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**Enhancing Urban Stormwater Management  
under Climate Change through Integrated  
Modeling and Multi-Objective Optimization of  
Green Infrastructure**



**Institute of  
SCIENCE TOKYO**

A Dissertation for Degree of

**Doctor of Philosophy**

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This dissertation structured around the critical challenges of enhancing urban stormwater management under climate change using green infrastructure (GI). The framework integrates hydrological modeling, sensitivity analysis, and multi-objective optimization to develop effective, climate-resilient solutions for urban stormwater challenges. Each chapter builds upon the findings of the previous one to systematically address the core issues related to GI planning, parameterization, and cost-effectiveness.

### **Chapter1: Introduction**

This chapter introduces the research problem, highlighting the increasing challenges of urban stormwater management in the face of climate change. It presents GI as a sustainable solution, outlines the key research gaps, and defines the main research questions. The chapter also provides an overview of the research objectives and the structure of the dissertation.

### **Chapter 2: Unraveling Urban Hydro-Environmental Response to Climate Change**

This chapter focuses on understanding how urban hydrological systems respond to climate change. Using climate data, the chapter simulates stormwater runoff and quality under various climate scenarios. The insights gained from this chapter form the foundation for subsequent chapters by providing critical data and understanding necessary for the evaluation of GI solutions.

### **Chapter 3: Cost-effectiveness of Green Infrastructure Under Climate Change: Model Parameterization, Uncertainty, and Sensitivity**

Building on the results of Chapter 2, this chapter assesses the effectiveness of different GI systems under future climate conditions. It

emphasizes the parameterization of GI models, focusing on key variables that influence system performance. Sensitivity and uncertainty analyses are conducted to understand how variations in parameters affect the outcomes of GI interventions. A cost-effectiveness analysis further evaluates the long-term economic viability of these systems, offering guidance on selecting GI configurations that maximize benefits while minimizing costs.

#### **Chapter 4: A Multi-Objective Optimization Framework for Spatial GI Planning**

This chapter develops a multi-objective optimization framework, using the Non-dominated Sorting Genetic Algorithm II (NSGA-II), to optimize the spatial allocation of GI systems. Integrating the results from Chapters 2 and 3, the framework accounts for the spatial heterogeneity of flood risk, pollutant loads, and land use. The optimization aims to balance multiple objectives, such as flood mitigation, water quality improvement, and cost-effectiveness, ensuring that GI solutions are deployed in the most beneficial locations.

#### **Chapter 5: Conclusion and Future Work**

The final chapter summarizes the key findings of the research and discusses their broader implications for urban stormwater management under climate change. It highlights the contributions of the developed hydrological and optimization models and suggests areas for future research, particularly in refining GI modeling techniques and expanding the optimization framework to address diverse urban environments and more complex climate projections.

