AN URBAN DENSITY-BASED RUNOFF SIMULATION FRAMEWORK TO ENVISAGE FLOOD RESILIENCE OF CITIES.

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218030 R

Degree of Master Science by Research

Department of Town & Country Planning

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Declaration

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The above candidate has carried out research for the Masters/~~MPhil/PhD~~ thesis/ Dissertation under my supervision.

Name of the supervisor: Supervisor1 : Dr.(Ms) Chethika Abenayake

Supervisor2 : Dr. Amila Jayasinghe

Signature of the supervisor:…… Date : ……03.07.2023……

Dr.(Ms) Chethika Abenayake

Signature of the supervisor:…… Date : ……03.07.2023……

(Dr. Amila Jayasinghe)

Abstract

Urban form densities play a decisive role in complex urban form scenarios. Therefore, learning to 'live with the floods'; has become a challenging issue to practice in most urban planning approaches. Several simulation studies have been conducted to examine the influence of urbanization scenarios on urban flood risk management. Yet, there is a gap remaining to optimize every component of flood hydrodynamics across a distinct urban form density. As a result, the economic loss to the urban system is hard to minimize. But planning an intervention with a proper quantification approach for a long-term flood management strategy is useful for making cities resilience to floods. The primary aim of this research is to create a spatial simulation framework that can evaluate how urban density(UD) affects surface runoff (SR) in urban watersheds in various urban form scenarios. First, examine the potential quantification indicators of urban form density. Second, develop a framework to quantify urban form density at the urban watershed scale, which applies to spatial structure. The third step involves creating an SR simulation model that utilizes the 13 selected UD indicators to verify and validate the previously developed framework with real-world data, with the main three categories (3Ds') as per the developed framework. The model evaluates itself with AI-based Decision Tree Analysis incorporated with correlation and experts' opinions. The model results indicate that the UD indicators including impervious coverage (accuracy level 98.7%), OSR (accuracy level 94.8%), and road density (accuracy level 93.5%) are the key indicators combined with the population density, accessibility, and built_up coverage to regulate SR in urban catchments. The ground verification of model results indicates an R2 value greater than 0.88. The ultimate goal of this study is to create a method of quantitatively evaluating the effects of physical UD as an independent variable, allowing for a more location specific manner. This study contributes a novel framework incorporating 3Ds (density, diversity, design) to quantify UD, which will aid subsequent processes of decision-making in the realm of urban flood mitigation and planning techniques.

Keywords: Urban flood, Urban density (UD), Surface runoff (SR), planning & decision-making, resilience

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Acknowledgment

First, I would like to express my sincere gratitude to my research supervisors, Dr.(Ms) Chethika Abenayake and Dr. Amila Jayasinghe from the University of Moratuwa, Faculty of Architecture, Department of Town and Country Planning, for their invaluable guidance, support, and encouragement throughout my research journey.

I would also like to extend my heartfelt appreciation to Dr. Nuwan Dias from the University of Huddersfield in the UK, my external supervisor, for providing me with his expert opinion, valuable suggestions and comments on my work.

Special thanks are also due to the Urban Development Authority (UDA) in Sri Lanka, for providing me with valuable data and resources during the course of my research. I am also grateful to Prof. J.N. Munasinghe, Head of the Department of Town and Country Planning and Dr. R.M.S.R. Rathnayake, Postgraduate Coordinator in the department, for their support and advice throughout my study.

I would like to thank my colleagues at the Laboratory of 'Urban Simulation Lab' who have been a constant source of inspiration, encouragement, and support. Their academic, logistic, and emotional support has been invaluable to me throughout my research journey.

Finally, I would like to thank my family and friends for their unwavering support, love, and encouragement throughout my academic pursuit.

List of Abbreviations

2D RRI	Two-Dimensional Rainfall-Runoff-Inundation
3Di	Three-dimensional flood model
3Ds	Density, Diversity, Design
AI	Artificial Intelligence
ARW	Access Road Width
BD	Building Density
BEATS	Biophysical Environments and Technologies Simulator
BH	Building Height
CD	Colombo District
DD	Derange Density
DE	Design Elements
DEM	Digital Elevation Model
DS	Digital Simulation
DTA	Decision Tree Analysis
EPA	Environmental Protection Agency
FAR	Floor Area Ratio
FSI	Floor Space Index
GI	Green Infrastructure
GIS	Geographic Information System
GSI	Ground Space Index
HEC-RAS	Horologic Engineering Center's River Analysis System
IC	Impervious Coverage
KD	Kalutara District
L	Local
LID	Low Impact Development
ML	Machine Learning
NBS	Nature based solution
OSR	Opens space ratio
PCSWMM	Personal Computer Storm Water Management Model
PD	population density
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
R	Regional
RD	Road density
RS	Remote Sensing based
SD	Spatial Density
SR	Surface Runoff
SUDS	sustainable urban drainage system
SWMM	Storm Water Management Model
UD	Urban Density
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
USD	United States Dollar
USMS	Urban water management system/techniques
WSUD	water sensitive urban design