Evaluating the effect of nature-based solutions on urban runoff using hydraulic modelling: a case study in Sekondi-Takoradi, Ghana.

Rapid urbanization, combined with climate change, poses severe threats to future generations. The rapid development of built-up areas leads to a transformation of surface cover that disrupts the hydrological cycle and increases flood risk. Sub-Saharan African countries, in particular, are susceptible to associated hydro-meteorological risks. The implementation of Nature-Based Solutions (NBS) is still in its early stages, its potential remains untapped. The purpose of this research report is to investigate the effects of several urban NBS on the water system in a Sub-Saharan African urban environment. This case study focuses on Sekondi-Takoradi in Ghana. These regions are characterized by limited quantitative data and limited related NBS studies, mainly due to the complexity of NBS modelling. Parametrizing NBS is challenging, especially for hydraulic models. A basic hydraulic HEC-RAS model from the company HKV lijn in water was enhanced to improve accuracy, incorporating insights from literature review and expert input. The most influential model parameter was found to be roughness. To enhance land cover representation, satellite images were utilized to refine the model grid significantly. A sensitivity analysis of the five hydraulic parameters of HEC-RAS was performed to understand their impact on the model. The results of the sensitivity analysis were used to implement NBS in the model. It was found that considering different NBS effects, such as inundation depth, area, discharge, and surface runoff coefficient, is crucial for accurately simulating their impacts. Validation of the effects is only possible in terms of their magnitude and tendency due to spatial variability, lack of quantitative observations, and limited prior research on hydraulic implementation and combination of NBS. Nonetheless, the simulated NBS effects exhibited a significant reduction in the maximum discharge of hydrographs and surface runoff coefficient values. Combining NBS interventions could reduce these values by approximately 50%. Among the considered NBS, urban forest and bioretention areas demonstrated the largest absolute effects based on the given area characteristics, while check dams and stream renaturation NBS exhibited the largest unit effects. In conclusion, this research report has demonstrated the implementation of Nature-Based Solutions in a hydraulic (HEC-RAS) model and the corresponding effects. The findings shed light on the relevance of NBS, the effects of different NBS implementations, and the influence of scale and spatial factors on their effectiveness. The next steps should include monitoring and local measurements to further refine the model.

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HKV lijn in water
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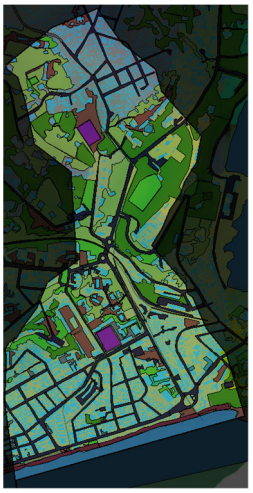

Figure 1: Study Area

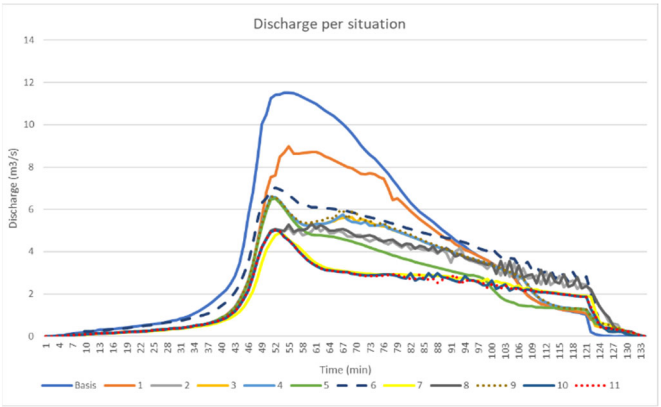

Figure 2: Discharge waves of NBS implementation scenarios in the whole catchment, to see the tendency of the effects (top blue is the original situation).

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