

Urban Sustainability

Ali Cheshmehzangi
Maycon Sedrez
Andrew Flynn *Editors*

Rethinking Stormwater Management through Sustainable Urban Design

 Springer

Urban Sustainability

Editor-in-Chief

Ali Cheshmehzangi, School of Architecture, Design and Planning, The University of Queensland, Brisbane, QLD, Australia

The Urban Sustainability Book Series is a valuable resource for sustainability and urban-related education and research. It offers an inter-disciplinary platform covering all four areas of practice, policy, education, research, and their nexus. The publications in this series are related to critical areas of sustainability, urban studies, planning, and urban geography.

This book series aims to put together cutting-edge research findings linked to the overarching field of urban sustainability. The scope and nature of the topic are broad and interdisciplinary and bring together various associated disciplines from sustainable development, environmental sciences, urbanism, etc. With many advanced research findings in the field, there is a need to put together various discussions and contributions on specific sustainability fields, covering a good range of topics on sustainable development, sustainable urbanism, and urban sustainability. Despite the broad range of issues, we note the importance of practical and policy-oriented directions, extending the literature and directions and pathways towards achieving urban sustainability.

The series will appeal to urbanists, geographers, planners, engineers, architects, governmental authorities, policymakers, researchers of all levels, and to all of those interested in a wide-ranging overview of urban sustainability and its associated fields. The series includes monographs and edited volumes, covering a range of topics under the urban sustainability topic, which can also be used for teaching materials.

Ali Cheshmehzangi · Maycon Sedrez ·
Andrew Flynn
Editors

Rethinking Stormwater Management through Sustainable Urban Design

 Springer

Editors

Ali Cheshmehzangi
School of Architecture, Design
and Planning,
The University of Queensland
Brisbane, QLD, Australia

Maycon Sedrez
Deakin University
Geelong, VIC, Australia

Andrew Flynn
Cardiff University
Cardiff, UK

ISSN 2731-6483

Urban Sustainability

ISBN 978-981-97-4923-2

<https://doi.org/10.1007/978-981-97-4924-9>

ISSN 2731-6491 (electronic)

ISBN 978-981-97-4924-9 (eBook)

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Singapore Pte Ltd. 2024

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd. The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

If disposing of this product, please recycle the paper.



The Redemption Island Photo taken by Ali Cheshmehzangi, the closest beach to Chengyang, the City of Qingdao, 2 October 2023

For the vulnerable Communities who need urgent attention and support.

We collectively dedicate this book to the vulnerable communities worldwide who are disproportionately affected by the hazards of weather-water-related disasters, encompassing phenomena such as drought and aridification, floods, water scarcity, wildfires, pollution, and others. Our dedication is underscored by the recognition of the imperative for genuine reconsideration towards the development of environmentally focused innovations and human-centric solutions. Failure to address these pressing issues may exacerbate the phenomenon of “forced displacement”, amplifying its impact on vulnerable populations.

Preface

“Just as the philosophers of the past challenged the paradigm that guided mankind for thousands of years, we too must challenge the current paradigm we find ourselves trapped in—the industrialist, capitalist world order”.

—Yamin Kogoya

In the relentless process of urbanisation and the almost-non-ending process of development and growth, cities have emerged as critical epicenters of human activity, innovation, and opportunity. Yet, amidst the towering skyscrapers, bustling streets, and vibrant communities, lies many urban pressures and hidden challenges—one of which is “stormwater management” that correlates well with resilience and healthiness of our cities and urban environments. Traditional approaches to managing stormwater in urban environments have often been inefficient, unsustainable, and environmentally damaging. Some even had adverse impacts on our cities’ structure, ecological capacity, biodiversity, infrastructures, etc. However, in recent years, a paradigm shift has begun to take shape, one that embraces sustainable urban design as the key to rethinking stormwater management.

To follow this shift—and hopefully new direction—this book, ***“Rethinking Stormwater Management through Sustainable Urban Design.”*** delves into the critical intersection of urban development (and design) and water management. It explores innovative strategies, cutting-edge technologies, and holistic approaches that promise to revolutionise how we think about and manage stormwater in our cities. The need for a new approach to stormwater management has never been more compelling, particularly as we experience climate change impacts on our cities. With rapid urbanisation, sprawling impervious surfaces, and the looming specter of climate change, traditional stormwater infrastructures are increasingly strained and inadequate. Urban flooding, water pollution, habitat destruction, and ecosystem degradation are just some of the consequences of our current system’s shortcomings.

Yet, within these challenges lies an opportunity for transformation; i.e., in a sort of paradigm shift mindset towards enhancing sustainable urban design solutions

in practice and via policy development. Sustainable urban design offers a pathway towards resilience, efficiency, and harmony with the natural world. By integrating green infrastructure, low-impact development techniques, sponge city initiatives and KPIs, nature-based solutions (NBSs), and smart water management practices, cities can not only mitigate the impacts of stormwater but also enhance their liveability, sustainability, and overall quality of life.

This book is a testament to the power of interdisciplinary collaboration and forward-thinking innovation. It brings together insights from urban planners, architects, engineers, ecologists, policymakers, and key stakeholders to present a comprehensive overview of the state-of-the-art in sustainable stormwater management, particularly through sustainable urban design.

Through a series of case studies, best practices, and theoretical explorations, readers will gain a deep understanding of the principles and practices driving the shift towards sustainable urban design. From green roofs and permeable pavements to rain gardens and constructed wetlands, a diverse array of strategies is discussed (even if not showcased *per se*), each demonstrating the potential to transform our cities into more resilient, adaptable, and sustainable landscapes. With all these, we plan to move ahead with a forward-thinking approach/mindset in making cities healthier and more resilient, too.

At its core, this book is about reimagining the relationship between cities and water beyond just the traditional management perspectives. It challenges us to move beyond the outdated notion of stormwater as a nuisance to be swiftly drained away, and instead, embrace it as a valuable resource to be managed, utilised, and celebrated. Hence, new policy development and paradigm shifts are essential. By adopting a more holistic and integrated approach to water management, cities can unlock a host of benefits, from improved water quality and reduced flood risk to enhanced biodiversity and enhanced urban aesthetics. Nonetheless, the transition to sustainable stormwater management is not without its challenges. It requires a fundamental shift in mindset, policy, and practice, as well as a willingness to embrace uncertainty, complexity, and experimentation. It also demands collaboration across disciplines, sectors, and scales, as well as meaningful engagement with local communities and stakeholders.

As sustainable urban futures are become closer to reality beyond their initial conceptions, it is essential to acknowledge the interconnectedness of our actions and their broader implications on cities and communities worldwide. What happens upstream affects downstream, and what we do in our cities reverberates across landscapes, watersheds, and ecosystems. A healthier cycle of development is, therefore, ever needed before we come up with new forms of development and higher quality urbanisation patterns. Therefore, our approach to stormwater management must be as holistic and interconnected as the systems it seeks to protect and enhance. This can happen through the sphere of sustainable urban design where interdisciplinary practices are embedded, encouraged, and practiced.

This book is intended to serve as a guide, a catalyst, and a call to action for anyone involved in the planning, design, development, or management of urban environments. In particular, it helps designers, planners, and policy makers who are constantly involved with various urban challenges. Whether you are an experienced

practitioner, a concerned citizen, or a curious student, there is something here for you to gain knowing that it is time to rethink our practices and paradigms and shift away from business-as-usual (BAU) scenarios. It is our overarching hope that the insights, ideas, and inspiration contained within this book will spark new conversations, foster innovative solutions, and ultimately contribute to the creation of more resilient, sustainable, and equitable cities for all. We advocate all to use these innovation, suggestions, and examples as the backbone of what may—and must—become the new era of sustainable urban design. Let us not just embrace these transformations but lead them in the most people-centric, environmentally friendly, and viable way.

Brisbane, Australia
Geelong, Australia
Cardiff, UK

Ali Cheshmehzangi
Maycon Sedrez
Andrew Flynn

Acknowledgements

We would like to express our gratitude to all authors, co-authors, chapter contributors, and collaborators who have contributed their expertise, passion, and creativity to this endeavour. Their dedication and vision have made this book possible, and we are glad to have been a part of this collaborative effort with excellent global scholars. Together, let us continue to rethink stormwater management and shape a brighter future for our cities and our planet.

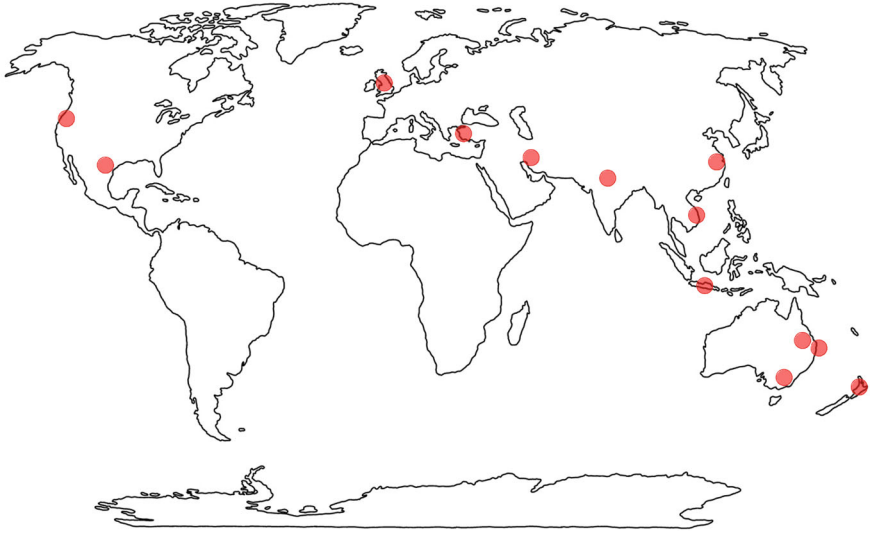
About This Book

This book provides a different narrative and approach to *rethinking stormwater management through sustainable urban design*. It delves into design interventions and innovative strategies that lead to solving context-specific issues of flooding, water scarcity, etc. Starting with an overarching introduction and discussion on stormwater management research, the book then primarily focuses on sustainable urban design practices, strategies, and policy guidelines.

By summarising a selection of successful global case study examples, the book highlights how we should rethink stormwater management practices and policies from the design perspective. Through sustainable urban design suggestions, the book covers a wide range of conceptual examples to design and policy guidelines, as well as best practices that could be utilised for other contexts.

The book is divided into two sections of: (1) architectural and urban design practices and interventions, and (2) policies and action plans. This collection helps researchers and scholars rethink stormwater management and consider innovative—and, more importantly, sustainable—design strategies that could help develop new paradigms and policies for water-related issues in cities and communities. This will interest multiple stakeholders, mainly urban policymakers, planners, urban designers, urban specialists, landscape architects, architects, and urban ecologists. It could be treated as a case study-based guide for governmental units dealing with water-related issues in cities and urban areas.

The book brings together case study examples from around the world. The map below is just to provide a summary of the case study locations.



Contents

Stormwater Management: Issues, Opportunities, and Challenges in Cities and Communities	1
Ali Cheshmehzangi, Maycon Sedrez, and Andrew Flynn	
Architectural and Urban Design Practices and Interventions	
Urban Stormwater Runoff Management Using Low-Impact Development: Case Study of Portland	25
Amirmohamad Parvanehdehkordi, Borhan Sepehri, and Mohammad Anvar Adibhesami	
Towards Water-Sensitive Urban Design Through Polycentric Participatory Approaches. The Case Study of Sariharjo, Sleman Regency, Indonesia	45
Xhesika Hoxha, Anna Wilk-Pham, Frederic Hebbeker, and Tino Imsirovic	
The Urban Growth Challenges of Implementing Nature-Based Solutions for Stormwater Management in Ho Chi Minh City, Vietnam	75
Nigel K. Downes, Pham Quoc Viet, Trong Nhan Huynh, Thanh Hung Dang, and Harry Storch	
UoNJC and ANR: The Two UK Case Studies of Stormwater Management Through SuDS	89
Yanhui Lei	
Waterfront Public Spaces and Collective Assemblages	117
Teresa Hoskyns	
From Recovery to Adaptation: The Impact of Floodwater on Suburban Sporting Fields and Communities	133
Kirsty Volz, Kylie Keioskie, and Daniel Nyandega	

Harmonising Water Sensitive Design for Sustainable Stormwater Management: Challenges and Opportunities in Auckland’s Urban Development 153
 Iresh Jayawardena

Policies and Action Plans

Sustainable Urban Design for Stormwater Management: Concepts and Reviews 179
 Reza Farhadi, Keramatollah Ziari, Shima Bakhshayeshi, Maryam Noroozi, Saeedeh Nasehi, and Reza Askarizad

Geospatial Thinking to Prioritise and Inform LID Retrofits and Ecological Placemaking for BMP Sites 197
 Azza Kamal

Assessing Australian Construction Industry’s Stormwater Management Policy Coherence and Coordination in the Lens of Circular Economy 215
 Gayani Karunasena and Yi Lu

An Analysis of Key Performance Indicators for Sustainable Urban Stormwater Management: A Case Study of Bursa, Turkey 235
 Abdulrahman Hassanin and Didem Güneş Yilmaz

Framework for Stormwater Management in Subtropical Australian Cities Using Green Hydrogen 249
 Hirou Karimi, Mohammad Anvar Adibhesami, Borhan Sepehri, Amirmohammad Parvanehdehkordi, Arman Karimi, and Aisan Salemi

Beyond Water: Step Wells and Community Hydraulics in Modern India 273
 Manu P. Sobti and Ali Rad Yousefnia

Rethinking the Design and Water Management of Urban Waterside to Improve the Sustainable Environmental Quality of Cities 293
 Hadi RezaeiRad and Behdad Beyranvand Nezhad

Aligning with Stormwater Management But from the Urban Design Perspective: Towards Sustainability-Driven and Water-Based Planning and Design 319
 Ali Cheshmehzangi, Maycon Sedrez, and Andrew Flynn

Editors and Contributors

About the Editors

Ali Cheshmehzangi is a Full Professor and Head of the School of Architecture, Design and Planning (ADP) at the University of Queensland, where he leads the School and researches across the fields of architecture, design, and planning/urbanism. He has been the World's top 2% field leader since 2022, recognised by Stanford University. He is among the top 30 global scholars in the urban sustainability research area. Ali is internationally known for his scholarly contribution and extended work on climate resilience and sustainable urbanism research. Prior to joining UQ, Ali held several strategic leadership and senior managerial roles, such as Vice-President for International Engagement and Global Partnership, Founding Director/Head of the Center for Innovation in Education and Research, Head of the Department of Architecture and Built Environment, Founding Director of the Urban Innovation Lab, Director of a university-wide Teaching and Learning platform, Director of International Research Network for Rural and Urban Development, Head of Research Group for Sustainable Built Environment, co-director of university-wide research priority areas, Director of Center for Sustainable Energy Technologies, and Interim Director of Digital Design Lab. So far, Ali has published over 500 journal papers, articles, conference papers, book chapters, and reports. He also has 26 other academic books, three of which have received awards at the national, provincial, and municipal levels. He also has received international awards and recognition for his research on urban resilience studies and sustainability research, as well as a Vice-Chancellor's award for his impactful contribution to higher education.

Maycon Sedrez is an architect and urban designer professional currently serving as a Lecturer in Architecture at Deakin University. His international academic journey includes a role as an Assistant Professor at the University of Nottingham Ningbo China from 2019 to 2023. During this tenure, Maycon contributed extensively as the Deputy Head of the department and Course Director. Notably, he led the Digital Design Lab, researching parametric design, traditional Chinese architecture, and

urban analytics. He also led the development of the innovative brainstorming game Greenicity—a tool to design greener cities. Prior to his role in China, Maycon worked as a postdoc researcher at the Institute for Sustainable Urbanism (TU Braunschweig) in Germany from 2016 to 2019. His research focused on urban-rural spaces, urban mobility, and sustainable development. During this period, he organized the international conference ISU Talks Future Cities; contributed to the development of TOPOI—a method for analysing settlement units; and the Berlin’s high-rises research for the city senate as part of the ISU + COBE Berlin team. Maycon’s multi-disciplinary approach is evident in his diverse works, ranging from analytical maps and participatory approaches to parametric designs. His engagement with art and illustration has led to publications in Brazil and Germany, with artworks exhibited in Brazil, China, and most recently in Australia. This artistic exploration informs his architectural design studios, creating a unique blend of research and creativity. His passion for these diverse fields reflects a holistic approach to both academic, teaching, and creative pursuits.

Andrew Flynn is a Full Professor in Environmental Policy and Planning. He is internationally known for his leadership in his research area, focusing mainly on planning and policy directions. He has a background in policy analysis and environmental geography. His principal research interests have been in the making and delivery of policy on sustainable development, the implementation of policy and its evaluation. In exploring the dynamics of policy and regulation he paid particular attention to the food system. His work on food supply chains and technological innovations in the food system have provided insights into the relationships between the state and key economic interests and how these have led to new patterns of regulation. This in turn, has helped to inform work on environmental regulation, particularly in relation to the role of supply chains.

Contributors

Mohammad Anvar Adibhesami School of Architecture and Environmental Design, Iran University of Science and Technology, Narmak, Tehran, Iran

Reza Askarizad Department of Urban and Regional Planning, Universidad Politécnica de Madrid, Madrid, Spain

Shima Bakhshayeshi Department of Horticulture and Landscape Architecture, Ferdowsi University of Mashhad, Mashhad, Iran

Behdad Beyranvand Nezhad Department of Urbanism, Faculty of Art and Architecture, Bu-Ali Sina University, Hamedan, Iran

Ali Cheshmehzangi School of Architecture, Design and Planning, The University of Queensland (UQ), Brisbane, QLD, Australia;

Network for Education and Research on Peace and Sustainability (NERPS),
Hiroshima University, Hiroshima, Japan

Thanh Hung Dang Ho Chi Minh City University of Architecture, Ho Chi Minh
University, Ho Chi Minh City, Vietnam

Nigel K. Downes College of Environment and Natural Resources, Can Tho
University, Can Tho City, Vietnam

Reza Farhadi Department of Human Geography, University of Tehran, Tehran,
Iran

Andrew Flynn School of Geography and Planning, Cardiff University, Cardiff,
Wales, UK

Abdulrahman Hassanin Programme of M.Sc. in Urban Design, Bursa Technical
University, Bursa, Turkey

Frederic Hebbeker Institute for Technology and Resources Management in the
Tropics and Sub-Tropics, Faculty of Spatial Development and Infrastructure
Systems, University of Applied Science, Cologne, Germany

Teresa Hoskyns CRAC Cross-Cultural Research in Architecture Collective,
London, UK

Xhesika Hoxha Institute for Technology and Resources Management in the
Tropics and Sub-Tropics, Faculty of Spatial Development and Infrastructure
Systems, University of Applied Science, Cologne, Germany

Trong Nhan Huynh Faculty of Architecture, Mien Tay Construction University,
Vinh Long, Vietnam

Tino Imsirovic Habitat Unit—Chair of International Urbanism and Design,
Technical University of Berlin, Berlin, Germany

Iresh Jayawardena School of Architecture and Planning, University of
Auckland, Auckland, New Zealand

Azza Kamal Program in Environmental Design, University of Colorado Boulder,
Boulder, CO, USA

Arman Karimi Kolektor Etra D.O.O, Ljubljana, Črnuče, Slovenia

Hirou Karimi Department of Architecture, Eastern Mediterranean University,
Famagusta, North Cyprus

Gayani Karunasena School of Architecture and Built Environment, Deakin
University, Geelong, Australia

Kylie Keioskie School of Architecture and Built Environment, Queensland
University of Technology, Brisbane, QLD, Australia

Yanhui Lei Department of Urban Planning and Design, Xi'an Jiaotong-Liverpool University, Suzhou, China

Yi Lu School of Architecture and Built Environment, Deakin University, Geelong, Australia

Saeedeh Nasehi Department of Environmental Planning, Management, and Education, University of Tehran, Tehran, Iran

Maryam Noroozi Department of Environmental Design Engineering, University of Tehran, Tehran, Iran

Daniel Nyandega School of Architecture and Built Environment, Queensland University of Technology, Brisbane, QLD, Australia

Amirmohammad Parvanehdehkordi Interuniversity Department of Regional and Urban Studies and Planning, Politecnico di Torino, Turin, Italy

Hadi RezaeiRad Department of Urbanism, Faculty of Art and Architecture, Bu-Ali Sina University, Hamedan, Iran

Aisan Salemi Department of Urban Planning & Design, Faculty of Arts and Architecture, Tarbiat Modares University, Tehran, Iran

Maycon Sedrez School of Architecture and Built Environment, Deakin University, Geelong Waterfront, Australia

Borhan Sepehri Department of Urban Planning and Design, Faculty of Arts and Architecture, Tarbiat Modares University, Tehran, Iran

Manu P. Sobti School of Architecture, Design & Planning, The University of Queensland, Brisbane, QLD, Australia

Harry Storch Independent Researcher, Berlin, Germany

Pham Quoc Viet Deutsche Gesellschaft Für Internationale Zusammenarbeit (GIZ) GmbH, Can Tho, Vietnam

Kirsty Volz School of Architecture and Built Environment, Queensland University of Technology, Brisbane, QLD, Australia

Anna Wilk-Pham Habitat Unit—Chair of International Urbanism and Design, Technical University of Berlin, Berlin, Germany

Didem Güneş Yılmaz Department of Architecture, Bursa Technical University, Bursa, Turkey

Ali Rad Yousefnia School of Architecture, Design & Planning, The University of Queensland, Brisbane, QLD, Australia

Keramatollah Ziari Department of Human Geography, University of Tehran, Tehran, Iran

Stormwater Management: Issues, Opportunities, and Challenges in Cities and Communities



Ali Cheshmehzangi, Maycon Sedrez, and Andrew Flynn

Abstract Stormwater management poses significant challenges for urban and community settings, demanding innovative solutions to mitigate its adverse impacts and capitalise on opportunities for sustainable development. This chapter explores the multifaceted landscape of stormwater management, investigating its issues, opportunities, and associated challenges within cities and communities. As we know, the excess of impervious surfaces aggravates stormwater runoff, leading to several problems in our cities, such as, pollution, flooding, and erosion. Traditional infrastructure struggles to cope with these pressures, requiring a shift towards green infrastructure and nature-based solutions. Opportunities arise in the integration of well-known sustainable design principles, such as green roofs, permeable pavements, and rain gardens, which not only manage stormwater but also enhance urban aesthetics and biodiversity. However, implementing these solutions encounters challenges ranging from financial constraints to regulatory barriers and community engagement. Effective stormwater management demands interdisciplinary collaboration, stakeholder involvement, and adaptive strategies tailored to local contexts. By addressing these challenges and embracing opportunities, cities and communities can forge resilient, sustainable, and liveable environments amidst the complexities of stormwater management. This ice-breaking chapter delves into arguments around water sustainability issues, SDGs and water security matters, questioning particular stormwater management factors that need further attention and research. Lastly, the

A. Cheshmehzangi (✉)

School of Architecture, Design and Planning (ADP), The University of Queensland, Brisbane, Australia

e-mail: a.chesh@uq.edu.au

Network of Education and Research for Peace and Sustainability (NERPS), Hiroshima University, Hiroshima, Japan

M. Sedrez

School of Architecture and Built Environment, Deakin University, Geelong Waterfront, Australia

A. Flynn

School of Geography and Planning, Cardiff University, Cardiff, Wales, UK

© The Author(s), under exclusive license to Springer Nature Singapore Pte Ltd. 2024

1

A. Cheshmehzangi et al. (eds.), *Rethinking Stormwater Management through*

Sustainable Urban Design, Urban Sustainability,

https://doi.org/10.1007/978-981-97-4924-9_1

chapter provides an overview of the book's structure as well as the chapter abstracts from all our contributing authors.

Keywords Stormwater management · Sustainable urban design · Sustainable urbanism · Urban design · Flooding · Water-based design · Urban environments · Sustainability

1 Stormwater Management as Strategy to Secure Water Sustainability

This chapter begins with a less optimistic perspective for water and cities in the near future, which highlights the relevance of the research conducted in this book to society. As population grows in most countries, urban population increases, and urbanization processes accelerate, the pressure on water resources intensifies. Water is an indispensable resource for human existence and presents a dual challenge in urban environments. Firstly, mismanagement, contamination, and the degradation of water-related ecosystems pose major threats to cities and populations across the globe, manifesting in floods, droughts, and ecosystem failures. According to projections by the United Nations [1], within less than six years, the essential daily needs of billions of people, including access to safe drinking water, adequate sanitation, and proper hygiene, could be compromised. Unfortunately, the chances that Sustainable Development Goals' targets will not be met by 2030 is significant in most of places [2]. This eminent crisis underlines the urgency of addressing water problems on a global scale. It is imperative that efforts are made to implement sustainable water management practices, ensure equitable access to clean water and sanitation infrastructure, and foster community resilience in the face of mounting water-related challenges.

Secondly, beyond direct human consumption, water is crucial to sectors like construction, agriculture, and certain industries, which heavily rely on this resource for production of infrastructure, food and goods, that also support human life. Consequently, urban designers and planners, cities and governments are increasingly called upon to integrate strategies for reducing, saving, reusing, and recycling water within their design approaches, recognising the transformative potential inherent in such endeavours. However, if urgent actions to rethink water management are not implemented, the impacts of in our society might be devastating.

Water is not only vital for direct human consumption but also serves as a primary resource for various sectors crucial to supporting human life and civilization [3–6]. Industries such as construction, agriculture, and manufacturing heavily rely on water to produce infrastructure, food, and goods. Thus, we see multiple benefits across the spectrum of urban development, from environmental governance strategies [7] to the development of holistic sustainable urbanism directions [8]. Without adequate water resources, the associated sectors (and not limited to the ones named above)

would struggle to meet the needs of society, leading to cascading effects on human well-being and economic stability. In response to the growing recognition of water scarcity and the importance of sustainable water management, landscape architects, urban designers, urban planners, architects, and city officials are increasingly being urged to integrate innovative strategies into their approaches [9]. These strategies focus on reducing water consumption at the higher level, but also emphasising new directions for implementing efficient water-saving technologies, promoting water reuse and recycling, and integrating green infrastructure solutions to enhance water retention and filtration.

By embracing these water-centric design principles, stakeholders can unlock transformative potential in their development strategies, such as planning, retrofitting, and building the next urban environment [10]. For instance, integrating rainwater harvesting systems into urban infrastructure not only reduces demand on potable water sources but also helps mitigate stormwater runoff, alleviating pressure on drainage systems and reducing the risk of urban flooding [11–14]. Similarly, adopting water-efficient irrigation techniques in agriculture can conserve water resources [15–18], enhance crop yields, and promote sustainable food production practices. However, the urgency of rethinking water management cannot be overstated. Without swift and decisive action, the consequences for society could be devastating [19]. Water scarcity can aggravate social inequalities, exacerbate conflicts over dwindling resources, and undermine economic development [20]. Furthermore, climate change-related impacts such as droughts, floods, and water pollution are expected to further strain water resources [21], amplifying the urgency of implementing sustainable water management practices.

Since the 2010s, the management of stormwater is also increasingly being integrated into the design of buildings and public places [22]. Holistic monitoring systems and practices such as the UN Integrated Monitoring Initiative for SDG 6 (IMI-SDG6) supports the assessment of real development and impact of stormwater strategies in improving water management [23]. Tools like this focus more on macro level planning interventions and rely on many agents to collect data and process such data. The UN Integrated Monitoring Initiative for SDG 6 (IMI-SDG6) represents a significant step towards comprehensive assessment and monitoring of sustainable water management practices, particularly in the context of stormwater strategies. This initiative emphasises a holistic approach, aiming to capture the multifaceted aspects of water management and its impact on development. However, while such macro-level tools provide valuable insights into broad trends and overall progress, they may encounter challenges in capturing the nuanced dynamics of smaller-scale design interventions and localised impacts. Hence, we suggest tools relevant to smaller scale design interventions, which could be more effective to improve water management and stormwater management practices. These tools can offer better insights into the effectiveness of specific stormwater management practices and their impact on local water systems. By focusing on smaller scales, these tools can capture the intricacies of microclimates, land use patterns, and infrastructure configurations that significantly influence water management outcomes.

Furthermore, smaller-scale design interventions often involve a more manageable number of stakeholders, making data collection and analysis more streamlined and efficient [9, 24]. This targeted approach enables closer collaboration between stakeholders, including local communities, authorities, and environmental experts, fostering a more participatory and contextually relevant approach [19] to water management. Similarly, approaches to educate architects, designers and planners about prioritising water-related urban strategies have emerged in the last decades [25]. However, the outcomes of new professionals adopting innovative approaches is not immediately noticed in the field of architecture and urban design, since certain long-term used practices might prevail.

1.1 What Is Stormwater Management?

As cities developed in the nineteenth century, the implementation of systems for stormwater drainage were implemented. At that point, the water was quickly polluted and improper to use, thus draining was the best alternative [22]. With new sustainable practices being incorporated into the design of cities in the twentieth century, strategic frameworks were formulated in different parts of the world, such as: Best Management Practices (BPM), Stormwater Quality Improvement Devices (SQID) and Stormwater Control Measures (SCM), to concepts such as Sustainable Urban Drainage Systems (SUDS); and broad principles that consider the whole-of-urban water cycle management such as Water Sensitive Urban Design (WSUD), Sponge City Program (SCP), Low Impact Development (LID) and Integrated Urban Water Management (IUWM), Nature-Based Solutions (NBS) [26, 27]. Stormwater management consists of solutions that plan, implement, control, or assess the destination of rainfall water. These solutions can be relevant to existing practical directions suggested under the overarching plans named above (e.g., WSUD, SCP, SUDS, NBS, LID, etc.). In addition, stormwater management encompasses a diverse array of solutions aimed at effectively managing the runoff generated by rainfall. These solutions are essential for mitigating the impacts of urbanisation on natural hydrological systems and reducing the risks of flooding, erosion, and water pollution [24]. Key components and strategies involved in stormwater management include: (1) green infrastructure, (2) detention and retention basins, (3) stormwater harvesting, (4) erosion control measures, (5) water quality management, and (6) integrated planning and management. We believe these could lead to develop the next generation of sustainable urban design (SUD) practices.

Overall, stormwater management solutions encompass a range of techniques and practices aimed at minimising the adverse impacts of urbanisation on water resources and promoting sustainable development. These key points will be highlighted more extensively through case study chapters of the book. By implementing these solutions, communities can enhance resilience to climate change, protect water quality, and improve overall environmental health and well-being. Through these, the process to secure water sustainability involves a comprehensive process that

encompasses various strategies and actions aimed at ensuring the availability, accessibility, and quality of water resources for current and future generations. Key areas to consider include “assessment and monitoring”, “policy development and governance”, “water conservation and efficiency”, “infrastructural development”, “natural resource management”, and “climate change adaptation and mitigation strategies”. Water sustainability is a global challenge that requires collaboration and cooperation among countries sharing transboundary water resources [19]. International agreements, treaties, and partnerships play a crucial role in promoting equitable water sharing, conflict resolution, and sustainable development. Hence, the need for adequate institutional capacity [28] and promoting international or regional cooperation [29] are needed. Additionally, supporting capacity-building initiatives and technology transfer programs can help enhance the water management capabilities of developing countries.

While this book explores context-specific examples of rethinking stormwater management through sustainable urban design, we believe they provide necessary guideline and suggestions for other contexts too. The absence of two important regions/sub-continent/continents of Latin America and Africa in the book indicate there is still room for further progress and development in developing nations. This also applies to countries in Eastern Europe, Western Asia (or Middle East), and Central Asia. The complexities in island nations of Oceania and Caribbean are somewhat different but also indicate the need for careful consideration of water management strategies before it becomes too late. The rising sea levels, while threatening such nations and coastal cities, indicate the fact that we must learn how to design with water in a more holistic way. Otherwise, the end results are reasonably evident, and the current pathways will not help us achieve better goals and directions. Aligned with this view, the book urges for new paradigm shifts through this new era of sustainable urban design.

2 SDGs as Propeller for Water Security

The United Nations, projecting a dire future, estimates that by 2030, 1.6 billion people will lack access to safe drinking water, while 2.8 billion will lack adequate sanitation, emphasising the urgency of accelerating efforts to secure humanity’s survival on the planet. Aligned with this scenario, the UN’s Sustainable Development Goals (SDGs) include six goals—Good Health and Well-being (Goal 3), Clean Water and Sanitation (Goal 6), Sustainable Cities and Communities (Goal 11), Responsible Consumption and Production (Goal 12), Life Below Water (Goal 14), and Life on Land (Goal 15)—with specific targets related to water management, conservation, restoration, and utilisation across diverse conditions and contexts. Such comprehensive strategies are complementary or co-dependent to each other but start from the principle that global actions are in place now. In this sense, seventeen targets within these six goals reveal the multifaceted nature of water sustainability efforts, encompassing objectives such as ensuring safe and affordable water and sanitation, restoring ecosystems,



Fig. 1 United Nations sustainable development goal 6, clean water and sanitation, and target 6.5, implement integrated water resources management

and fostering community participation in water governance, but most importantly, implementing integrated water resources management at all levels (Fig. 1. Goal 6, Target 6.5).

Historically, stormwater management has been predominantly approached through engineering solutions, albeit with emerging recognition of the importance of design considerations in addressing these challenges [22]. These engineering solutions aim to efficiently convey, store, and discharge stormwater to minimise damage to property and infrastructure. However, there has been a growing recognition of the limitations of purely engineering-focused approaches to stormwater management, hence, the call for “*rethinking*” our recent and current practices in the field. While such solutions are effective at managing the quantity of stormwater, they often neglect important considerations related to water quality, ecological impacts, and community well-being [3]. Additionally, conventional engineering practices can be costly, resource-intensive, and environmentally disruptive.

In response to these shortcomings, there has been an increasing emphasis on integrating design considerations into stormwater management practices. These are often looked at from the sustainability perspectives, and essentially from sustainable urbanism or urban design practices. Design-led approaches prioritise the creation of multifunctional, sustainable, and aesthetically pleasing stormwater solutions that not only mitigate flooding and erosion but also enhance urban liveability, biodiversity, and resilience to climate change. This reminds of the idea of “Design for Sustainable Change”, which was discussed by Chick and Micklethwaite [30] and suggested the importance of design thinking and design-led opportunities for future development

plans. Keeping these in mind help us provide a unique narrative to this book, more than just the usual exploration of theories and branding practices.

To uncover new concepts in these topics, we invited chapters that provide a better understanding of potentials, solutions, roadblocks and fragilities of implementing stormwater management through innovative urban design approaches. These chapters address projects, tools, policies, and assessment methods to create awareness of robust design possibilities. We believe that this discussion can inform, from cities stakeholders to designers and planners, that actions towards water security should be prioritised in any development. We have no choice but to recognise and value water as a fundamental resource essential for human well-being, economic prosperity, and environmental health. Thus, it is imperative to adopt proactive measures that ensure its availability, accessibility, and quality. We need to create room for new design-based water capture solutions, micro-level green infrastructure, enhanced and high-quality nature-based solutions, infrastructural upgrades, and waster-sensitive design in relevant sectors including also important sectors of agriculture. Hence, the urgency of responsibility to integrate water sustainability principles into every stage of the planning, design, and management of urban environments. By fostering collaboration, innovation, and informed decision-making, we can create resilient and sustainable cities that thrive in the face of water-related challenges.

3 The Aim and Objectives of the Book

This book aims to provide a distinct narrative and approach to rethinking stormwater management through sustainable urban design. It delves into design interventions and innovative strategies that lead to solving context-specific issues of flooding, water scarcity, etc. Starting with this overarching introduction and discussion on stormwater management research, the book then primarily focuses on sustainable urban design practices, strategies, and policy guidelines. The remaining parts of the book focus on worldwide case studies examples with embedded lessons learnt for other contexts. While some suggested directions may seem context-specific, we believe there are overarching principles and guidelines that could help enhance architecture, design, and planning of our cities as well as building design practices, environmental design strategies, and necessary paradigm shifts.

Therefore, by summarising a selection of successful global case study examples, the book highlights how we should rethink stormwater management practices and policies from the design perspective. This so-called “rethinking” is critical as we hope to see changes that may be needed beyond typical business-as-usual practices. Through sustainable urban design suggestions, the book covers a wide range of conceptual examples to design and policy guidelines, as well as best practices that could be utilised for other contexts.

Unlike other books written in this research area that focus mostly on theories in stormwater management, we refrain from recycling theories and suggestions that are known to most academics, researchers, and policy makers. In essence, most of

what happens in our literature are driven directly from the industry where new tools, practices, and directions are often tested or even scaled up. Therefore, by bringing various cases together, we aim to revolutionise the way we perceive and address stormwater management challenges within urban environments, infrastructure, and landscapes. At its core, the book therefore advocates for a paradigm shift towards sustainable urban design principles, offering a fresh perspective on tackling issues such as flooding and water scarcity.

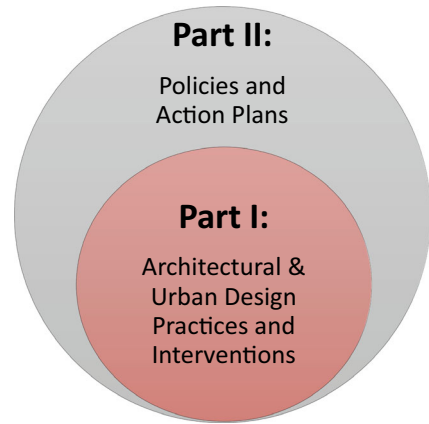
By thoroughly examining design interventions and innovative strategies, the book serves as a comprehensive guide for urban planners, architects, and policymakers seeking to adopt a more holistic approach to stormwater management. Through a synthesis of research findings and practical insights, it lays the groundwork for implementing context-specific solutions tailored to the unique needs of diverse urban environments. Meanwhile, it also suggests directions that are adaptable and adoptable, where we see potential for piloting innovation in urban design practices, particularly from the lens of sustainable development. Central to its narrative are real-world case studies drawn from around the globe, each offering valuable lessons and inspiration for reimagining urban spaces. These case studies not only showcase the efficacy of sustainable design practices but also highlight the importance of embracing flexibility and adaptability in the face of evolving environmental challenges; hence, a possibility to move into adaptive planning and for the future development of mitigation strategies in sustainable design and planning. In this regard, the book points out the universality of its principles, emphasising how lessons learned from one context can be extrapolated and applied to others. By fostering dialogue and collaboration among stakeholders, we envision a future where cities are not only resilient to the impacts of climate change but also vibrant, liveable spaces that prioritise the well-being of both people and the planet.

In sum, this book serves as a call to genuine action, not just to be considered as another report to be placed on a big pile of many other reports. We see the need for genuine action against all climate change impacts on cities, communities, and our environments—both natural and built. Thus, the action is needed to urge us to transcend conventional modes of thinking and embrace a more enlightened approach to urban design—one that holds the promise—if not yet seen as a direction—of a more sustainable and equitable future for generations to come. This is the urgent call for immediate change, not just gradual money-making transitions, but genuine transformative innovation that could create a new era of sustainable urban design.

4 Structure of the Book

This book is divided into two sections of: (1) architectural and urban design practices and interventions, and (2) policies and action plans (Fig. 2). This collection helps researchers and scholars rethink stormwater management and consider innovative—and, more importantly, sustainable—design strategies that could help develop new paradigms and policies for water-related issues in cities and communities. This

Fig.2 Summary of two sections/parts of the book and how they sit within one another



ought to interest multiple stakeholders, mainly urban policymakers, planners, urban designers, urban specialists, landscape architects, architects, and urban ecologists. It could be treated as a case study-based guide for governmental units dealing with water-related issues in cities and urban areas; but surely, it cannot be seen as a mere reporting of cases. We hope readers could see embedded lessons learnt from each case study examples and think holistically and reflectively about how new directions, innovation, and paradigms could emerge now and in the near future.

Part I: Architectural and Urban Design Practices and Interventions

Chapter 2: Urban Stormwater Runoff Management Using Low-Impact Development: Case Study of Portland

By Amirmohammad Parvanehdehkordi, Borhan Sepehri, and Mohammad Anvar Adibhesami

Abstract

The adaptation of cities to recent climate change is crucial. One challenge is stormwater runoff management, which can affect urban environment and transportation. Low-impact development is a policy that emphasises fast, cost-effective, and environmentally friendly solutions. This study aims to design a commercial complex that incorporates low-impact development strategies for stormwater runoff reduction in Portland, a high-rainfall city. The research methodology consists of three stages. Firstly, standard rainfall data is analysed using SWMM software. Secondly, an urban plan is developed, which includes the design of a commercial complex that incorporates rainwater management and the reduction of stormwater runoff based on low-impact development policies. Finally, the simulated data generated by the proposed design is re-analysed using SWMM software, and the final results are compared.

The research findings indicate that all three sub catchments in the studied site have a high potential for runoff. Furthermore, the results demonstrate that the implementation of low-impact development strategies, such as roof gardens, permeable pavement, and biological preservation materials, can reduce runoff by 35%, and save

or reuse 40% of the rainwater. These findings provide valuable insights for private and public stakeholders, encouraging them to incorporate low-impact development policies into urban plans, particularly in Portland, to enhance runoff management and water conservation.

Keywords: Low-impact development (LID); Stormwater runoff management; Commercial complex design; SWMM software; Portland

Chapter 3: Towards Water-Sensitive Urban Design Through Polycentric Participatory Approaches. The Case Study of Sariharjo, Sleman Regency, Indonesia

By Xhesika Hoxha, Anna Wilk-Pham, Frederic Hebbeker, and Tino Imsirovic

Abstract

Cities in Southeast Asia are vulnerable to disasters such as floods, earthquakes, and storms. These hazards are exacerbated by poorly regulated urbanisation and inadequate infrastructure in high-risk areas, leaving many cities ill-prepared to withstand these threats. Secondary and tertiary cities in the region, and many in Indonesia like Sariharjo, are prone to pluvial and fluvial flooding due to extreme rainfall events, stormwater runoff, overflowing sewage systems, floodplain encroachment, and upstream land use change. Adverse effects, particularly the degradation of natural watersheds, reduced drainage system capacity, and increased non-permeable surfaces, contribute to prolonged flooding. Resolving these issues requires redefining stormwater management, integrating an environmental dimension into urban planning, and moving beyond a narrow technical focus. This chapter introduces the polycentric participatory approach to the management of urban water and explores the design and implementation of collaborative planning processes, which plays a fundamental role to integrate water management into urban planning. Furthermore, the chapter promotes a deeper understanding of multi-stakeholder engagement for participatory methods. Based on practical case study experience, the chapter introduces a novel methodology, rooted in the principle of participatory urban planning. Through its trans- and interdisciplinary nature, coordination among stakeholders and institutions became a key requirement to enhance integration of water management into urban planning processes. Combining these two elements, the polycentric participatory approach utilises tools for cross-sectoral cooperation through multi-stage combination of empirical research, stakeholder interviews, focus group discussions, and system analyses. The results reveal that adopting a polycentric approach to urban water management can empower secondary and tertiary cities in Southeast Asia to actively influence their water-sensitive transformation. The diverse development dynamics of cities across social, physical, natural, and institutional dimensions are considered, and application further fosters effective co-production and multi-stakeholder engagement. It offers essential contributions to sustainability and long-term effectiveness of implemented solutions.

Keywords: Co-design; Community engagement; Urban planning, and design; Inter- and transdisciplinary; Polycentricity; Sustainable development; Water management

Chapter 4: The Urban Growth Challenges of Implementing Nature-Based Solutions for Stormwater Management in Ho Chi Minh City, Vietnam

By Nigel K. Downes, Pham Quoc Viet, Trong Nhan Huynh, Thanh Hung Dang, and Harry Storch

Abstract

Peri-urbanisation is a particular pattern of urbanisation defined by rapid and fragmented growth. Understanding the expansion and densification of peri-urban areas aids local policy-makers and planners in developing intervention strategies for addressing urban planning challenges. This chapter explores our understanding of the recent urban growth dynamics of flood prone Ho Chi Minh City, Vietnam. Here, flood risks are not effectively considered in urban planning, with an excessive over-reliance on traditional drainage systems. Using geospatial mapping and fieldwork-based methods, the results highlight the structures, scale, and rapid loss in the existing natural capacity to implement decentralised nature-based solutions for stormwater management. Characterising the unique processes and drivers of change, the results show the rapidity of urbanisation and the importance of precautionary planning principles. Required planning interventions are discussed within the context of specific growth challenges, including negative lock-ins, maladaptation and unsustainable urbanisation, providing a better understanding of downscaled stormwater risks and management opportunities. The chapter stresses the need for urban planners, decision- and policy-makers to understand the past, current and future trends of expansion and densification; and take proper decisions for enhancing sustainable urban stormwater management.

Keywords: Ho Chi Minh City; Peri-urbanisation; Storm water management; Nature-based solutions; Sponge city concepts; Rural–urban transition

Chapter 5: UoNJC and ANR: The Two UK Case Studies of Stormwater Management Through SuDS

By Yanhui Lei

Abstract

More severe problems, such as flooding, erosion, turbidity, sanitary sewer system overflow, infrastructure damage, and even casualties, have been caused by stormwater in urban and developed areas with impervious surfaces like pavement and roofs preventing precipitation from naturally soaking into the ground. Many researchers have tried to seek theoretical and practical solutions based on the conventional paradigm, which is increasingly ineffective. It is significant to rethink other promising alternative strategies for stormwater management. This chapter will focus on ‘How stormwater management benefits in the UK context through Sustainable Drainage Systems (SuDS) of sustainable design practices’ in the two cases of the University of Nottingham Jubilee Campus (UoNJC) and Attenborough Nature Reserve (ANR). The UoNJC site of case one was originally the industrial factory of the world-famous Raleigh cycles. After the company moved, it appeared lifeless. Could you imagine that the UoNJC has achieved many awards, for example, the RIBA