Preface

RATIONALE

We need to convey two important messages in this book. First, ensuring the sustainability of the urban water environment is not the prerogative of a single discipline. It needs a multi-disciplinary approach for problem identification and more importantly, problem solution. Second, knowledge creation is of limited value; unless this knowledge is translated to enable practical application to solve real-world problems. This book has been created to comply with these key messages.

Water – the very essence of life is becoming an increasingly precious commodity. Access to safe sources of water has immeasurably enhanced human well-being and increased our longevity by reducing the disease burden. Access to safe water is considered a fundamental human right. However, it is also important to note that water possesses many other facets to improve human well-being and quality of life. The aesthetic and recreation values that the water environment provides are also important for community well-being. This aspect is sometimes neglected in the management of the water environment. In this regard, the urban water environment is under increasing threat.

The rapid growth in the urban population and consequent spread of urbanisation, which is a global phenomenon, and increasing industrialisation, which is a symptom of increasing affluence of the global population, has made the urban water environment particularly vulnerable. In the recent past, some countries have made concerted efforts and concomitant investments in managing and treating the point sources of polluted water being discharged into water bodies. Unfortunately, managing and treating stormwater, which is the most significant non-point source of pollution to urban water bodies remains an almost intractable problem. Research studies have confirmed that urban stormwater runoff can be more polluted than secondary treated sewage. Urban stormwater runoff carries a wide range of pollutants, which are not only harmful to fauna and flora, but also to human health. Therefore, the appropriate management and treatment of urban stormwater runoff can contribute significantly to a 'sustainable urban water environment'.

The drawbacks to the development of effective and sustainable strategies to mitigate the quantitative and qualitative impacts of urban stormwater runoff are many. These include: (a) the knowledge gaps in relation to key pollutant processes; (b) the uncertainty relating to the potential climate change impacts on stormwater runoff characteristics and the receiving water environment; and (c) the lack of in depth understanding of the key operational and maintenance needs of current pollution mitigation strategies being implemented and organisational barriers to their implementation. These issues are discussed in depth in Part I in order to bring these topics together into a consolidated work and to 'shine a spotlight' on them to generate debate and action.

An in-depth understanding of the relevant issues achieves only a part, albeit an important part of the ultimate objective of achieving the sustainability of the urban water environment. It also requires action on the ground, in the laboratory and on the desktop for the formulation of effective and innovative solutions. This translates to developing an essential understanding of: (a) sampling, measuring and characterising urban stormwater pollutants; (b) the application of innovative data analysis techniques; and (c) the use of knowledge derived from fieldwork programmes and the outcomes from data analyses in water pollutant process modelling and prediction. Accordingly, Part II discusses these issues in detail.

The real value of the knowledge created can only be demonstrated by its application for developing practical solutions. This in turn requires problem identification and the identification of appropriate and versatile solution tools based on a holistic understanding of the interacting issues and domains. It is important to realise that the sustainability of the urban water environment cannot be looked at in isolation and a systems approach is required. The urban environment is an integral component of the urban system and is strongly influenced by the land use and the transport system. Therefore, in order to adopt a systems approach, state-of-the-art tools are needed for determining urban sustainability performance and the component ecosystems and decision tools for sustainability and urban water management. Part III provides an in-depth discussion and recommendations for the way forward for strengthening the sustainability of the urban water environment.

The catalyst for this publication arose from a research grant awarded to us by the Australian Research Council, entitled, 'Adaptation of Water Sensitive Urban Design (WSUD) to Climate Change, Changing Transport Patterns and Urban Form'. The primary aim of the project was to develop adaptive methodology for designing better stormwater quality infrastructure by creating fundamental knowledge for predicting

future pollutant loads from changing urban environments based on the in-depth understanding of the interaction between three dynamic systems: climate, urban system and transport system. In the course of undertaking the project, we came to realise: (a) the extent of the current knowledge gaps; (b) the all too common mono-disciplinary approach to knowledge creation and the essential need for knowledge integration; and (c) the important need to translate knowledge currently in the research domain to facilitate practical application. This book has been written with these objectives in mind.

The urban water environment and its sustainability is not the domain of a single discipline. To a very significant extent, this mindset has been a major constraint in the development of practical solutions to safeguard the urban water environment and to ensure its sustainability into the future. The team that came together to undertake the research project noted above and consequently co-author this book is a significant departure from this norm as the biographical details given below clearly attest.

AUTHORS

Ashantha Goonetilleke is a Professor in Water/Environmental Engineering at Queensland University of Technology, Brisbane, Australia. He has an established track record for undertaking research in relation to the sustainability of the water environment and in particular the urban water environment. He has also achieved significant success in developing extensive industry collaborative links, producing research outcomes of relevance to industry and the community and the translation of research outcomes for practical application. Professor Goonetilleke has published widely in the areas of stormwater quality, stormwater pollutant processes and climate change impacts on the water environment. Additionally, for five years he was the Director for Infrastructure Research in the Faculty of Built Environment and Engineering, Queensland University of Technology and served for ten years in a technical advisory role in sustainability with Brisbane Airport Corporation and held the Professorial Chair in Airport Innovation. He also possesses almost two decades of professional experience in planning, design and construction of internationally financed projects in the areas of water resources management, water supply and wastewater treatment and rural development.

Tan Yigitcanlar has a multi-disciplinary background with over two decades of international work experience in Australia, Finland, Japan and Turkey,

in private consulting, government and academia. Dr Yigitcanlar is an Associate Professor in Urban Planning and Development at Queensland University of Technology. He holds an Executive Director position at the World Capital Institute and serves as an Expert Group Member at the UN-Habitat's World Secretariat of City Prosperity Index. Along with a number of editorial board positions of respected journals, he is the founding Editor-in-Chief of the *International Journal of Knowledge-Based Development* and currently serves as an Associate Editor of the journal. He undertakes the Chairperson role at the annual 'Knowledge Cities World Summit', and sits on the international scientific committees of a number of international academic and professional conferences. He has delivered over 30 keynote speeches and invited talks at esteemed international conferences. The main foci of his research are advocating and promoting knowledge-based urban development, and sustainable urban, infrastructure and transport development in city regions. Beyond a large number of high-impact academic journal article publications, he has (co) authored two books, *Knowledge and the City* and *Sustainable Urban Water Environment*; and (co)edited six books, *Building Prosperous Knowledge Cites*, *Knowledge-Based Urban Development*, *Creative Urban Regions*, *Knowledge-Based Development for Cities and Societies*, *Sustainable Urban and Regional Infrastructure Development* and *Rethinking Sustainable Development*.

Godwin Ayoko is a Professor of Chemistry, a Fellow of the Royal Australian Chemical Institute and Leader of the Nanotechnology and Molecular Sciences Discipline at Queensland University of Technology. The main themes of his research in the past decade have been centred on monitoring and modelling of pollutants in water, air and soil and the application of multivariate data analysis techniques, and synthesis, characterisation and use of novel inorganic materials for the removal of water contaminants. Professor Ayoko has published extensively on a wide range of topics, including urban stormwater and air quality and synthesis, characterisation and applications of inorganic materials for the removal of water pollutants, in reputable journals such as *Water Research*, *Environmental Science and Technology*, *Science of the Total Environment*, *Environmental Pollution*, *Atmospheric Environment*, *Water, Air and Soil Pollution* and *Journal of Colloid and Interface Science*. He has contributed chapters to authoritative books and an encyclopaedia, such as *Rethinking Sustainable Development*, *The Handbook of Environmental Chemistry*, *Organic Indoor Air Pollutants*, *Encyclopaedia of Analytical Science* and *Airborne Particles and Settled Dust in the Indoor Environment*.

Prasanna Egodawatta has over a decade of experience in both industry and academia in water and environmental engineering fields. The main foci of his current research are urban hydrology, stormwater quality and water, and environmental systems modelling. Dr Egodawatta is a Senior Lecturer in Water/Environmental Engineering at Queensland University of Technology. Dr Egodawatta has published extensively in environmental science and environmental engineering fields with key focus on stormwater quantity and quality modelling. As a Research Engineer at Lanka Hydraulic Institute in Sri Lanka and academic staff member at Queensland University of Technology Dr Egodawatta has undertaken a number of research and consultancy projects establishing links between the research domain and industry practice.

The scope of the book is both broad and deep, with issues at the forefront of technical and policy areas discussed in various chapters of the book. It is, thus, a valuable addition to the catalogue of literature on sustainable urban water environment.

CONTENT OF THE BOOK

The Foreword of this book by Professor Paul Burton of Griffith University, Gold Coast, Australia focuses on the key issues impacting sustainability of urban water environment. These issues – the extent, quality and continuity of drinking water services; the extent and quality of wastewater collection and treatment; the control of urban stormwater; charging, tariffs and cost recovery; and the freedom of urban dwellers to use (or not) urban water services – underline the research agenda that the book sets out to tackle.

The body of the book is organised into three main parts, each clustering a number of chapters dealing with specific aspects of sustainable urban water environment: (Part I) Risks and challenges; (Part II) Impacts and predictions; and (Part III) Opportunities and directions.

Part I Risks and Challenges

In the 'Risks and Challenges' part of the book, after highlighting the crucial importance of water and urban water environment, we present the major problems that urban water bodies face, and the appropriate strategies to ensure the sustainability of the urban water environment.

Chapter 1 focuses on the impacts of activities associated with the effect of urbanisation on the water environment as consequences of rapid and unsustainable urbanisation. Important issues in relation to urban popu-

lation growth and sprawl, and consequences of the changes in lifestyle from rural to urban are discussed in detail. Additionally, the resulting environmental impacts in relation to the pollution of air, water and soil, human and ecosystem health impacts and motor vehicle dependency are also examined.

Chapter 2 presents the predicted impacts of climate change on the water environment. The chapter discusses causes and evidence of climate change and the predicted future changes in climate both at global and regional scales – particularly in the Australian context. This chapter elaborates on the future climate prediction scenarios and impacts on the water environment in relation to water quantity, water quality and ecosystems.

Chapter 3 deals with the strategies adopted for mitigating water quantity and quality impacts on receiving waters in urban areas. The chapter introduces water sensitive urban design strategies as a novel method to cope with the impacts of the changing climate. This chapter also elaborates on the contributions of these strategies to sustainability of the urban water environment. Furthermore, the chapter emphasises the need for knowledge creation to overcome challenges for sustaining the urban water environment.

Part II Impacts and Predictions

In the 'Impacts and Predictions' part of the book, we present the common concerns about the diversity and quantity of pollutants entering the water environment, particularly through stormwater runoff, and suggest modelling methods factoring in the changing climate and future urban and transport scenarios.

Chapter 4 surveys common and emerging pollutants, and highlights the available techniques and procedures for sampling and measuring these pollutants. The chapter presents methods on how the knowledge derived from pollutant measurements can be used to compute and assess the overall water quality index for a given water body. This chapter uses examples from the literature to demonstrate the effects of stormwater runoff on receiving water in the urban environment.

Chapter 5 focuses on initiating and monitoring the effectiveness of source control measures, and collection of accurate information that can be used for identifying both water quality and the sources of pollutants. The chapter introduces appropriate statistical – that is, multivariate data analysis – and receptor modelling techniques, and discusses the applications of such techniques to urban water quality data.

Chapter 6 concentrates on stormwater quality modelling that plays a pivotal part in informed decision-making. The chapter advocates the

inclusion of climate change and future transport- and urban systems-related inputs into such models along with incorporating added capabilities to stormwater quality models to predict future scenarios. Moreover, this chapter discusses the advanced knowledge requirements in relation to urban stormwater pollutant processes and modelling frameworks.

Part III Opportunities and Directions

In the 'Opportunities and Directions' part of the book, we link the sustainable urban water concept with the sustainable urban and transport development and sustainable urban ecosystems concepts, and demonstrate the capabilities of two urban sustainability assessment models in empirical studies.

Chapter 7 introduces an urban sustainability assessment model (that is, ILTIM), which incorporates the key factors impacting urban sustainability levels as indicators, and discusses adaptation of the urban sustainability assessment model in the urban planning process. The chapter presents the operational details of the implementation of the model in a local government context and provides insights for development and adaptation of such metrics in the local sustainability endeavours.

Chapter 8 presents another urban sustainability assessment model (that is, MUSIX), which evaluates urban ecosystem sustainability by focusing on six key dimensions – that is, hydrology, ecology, pollution, location, design and efficiency. The chapter elaborates the methodology of the model, demonstrates the performance of the model in a local test-bed case, and provides insights on the sustainability performance of the case study area with reference to the model findings.

Chapter 9 further elaborates the insights generated in Chapters 7 and 8. The chapter puts forward useful recommendations for adaptation in order to achieve urban sustainability to protect the ecological health of urban water environments. This chapter also underpins the requirements for sustainable urban form and transportation infrastructure, and highlights and introduces promising planning and decision support systems relevant to sustainable urban water environment.

Chapter 10 concludes the book by setting and summarising the current and future potential directions in achieving water sustainability. The chapter also proposes a practical roadmap for securing the sustainability of urban water environments. This chapter also points out new directions for future research and investment, and suggests a comprehensive approach for the investigation of urban water environments – that is, focusing on the integration of critical issues of urban form, transport systems, climate change as well as human behaviour alteration.

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