Chapter 7
Smart Stormwater Systems:
AI-Driven Forecasting, Optimization, and Real-Time Control

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ABSTRACT

This chapter emphasizes the potential of integrating green infrastructure (GI) with computational techniques to revolutionize urban stormwater management. Conventional gray infrastructure is inadequate in mitigating urban flooding and pollution, whereas green infrastructure such as rain gardens and bioswales provides nature-based remedies. Nonetheless, their efficacy is contingent upon local context, rendering models such as SWMM and GIS indispensable for planning. Machine

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learning, IoT sensors, and digital twins significantly improve forecasting, control, and optimization. Despite ongoing issues related to data quality and fairness, the amalgamation of intelligent technology with ecological design offers a robust and flexible strategy for constructing sustainable, flood-resilient, and inclusive urban water systems in a dynamic environment.

INTRODUCTION

As cities struggle with increased rainfall, deteriorating infrastructure, and rapidly changing land cover, urban stormwater is becoming an increasingly significant issue. The dynamic hydrological pressures of a 21st-century city cannot be handled by conventional gray infrastructure, which is frequently overworked and stiff. Designing sustainable, adaptive stormwater systems instead requires a hybrid model that combines computational innovation with nature-based solutions.

By encouraging infiltration, evapotranspiration, and biogeochemical treatment, green infrastructure (GI) is designed to replicate natural hydrological cycles. Core GI technologies, such as rain gardens, bioswales, green roofs, and permeable pavements, are designed to capture, delay, and clean urban runoff. Through sedimentation, filtration, and biological uptake, these systems lessen peak flow, postpone the time of concentration, and make it easier to remove pollutants.

For instance, in field settings, bioretention systems have shown significant efficiency in lowering heavy metals, total nitrogen (TN), and total suspended solids (TSS)(Fang et al., 2021) .They frequently have underdrains and several filtering layers in their design, which work together to control water quality and amount. Similarly, by capturing precipitation and temporarily storing it in substrate media, green roofs help with biodiversity and thermal insulation while lowering rooftop runoff (Sharma & Malaviya, 2021).

GI performance is quite context-sensitive, though. The effectiveness of treatment is significantly impacted by variables like land use, vegetation cover, soil permeability, and precipitation intensity. The necessity for computer models that simulate, optimize, and track large-scale green actions is highlighted by this heterogeneity.

For a long time, computational models like HYDRUS-1D and SWMM (Storm Water Management Model) have been essential resources for simulating hydrology and pollutant transport in urban watersheds. These models may mimic long-term stormwater behavior under different rainfall, land use, and GI deployment scenarios with plug-ins and scripting capabilities

Newer systems use Geographic Information Systems (GIS) for spatial data integration and visualization in order to get over limits in scalability and real-time analysis. Runoff hotspots, terrain restrictions, and appropriate GI placement based

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