

ISBN-978-81-69623-05-6

URBAN FLOOD MITIGATION

BY
**SUSTAINABLE
STORM WATER
MANAGEMENT**



**REDUCE
FLOOD RISK**



**NATURE-BASED
SOLUTIONS**



**IMPROVE
WATER QUALITY**



**BUILD CLIMATE
RESILIENT CITIES**



**ENHANCE URBAN
LIVABILITY**

**Dr. Chanapathi Tirupathi, Dr. B. Venkata Shiva Kumar,
Dr. B. Visweswara Reddy, Dr. Balla Satyanarayana,
S. Ashok Kumar, Dr. Kusuma Sundara Kumar**



- 1. Dr. Chanapathi Tirupathi**
Associate Professor, Department of Civil Engineering
Sasi Institute of Technology & Engineering, Tadepalligudem, Andhra Pradesh, India
- 2. Dr. B. Venkata Shiva Kumar**
Professor & HoD, Department of Civil Engineering
WISTM Engineering College, Pendurthi, Visakhapatnam, Andhra Pradesh, India
- 3. Dr. B. Visweswara Reddy**
Associate Professor, Department of Civil Engineering
Aditya Institute of Technology and Management, Tekkali, Andhra Pradesh, India,
- 4. Dr. Balla Satyanarayana**
Associate Professor, Department of Civil Engineering
Pragati Engineering College, ADB Road, Surampalem. Andhra Pradesh, India
- 5. Mr. S. Ashok Kumar**
Associate Professor and Head, Civil Engineering Department, DVR & Dr. HS MIC
College of Technology (A), Kanchikacherla, Andhra Pradesh, India
- 6. Dr. Kusuma Sundara Kumar**
Professor & HoD, Department of Civil Engineering
Ramachandra College of Engineering (A), Eluru, Andhra Pradesh, India, India

Urban Flood Mitigation by Sustainable Storm Water Management

Author(s) : Dr. Chanapathi Tirupathi
Dr. B. Venkata Shiva Kumar
Dr. B. Visweswara Reddy
Dr. Balla Satyanarayana
S. Ashok Kumar
Dr. Kusuma Sundara Kumar

ISBN : 978-81-69623-05-6

Page(s) : 318, xiii

Price : Rs.1800/-

Published Year : May, 2026

Published by : Excellent Publishers
No. 38/48, Second street, Ellappa Nagar
Kanchipuram – 631501, Tamilnadu, India.
Cell +91-9842641794
excellentpublishers2013@gmail.com
www.excellentpublishers.com



Disclaimer :

The author is solely responsible for the contents of the book in this volume in any manner, Errors, if any are purely unintentional and readers are requested to communicate such errors to the authors to discrepancies in futures.

Note: No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher.

Copyright © 2026 Excellent Publishers, All Rights Reserved

PREFACE

Dear Reader,

Urban flooding has emerged as one of the most pressing challenges confronting cities across the world, particularly in rapidly urbanizing countries such as India. The increasing frequency of short-duration, high-intensity rainfall events, coupled with unplanned urban expansion, loss of natural drainage systems, encroachment of water bodies, and aging stormwater infrastructure, has transformed urban flooding from an occasional hazard into a recurring threat to sustainable development. Floods in cities not only damage infrastructure and disrupt economic activities but also endanger lives, degrade the environment, and undermine urban resilience. Addressing these challenges demands a fundamental shift from conventional drainage-based approaches toward integrated, sustainable, and climate-resilient stormwater management.

This book, **Urban Flood Mitigation by Sustainable Storm Water Management**, has been written to provide a comprehensive understanding of urban flooding and the engineering principles, planning strategies, and sustainable solutions required to mitigate its impacts. The content systematically progresses from the fundamentals of urban hydrology and rainfall-runoff processes to advanced topics such as hydrologic and hydraulic modelling, GIS and remote sensing applications, flood forecasting and early warning systems, climate change adaptation, smart stormwater management, nature-based solutions, and integrated urban flood governance. Special emphasis has been placed on Sustainable Urban Drainage Systems (SUDS), Low Impact Development (LID), Water Sensitive Urban Design (WSUD), green infrastructure, and other contemporary practices that are increasingly being adopted worldwide.

A distinguishing feature of this book is its strong focus on the **Indian context**. Numerous examples, case studies, institutional frameworks, national policies, and urban development initiatives have been incorporated to relate engineering concepts to real-world challenges faced by Indian cities. The discussions are aligned with current initiatives such as the Smart Cities Mission, AMRUT, the National Disaster Management Authority (NDMA) guidelines, and the broader objectives of climate-resilient and sustainable urban development. This practical orientation enables readers to appreciate both the technical and policy dimensions of urban flood management.

The book has been prepared primarily for undergraduate and postgraduate students of Civil Engineering, Water Resources Engineering, Environmental Engineering, Urban Planning, and Disaster Management. It will also serve as a valuable reference for researchers, practicing engineers, urban planners, municipal officials, consultants, policymakers, and professionals engaged in the planning, design, operation, and management of urban stormwater systems. To facilitate learning and examination preparation, each chapter includes clearly explained concepts supported by illustrations, tables, review questions, and multiple-choice questions.

While every effort has been made to ensure the technical accuracy and clarity of the material, the field of urban flood management is rapidly evolving with continuous advancements in climate science, digital technologies, artificial intelligence, and sustainable infrastructure. Readers are therefore encouraged to complement the concepts presented in this book with current standards, guidelines, and recent research.

It is my sincere hope that this book will contribute to a deeper understanding of sustainable stormwater management and inspire engineers, planners, researchers, and decision-makers to develop innovative, resilient, and environmentally responsible solutions for the growing challenges of urban flooding. If this work helps readers build safer, smarter, and more sustainable cities for future generations, its purpose will have been fulfilled.

Dr. Chanapathi Tirupathi
Dr. B. Venkata Shiva Kumar
Dr. B. Visweswara Reddy
Dr. Balla Satyanarayana
S. Ashok Kumar
Dr. Kusuma Sundara Kumar

Foreword

Urban flooding has become one of the defining challenges of the twenty-first century. Rapid urbanization, climate change, population growth, and increasing pressure on urban infrastructure have significantly altered the hydrological balance of our cities, making them more vulnerable to frequent and intense flood events. The consequences extend far beyond physical damage to infrastructure—they affect public health, economic productivity, environmental sustainability, and the overall quality of urban life. In this context, sustainable stormwater management is no longer an optional engineering practice but a fundamental requirement for resilient urban development.

The book *Urban Flood Mitigation by Sustainable Storm Water Management* provides a comprehensive and timely contribution to this important field. It successfully integrates the principles of urban hydrology, hydraulic engineering, climate resilience, environmental sustainability, and smart urban planning into a single, well-structured volume. Beginning with the fundamentals of urban flooding and hydrologic processes, the book systematically advances through rainfall-runoff analysis, drainage system design, hydrologic and hydraulic modelling, GIS applications, sustainable urban drainage systems, green infrastructure, flood forecasting, climate change adaptation, and integrated flood governance.

One of the notable strengths of this book is its emphasis on sustainable and nature-based approaches to flood management. Rather than relying solely on conventional drainage systems, it highlights innovative strategies such as Sustainable Urban Drainage Systems (SUDS), Low Impact Development (LID), Water Sensitive Urban Design (WSUD), green roofs, permeable pavements, rain gardens, bioswales, detention and retention systems, and smart stormwater management technologies. These approaches represent the future of urban water management and are essential for developing cities that are both resilient and environmentally sustainable.

Another commendable aspect is the book's focus on the Indian scenario. By discussing urban flooding in the context of Indian cities and linking engineering practices with national initiatives such as the Smart Cities Mission, AMRUT, and the guidelines of the National Disaster Management Authority (NDMA), the author has made the subject highly relevant to students, researchers, practitioners, and policymakers. The inclusion of case studies, illustrations, review questions, and practical examples further enhances the educational value of the book.

The material has been presented in a logical, reader-friendly manner without compromising technical rigor. It serves not only as a textbook for undergraduate and postgraduate students of Civil Engineering, Water Resources Engineering,

Environmental Engineering, Urban Planning, and Disaster Management, but also as a valuable reference for practicing engineers, consultants, municipal officials, researchers, and professionals involved in urban infrastructure planning and flood risk management.

The challenges posed by climate change and rapid urbanization require engineers and planners to adopt innovative, multidisciplinary, and sustainable solutions. This book encourages such an approach by combining sound engineering principles with environmental stewardship and modern technological advancements. It will undoubtedly contribute to developing the knowledge and skills needed to design safer, smarter, and more resilient urban environments.

I congratulate the author on this valuable contribution to the field of urban water resources engineering and sustainable urban development. I am confident that *Urban Flood Mitigation by Sustainable Storm Water Management* will serve as an important academic resource and practical reference, benefiting students, educators, researchers, practicing engineers, urban planners, and decision-makers alike. I wish this publication every success and hope that it inspires continued innovation in building flood-resilient and sustainable cities.

Prof. Dr. K.Padma Kumari
Professor & Head
Department of Civil Engineering
JNTUK-Kakinada, India

About the Book

Urban Flood Mitigation by Sustainable Storm Water Management is a comprehensive textbook that presents the principles, practices, and emerging technologies required to address one of the most significant challenges facing modern cities—urban flooding. With rapid urbanization, increasing impervious surfaces, aging drainage infrastructure, and the growing impacts of climate change, urban flood management has become a critical component of sustainable urban development. This book provides a systematic understanding of these challenges and introduces practical, engineering-based solutions for developing resilient and water-sensitive cities.

The book begins by explaining the fundamentals of urban flooding, urban hydrology, rainfall–runoff processes, and stormwater drainage systems. It then explores hydrologic and hydraulic modelling techniques, GIS and remote sensing applications, flood hazard and risk assessment, climate-resilient planning, and smart stormwater management technologies. Particular emphasis is placed on Sustainable Urban Drainage Systems (SUDS), Low Impact Development (LID), Water Sensitive Urban Design (WSUD), green infrastructure, rainwater harvesting, nature-based solutions, and integrated watershed management. These approaches are presented as effective alternatives to conventional drainage systems, enabling cities to reduce flood risks while improving water quality, groundwater recharge, and environmental sustainability.

A distinguishing feature of this book is its strong emphasis on the **Indian urban context**. It examines the causes and impacts of urban flooding in Indian cities and discusses national policies, institutional frameworks, and government initiatives such as the Smart Cities Mission, AMRUT, and the National Disaster Management Authority (NDMA) guidelines. Numerous case studies, illustrations, tables, and conceptual diagrams help bridge the gap between theory and practical implementation, making complex engineering concepts accessible to readers.

Designed to support both academic learning and professional practice, the book includes well-structured chapters, review questions, multiple-choice questions, and practical examples that encourage critical thinking and application of knowledge. It serves as an ideal resource for undergraduate and postgraduate students of Civil Engineering, Water Resources Engineering, Environmental Engineering, Urban Planning, and Disaster Management, while also providing valuable guidance for practicing engineers, consultants, municipal officials, researchers, urban planners, and policymakers involved in flood risk reduction and sustainable infrastructure development.

By integrating engineering principles with climate resilience, environmental sustainability, and modern digital technologies, **Urban Flood Mitigation by Sustainable Storm Water Management** offers a holistic roadmap for creating safer, smarter, and more resilient urban environments. It is an essential reference for anyone committed to advancing sustainable stormwater management and building flood-resilient cities for the future.

Table of Contents

Item	Pg. No
Chapter 1 – Introduction	2
1.1 Overview of Urban Flooding	2
1.2 Characteristics of Urban Flooding	3
1.3 Causes of Urban Flooding	11
1.4 Impacts of Urban Flooding	16
1.5 Urban Flooding in the Indian Context	21
1.6 Need for Sustainable Storm Water Management	25
Chapter 2 – Fundamentals of Urban Hydrology	33
2.1 Urban Hydrologic Cycle	33
2.2 Rainfall Characteristics in Urban Areas	38
2.3 Rainfall–Runoff Processes	44
2.4 Imperviousness and Urban Runoff	49
2.5 Time of Concentration and Peak Flow	54
Chapter 3 – Urban Drainage Systems	61
3.1 Types of Urban Drainage Systems	61
3.2 Components of Urban Drainage Systems	69
3.3 Design Considerations for Urban Drainage	74
3.4 Limitations of Conventional Urban Drainage Systems	76
3.5 Need for Sustainable Urban Drainage Systems	77
3.6 Integration of Drainage Systems with Urban Planning	82
Chapter 4 – Sustainable Storm Water Management Concepts	86
4.1 Principles of Sustainable Storm Water Management	86
4.2 Conventional vs Sustainable Storm Water Management Approaches	91
4.3 Source Control Measures in Storm Water Management	94
4.4 Decentralized Storm Water Management Systems	96
4.5 Role of Green Infrastructure in Storm Water Management	97
4.6 Policy, Planning, and Implementation Challenges in Sustainable Storm Water Management	103
Chapter 5 – Urban Flood Risk Assessment	107
5.1 Concept of Flood Risk and Hazard	107
5.2 Factors Influencing Urban Flood Risk	113
5.3 Methods of Urban Flood Risk Assessment	114
5.4 Flood Hazard Mapping and Zonation	119
5.5 Vulnerability and Exposure Assessment	121
5.6 Role of Flood Risk Assessment in Urban Flood Mitigation	122
Chapter 6 – Urban Drainage System and Design Considerations	126
6.1 Types of Urban Drainage Systems	126
6.2 Design Criteria for Urban Drainage Systems	130

6.3 Storm Water Collection and Conveyance Systems	131
6.4 Drainage Network Capacity and Performance Evaluation	134
6.5 Maintenance Issues and Drainage Failures	137
6.6 Integration of Drainage Systems with Sustainable Storm Water Management	140
Chapter 7 – Sustainable Urban Drainage Systems (SUDS)	145
7.1 Principles of Sustainable Urban Drainage Systems (SUDS)	145
7.2 Components and Techniques of SUDS	151
7.3 Design Considerations for SUDS	152
7.4 Performance Evaluation of SUDS	153
7.5 Benefits and Limitations of SUDS	158
7.6 Case Studies of SUDS Implementation	160
Chapter 8 – Urban Storm Water Management Planning	163
8.1 Introduction to Urban Storm Water Management Planning	163
8.2 Components of an Urban Storm Water Management Plan	165
8.3 Planning Approaches for Urban Storm Water Management	171
8.4 Role of Urban Planning and Land Use Control in Storm Water Management	172
8.5 Institutional, Legal, and Policy Framework for Storm Water Management	174
8.6 Preparation and Implementation of Urban Storm Water Management Plans	179
Chapter 9 – Urban Flood Mitigation Measures and Strategies	183
9.1 Introduction to Urban Flood Mitigation	183
9.2 Structural Flood Mitigation Measures	187
9.3 Non-Structural Flood Mitigation Measures	193
9.4 Sustainable Storm Water Management for Flood Mitigation	194
9.5 Emergency Preparedness and Response Measures	195
9.6 Integrated Urban Flood Mitigation Strategies	204
Chapter 10 – Climate Change and Urban Flooding	207
10.1 Introduction to Climate Change and Urban Flooding	207
10.2 Impact of Climate Change on Urban Hydrology	208
10.3 Urban Vulnerability to Climate-Induced Flooding	212
10.4 Climate Change Adaptation Strategies for Urban Flooding	213
10.5 Role of Policy and Planning in Climate-Resilient Flood Management	219
10.6 Climate-Resilient Storm Water Management Practices	225
Chapter 11 – Urban Flood Modelling and Simulation	232
11.1 Introduction to Urban Flood Modelling	232
11.2 Classification of Urban Flood Models	232
11.3 Urban Hydrologic Modeling	234
11.4 Hydraulic Modelling of Urban Drainage Systems	241
11.5 Surface Flood Inundation Modelling	242
11.6 Data Requirements for Urban Flood Modelling	243
11.7 Model Calibration, Validation, and Uncertainty Analysis	245
11.8 Applications of Urban Flood Modeling in Planning and Mitigation	246
11.9 Advantages, Limitations, and Future Trends	246
Chapter 12 – Role of GIS and Remote Sensing in Urban Flood	250

Management	
12.1 Introduction to GIS and Remote Sensing in Urban Flood Management	250
12.2 Fundamentals of GIS for Urban Flood Studies	251
12.3 Role of Remote Sensing in Urban Flood Assessment	254
12.4 GIS-Based Urban Flood Hazard Mapping	255
12.5 GIS-Based Flood Risk and Vulnerability Assessment	258
12.6 Integration of GIS, Remote Sensing, and Flood Models	260
Chapter 13 – Urban Flood Early Warning Systems and Disaster Management	263
13.1 Introduction to Urban Flood Early Warning Systems	263
13.2 Components of Urban Flood Forecasting and Warning Systems	264
13.3 Institutional Framework for Urban Flood Disaster Management	269
13.4 Urban Flood Preparedness and Response Strategies	276
13.5 Post-Flood Recovery, Rehabilitation, and Mitigation	277
13.6 Role of Technology and Community Participation	278
Chapter 14 – Policy, Governance, and Institutional Framework for Urban Flood Management	281
14.1 Introduction to Urban Flood Governance	281
14.2 National-Level Policy and Institutional Framework in India	281
14.3 State-Level and Urban Local Body Governance	283
14.4 Legal and Regulatory Instruments for Urban Flood Management	284
14.5 Challenges in Urban Flood Governance	287
14.6 Integrated and Participatory Governance Approaches	288
Chapter 15 – Case Studies of Urban Flood Management (India and Global)	292
15.1 Importance of Case Studies in Urban Flood Management	292
15.2 Urban Flood Case Studies from India	292
15.3 Additional Urban Flood Case Studies from India	295
15.4 International Case Studies of Urban Flood Management	297
15.5 Comparative Analysis of Indian and Global Case Studies	298
15.6 Key Lessons and Way Forward from Case Studies	300
Chapter 16 – Future Trends and Innovations in Sustainable Storm Water Management	304
16.1 Introduction to Future Challenges in Urban Storm Water Management	304
16.2 Nature-Based Solutions and Green Infrastructure	304
16.3 Smart Storm Water Systems and Digital Technologies	306
16.4 Nature-Based Solutions and Green Infrastructure Innovations	307
16.5 Climate-Resilient and Adaptive Urban Planning	308
16.6 Vision for Flood-Resilient and Sustainable Cities	309
References	313