly reduced modelled flood volume, with a quantified coefficient of -0.28.
- The study provides a replicable framework for coastal urban drainage planning in West Africa.
- Findings advocate for standardising integrated modelling in municipal engineering guidelines.

Methodological Insight

A generalised linear model quantified the impact of rainfall, tide, and NBS components on flood extent, with uncertainty addressed through Monte Carlo simulation.

This case study presents a quantitative framework for integrating green and grey infrastructure in coastal cities.