Enhancing context specificity of Water-Sensitive Urban Design

An urban design perspective on Indian secondary cities

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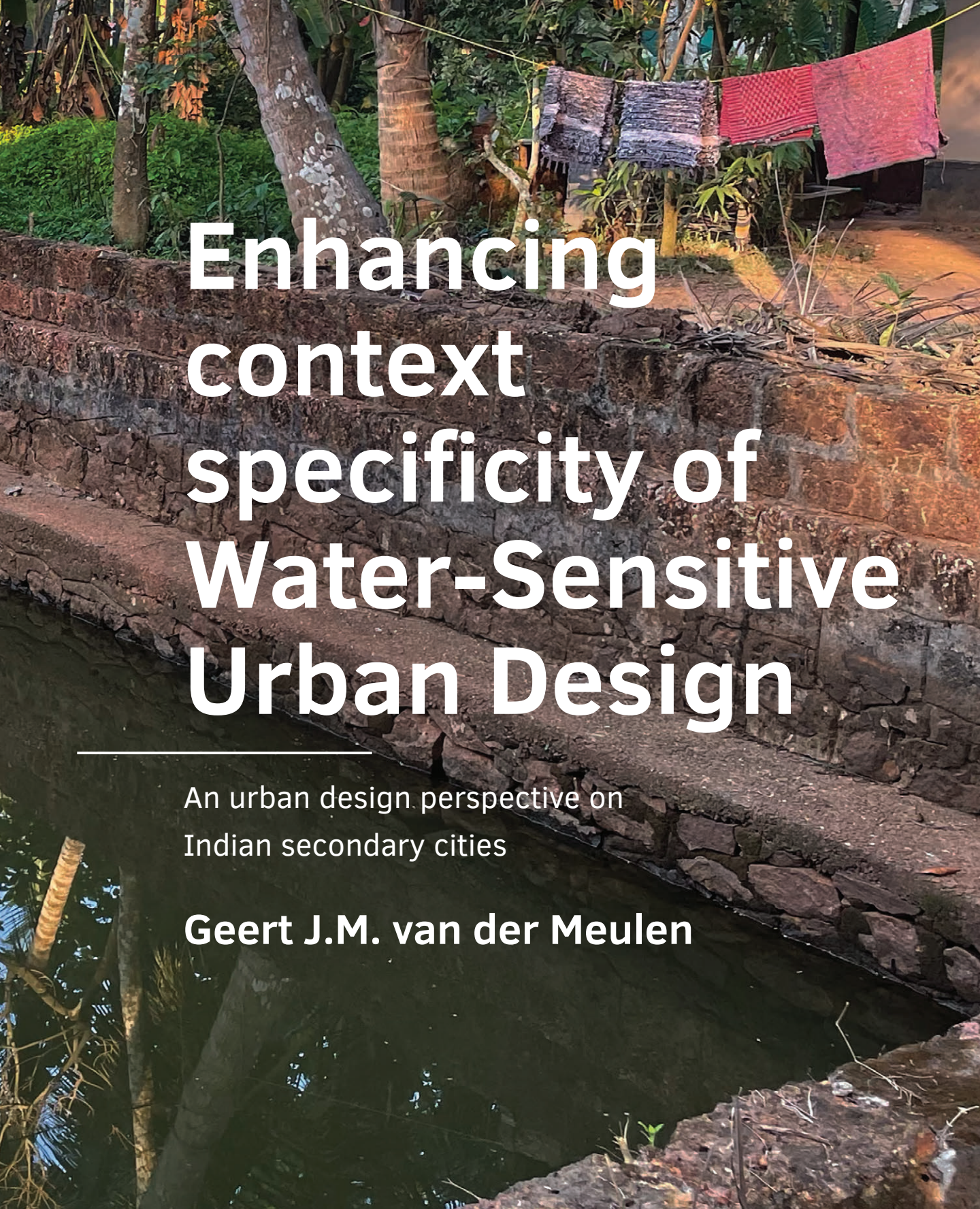
DOI
10.71690/abe.2024.16

Publication date
2024

Document Version
Final published version

Citation (APA)
van der Meulen, G. J. M. (2024). *Enhancing context specificity of Water-Sensitive Urban Design: An urban design perspective on Indian secondary cities*. [Dissertation (TU Delft), Delft University of Technology]. A+BE | Architecture and the Built Environment. https://doi.org/10.71690/abe.2024.16

Important note
To cite this publication, please use the final published version (if applicable).
Please check the document version above.



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A+BE | Architecture and the Built Environment | TU Delft BK

24#16

Design | Sirene Ontwerpers, Véro Crickx

Cover photo | Sacred grove and pond in the Kottuli wetlands along the Kalipoika Road in Kozhikode, India

ISBN 978-94-6366-947-4
ISSN 2212-3202

This dissertation is open access at https://doi.org/10.7480/abe.2024.16

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Enhancing context specificity of Water-Sensitive Urban Design

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Dissertation

for the purpose of obtaining the degree of doctor
at Delft University of Technology
by the authority of the Rector Magnificus, prof.dr.ir. T.H.J.J. van der Hagen
chair of the Board for Doctorates
to be defended publicly on
Thursday, 31 October 2024 at 10:00 o'clock

by

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This dissertation has been approved by the promotors.

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This study was financed by the Dutch Research Council (Nederlandse Organisatie voor Wetenschappelijk Onderzoek - NWO) under Grant W 07.7019.103, and the Indian Government Department of Science & Technology (DST) under Grant DST-1429-WRC.

Preface

This research was conducted within the framework of the Water4Change (W4C) research programme. W4C constitutes a consortium of research institutes in the Netherlands and India representing a variety of specialist disciplines ranging (e.g., geo-information science, governance, planning, social sciences, transition studies, urban design, water resource management). These research institutes collaborated to address the urban water challenges faced by fast-growing secondary Indian cities among the needed adaptation urgencies and uncertainties. The project's deliverables are twofold: a water-sensitive city framework and fit-for-purpose guidelines, through which W4C aims to enable water-sensitive urban development which accounts for context specificities and local and traditional knowledge and practices. These deliverables were co-created with local actors of three case study cities, Bhopal (Madhya Pradesh), Bhuj (Gujarat), and Kozhikode (Kerala), selected for their exemplarity in a country with diverse climatic conditions and urban water challenges (e.g., too much, too little, too dirty, too unequal). At the time of writing this dissertation, completion of the deliverables was still in progress.

Representing the discipline of urban design and the Delft University of Technology (Faculty of Architecture and the Built Environment, Department of Urbanism) within W4C, this study provided its insights to develop the W4C project and contribute to its co-creation activities and deliverables. While doing so, the study enjoyed the freedom to conduct the research bundled in this dissertation in the ways fit to its own research aim. Adhering to the W4C context of interest, the study could benefit from the multidisciplinary collaborative environment of W4C and the opportunities to host co-creation activities (e.g., fieldwork, workshops, interviews) with relevant local experts in a sub-selection of case study cities: Kozhikode and Bhuj (see Figure 1.2).

The research was conducted in the period between January 2020 and April 2024 which implies its inception coincided with the global Covid-19 pandemic. Travel restrictions between India and the Netherlands were put in place prior to initial field visits and familiarisation with the case study cities. The uncertainty surrounding the travel restrictions and health measures that would follow, additionally affected development and execution of the research and startup of W4C collaborations. Travel restrictions lasted until June 2022 after which the first field visit was conducted.

W4C's funding sources had no involvement or influence in any part of this research.

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Summary

To respond to the challenges of urbanisation and the climate crisis in urban environments, the field of urban water management intends to join forces with urban design in an approach called Water-Sensitive Urban Design (WSUD). WSUD calls for using cities as water supply catchments with fit-for-purpose water sources, providing ecosystem services and building the socio-political capital for sustainability and water-sensitive behaviour of its inhabitants. Successful operationalisation of the approach in local urban design and water management practices in countries like Australia, Singapore, and the Netherlands, has made WSUD to be considered among the state-of-the-art approaches. The climatic differences between these contexts suggests a broad applicability and suitability of the approach and universality of its principles. A universality which is coveted as the pace and complexity of urban and climate challenges increases. Against this backdrop, the urban development model of WSUD and its pursued 'water sensitivity' are transferred to and adopted by other contexts around the world.

Urban design, which WSUD calls upon, however, is by definition context-specific. The urban design process is characterised as an explorative process of developing alternatives, following a guiding concept, using its own visual language, and contextualised by means of the defined physical and socio-cultural site and accompanying context variables it addresses and frame of references it uses. When overlaying these characteristics with WSUD, water sensitivity as the guiding concept stands out. Devoid of contextualisation, the water-sensitive ideal carries a risk of superimposition of values which is particularly detrimental when considering that the climatic and urban challenges are not just spatial, but also societal issues linked to local value systems. Therefore, the research aim is to enhance context specificity of WSUD and is guided by the research questions: *What role do the concept of water sensitivity and urban design methods play in the distinct operationalisation that WSUD requires per context?; What contribution do urban design methods provide to situating the concept of water sensitivity?;* And *how can context specificities be accounted for in WSUD?*

The research commences by repositioning urban design processes in WSUD and reconceptualising water sensitivity for it to also be recognisable in a context at present or in its past. The framing suggests water sensitivity equally is a context variable, influencing and influenced by other context variables, and as such will

materialise differently in each urban environment without implying these locations are suboptimal for WSUD. As a guiding concept, water sensitivity can then provide direction in how to address a context, whereas present water sensitivity, among other context variables, is fundamental to the realisation of the concept.

This reconceptualisation is tested by means of a non-exhaustive selection of urban design analysis methods in two secondary cities in India: Kozhikode and Bhuj. As secondary cities in terms of their subnational size and administrative function, they are a relevant case study by being among the world's most rapidly developing and growing cities, yet least researched and documented and, as such, unacknowledged in development of urban water management or design approaches, like WSUD. Kozhikode and Bhuj, furthermore, represent different climates, being located in a tropical monsoon and hot desert climate, respectively.

Immersive fieldwork, common to urban design, provides ways of seeing and reading the urban landscape to WSUD. Fieldwork enables observations and gathering context knowledge on site for an improved understanding of local urban, social, and hydrological processes through scales and in relation to associated and non-associated physical and hidden forces. Commonly unaccounted for in WSUD, the multiscalar intersection of these forces with water are decisive to local water sensitivity. Elaborating fieldwork with historical analysis in contexts deficient of documentation and with a primary idiom of urbanisation being informal, entailed inclusion of local actors and traditional knowledge. These inquiries disclosed the evolution of contextual water sensitivity, as well as its potentially conflicting perception and practices over time. By doing so, urban design is capable of situating water sensitivity by visualising and connecting a local community's culture and its territory.

The urban design perspective casts light on how conventional WSUD belongs to certain groups of people and certain contexts and thus carries pervading values and implicit agreements on how water should be managed and the designs used. Mobilisation of WSUD may be part of unfit and exclusive water management and uneven urban development agendas. As interdisciplinary urban design methods, fieldwork, historical analysis, and actor consultation, facilitate articulation of more diverse and context-specific knowledge and characteristics in WSUD. Instrumentalising and emphasising urban design in WSUD contributes to decentralising its universalised notions and frame of references while retrieving local equivalents whose qualities can be regained or stressed. As such, urban design can shift the primary focus of WSUD from optimization and general principles for systems of water service provision to the hydro-cultural dimension, defining how to context-specifically design and manage water for each unique urban environment.

Samenvatting

In reactie op uitdagingen van verstedelijking en de klimaatcrisis in steden, oppert het vakgebied van stedelijk waterbeheer om krachten te bundelen met stedelijk ontwerp in de Water-Sensitive Urban Design (WSUD) benadering. WSUD stelt voor steden te gebruiken als opvanggebieden voor watervoorziening met diverse waterbronnen passend bij verschillende water behoeftes en steden '*ecosystem services*' te laten leveren en zo de sociaal-politieke middelen voor duurzaamheid en waterbewust gedrag van zijn inwoners op te bouwen. Succesvolle toepassing van de benadering in lokale stedelijke ontwerp- en waterbeheerpraktijken in landen als Australië, Singapore, en Nederland heeft ertoe geleid dat WSUD inmiddels wordt beschouwd als een van de state-of-the-art benaderingen. Het verschil in klimaat tussen deze landen suggereert een brede toepasbaarheid en geschiktheid van de benadering en universaliteit van zijn principes. Deze universaliteit wordt begeerd aangezien het tempo en de complexiteit van stedelijke en klimaatuitdagingen oplopen. Het stedelijk ontwikkelingsmodel van WSUD en de nagestreefde 'water sensitiviteit' worden hierdoor in toenemende mate doorgegeven aan en overgenomen door stedelijke omgevingen wereldwijd.

Stedelijk ontwerp, waarop WSUD een beroep doet, is echter per definitie contextspecifiek. Het stedelijke ontwerpproces wordt gekenmerkt door een exploratief proces van het ontwikkelen van alternatieven dat een leidend concept volgt, gebruikmaakt van een eigen visuele taal, en gecontextualiseerd is door middel van de gedefinieerde fysieke en socio-culturele locatie met bijbehorende contextvariabelen die het aanpakt en de referentiekaders die het gebruikt. Door deze kenmerken op WSUD te projecteren, valt water sensitiviteit als leidend concept op. Zonder contextualisering draagt het water-sensitieve doel echter het risico bepaalde waarden op te leggen. Dit kan nadelige gevolgen hebben, gezien het feit dat de klimaat en stedelijke uitdagingen niet alleen ruimtelijke, maar ook maatschappelijke kwesties zijn, die verbonden zijn aan lokale waardesystemen. Daarom is het onderzoeksdoel om de context specificiteit van WSUD te verbeteren. Dit doel wordt begeleid door de onderzoeksvragen: *Welke rol spelen het concept van water sensitiviteit en stedelijke ontwerpmethoden in de distinctieve toepassing van WSUD per context?; Welke bijdrage leveren stedelijke ontwerpmethoden aan het situeren van het concept van water sensitiviteit?;* En *hoe kan context specificiteit worden meegenomen in WSUD?*

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Het onderzoek begint met het herpositioneren van het stedelijke ontwerpproces in WSUD en het herconceptualiseren van water sensitiviteit zodat het ook herkenbaar is in een huidige context of in zijn verleden. Deze framing suggereert dat water sensitiviteit evenzeer een contextvariabele is, die andere contextvariabelen beïnvloedt en erdoor beïnvloed wordt. Als zodanig zal water sensitiviteit zich anders manifesteren in elke stedelijke omgeving zonder dat dit betekent dat deze locaties suboptimaal zijn voor WSUD. Als leidend concept kan water sensitiviteit dus richting geven aan hoe een context moet worden aangepakt, terwijl de huidige water sensitiviteit van een context, naast andere contextvariabelen, bepalend is voor de uitvoering van het concept.

Deze herconceptualisering wordt getest aan de hand van een selectie van stedelijke ontwerp-analysemethoden in twee secundaire steden in India: Kozhikode en Bhuj. Als secundaire steden, wat betreft hun subnationale omvang en administratieve functie, zijn ze een relevante case study omdat ze behoren tot de snelst ontwikkelende en groeiende steden ter wereld welke het minst onderzocht en gedocumenteerd zijn waardoor zij niet erkend worden in de ontwikkeling van stedelijke waterbeheer- of ontwerpmethoden zoals WSUD. Kozhikode en Bhuj vertegenwoordigen bovendien verschillende klimaten, aangezien ze zich respectievelijk in een tropisch moesson- en warm woestijnklimaat bevinden.

Immersief veldwerk, wat gebruikelijk is in stedelijk ontwerp, biedt nieuwe manieren aan WSUD om naar het stedelijke landschap te kijken. Veldwerk maakt observaties en het verzamelen van kennis over een context mogelijk voor een verbeterd begrip van lokale stedelijke, sociale, en hydrologische processen door schalen heen en in relatie tot bijbehorende en externe fysieke en immateriële invloeden. Hoewel de multiscalaire raakvlakken van deze invloeden met water bepalend voor lokale water sensitiviteit, worden deze vaak niet meegenomen in WSUD. Om veldwerk uit te kunnen breiden met historische analyse, in deze locaties met een tekort aan documentatie en waar verstedelijking grotendeels informeel gebeurt, was het belangrijk om lokale belanghebbenden en traditionele kennis erbij te betrekken. Deze analyses brachten de evolutie van contextuele water sensitiviteit in de loop der tijd in kaart, evenals de mogelijk conflicterende perceptie ervan en praktijken eromheen. Hierdoor kan stedelijk ontwerp water sensitiviteit duiden in een bepaalde context en de cultuur van een lokale gemeenschap en hun landschap verbinden en visualiseren.

Het stedelijke ontwerp perspectief laat zien hoe conventionele WSUD toebehoort aan bepaalde groepen mensen en bepaalde contexten en daarmee overheersende waarden en impliciete overeenkomsten bevat over hoe water zou moeten worden beheerd en welke infrastructuur zou moeten worden gebruikt. Mobilisatie van WSUD kan zo deel uitmaken van ongeschikt en buiten-sluitend waterbeheer en ongelijke stedelijke ontwikkeling agenda's. Als interdisciplinaire stedelijke ontwerpmethoden maken veldwerk, historische analyse, en consultatie van lokale belanghebbenden de articulatie van meer diverse en contextspecifieke kennis in WSUD mogelijk. Het instrumentaliseren en benadrukken van stedelijk ontwerp in WSUD draagt bij aan het decentraliseren van de universele opvattingen en referentiekaders. Tegelijkertijd kan het lokale equivalenten identificeren waarvan de kwaliteiten kunnen worden aangezet of teruggewonnen door middel van ontwerp of waterbeheer. Zo kan stedelijk ontwerp de primaire focus van WSUD verschuiven van optimalisatie en algemene systeemprincipes voor watervoorziening naar de hydro-culturele dimensie welke bepalend is voor contextspecifiek ontwerp en waterbeheer voor elke unieke stedelijke omgeving.

1 Introduction

1.1 Background

Modern-day challenges of the climate crisis and urbanisation are manifold and interlink in complex ways. Among them, flooding, droughts, and water pollution strike areas around the world causing an environmental crisis, alongside damage and unhealthy situations in urban environments which may lack infrastructure for drainage, water supply, sewerage, and waste collection. Nevertheless, in many urban areas, population densities and land values surge, resulting in complexities in and pressures on the urban environment. To address these, oftentimes, the need for collaborative attitudes and interdisciplinary design approaches has been acknowledged (Hooimeijer et al., 2022). Approaches to do so are increasingly transferred between professional fields, but also across locations around the world. However, for design approaches addressing the physical environment, site matters (Kahn & Burns, 2021) and, thus, context specificity is key.

On the one hand, the importance of context specificities is understood as approaches are tailored to address local manifestations of the climate crisis or urbanisation (e.g., Kuller et al. 2017). On the other hand, the pace of its challenges drives a search for universal principles to address them in a widest range of contexts (Kahn & Burns, 2021). Transposition of notions which are assumed or proclaimed universal carries a risk to superimpose exogenous values. Awareness of the latter is particularly important in light of the ways in which impacts of climatic and urban challenges are not just spatial, but also societal issues and link to value systems.

Water is a pivotal element among those challenges, their spatial and societal implications, and ties to culture and related value systems (Gandy, 2004). An approach intended to manage water, therefore, takes the central stage in this dissertation. Water-Sensitive Urban Design (WSUD) (Wong, 2006) is an approach of significant relevance in light of the challenges, efforts to address them, and dissemination of its principles. The approach experiences rapid uptake in a growing

variety of contexts worldwide (Abbott et al., 2013; Cook et al., 2019). This variety of contexts includes the world's most rapidly developing or growing, yet least researched or documented, cities. By means of two Indian examples of such urban contexts, the research will provide ways to situate the design endeavour of WSUD. The originality of this research lies in challenging the assumed and proclaimed universality of urban water management and design notions for these contexts, and using a critical reflection from the field of urban design to do so.

1.2 Key concepts

The dissertation requires the introduction and positioning of a few key concepts to secure understanding for a broader readership: urban design, WSUD, and secondary cities in India. Their definitions form the point of departure for this research as WSUD will be the approach under investigation by means of an urban design perspective to which Indian secondary cities provide a testing context. Following the key concepts, in chapter 1.3, the research aim is presented, as well as three research questions to work towards that aim. The methodology elaborates how the research will be conducted and, at last, a dissertation outline will structure the following chapters.

1.2.1 Urban design

Urban design is a broad field of research and practice that focuses on the fundamentals of the shaping or reshaping of places for human and non-human residents and visitors, necessary infrastructures, interaction and relationships between ecology and people, and their quality of life within the changing urban spaces (Carmona et al., 2003; Meyer et al., 2020). Rather than engaging in urban design, or designing, this research identifies more with the ‘science of design’ (Cross, 2001), ‘research for design’ (Nijhuis et al., 2017), or ‘design ethnography’ (Müller, 2021). This implies that the study focuses on a design’s metaproject (De Moraes, 2010) as everything which sets the base for design to realise and that the study is directed at improving understanding of the design discipline, its process, and credibility. Urban design is the type of design key to the area, spatial and temporal scales, and type of knowledge of interest to this research. In fact, the type of knowledge (i.e., context knowledge) and its approach through urban design is one

of the main subjects of reflection in this study. Therefore, framing the core of urban design as a key concept is necessary. Recognised, however, must be that, besides this core, lots more happens at the edges of the field of urban design.

Core mechanisms deployed in urban design include abstract, complex, and open-ended processes. Despite its different appearances, several generic elements within design processes can be distinguished, framed as followed by Van Dooren et al. (2013; 2014). 1) Design is a dialectical explorative process of developing alternatives while seeking criteria to evaluate them with. 2) Design processes follow a guiding concept or intended set of qualities, commonly based on what is considered fit for the context of the design and fitting the vision for that context. 3) Design processes draw on their own visual language system (e.g., through drawing, mapping, and modelling, among other forms of representation). And 4) each design discipline works with or within physical and contextual elements about which statements must be made, such as composition, structure, and function. Urban design, in particular, is by definition context-specific and the key elements include urban space and materialisation; program; planning, management, and legal systems; socio-spatial setting; and economic, ecological, cultural, and historical context. These elements make urban design multi-scalar, moving through and engaging with scales in both the spatial and temporal sense. Beyond context as physical embedding and conditioning of urban design, 5) the design process is similarly contextualised in terms of it taking place within a frame of relevant references in a specific professional culture and personal or local preferences which function as rules of thumb, best practice, establishment, analogies, or typologies (Rowe, 1987). Reference projects, with a certain status in light of a specific design task or problem, often influence design processes by functioning as examples of how context specificities come together to shape a design in different contexts (Van Dorst, 2005).

Urban design is not limited to the projection, imposition, or realisation of physical changes in space (Kahn & Burns, 2021). Instead, its processes dwell on non-sequential iterative efforts of analysis and synthesis, preceding the projections making or transforming an urban environment (Jonas, 2007; Roggema, 2016), reviewing possible, probable, and desirable futures for a context (De Jong & Priemus, 2002; Kahn & Burns, 2021). Analysis and synthesis (e.g., through preliminary and ongoing reading, inventorisation, mapping, framing, and representation of urban space, its underlying and surrounding territory, and all processes and dynamics within them) are acts of design equally creative and formative as urban design informing physical changes. They are instrumental to construe and comprehend lived space and capable of revealing and realising hidden potentials, dynamics, or forces to a place, uncovering realities or possibilities previously unseen or unimagined

among local complexities and contradictions. Hidden potentials may include natural processes, communal uses, or historical events which the design act allows to be unfolded and actualised (Corner, 1999; De Jong, 2002; Nijhuis et al., 2017). As such, these acts can enhance specificity of urban design to an evolving context, as opposed to tabula rasa design approaches and beyond static instances or identities of a site (Diedrich, 2021). In this research on design processes, these design acts of analysis and synthesis are, therefore, central.

Urban design addresses open societal systems without clearly defined boundaries and are therefore interdisciplinary processes, including a wide range of methods and combining expertise (Hooimeijer et al., 2022). Being design methods, they involve designerly ways of knowing (Cross, 2006), do not always follow a defined outline, and instead reflect assimilated past experience (Westrik, 2002) or follow a personal or cultural approach (Van Dooren et al., 2013). At the same time, interdisciplinary urban design requires exchange and integration of knowledge from multiple specialist disciplines (Hooimeijer et al., 2022; Nijhuis et al., 2017; Van der Veen & Muñoz Sanz, 2022). This implies that within different urban design approaches, different forms of knowledge may prevail and urban design can play a role in articulating certain or more diverse knowledge. Examples of forms of knowledge, beyond specialist disciplines, are what is known or perceived within an indigenous or professional community or historically, which may coexist or contradict with the knowledge framework and frame of references from the context from which a design approach or designer originates (Akama et al., 2019). With the framing of urban design's generic elements, acts of analysis, synthesis, and projection, and its interdisciplinarity and forms of knowledge, the research focuses on WSUD. WSUD is an example of an interdisciplinary urban design approach in which the discipline of water management sought to use its collaborative nature and in which water management experience and knowledge outline norms and values for its ways of analysis and output.

1.2.2 Water-Sensitive Urban Design (WSUD)

WSUD is an approach which emerged from the academic field of urban water management in Australia at the latest turn of the century (Bichai & Cabrera Flamini, 2018; Radcliffe, 2019; Wong, 2006). WSUD shows similarities to other recent approaches which have emerged in other contexts or focus on specific urban water cycles or means to intervene in them, such as Low Impact Development (Coffman, 2000) and Best Management Practices (Clary et al., 2002) in North America, Sustainable Urban Drainage Systems (Woods Ballard et al., 2007) in the United Kingdom, Nature-Based Solutions (e.g., Cohen-Shacham et al., 2016) and Green-Blue Infrastructure (e.g., Pötz, 2016) in Europe, and Sponge Cities (e.g., Zevenbergen et al., 2020) in China. These approaches are at times used interchangeably in literature and are considered the state-of-the-art urban water management of the Global North (Fletcher et al., 2015). In this dissertation the focus is on WSUD because of its intended operationalisation of urban design as interdisciplinary practice and its holistic approach to management of urban water cycles.

Despite advancement of urban water management, in practice, the globally prevailing approach is still based on the Modern Infrastructural Ideal (MII) (Graham & Marvin, 2001) which emerged in the late 19th century in response to lacking water services jeopardising public health. Based on belief in 'makability', the MII confides in technological advancements to achieve development and centralisation of all kinds of urban infrastructures. This ideal, however, got under pressure by the recognition of climate change, resource pollution and depletion, increasing urbanisation and demand, ageing infrastructures, frequency of disruptive events, and growing awareness of the value of the natural environment and processes. A paradigm shift ought to happen and was initiated by urban water managers from academia to overcome the negative impacts on natural water cycles and limitations to environmentally, socially, and economically sustainable development that the MII poses. Instead of importing water into town to exploit and dispose of out of town when polluted or of nuisance, emphasis moves to alternative, decentralised, and fit-for-purpose systems to efficiently treat, provide, and drain water as a resource for a multitude of urban factors with the required quality for its end use. Beyond changes in the techniques deployed, institutional alterations are required to engage more diverse stakeholders in water governance. The latter is called for as consideration and participation of more diverse stakeholders in planning allows for redistribution of responsibilities and enhancement of its sustainability (Bichai & Cabrera Flamini, 2018).

In the case of WSUD, the calls for this paradigm shift are responded to by operationalizing the interdisciplinary, collaborative, and integrative nature of urban design. The collaboration proposes the fusion of water-cycle management,

protection, and conservation into urban design practice and the prioritisation of water in urban design agendas (Brown & Clarke, 2007). Urban design is not only mobilised as a spatial practice but moreover to facilitate integration in fivefold: 1) integration of engineering, environmental, and social sciences disciplines; 2) integration of management of water supply, wastewater, and stormwater; 3) integration of water management into built form; 4) integration of various scales of investigation and intervention ranging from streets, buildings, and backyards to entire catchments or regions; and 5) integration of structural and non-structural initiatives ranging from physical infrastructures to policy frameworks (Wong, 2006).

For these intended integrations, the spatial field of operation of WSUD is set out by the amplitude of natural water systems, ranging from atmosphere to ground- and subsurface, yet includes human interference and operationalisation of this cycle for delivery of services, such as water provision, sanitation, and drainage and how people and society relate to the water cycle (Sugano et al., 2024). Therefore, emphasis of WSUD is on the urban water cycles. Through and in consideration of natural hydrological and ecological processes, the management of water, in states of balance, excess, scarcity, or contamination, is approached with urban design processes. Generally, this is done by system interventions and manipulating (i.e., (re)designing) urban surfaces and built-up elements. Processes deployed include the retention capacity of vegetation, infiltration capacity of soils, permeability of surfaces, and degree of connectivity of spatial configurations, alongside minimisation of import of potable water and export of wastewater through demand management and fit-for-purpose reuse. Furthermore, through urban design, WSUD intends to address modes of usage, participation, maintenance, management, and capacity building for these processes, perceptions, and interactions. Crucial is the consideration of the spatiotemporal dimensions and how all aforementioned aspects may both evolve over time and differ per spatial scale (Bacchin, 2015).

To understand historical development of urban water management and to evaluate its current state and progress, the Urban Water Transitions Framework (UWTF) (Brown et al., 2009) was established as a theoretical framework accompanying WSUD. Although WSUD and the UWTF can be considered independent of one another, the framework has become a common guide for assessments of urban infrastructure and development and illustrating potential progress and foreseen transitions. Despite the fact that there are no fully transitioned ‘water-sensitive cities’ in the world to date, the UWTF demonstrates its systematic underpinning, including the different temporal, technological, and ideological city states and their accompanying socio-political ‘drivers’ and service delivery functions, through which cities should transition (i.e., water-supply city, sewered city, drained city, waterways city, water-cycle city, water-sensitive city) (Figure 1.1) (Wong & Brown, 2009).

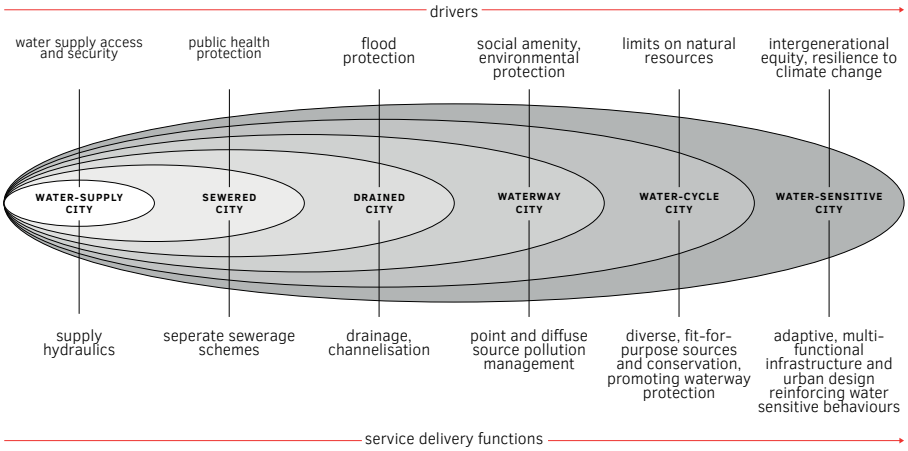

FIG. 1.1 The Urban Water Transitions Framework (UWTF) (adapted from Brown et al., 2009).

As such, the UWTF describes the 'road' to the water-sensitive city goal and suggests a process to go through, while WSUD refers to all the current efforts which that pursuit may entail (Fletcher et al., 2015), yet without methodological support on either water sensitivity or urban design. To the urban design process, the water-sensitive city goal can be considered as a guiding concept and intended qualities of the vision for an urban area. Key pillar principles include using cities as water-supply sub-catchments, instead of an obstacle within macro catchments, with diverse fit-for-purpose water sources, providing ecosystem services, and building socio-political capital for sustainability and water-sensitive behaviour of a caring and aware community (Wong & Brown, 2009). This way, the attempt is to minimise the hydrological impact of the urban environment on its surrounding and enclosed natural environment (Kuller et al., 2017) while maximising positive impacts by adding functionality and benefits through ecosystem services (TEEB, 2010). How to achieve these principles and targets, however, is not methodologically underpinned in WSUD and is left open.

In the UWTF, each city state is characterised by hydro-social 'contracts' (Lundqvist et al. (2001), encompassing the implicit agreements between the public and government or water service providers on how water is managed and by who. Each city state and accompanying hydro-social contract influence and shape the transition to the following city state (Wong & Brown, 2009) and therefore the UWTF can be considered cumulative and linear. Successive hydro-social contracts define the necessary socio-technical overhauls to transition. Embodying conventional, cultural, and deep-rooted water management practices, the existing hydro-social contract may often pose the greatest transition barrier (Mguni et al., 2016), calling attention to the major role culture plays in these processes and practices.

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Through shifting local social capital, knowledge building and formalisation opportunities, case studies with demonstrable results, target and benchmark establishment, and bridging organisations, institutional legitimacy of WSUD was, nevertheless, improved (Abbott et al., 2013; Brown & Clarke, 2007) and translated into a strong discourse on the leverage of the disciplinary integration it proposes. As such, the value of WSUD for urban development practices across the world is proclaimed by advocates from academia and policy making and WSUD has successfully been operationalised in local urban design and water management practices in Australia, Germany, Singapore, the Netherlands, and the United States, among others (Abbott et al., 2013; Brown & Clarke, 2007; Cook et al., 2019).

To society, application of WSUD in these contexts in response to urban and climatic challenges feeds into hydro-social 'imaginaries'. These are the collectively held visions of an expected or desired present or future state of urban nature and urban environments and how to live in them and thus influencing spatial relations and urban development practices (Davoudi & Machen, 2022). Circulation and normalisation of the imaginary of water sensitivity provides a contemporary opposition to the MII, regardless of the fact that WSUD interventions are often applied non-systemic and at relatively small scales, incomparable to MII application. MII is done systematically and on large scales and remains the accustomed norm for its standardised infrastructure and perceived efficiency, cost-benefit ratio, and contribution to welfare (Graham & Marvin, 2001). Furthermore, the mentioned contexts with WSUD application are predominantly without pressing concerns among their inhabitants regarding local water management systems, as water effortlessly appears from taps or with rain and disappears down drains without significant nuisance (Leonard et al., 2019). By means of these applications, the water-sensitive ideal increasingly makes up the frame of reference in urban design processes. Asymmetry of powers in society further enforces this by obstructing materialisation of alternative hydro-social imaginaries (Duarte-Abadía & Boelens, 2016). In response to the fixating perception of water sensitivity, frameworks attempt to track an urban environment's suitability to receive WSUD and its potential efficiency and effectiveness by means of parameters to aid urban design, planning, and management endeavours (Kuller et al., 2017).

1.2.3 Secondary cities in India

Specificities of secondary cities remain underexposed, with most of the frequent reports on patterns of urbanisation and development of cities and their infrastructures primarily focusing on macro trends and the world's biggest and most competitive cities (Roberts, 2014; Roberts et al., 2022). As such, the term secondary cities, on the one hand, suggests a hierarchical system of cities and, on the other hand, refers to their obscurity. The hierarchical order can be explained based on variables. Most common are a city's size of population or area (Roberts, 2019), yet differentiations of more functional specialisations, like political (e.g., Beijing, Bruxelles, Washington), religious (e.g., Bethlehem, Lourdes, Mecca), or historical significance (e.g., Luxor, Persepolis, Rome), also exist. It shows the meaning of primary and secondary can differ depending on the context in which it is used and the scale it is regarded. Therefore, no definition for primary and secondary cities is universally agreed upon (Song, 2013).

In light of the focus on urban and water infrastructure design, interest of this research lies with magnitude and speed of population growth and urbanisation, which, contrary to the common perception, has for a while been biggest and most pressing in relatively smaller cities in developing contexts (Roberts, 2014). When is said that 68% of the world's population is expected to live in urban areas by 2050, only 8,5% of that share lives in the well-studied megacities with 10 million inhabitants or more, whereas close to half centres themselves in the less-investigated urban settlements of a secondary nature (UN DESA, 2019). This still implies that the percentage of the world population living in megacities will increase most but that the absolute population growth is biggest in secondary cities, making the collective environmental impact of secondary cities considerable, as well as their potential to address it as their growth is still taking place.

Globally, population growth contributes most to the urban increment in India, where, since 1950 its population has tripled, from 376 million to 1,35 billion, and the level of urbanisation has doubled to 34% with the increase still ongoing (UN DESA, 2019). Being 'primary' in growth and speed of associated socio-economic change, their 'secondarity' is seen in their subnational size and administrative function, following India's division into states and districts each with its capital and district headquarters, respectively. Examples of such secondary Indian cities are Kozhikode, capital of the namesake district in Kerala, and Bhuj, capital of the district Kutch in Gujarat (Figure 1.2), which are the key cases in this research.

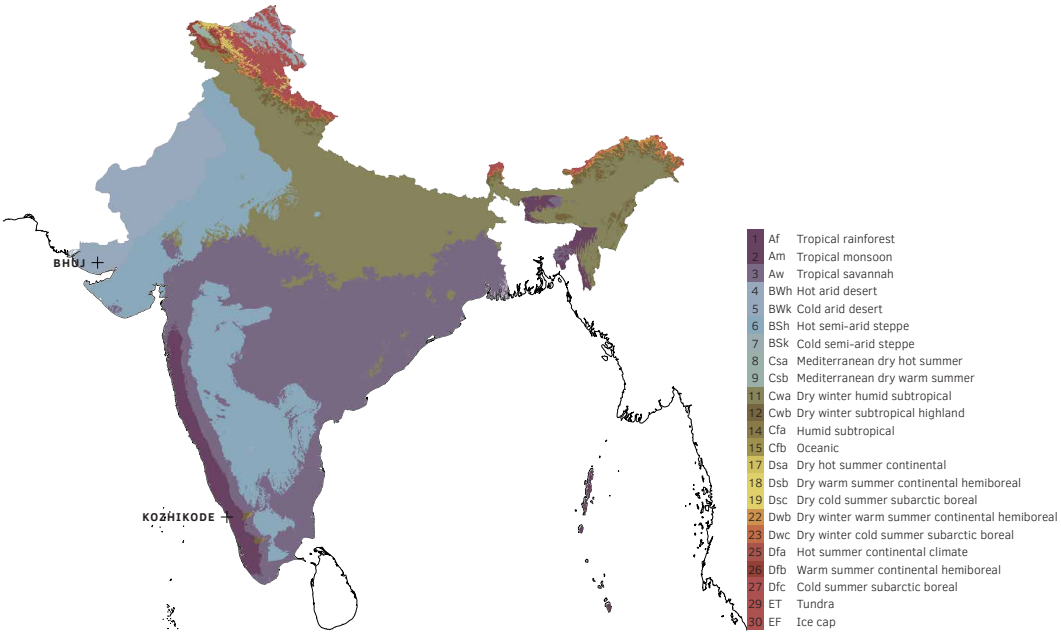

FIG. 1.2 Locations of case study cities Bhuj and Kozhikode in India in their climatic zone (adapted from Beck et al., 2018).

In terms of secondary city obscurity, the environmental impact of Indian secondary cities is aggravated by their frequently deficient initial conditions, such as lacking infrastructure and service provision (Roberts, 2019). These development-urgencies have incessantly existed under increasing pressure by rapid urbanisation without extensive urban planning (Roberts, 2014; Roberts et al., 2022), nor sufficient data availability to execute such plans or data collection resources to keep pace with the high speed of changes (Lindley et al., 2018). As such, secondary cities are also less studied and known and, therefore, at times, unacknowledged in the development of urban design approaches, like WSUD. On those accounts, in this study we refer to secondary cities as cities administratively key at a subnational level, following the country's biggest cities in size yet rapidly growing and with a backlog in infrastructure, service provision, and data availability or documentation.

The inquiry of this research into secondary cities Bhuj and Kozhikode in India is, furthermore, motivated by the Water4Change research program within which this research is embedded. These cities are among three secondary Indian cities (including Bhopal, Madhya Pradesh) selected by consortium members in the program for the city's exemplarity in a country with diverse climatic conditions and urban water challenges (e.g., too much, too little, too dirty, too unequal). Due to travel limitations, the study focuses on the sub-selection of Bhuj and Kozhikode, having the smallest area and population size and – in the context of India – most contrasting, yet exemplary, climates

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of the three. At the latest census in 2011 (the 2021 census has been postponed until after the 2024 Indian general elections), Bhuj had a population of 188,000 and Kozhikode a population of 550,000 (Census of India, 2011). Bhuj has a hot desert climate and Kozhikode a tropical monsoon climate, according to the Koppen-Geiger climate classification and in consideration of climatic changes (Beck et al., 2018) (Figure 1.2). Additionally, the collaborations of the research program provided opportunities to collaborate with local research institutes or initiatives in these particular cities.

1.3 Research conceptualisation

At the cross section of the three key concepts, introduced in chapter 1.2, the adressed research gap can be found to which the research aim is formulated. Following the research aim, the research questions which guided the pursuit towards that aim will be presented, as well as the methodology which elaborates how the research is conducted. The outline provides the structure of the dissertation.

1.3.1 Research aim and research questions

Despite the intention of WSUD to operationalise urban design for its objective, the importance of contextualisation in the urban design process (i.e., recognised in the suitability of the guiding concept, addressing a physical and cultural setting, and the frame of references used) seems underrepresented. Literature research revealed a gap regarding the suitability of WSUD in contexts with a different establishment or state of urban water management and hydro-social contracts than the countries in which WSUD was conceptualised (Bichai & Cabrera-Flamini, 2018). There is need for distinct design guidance on WSUD implementation in rapidly developing contexts and growing cities with consideration of context specificities (Rashetnia et al., 2022). Through growing institutional legitimacy and widespread implementation, WSUD, however, gains traction and its universality is increasingly assumed or proclaimed. The benefits of WSUD indicated for cities across the world (e.g., Abbott et al., 2013; Charlesworth, 2010; Cook et al., 2019), in fact, are equally desired in the Indian secondary cities. However, caution is warranted as progress in urban water systems in one context may not be achieved by using the infrastructure and following design approaches conventional in another (Poustie & Deletic, 2014).

Being an established approach of design, WSUD should follow the recognition that this approach will also relate to a particular cultural context and articulates a particular way of knowing and seeing. The interdisciplinarity at the core of urban design, intended to be adopted by water managers for WSUD, should be able to include such local or diverse knowledge. The ways design approaches, like WSUD, arrive in and relate to contexts, the ways their designs can reconfigure local norms and values, and its implications should be acknowledged. Design as a means of knowledge production, as such, should be a situated and relational activity rather than a superimposed or imported approach (Schultz et al., 2018). By means of an urban design perspective, this dissertation thus intends to critically evaluate and challenge the universality of WSUD.

The aim of this research is to enhance context specificity of WSUD, by means of urban design. To achieve this, the research reconceptualises and situates water sensitivity as an urban design concept and shows how becoming – and being at present – water sensitive implies being context specific. To do so, the research, furthermore, repositions urban design within WSUD to provide for promising combinations between WSUD and a context and its water sensitivity, and enrich the vocabulary of urban design methods for WSUD. The contexts used to situate water sensitivity and test its reconceptualisation and repositioning of urban design in WSUD are Indian secondary cities. These cities, therefore, provide the context to all the following questions which guided the inquiry.

The research questions are:

1 *What role do the concept of water sensitivity and urban design methods play in the distinct operationalisation that WSUD requires per context?*

2 *What contribution do urban design methods provide to situating the concept of water sensitivity?*

3 *How can context specificities be accounted for in WSUD?*

1.3.2 Methodology

Guided by the research questions, this research challenges and deconstructs WSUD with a selection of qualitative methods: literature review, fieldwork, historical analysis, and actor consultation by means of workshops and semi-structured interviews. The literature review, as a qualitative method, focuses on a single concept (i.e., water sensitivity) within the contexts of attention, and allows for personal values and positioning of oneself (Creswell, 2009). The latter elevates the method of literature review to a crucial component of the overall research in expressing its need and framing, providing for the critical positioning towards WSUD, and repositioning of water sensitivity and urban design within the water management approach (Chapter 2).

The qualitative approach arose from the combination of the research aim of context specificity with the Indian secondary case study cities. Being characterised by lacking documentation and data availability or accessibility, the cities called for data collection fieldwork which honoured their uniqueness and implied personal engagement with the sites to understand its mechanisms. This allows for procedures to emerge as insights advance, rather than positioning the cities as experiments (Creswell, 2009). Having two case study cities contributes to testing limitations of conventional WSUD and possible contributions of urban design on diverse yet exemplary contexts. Fieldwork was conducted twice in both case study cities to additionally review seasonal differences of urban water challenge (i.e., in July 2022 and February-March 2023). During fieldwork, key data collection at the basis of chapter 3, 4, and 5, was conducted through observations to gather context knowledge. Onsite, observations were provided by walking, while photographing, sketching, and writing amplified accuracy of the observations. Post fieldwork, drawing, mapping, and narrating, as forms of representation, formalised the documentation of the observations.

Walking and drawing, onsite and post-fieldwork, enable observation and are a personal act of learning and information gathering, contributing to developing a sense of place and engaging with both the larger scale landscape as well as its inhabitants and their culture to reveal relations between individuals or communities and the landscape. Walks can thus enable alternative interpretations of the walked context, while deviations allow investigation physically and thematically around the walked paths and unanticipated encounters (Hemel, 2023; Li, 2021; Staničić, 2023). Physical and natural features are combined with social and cultural features which facilitates understanding spatial elements as ensembles (Schultz, 2014). The walk becomes like a necklace stringing together such ensembles (e.g., neighbourhoods, water bodies). Walking advances the reading and understanding of the territory

from within, informed by what the landscape has to offer (Li, 2021), and, as such, connecting small and large scale, community and territory. In Kozhikode, a canal and a pattern of ponds and sacred groves provided the scale and subject of the walks (Chapter 3 and 5). In Bhuj, this was provided by a 16th century man-made water system (Chapter 4).

Post-fieldwork, the observations and personal reading of the landscape informs documentation through drawing. In response to both lacking documentation of the area, as well as to document with intention. The intention in this research being to become sensitive to the water of the context and enhance context specificity of the design approach. The form of representation of the documentation depends on the capability of the format to map its topic of interest while connecting to the necessary relevant other aspects. Examples of drawing formats from this dissertation are a series of sections to map lived space (Chapter 3) and mapping to visualise the spatial retracings of lost traditional water system knowledge (Chapter 4), while both representing urban hydrological processes. Such forms of representation can include multiple physical and non-physical forces, dimensions, or interrelations and can, following personal acts of information gathering and processing, uncover, articulate, and visualise possibilities for a context and a local potential for design to be actualised (Corner, 1999). In this research, especially through observations by combining walking and drawing, the contribution of urban design in reading and developing an understanding of the urban context and bringing it to life is shown (Cullen, 1961, 17).

Fieldwork also deploys the lens of historical analysis as traces of history – useful active or inactive parts of the past (Descombes, 2016), changeable or unchanging – are found in the landscape and retrieved to be shown in relation to the present and future (Kimic, 2023). Evidence of a context's history is equally found by consultation of actors. Within the framework of the Water4Change project, series of workshops were hosted to engage with local actors from both case study cities (i.e., online workshop in 2022 and onsite workshops in 2022 and 2023 in each city and one collective workshop in New Delhi in 2023) and collect their perspectives on urban water challenges, contextualised visions for water sensitivity, and pathways to achieve the required transition. Not only did attendees supplement, update, or validate the limited data, they also provided different insights and pointed out additional interrelations unable to acquire or identify without stakeholder participation. Attendees of the workshops included members from public agencies, NGOs, academia, design practice, and local communities. Moreover, the workshops facilitated follow-up interactions with diverse actors through semi-structured interviews to share their different knowledges and perceptions of water or water services in their cities and how those developed or shifted over time (Chapter 4

and 5). Divergence and convergence of actor perspectives were identified by means of data triangulation (Denzin, 1970), situating commonalities and substantiating and validating arguments. Combining communication of observations and actor consultations required the construction of a collaborative narrative in which personal findings, data, and actor perspectives are combined. By doing so, both fieldwork as personal and historic knowledge-gathering becomes an interdisciplinary act, key to urban design (Hooimeijer et al., 2022), with actors representing either specialist disciplinary knowledge or communal traditional knowledge to articulate. Both insights into the history and culture of a place ultimately allow one to better read its urban environment (Kostof, 1991).

1.3.3 Societal relevance

Pressures of the climate crisis include longer and irregular periods of heat, precipitation, or absence thereof, with consequential hazards like droughts, wildfires, storms, and flooding, affecting mankind and its surrounding ecosystems (IPCC, 2023). Last century's dominant water infrastructure in place is increasingly outdated, insufficiently flexible, or unable to confront these increasing pressures. Nor are its underlying water management approaches able to address these escalations (Bell, 2015). Impacts of the climate crisis and infrastructure deficiency, however, are additionally amplified by urbanisation-driven land use and land cover changes which alter or abrupt hydrological cycles. Societal relevance of this research is, therefore, in the first place, to be found in the contributions to WSUD theory and practice which play a role in addressing the above mentioned impacts on society and their surroundings worldwide.

The drivers and rapid uptake of WSUD highlights the significance of the inquiry into WSUD as a new and state-of-the-art urban water management and urban design approach replacing its predecessors. Particularly, as it is happening despite the absence of distinct design guidance for its implementation and consideration of context-specific conditions. These would be most imperative for contexts facing rapid urbanisation (Rashetnia et al., 2022), like secondary cities and India. The research gains additional societal relevance by focusing on examples of such secondary cities. Being frequently overlooked or understudied, yet facing growth projections and having a large collective environmental impact (Roberts, 2014; Roberts et al., 2022), the findings on these contexts, therefore, serve a significant and relevant society.

The inquiry into the uptake and universality or context specificity of notions of WSUD and accompanying urban design methods gains additional relevance against the backdrop of high-level promotion of new exogenous water management approaches and design concepts, such as WSUD and water sensitivity. Water management and urban design approaches, like WSUD, are exported and applied from one context to another, under the heading of cooperation, aid, or knowledge sharing and directly or indirectly subsidised by international, national, or municipal governments. The approach will have resulted in successful interventions or infrastructure in a certain context. However, lacking systematicness, these may be limited to stand-alone pilots. Nevertheless, they now contribute to identifying problems in a very different other context and are then exported as solutions to those problems. These schemes highlight a lack of consideration of context specificity of urban water management challenges and applicability and suitability of urban water management or urban design approaches, concepts, or solutions. At the same time, examples of such schemes, such as the collaboration between sister cities Rotterdam, the Netherlands, and Surat, India, on water squares and green-blue roofscapes (Molenaar et al., 2019), show how promotion and export of design concepts presented as universal takes place at present in practice, without review of the full extents of context specificity, nor the perceived necessity to do so. These cross-cultural and international schemes indicate societal relevance in how they inform incomplete or insensitive local problem framing with potential policy implications.

Ultimately, the greater project of decolonising design (Schultz et al., 2018) has been a driving force behind this research. It is an imperative to which all design endeavours should be directed, including water management, water infrastructure design, and urban design, and thus also WSUD. Decolonising design implies carefully questioning accustomed roots and origins of design approaches. By unlearning them, societal relevance is found in making space for context-specific and locally suitable design practice and enabling those design practices and outputs to be valued as equally, if not more, valid among local and global public. With stronger ties to local culture and knowledge, engagement of local practitioners and local appropriation of context-specific WSUD can be facilitated.

1.3.4 Dissertation outline

In pursuit of the research aim, this introduction is followed by five chapters. Chapter 2 to 5 present four scientific papers which work around the formulated research questions and aim. Three of these papers have been published and one is currently under review. The chapters, therefore, contain their own introduction of theories and methods and conclusion section. The contents of these papers divide the dissertation into two parts (Figure 1.3). The first part consists of only chapter 2 and introduces the need for context specificity in WSUD. It brings forth the foundation and the critical positioning of the objective of this research. Being occupied with the first research question, it reconceptualises water sensitivity and repositions the roles of context and urban design in WSUD.

The second part of the research, chapter 3, 4, and 5, builds on the foundation of the first part and discusses and tests urban design methods to address the aim (Figure 1.3). Motivated by the second research question, chapter 3 and 4 use urban design as ways of seeing, reading, understanding, and engaging with the Indian secondary city contexts. These chapters, therefore, regard the two case study cities, Kozhikode and Bhuj. Firstly, in chapter 3, through fieldwork and observation by means of walking and drawing, to arrive in the city of Kozhikode and situating chapter 2's findings. The conducted immersive fieldwork exercises provide a focus on the physical spatial scales with which urban design can engage and the additional dimensions of a context it can uncover to support water sensitivity. Secondly, chapter 4 moves to Bhuj to elaborate chapter 3's effort by making explicit how urban design operates and water sensitivity evolves or shifts through temporal scales, by means of historical analysis, development of time periods, and actor consultation. At last, through the focus on the agency of WSUD and urban design, chapter 5 addresses the final research question. Through discussion of the situatedness of urban design and WSUD and the efforts and methods of situating, chapter 5 provides valuable insights on the agency of WSUD and on what it takes and what it means for WSUD to be context specific. Chapter 6 follows to provide the discussion on the findings in this research and conclusions, including their scientific relevance, limitations, and suggestions for future research.

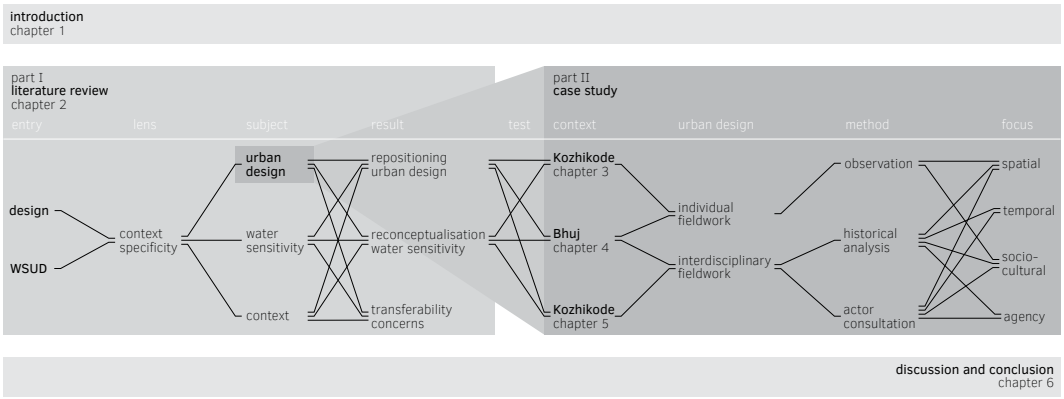

FIG. 1.3 Diagrammatic outline of the dissertation.

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2 Water sensitivity and context specificity - concept and context in WSUD for secondary cities

Van der Meulen, G.J.M., Van Dorst, M.J., & Bacchin, T.K. (2023). Water sensitivity and context specificity – concept and context in Water-Sensitive Urban Design for secondary cities. *Urban Water Journal, 20 (1)*, 15-25. DOI: 10.1080/1573062X.2022.2153704.

This chapter is published in the Urban Water Journal as referenced above. However, the titles of chapter 2.2, 2.3, and 2.6 have been changed to match the other chapter titles of the dissertation. 2.2 'Methodology - Literature review from an urban design perspective' is called 'Methodology' in the journal, 2.3 'WSUD - The concept and its operationalisation' is called 'Water-Sensitive Urban Design' in the journal, and 2.6 'Discussion - Rethinking WSUD' is called 'Discussion' in the journal.

ABSTRACT

Water-Sensitive Urban Design (WSUD) offers an approach for alternative spatial organisation of cities and water infrastructures fit to address urban and climatic challenges. However, its relevance in all contexts is questioned and transferability concerns arise when mainstreamed. Instead of considering water sensitivity as a guiding concept for the ultimate state or performance of an urban environment, this article argues that (storm)water sensitivity is a context-and culture-specific variable, dictated and confined by other site variables. As such, WSUD implies an interaction between water sensitivity as context and concept, in which context shapes concept and concept provides focus on how to address context. Sensitivity therefore refers to the thoughtfulness of reading a context, highlighting to what extent site-specific

urban conditions can be identified to potentially be considered water-sensitive. This understanding enables local urban designers and water managers to appropriate and engage in WSUD fit for the cultural, socio-economic, and physical context.

2.1 Introduction

Urban environments worldwide are facing challenges due to an accelerating increase in urban population. By 2050, 68% of the world's population is expected to live in urban areas. Of that share, only 8.5% will live in the well-studied megacities with 10 million inhabitants or more, whereas approximately half will live in the relatively smaller and less-investigated urban settlements of a secondary nature (UN DESA, 2019). This still means that the percentage of the world population living in megacities will increase most but that the absolute population growth and speed and magnitude of related socio-economic change is greatest and most pressing in secondary cities, making the collective environmental impact of secondary cities considerable, additionally due to frequently poorer initial conditions and lacking infrastructure and service provision (Huang et al., 2018; Maru et al., 2021; Pathirana et al., 2018a; 2018b) under increasing pressure from rapid urbanisation without extensive urban planning (Roberts, 2014).

Urban areas worldwide are also facing the climate crisis, with longer and more irregular and unpredictable periods of extreme precipitation or heat resulting in hazards like droughts, flooding, and mudslides, among others. Its impacts, however, are arguably driven in a similar way by urbanisation-driven modifications to land cover and subsequent abruptions in the hydrological cycle. In urban areas, the effects of these modifications are most impactful to human lives. With rapid urbanisation in secondary cities, these modifications occur expeditiously. In intertropical African cities, for instance, urban floodplains are commonly claimed for activities like sports facilities, garbage dumps, or urban agriculture without sufficient infrastructure to prevent flooding (Douglas, 2018), or themselves functioning as obstructions in the hydrological system, causing flooding. In Dar es Salaam, Tanzania, the rapid and uncontrolled growth of informal settlement in such hazardous areas is a principal cause of increased flood risk (Mguni et al., 2015).

In addition to human and hydrological systems, climatic changes negatively affect terrestrial and marine ecosystems; numerous species of flora and fauna face increased risk of extinction (IPCC, 2022), in turn affecting the urban and natural environment.

Urban growth projections (Veerbeek et al., 2011), occasionally in combination with partially uncontrolled distribution and climatic pressures, introduce mitigation and adaptation challenges in cities for urban water management and urban design, planning, and decision-making professionals. The dynamic nature of secondary cities also presents opportunities to reconsider the spatial organisation and systems of water management in urban environments, for instance, advancing environmental conservation and multifunctional infrastructure. Water-Sensitive Urban Design (WSUD) is a concept and intention for the collaborative integration of water-cycle management with the built environment through urban planning and design (Abbott et al., 2013). In the context of Australian primary cities, this concept has a 'track record' of being successfully operationalised (e.g., Brown & Clarke, 2007; Cook et al., 2019), and is considered fit to address urban and water challenges while effectively delivering multiple benefits and qualities (Rijke et al., 2016). The increasing geographical spread of WSUD application in Australia and elsewhere indicates its suitability in a wide range of climatic conditions (Abbott et al., 2013; Cook et al., 2019). For the relevance, suitability, and applicability of WSUD in the pressured and rapidly changing contexts of secondary cities, more research is warranted on WSUD implementation that takes into account local development processes and contextual conditions (Rashetnia et al., 2022).

2.2 Methodology - Literature review from an urban design perspective

Motivated by the objective to facilitate an extension of the successfully initiated paradigm shift (Bichai & Cabrera Flamini, 2018) in the context of secondary cities, this article highlights how the WSUD concept may require distinct interpretation and operationalisation per context. Rather than testing the application of the extraneous interpretation of the WSUD concept as a method in a secondary city (with differently established urban design and water management practices and different social, economic, and climatic change intensities within which they operate), core elements of WSUD are discussed through a literature review from an urban design perspective. By reviewing the inceptive intents and qualities of WSUD, the urban design process, and arising transferability concerns, the notion of sensitivity in WSUD is reflected upon, beyond its reference to environmental, urban, and water issues, as a way of considering and working with a context and its variables and dynamics. As such, the article focuses on the situatedness of the WSUD concept, the repositioning of the notion of water sensitivity, and the revaluation of highly contextualised urban design within WSUD.

Reflecting on WSUD and water sensitivity from an urban design perspective can help embed WSUD in urban design practice and, more importantly, provide a WSUD approach to appropriate in a wider range of contexts, given any set of local initial conditions, dynamics, complexities, and means. Both the propositions developed, to embed WSUD in urban design and to situate WSUD, inquire into the emphasis of the consideration of context and to regard water sensitivity as a part of the considered context rather than merely a goal.

2.3 WSUD – The concept and its operationalisation

WSUD proposes the fusion of water-cycle management, protection, and conservation into urban design and planning practice, and prioritisation of water in urban design and planning agendas. Introducing water sensitivity into the urban design process demands operationalisation of the multidisciplinary and collaborative nature of urban design to 1) integrate engineering, environmental, and social science disciplines; 2) integrate management of water supply, wastewater, and stormwater; 3) integrate water management into built form (e.g., building architecture, landscape architecture, urbanism, public art); 4) integrate various scales of investigation and intervention ranging from buildings, backyards, and street profiles to complete catchments and regions; and 5) integrate structural and non-structural initiatives ranging from policies to infrastructures (Wong, 2006). By doing so, the WSUD concept encourages urban development with integrated urban water management (Fletcher et al., 2015) as an interdisciplinary effort to minimise negative hydrological impacts on its surroundings.

As a theoretical framework accompanying the WSUD concept, the Urban Water Transitions Framework (UWTF) (Brown et al., 2009) (Figure 2.1.a) was established to evaluate the state and progress of urban water management transitioning toward the 'water-sensitive city'. Although WSUD can be considered independent of the UWTF, the framework has become a frequent companion, informing assessments of urban development and potential progress in terms of water sensitivity, and visualising foreseen transitions. Despite the fact that there are no fully transitioned water-sensitive cities in the world to date, the UWTF presents its systematic underpinning by defining different temporal, technological, and ideological city states, with the accompanying socio-political drivers and delivered services, through which cities should transition when pursuing a sustainable future. In this light, the UWTF describes the 'road' to the water-sensitive city 'destination', whereas the WSUD concept regards everything that process entails (Fletcher et al., 2015). Toward the ideal of the water-sensitive city, cities are said to first transition through the 'water-supply city', 'sewered city', 'drained city', 'waterways city', and the 'water-cycle city'. In the urban design process, the water-sensitive city ideal provides design criteria as a guiding design concept with three key pillar principles for practice: 1) to use cities as water supply catchments with diverse fit-for-purpose water sources and centralised and decentralised infrastructures; 2) to provide ecosystem services; and 3) to build socio-political capital for sustainability and water-sensitive behaviour

(Wong & Brown, 2009). As opposed to the guiding design concept, WSUD literature refers to best-practice and illustrative reference projects (Wong & Brown, 2009), accompanied by assessment tools and indices as concrete instruments for practice, informing urban planning and design decisions and trajectories (Lerer et al., 2015; Rogers et al., 2020).

In the UWTF, each of the city states is characterised by 'hydro-social contracts' (Lundqvist et al., 2001) that describe the inherent norms, values, expectations, and agreements in society on how water is managed and its physical manifestation in existing infrastructures. Each city state contract can be considered to influence and shape the subsequent transition state (Wong & Brown, 2009) and therefore the UWTF has a cumulative nature. Correspondingly, hydro-social contracts define the gradient amid the dichotomy between 'developing' and 'developed' contexts of relevance in this article as it outlines the evolving state and performance of water management infrastructure and institutional arrangements, above the disputed economic, industrial, and welfare categorisations commonly used to distinguish 'developed' from 'developing'. Simultaneously, the successive hydro-social contracts define the necessary socio-technical overhauls in transitioning toward water sensitivity (Wong & Brown, 2009). Embodying conventional and frequently deep-rooted water management practices, the existing hydro-social contract potentially poses the greatest barrier (Mguni et al., 2016) to progress in the developmental dichotomy.

In Australia, conceptualisation of WSUD, nevertheless, translated into a strong discourse on the leverage and value of the integration it proposes. Through shifting local social capital, knowledge building and formalisation opportunities, case studies with demonstrable results, and target and benchmark establishment, it gained institutional legitimacy and has been operationalised in urban design and water management practices (Brown & Clarke, 2007), engaging decision makers, politicians, and society (Fletcher et al., 2015). Similarly, the WSUD concept has been successfully operationalised and applied in different climatic conditions in Germany, Singapore, the Netherlands, and the United States, among others (Abbott et al., 2013). However, it is recognised that these locations are predominantly without pressing concerns among their inhabitants regarding local water management systems, as water effortlessly appears from taps or with rain and disappears down drains without significant nuisance (Leonard et al., 2019). Having emerged from the developed Australian primary city context, the site-specific relevance of WSUD for contexts with a different establishment or state of hydro-social contracts and influence of local speed of changes can be questioned (Bichai & Cabrera Flamini, 2018) which calls for distinct advice and guidance for WSUD implementation (Rashetnia et al., 2022).

2.4 Transferability concerns

As urban water management approaches are mainstreamed across discourses globally, research increasingly questions their suitability in rapidly changing contexts (Poustie et al., 2015). With the worldwide operationalisation and uptake of the WSUD concept and its multidisciplinary and collaborative intent, transferability concerns have arisen from a multitude of related perspectives, such as governance, economics, urban planning and design, equity, and community engagement and awareness (e.g., Dorst et al., 2022; Madonsela et al., 2019; Rogers et al., 2020), highlighting local shortcomings, gaps, or complications in WSUD approaches and assets. Here focusing on the urban design perspective when operationalising the WSUD concept to an approach, concerns arise foremost from the limited applicability of WSUD in specific contexts, i.e., its contextualisation. Beyond site-specific conditions (e.g., climate, topography, soil, ecology, urban pattern, infrastructure) impacting operationalised hydrological processes or suitability studies of WSUD assets, the highlighted concerns are informed by, for example, cultural conditions, local speed and magnitude of changes, and resources to map these conditions and implement these assets. Concerns equally arise from the limits of generically experienced WSUD qualities, i.e., its conceptualisation. In the literature, the concerns include 1) the negligence of the WSUD concept and the UWTF in coexisting formalities, dynamics, adaptation demands, and site-specific variables of the urban environment; 2) the benefit inequity and extraneous attributes of the means of WSUD, such as green-blue infrastructure; and 3) the limited data availability, data accessibility, and data resources required to practise WSUD. This set of concerns is not exhaustive; more context-specific transferability concerns may arise as WSUD application expands globally.

2.4.1 Transferability concerns regarding the Urban Water Transitions Framework

The cumulative nature of the UWTF fails to recognise regular coexistence of multiple city states within the administrative boundaries of a single city or natural boundaries of its catchment area (Fisher-Jeffes et al., 2017), which follow distinct rates of change and requiring simultaneous retrofitting and development, instead of only new development as the literature suggests (Rashetnia et al., 2022). The UWTF may give the suggestion (Figure 2.1.a) a city can exclusively be a water-supply city, or a drained city, whereas in fact these states coexist or are fluid, and a city is rather in

a state of transition, polarised into formal and informal built-up or greenfield areas (Figure 2.1.b) (Fisher-Jeffes et al., 2017), as is the case in secondary city contexts with differently established hydro-social contracts and high speed of change.

However WSUD and the UWTF being in theory free-standing (i.e., the UWTF frames the 'steps' to the water-sensitive city objective, the WSUD concept refers to everything that process entails (Fletcher et al., 2015)), the UWTF gives reason for transferability concerns of WSUD as it became a common aid to WSUD in identifying a city's urban development needs and potential progress towards water sensitivity. Differing sets of context-specific needs in urban areas can best be illustrated by distinguishing two perspectives on adaptation. Cities with developing hydro-social contracts, like many secondary cities, frequently require adaptation to deficits in infrastructures that in less pressured cities or cities with more developed water management infrastructure are already adequate or close to adequate. This is referred to as type I adaptation, characterised by urgency, addressing current shortcomings or absences. Additionally, all cities require adaptation due to local social, economic, and especially climatic changes. This is referred to as type II adaptation, characterised by uncertainty, addressing long-term changes (Burton, 2004; Radhakrishnan et al., 2017). In practice, when both types are required, they often interfere (Brown, 2011), leading to additional expenditure, inefficiency, or other unforeseen consequences (Bichai & Cabrera Flamini, 2018) as adaptation demands for water management are often addressed separately or sequentially instead of in an integrated manner. The drainage plan for a secondary Vietnamese city, Can Tho, for example, recommends future climate measures (type II adaptation) that may be ineffective without addressing current deficits (type I adaptation) (Pathirana et al., 2018a). At the same time, proposed urban developments in Can Tho, such as road improvements and new dike rings (type I adaptation), are path-dependent and unsuitable for addressing sudden or uncertain future changes (type II adaptation) (Pathirana et al., 2018b).

However suitable for primary city contexts, the cumulative UWTF in this light seems to disregard its 'leapfrogging' potential in secondary and developing city contexts. Leapfrogging implies bypassing conventional development and directly implementing transitional water-sensitive system alternatives by learning from design, planning, and implementation practices in locations that have undergone a certain development, eliminating the mistakes made there, not to simply match these locations, but to advance and become a frontrunner (Binz et al., 2012). Likewise, the applicability and results of assessment tools, providing handles and levers for WSUD outside of the contexts for which they were developed, are challenged by parameter sets differing between contexts and implicit local assumptions, culture, traditions, and socio-political structures that are invalid elsewhere (Lerer et al., 2015).

2.4.2 Transferability concerns regarding green-blue infrastructure

Transferability concerns are observed in the suitability of assets intrinsic to WSUD and their underlying theories and practices, conceptualised from the perspective of cities with further developed urban water management infrastructures and hydro-social contracts (Lindley et al., 2018). To address increasing water management challenges and opportunities, a persistent shift away from grey water management infrastructure approaches toward green-blue infrastructure approaches is recognised (Mguni et al., 2015). By disconnecting stormwater discharges from wastewater management systems and operationalising the urban landscape to process these flows instead, green-blue infrastructures offer advantages through their multifunctional nature and the ecosystem services they deliver.

Urban communities living in formal built-up areas, and especially those in informal built-up areas which are increasingly present in secondary cities, often already benefit from or are vitally dependent on access to provisional, regulating, supporting, and cultural ecosystem services including food, fuel, fresh water, shade, tourism, and spiritual and religious values. However, this implies that they are, directly or indirectly and in the short- and long-term, vulnerable to the potentially declining quantity and quality of these services. For example, certain communities in Addis Ababa, Ethiopia, are dependent on the urban field crops and vegetable produce for household consumption, income, and employment. Now a potential 40% loss of urban farmland area to settlement between 2011 and 2025 is expected (Abo-El-Wafa et al., 2018), directly impacting the communities engaged with urban farmland and dependent on its ecosystem services.

Alongside declining ecosystem services, urban communities can be equally exposed to ecosystem disservices, referring to possible flipsides of ecosystem services that are elsewhere experienced as favourable, ranging from flood risk and vector-borne diseases to decreasing or increasing land values (Roy et al., 2018; Schröter et al., 2014). The latter results in forced displacement of poorer urban communities led by a real estate market-driven increase in housing or rental prices in, for instance, sub-Saharan cities (Mguni et al., 2016). In other cases, urban green-blue interventions, as a cause and means of increasing land value, have undermined the sense of belonging in local communities, leading to other dimensions of displacement such as socio-cultural erasure and decreased access to urban amenities in previously disinvested neighbourhoods of Dallas and New Orleans in the US, where prior cultural or artistic practices or aesthetics of original communities were excluded in novel green-blue designs (Anguelovski et al., 2021).

This last example reflects ecosystem service decline, ecosystem disservice, and the possible inappropriateness of certain green-blue interventions. 'Green-blue' as an adjective can be reminiscent of the colonial norm in locations with a general brown-blue appearance of autochthonous nature (Shackleton & Gwedla, 2021). However unsuitable the soil conditions, green lawns are still a preeminent colonial symbol in Australia, contrasting with indigenous wilderness (Ignatieva et al., 2020). In Queenstown, South Africa, the percentage of public urban green space in neighbourhoods reveals ongoing inequality, ranging from 0.9% in townships to 74.1% in affluent areas (Shackleton & Gwedla, 2021). Similar spatial inequity is observed in South African communities with unequal proximities to public green space (Venter et al., 2020). Colonial administrations equally influenced water management and hydraulic engineering practices by addressing the needs of a small demographic and elite minority (Hazareesingh, 2001). In Mumbai, as in many Indian cities, this resulted in water management systems in which discriminations remain to be legitimised and performed through daily maintenance and management (Anand, 2017, 35-36). The imposition of knowledge produced a shifting appreciation of natural phenomena such as rain and water discharge, increasingly associated with efficiency, uncertainty, despair, and fear, whereas they were once celebrated in certain Indian cases (Da Cunha, 2019). Likewise, colonial rules influenced urban planning and design practice, noticeable in the configuration of the urban environment (e.g., urban grid system of Christchurch, New Zealand), its green spaces (e.g., picturesque European parks and private gardens in Australia and the US), and the quantity and types of plant species they contain (Ignatieva & Stewart, 2009; Stewart et al., 2004). In this light, addressing water challenges with green-blue infrastructures can have the danger of being seen as something of a luxury or beautification (Drosou et al., 2019; Herslund et al., 2018; Lindley et al., 2015).

Types of green-blue infrastructure should rather be selected and designed with properties and services attuned to the biophysical, socio-economic, and governance context (Ahmed et al., 2019; Kuller et al., 2017) and with diverse local species, eliminating or minimising supplemental irrigation (Ignatieva et al., 2020), as is successfully studied and applied in brown-blue arid and semi-arid secondary city contexts in Australia, Egypt, and Mexico, among others (e.g., Bigurra-Alzati et al., 2020; Ignatieva et al., 2020; Mahmoud & Selman, 2011). The transferability concerns regarding green-blue infrastructure, however, highlight the sensitivity and complexity of its effects.

2.4.3 Transferability concerns regarding data

Ultimately, WSUD and its intrinsic assets and assessment tools are rather data-intensive (Sharma et al., 2019) which becomes a concern in secondary city contexts and contexts with developing hydro-social contracts frequently characterised by limited data resolution and limited data collection and processing resources. In such contexts, the hydrological evidence with which urban water management and design decisions are made is often limited (Poustie et al., 2015; Zogheib et al., 2018). In sub-Saharan African cities, for instance, data is commonly insufficiently available, appropriate, or up to date throughout spatial and temporal scales to practise WSUD, whereas the dynamics of relevant context variables are recurrently greater here (Lindley et al., 2018). In Quito, Ecuador, the available data is insufficient to analyse impacts of WSUD interventions (Zogheib et al., 2018).

Beyond unavailability, inappropriateness, and outdatedness, lacking data management and coordination and collaboration efforts additionally challenges WSUD. In secondary Indian cities, for example, datasets are stored at different (private) agencies or siloed departments and centralised data bases are non-existent, limiting data generation, accessibility, and exchange (Water4Change, forthcoming). Reasons for lacking data sharing in Thailand are perceived loss of control of data, national security standards, insufficient gain, or a perceived insufficient level of technology and skills to engage in data sharing (Plengsaeng et al., 2014). Exclusive data management can also purposefully be mobilised for specific agendas (Zogheib et al., 2018). Correspondingly, ethnographic collected and managed water data has the risk of criminalising marginalised communities (which it initially might seek to support) or risks under- or mis-representing those marginalised communities when knowledge is kept from officials or scientist out of fear for criminalisation (O'Leary, 2018). Furthermore, the data-intensive WSUD assessment tools can be incomprehensible (Lerer et al. 2015). This additionally sustains exclusivity and restricts their usability to niche practitioners, limiting the interdisciplinary process, as is the case with computational urban water management models, which are regularly excluded from participation in initial urban design stages (Bacchin et al., 2011).

Data relevant to WSUD include parameters prescribing the resistance overland and groundwater flow experience when moving through space. Such climatic, topographic, ecologic, and soil variables shape the impedance a water flow encounters within and around urban environments. Additionally, urban patterns of built-up elements and infrastructure, related open spaces, their densities, and the networks within them can be observed as elements of possible friction for water flow in the urban environment. Such elements and infrastructure introduce changes in the

physical properties of the pre-urban natural environment, affecting the hydrological cycle in the way they cover or are imposed on soil and topography (Bacchin et al., 2011). However elementary, objective, observable, quantifiable, or known these variables and their global variability may be, their precise local susceptibility to differences and diverging spatial and temporal deviation determine, or are determined by, the unique local speed and magnitude of changes, and can drastically alter local hydrological processes. Sufficiently high-resolution data on all scales and resources to update data at the frequency required to keep pace with such dynamics, however, are consistently lacking (Lindley et al., 2018).

The diverse nature and angles of transferability concerns (i.e., theoretical and assessment frameworks, assets and interventions, data and data resources) arise the moment the WSUD concept lands in a context different from the one it was conceptualised in. Transferability concerns originate both from prior conceptualisation (e.g., unfit and non-inclusive understanding) and during contextualisation (e.g., local limitations, conditions, and unintentional effects) (Table 2.1), highlighting the local context sensitivity for operationalisation of WSUD and how alternative and potential water sensitivity is context- and culture-bound and brings up the question what is challenging the suitability of WSUD and how water sensitivity, urban design, and context relate to one another.

TABLE 2.1 Examples from literature of transferability concerns arising from conceptualisation or contextualization.

	Framework	Means	instruments
	Urban Water Transitions Framework	Green-blue infrastructure	Data
	Transferability concerns and references	Transferability concerns and references	Transferability concerns and references
Conceptualisation	– Unfit cumulative nature; – Overlooking joint need for retrofit and development (Fisher-Jeffes et al., 2017)	– Benefit inequity (Mguni et al., 2016); – Extraneous attributes, colonial (Da Cunha, 2019; Ignatieva & Stewart 2009; Shackleton & Gwedla 2021); – Ecosystem disservices (Roy et al., 2018; Schröter et al., 2014); – Beautification / luxury (Drosou et al., 2019; Herslund et al., 2018; Lindley et al., 2015)	– Data-intensive, incomprehensive (Lerer, et al., 2015; Poustie et al., 2015; Zogheib et al., 2018); – Restricted to niche practitioners, limiting interdisciplinary process (Bacchin et al., 2011)
Contextualisation	– Coexisting city states (Fisher-Jeffes et al., 2017); – Adaptation urgencies / uncertainties (Burton, 2004; Radhakrishnan et al., 2017); – Varying / high rate of change (Lindley et al., 2018)	– Ecosystem service dependency / vulnerability to ecosystem service decrease (Abo-El-Wafa et al., 2018); – Discrimination (Anand, 2017, 35-36); – Inequality (Anguelovski et al., 2021; Shackleton & Gwedla 2021; Venter et al., 2020)	– Limited data resolution / availability / reliability, limited data collection resources (Lindley et al., 2018); – Limited data sharing / management / accessibility (Plengsaeng et al., 2014; Sharma et al., 2019; Water4Change, forthcoming); – Unjust mobilisation of exclusive data (O'Leary, 2018; Zogheib et al., 2018); – Varying / high rate of change (Lindley et al., 2018)

2.5 Cornerstones of WSUD

According to the characteristics and factors impacting WSUD and its systems, the two-sided definition for the suitability of a location to receive WSUD in practice by Kuller et al. (2017) differentiates the 'needs of WSUD (for optimal functioning)' and the 'needs for (the benefits of) WSUD', discussing respectively the efficiency and effectiveness of the WSUD approach at a given location. Rather than considering current examples of operationalised WSUD as fixed and more or less suitable, efficient, or effective in certain contexts, in response to the transferability concerns, this article casts light on the mutual relations between water sensitivity, urban design, and the specificities of a context as three cornerstones of the spatial manifestation of WSUD.

Contrary to the cumulative nature of the UWTF, in which the water-sensitive city and water sensitivity are generally presented as the ultimate and most advanced state and performance of the urban environment, this article stresses that water sensitivity is also an adjective based on a set of past and present site characteristics and past, present, and future urban design outcomes (Kuller et al., 2017). This implies that, beyond WSUD requiring consideration of local site conditions (Rashetnia et al., 2022), water sensitivity is a site-specific context variable dictated and confined by a set of other site variables characterising a context. It is for this reason that the close link between the freestanding WSUD concept and the UWTF is considered so relevant in this article. It repositions water sensitivity as merely a goal to a degree of (potential) water sensitivity, part of a current context and culture, and varying per location depending on hydrological conditions in relation to local climate (e.g., volatility of climate change projections, knowledge, awareness, and anticipation per context and local sensitivity of weather systems), topography (e.g., variety of watershed and slope configurations and their connectivity), soil (e.g., specific soil type compositions, their hydraulic properties, and capacities), ecology (e.g., variety and characteristics of vegetation and fragmentation and heterogeneity of the landscape and accompanying ecosystem services), and urban pattern (e.g., land use and cover, unique spatial morphology, density, state, materialisation, functioning, and management of man-made features and systems, and formality and rate of its expansion). The unique sum of such details constructs a context and regulates most hydrological processes and conditions that WSUD interventions frequently seek to operationalise (Bacchin, 2015; Kuller et al., 2017; Wanielista et al., 1997). Their local differences result in ephemeral or perennial events of drought or inundation and stagnant watercourses or flash floods, highlighting how context determines hydrological processes and consequently defines the degree of potential water sensitivity.

Recognising and acknowledging the value, validity, and importance of the core of the WSUD intention to operationalise urban design as an interdisciplinary facilitator to manage water in a sensitive manner and water sensitively develop the urban environment, water sensitivity should not be seen simply as something projected onto a unique context by means of urban design. The urban design process likewise operationalises water sensitivity. As a design discipline, urban design includes abstract, complex, and open-ended design processes that are, in the case of urban design, by definition site-specific. Nonetheless, in its different appearances, several generic elements can be distinguished. Pragmatically, urban design can be seen as an explorative process of projecting change, contextualised, generally following a guiding concept to reach a coherent design result, and using its own visual and verbal language. In this process, 'contextualised' implies to design for a defined site and socio-cultural context, and to design within a frame of relevant references in a specific professional culture (Van Dooren et al., 2013; 2014). Reference projects, with a certain status in light of a specific design task or problem, are common design tools and function as examples of how context variables come together to shape a design in different contexts (Van Dorst, 2005).

WSUD assigns priority to water (sensitivity) in urban design and planning agendas (Brown & Clarke, 2007) and, in the design process, water sensitivity can be recognised as a guiding concept and an intended set of qualities to frame and direct urban design and provide guiding principles. In addition, water sensitivity directs urban design through contextualisation, as a key context variable influenced by and influencing other site characteristics, and through reference WSUD projects. In fact, the two, water sensitivity as concept and as context are linked, as guiding concepts in design processes are commonly based on what is adequate for a particular site (Van Dooren et al., 2013). WSUD as an urban design process discusses promising combinations of urban development and water management in a context (Tjallingii, 2012) and implies interaction between water sensitivity as context and concept, in which context shapes concept and concept directs how to address context. Accordingly, preceding the urban design process shaping the urban environment, preliminary and ongoing reading of the urban space and the underlying and surrounding territory as context is equally essentially an act of design. The reading, mapping, and understanding of a context aids designers and planners in uncovering possibilities among many complexities and contradictions in urban environments, and in actualising and unfolding that potential (Corner, 1999). In this light, (water) sensitivity refers equally to the thoughtfulness of reading, mapping, and understanding a context and its dynamics, as to the change it projects within it. Supplementary emphasis on (the preliminary reading of) context is expected to invigorate and promote the essential prioritisation of water in local urban planning agendas. It facilitates going beyond the hypothetical levels and abstractness of

the concept, demonstrating what water sensitivity means at a specific location and exposing defining site-specific variables, local water practices and cultures, and dynamics as alternative qualities for emphasis and as a means for projecting water-sensitive change.

2.6 Discussion - Rethinking WSUD

The listed transferability concerns and reflection on water sensitivity, urban design, and context as three equal cornerstones of WSUD highlighted that water sensitivity should not be merely seen as an urban design goal and guiding concept. Water sensitivity is also a context variable to be considered in the urban design process and a context variable which is interwoven with other context variables, together defining a particular site and the potential and suitability of WSUD interventions. This supports the main idea of the article to shift from a water-sensitive goal to an already present and potential degree of water sensitivity which allows local practitioners to engage in a WSUD approach, more embedded in urban design practice and in line with local means and the physical, cultural, and socio-economic context. This will facilitate to push WSUD in urban planning agendas globally.

Considering transferability concerns and repositioning water sensitivity, urban design and context in WSUD while safeguarding its fit and applicable operationalisation in cities worldwide, however, challenges establishment of a systemic WSUD approach. Calling for a shift toward context and urban design within WSUD highlights further complexities in urban contexts and urban design research and practice including the intangible dimension of context and its multi-scalarity, both of which play an important role in urban design as universal notions, but with specific implications for WSUD.

Water sensitivity as context is influenced by, yet depends on more than the sum of observable parameters. The gaze of urban design, which WSUD operationalises, when reading context and projecting change, focuses on patterns and rates of change of physical aspects (e.g., climatic, topographic, ecologic, soil, urban, infrastructural) unique to each context, yet additionally, considers the relation and interaction between them and the intangible cultural, social, and economic structures in place. With the possible absence of data for such parameters, this intangible yet equally dynamic dimension underlines the complexity and context specificity of

WSUD. Observed in local climate change awareness and anticipation, ecosystem (dis) service inequity, and the way in which urban space through which water passes is used, valued, and perceived, this intangible dimension further informs and constrains an alternative consideration and potential of water sensitivity and its qualities. Transformation and production of space is namely, intentionally or not, driven and confined by spatial patterns of everyday human behaviour and practices (De Jong, 2015). The continuity and recognisability of urban spatial patterns enable place attachment (Meyer et al., 2020). Space plays an important role in construction of a spatial and cultural identity, especially in the public sphere, enabling appropriation and development of social capital, closely linked to community acceptance, which is particularly key for WSUD approaches (Leonard et al., 2019). Socially produced physical arrangements of space can differ within a polarised urban environment, resulting in different levels of service provision, community awareness, and social vulnerability that ultimately shape the degree of potential resilience of its users and inhabitants (Bacchin, 2015).

The contribution of WSUD to a city's water sensitivity depends on the interrelation between tangible and intangible structures and the hydrological processes in place. The relation and dependency vary through spatial and temporal scales (Kuller et al., 2017). WSUD calls for the activation and mimicking of the pre-urban natural hydrological system in the urban environment (Bell, 2015) and its time-sensitive services and benefits (Lindley et al., 2018). The temporal scale of relevance therefore ranges from minutes (e.g., of precipitation) to days (e.g., of heatwave) to months or seasons (e.g., with monsoons) to years (e.g., of ecological succession or climate change). As WSUD promotes operationalisation of a city to serve as an urban sub-catchment (Wong, 2006) rather than as an obstacle in the macro catchment, the spatial scales of relevance range from nano to macro and go beyond the local scales and administrative boundaries of urban environments, as water does not acknowledge such borders. The structures and hydrological processes of interest, therefore, operate on the full spectrum of spatial and temporal scales and these mutually influence each other. Different scales of primary consideration in urban design and water management practice can, however, produce contrasting views on, and strategies for, intervention (Douglas, 2018), challenging the effectiveness of meeting the intervention's objectives. An action may be effective in terms of one objective or for one agent but impose externalities at other spatial and temporal scales, 'downstream' or later in time, increase impacts on others, or reduce their opportunities to adapt. Furthermore, an action's effectiveness may depend on highly uncertain individual uptake and future conditions (Adger et al., 2005).

The interdependencies and interrelations of context variables through spatial and temporal scales and their different natures, including tangible physical variables and intangible socially produced variables of physical arrangements in space, ranging from relatively static to highly dynamic (spatially and temporally) and with different levels of observability, emphasise the high level of context complexity. However, it also underlines the key role context plays in informing and pursuing potential water sensitivity. The complexity of a context challenges the foundation of a WSUD approach that balances water sensitivity in relation to context (i.e., context confining potential water sensitivity and water sensitivity as a context parameter) and water sensitivity as a concept in the urban design process. Further investigation of the implications of context in water sensitivity and the organisation of common ground and variations can therefore help establish systemic local operationalisation of tailored WSUD approaches applicable and beneficial in both primary and secondary cities worldwide. This will result in manifestation and interventions of WSUD consistent with unique site variables and cultures and therefore distinctive for each context.

2.7 Conclusion

This article acknowledges the value of WSUD, noting its operationalisation successes and manifested interventions. However, knowing its elements and qualities, transferability concerns that arise as WSUD is mainstreamed across discourses and locations are carefully reviewed to highlight that, for similar operationalisation of the concept with different urban design and water management contexts, hydro-social contracts, and distinct influences of local dynamics, success is not guaranteed. Transferability concerns call for revaluation and repositioning of key WSUD elements: water sensitivity, urban design, and the role of context in each.

From an urban design perspective, the use of a utopian water-sensitive city ideal in the UWTF (Figure 2.1.a) is recognised as a valid guiding concept, common to the urban design process. The cumulative nature of the UWTF, however, does not seem to consider how technological and socio-cultural conditions and city states can coexist within an urban environment or a water catchment, as would be the case with greenfield developments or informal settlements (Figure 2.1.b). In most cases, the route to water sensitivity will be nonlinear and context variables, rate of development, and influential local dynamics differ greatly, both between cities and within cities. Thus, water sensitivity as a guiding concept does not always provide

sufficient support to practise WSUD, in spite of prioritisation of water in urban design and planning agendas, whereas context becomes the evenly, or more, informative support for potential water sensitivity in these agendas. In this article the link between the WSUD concept and the UWTF is regarded as important because the cumulative framework does not consider that city states can already be somewhat water-sensitive, as with ancient or local water practices and cultures. With this understanding, water sensitivity is a part of past, present, and future contexts, as are other context variables (Figure 2.1.c). As such, water sensitivity is both a concept and context in the urban design process; the concept provides direction in addressing a particular context and stimulates water-sensitive development. Through polarised contextual conditions (e.g., formal and informal built-up areas, infrastructural deficits, steady or rapid social, economic, and climatic changes, lacking or ample awareness) and context variables (e.g., climatic conditions, topographic configurations, soil typologies, local ecosystems, urban patterns), however, a particular context dictates and confines the degree of eventual water sensitivity and the scope of challenges and opportunities for urban design. Instead of projecting the same and similarly achievable water-sensitive city goal in each context, the present and reachable water sensitivity varies per context without implying they are suboptimal. Present and reachable water sensitivity must be reviewed per context in close connection with local urban design to determine to what extent urban conditions can be identified to potentially or alternatively be identified as water-sensitive.

For further study of WSUD beyond primary cities in urban environments worldwide, the approach would benefit from awareness that water sensitivity is a context variable in the urban design process that is reciprocally influenced, driven, and confined by other context variables. Placing context and its variables centre-stage in WSUD, instead of the water-sensitive city ideal and its visionary state and functioning of an urban context, would further promote water in urban planning agendas and discourage use of extraneous and unfit WSUD assets through consideration of site conditions, allowing operationalisation of a WSUD approach consistent with the means (e.g., data, data resources) available to determine the conditions, dynamics, and complexities of a context. For WSUD, this implies that water sensitivity is a highly contextual entry point, to be mixed with other angles and context variables per location, defining the local potential of WSUD and unlocking situated urban design and development. As such, WSUD is a valid concept to aid in the review and comprehension of contextual water sensitivity requiring operationalisation per location, instead of being imposed.

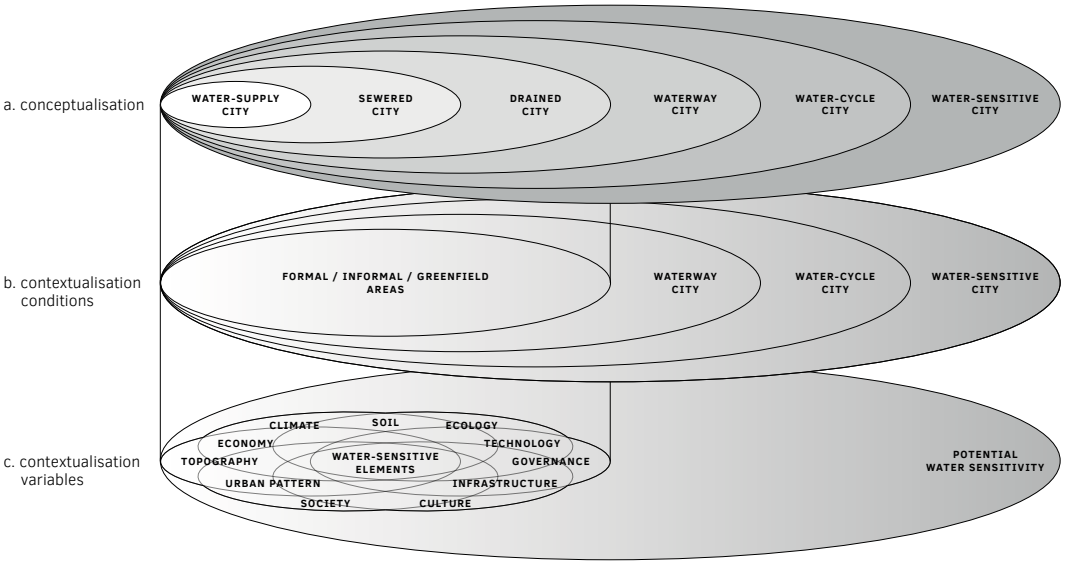

FIG. 2.1 a) The conceptual UWTF (adapted from Brown et al., 2009); b) the contextual UWTF with coexisting urban conditions (adapted from Fisher-Jeffes et al., 2017); and c) the mutually influencing context variables describing a context, including current water-sensitive elements, informing reachable potential water sensitivity

Ultimately, such a repositioning of water sensitivity, urban design, and context in the WSUD concept aids in 'decolonising' design (Schultz et al., 2018), as an imperative to which all design endeavours must be oriented, rather than an additional design approach (Abdulla et al., 2017). With the objective of local appropriation and application of the WSUD concept, decolonised design, in the reading of space and the projection of change, allows for stronger ties to culture and history, facilitating the mainstreaming of WSUD and enabling local urban design and water management practitioners worldwide to engage in WSUD fit for the cultural and socio-economic context aside from physical site specificities in pursuing a water-sensitive future. The concept of decolonising design equally calls for an emphasis on the cultural dimension of contexts, besides site-specific variables, as cultural contexts shape cognitive processes, emotions, and values, and thus behaviour in general, especially pro-environmental behaviours (Schill et al., 2019).

TOC

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3 The hydro-cultural dimension in WSUD for Kozhikode, India

Van der Meulen, G.J.M., Bacchin, T.K., & Van Dorst, M.J. (2023). The hydro-cultural dimension in Water-Sensitive Urban Design for Kozhikode, India. *Journal of Landscape Architecture, 18 (2-3)*, 22-33. DOI: 10.1080/18626033.2023.2347142.

This chapter is published in the Journal of Landscape Architecture as referenced above. However, the titles of chapter 3.2, 3.3, 3.4, and 3.5 have been changed to match the other chapter titles of the dissertation. 3.2 'WSUD - The concept and its secondary city contextualisation' is called 'On WSUD: The concept and its secondary city contextualisation' in the journal, 3.3 'Methodology - A design and fieldwork approach to WSUD' is called 'On methodology: A design and fieldwork approach to WSUD' in the journal, 3.4 'Kozhikode - Rain on an undulating terrain' is called 'On Kozhikode: Rain on an undulating terrain' in the journal, and 3.5 'Fieldwork - Reading water sensitivity' is called 'On Fieldwork: Reading water sensitivity' in the journal. Furthermore, the caption of figure 3.3 is shortened from ' Post-fieldwork illustrations of cross-sections cutting the transect walked along Conolly Canal, showing the position of the man-made water body in relation to different land uses adjacent to the canal.' to ' Post-fieldwork illustrations of cross-sections cutting the transect walked along Conolly Canal.' for layout purposes.

ABSTRACT

Water-Sensitive Urban Design (WSUD) identifies water sensitivity as a goal for cities to strive for and develop towards. Certain cities may face rapidly changing socioeconomic and urban dynamics, or lack of data and documentation, greater than those in which WSUD has been conceptualised. Landscape-informed, design-based fieldwork methods of walking, observing, describing and drawing can help to understand how hydrological systems are linked to local water cultures and practices. This shifts the definition of water sensitivity away from a universal ideal future scenario to one that is mutable and determined by local qualities. The case of Kozhikode, India, illustrates how fieldwork and its forms of representation, with an emphasis on the design processes that WSUD calls for to be operationalised, can shed light on urban hydro-cultural dimensions. These dimensions extend hydrological indicators by incorporating cultural insights to be integrated into WSUD, thereby enhancing the context specificity and appropriateness of the concept. As such, design methodologies and the hydro-cultural dimension offer valuable contributions to WSUD and can facilitate its adoption worldwide.

3.1 Introduction

Cities around the world are facing climate and urbanisation challenges that put enormous pressure on urban water cycles. Water-Sensitive Urban Design (WSUD), a concept that aims to integrate urban design, planning and water management, has recently gained traction worldwide. However, transferability concerns arise when applied in contexts with different characteristics from those in which WSUD was initially conceptualised (Van der Meulen et al., 2023) (for instance, in Australia in the 1990s by local academics and urban drainage professionals (Bichai & Cabrera Flamini, 2018; Fletcher et al., 2018)). This article focuses on the application of WSUD in such different contexts, namely through the case study of Kozhikode, India. Kozhikode is a relevant urban context for the discussion due to its rapid urban development and unique topographical conditions (such as an undulating coastal plain adjacent to steep mountains) and water cultures (such as the practice of various religions around water bodies and natural elements), each in complex relationship with pressurised urban water cycles.

This study responds to WSUD by elaborating on its intention to operationalise the integrative and multi-scalar nature of urban design (Wong, 2006). It employs a design perspective and fieldwork method that is new to WSUD, shedding light on local water practices and their spatial manifestation in residual water artefacts. As such, the approach promotes greater context specificity in WSUD, taking into account more than just local hydrological characteristics, by uncovering a hydro-cultural dimension that it urges be systemically emphasised for WSUD to be appropriate to secondary urban contexts.

3.2 WSUD - The concept and its secondary city contextualisation

WSUD is a water management concept that aims to integrate the management of stormwater drainage, wastewater sewerage and water supply with the protection and conservation of aquatic environments in urban areas into urban design and planning. It also aims to ensure that urban and water infrastructure development takes natural hydrological and ecological processes into account (Wong, 2006). WSUD has some overlap with other approaches (for example, Sustainable Urban Drainage Systems, Low Impact Development, Sponge Cities, Green-Blue Infrastructure, Nature-Based Solutions), which may focus on specific urban water cycles or means of intervening in them, or originate from different contexts or times. However, they all focus on the activation of natural processes and are therefore often used interchangeably in the literature (Fletcher et al., 2015). The emphasis here is on WSUD because of its intended holistic approach to urban water management and the operationalisation of urban design.

In the context of developed cities across the globe, the WSUD concept has been successfully operationalised in practice, resulting in, among other things, rehabilitated watercourses and progressive policies for improved catchment protection, and demonstrating its suitability to address urban challenges in different (changing) climates (Abbott et al., 2013). However, there is a lack of design guidance for WSUD that takes into account context specificities or for its implementation in unplanned developing cities (Rashetnia et al., 2022). Without guidance or methods of appropriation and implementation, WSUD may remain a foreign concept in such contexts. Nevertheless, based on successful results elsewhere, it is appealing to and demanded by cities with less developed urban infrastructures. Coming from developed urban contexts, the challenges of embedding the concept of WSUD in other contexts around the world arise from site- and culture-specific conditions and differently established infrastructures and urban development practices that constrain contexts from achieving a water-sensitive state, as well as from the conceptualisation of WSUD in approaching the transition to this ideal performance (Van der Meulen et al., 2023).

WSUD is accompanied by the Urban Water Transitions Framework (UWTF) (Brown et al., 2009), a theoretical tool to assess the state and progress of a city's urban water management and to underpin the WSUD concept by providing a pathway towards the goal of becoming a 'water-sensitive city': an ideal urban state with intergenerational equity, resilience to climate change, and adaptive and multifunctional infrastructure and urban design that reinforce water-sensitive behaviour. This ideal functions as a guiding concept in WSUD processes, with three principles for practice: access to diverse water sources through centralised and decentralised infrastructure, the provision of ecosystem services, and sociopolitical capital for sustainability (Wong & Brown, 2009). As such, WSUD coins water sensitivity, but fails to define 'sensitivity' as awareness of contextual and cultural specificities, such as particular uses and perceptions of space, cultural water artefacts, practices, implicit knowledge, and pace and scale of change. These concerns call for greater context specificity in WSUD, with a different perspective on the relevant data and knowledge to be considered and the methods to collect them.

While most of the frequent reports on patterns of urbanisation and development of cities and their water infrastructures, practices, and cultures provide knowledge on the world's biggest cities, the specificities of secondary city studies remain underexposed (Roberts, 2014). 'Secondary', on the one hand, suggests a hierarchical order of cities. In light of urban and water infrastructure design and development, the interest lies in the scale and speed of urban and population growth, which, contrary to common perception, is greatest and most urgent in relatively smaller urban settlements in developing contexts, with significant collective environmental impacts (Roberts, 2014). Being 'primary' in terms of growth and speed of socioeconomic change, their 'secondarity' can be seen in terms of subnational size, administrative function, and often inadequate starting conditions, such as a lack of infrastructure and service provision (Huang et al., 2018; Maru et al., 2021). This occurs under increasing pressure of rapid urbanisation without extensive urban planning (Roberts, 2014) or data collection resources sufficient to keep up with the speed of change (Lindley et al., 2018). On the other hand, the article addresses secondary cities as cities that are less known and unrecognised in the development of concepts such as WSUD.

This article focuses on Kozhikode, a city on the west coast of the Indian peninsula, as an interesting case from both a secondary city and water sensitivity perspective. The growth of secondary cities is high in India, where the population has tripled since 1950 and the level of urbanisation has doubled (UN DESA, 2019). Apace with Kozhikode's urbanisation and in combination with its striking topographic and climatic conditions, the city and its environs face major urban water challenges, including flooding (Figure 3.1), landslides, the encroachment of water bodies, water scarcity, pollution and the inequality that they suffer from.

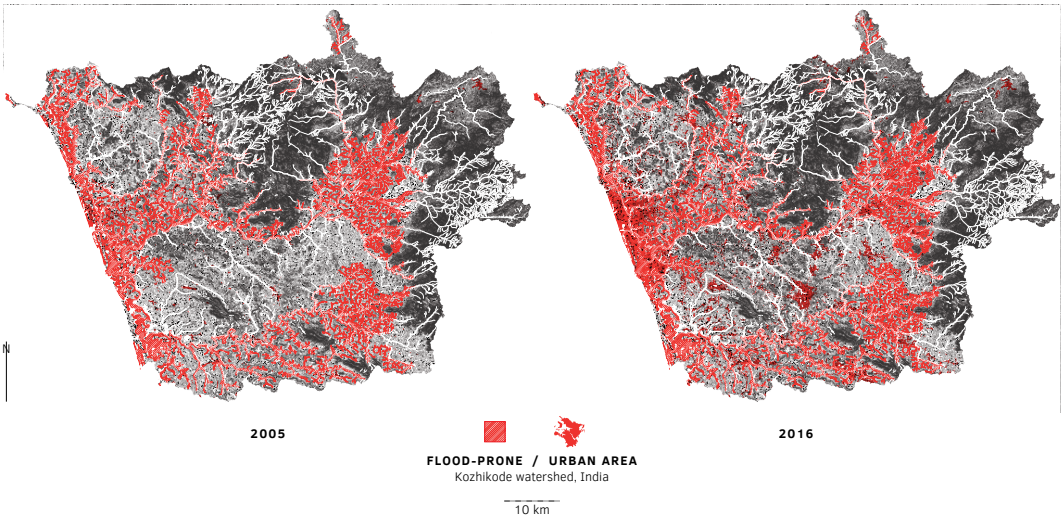

FIG. 3.1 Overlay mapping of urbanisation in 2005 and 2016 (adapted from NRSC, 2019) and flood prone area (adapted from NCESS, 2010) in the watershed in which Kozhikode is located, showing the rapid and hazardous urban sprawl in the undulating coastal plain up until the Western Ghats mountains.

WSUD offers opportunities for the spatial organisation of dynamic urban environments and their water management, such as water-related recreation, water harvesting and reuse, and flood control (Abbott et al., 2013), which the authorities in Kozhikode are taking advantage of. To critically situate water sensitivity in a context like Kozhikode, given the unique dynamics of monsoons, floods, urban sprawl and encroachment, the article focuses on mapping and representing site-specificities and local water cultures to reflect on WSUD in light of its response to physical, cultural and historical contexts.

By exploring these design methods and enriching their vocabulary, the article aims to answer how they can contribute to the context specificity of WSUD, following the hypothesis that fieldwork readings of an area and post-fieldwork forms of representation can bring to light a different or additional dimension and potential of the site, and thus encompass a formative and creative act of design (Corner, 1999). For example, a particular use, perception or history of water in a particular place, otherwise unseen or unacknowledged in WSUD, might reveal the water-sensitive ideal not as a distant goal, but rather as a retrospective uncovering of past and present qualities that can be designed with and reclaimed or emphasised for water-sensitive development.

3.3 Methodology - A design and fieldwork approach to WSUD

The adoption of urban design processes in WSUD inspires the design-driven methodology of this article. With the aim of advocating context specificity in WSUD, this article explores how a specific context can shape WSUD as a design process. Design is an intuitive process of projecting change or creating something, usually following a guiding concept or intended qualities, using a visual language and, particularly in the case of urban design processes, being by definition situated. 'Situated' in this process refers to a defined site or context and to a frame of reference (Van Dooren et al., 2014). For WSUD, this means that water sensitivity has the potential to touch on multiple aspects of design processes, providing guiding concepts, intended qualities and exemplary reference projects, while assessing site characteristics. The key, however, is to ensure that the correct dimensions of a context are considered in the design process and that the frame of reference and guiding concept with which a context is approached are appropriate.

Urban design processes involve non-sequential, iterative efforts of analysis, synthesis and projection (Jonas, 2007; Roggema, 2016), examining possible, probable and desirable futures for a context (De Jong & Priemus, 2002). Beyond water sensitivity as a desired future state projected onto a context, it should reflect a thoughtful analysis of that context and its dynamics, and a relational understanding of natural, hydrological and urban processes. In contexts where WSUD is conceptualised, a path between the present and the desired future may be easily identifiable, as is presented in the UWTF, or because the WSUD concept and references used in design fit more naturally. However, the construction of such a path, in Kozhikode, for example, is challenged by the interface of the city's topographical, climatic, socioeconomic and urbanisation conditions. This interface limits the design space for WSUD and requires an emphasis on reviewing and becoming acquainted with the context.

This article draws on immersive design fieldwork approaches that are new to WSUD. Along with the imperative to promote an understanding of urban and hydrological systems at finer scales than the territory or watershed, and the rapid and uncontrolled urban dynamics of secondary cities, this broadens the focus beyond the commonly studied hydrological and topographical characteristics, to include also social and cultural dimensions (Rolando, 2020). The scales and dimensions of interest, further motivated by the restricted availability of data (and familiarity), call for on-the-ground observations and the navigation of undocumented spaces

as a necessary extension to the usual prior remote or desk-based, historical, physiographic and big data site analysis (Lee & Diedrich, 2019), for which resolutions and information may be limited. In the design approach described here, fieldwork observation consists of two simple but key elements: walking and drawing.

While following and deviating from planned itineraries, walking allows one to develop a sense of place and engage with the landscape, its inhabitants and their water challenges through action, personal learning and information gathering (Schultz, 2014). Deviations encourage this by allowing for investigations physically adjacent to and thematically related to the transects walked and sites visited (Li, 2021). Walking can enable alternative interpretations of the contexts traversed and the development of grounded, implicit and embodied knowledge, relating physical, hydrological, social and cultural dimensions and understanding spatial elements as ensembles. It informs design by supporting the advancement of a territorial understanding from within, informed by what the landscape offers, and by facilitating the generation of ideas at smaller and larger urban and landscape scales, linking community to territory through observation (Lazzarini, 2020; Li, 2021; Schultz, 2014; Schultz & Van Etteger, 2017). Land artist Richard Long, known for his practice of planning, conducting and documenting walks (walked lines, circles or trajectories are his renowned works of art), proclaims walking as the most immediate and practical way of interacting with nature, capable of revealing intimate relationships between humans and nature (Moorhouse, 2002; Roelstraete, 2010).

Observations are collected and mapped through sketches, photographs (Figure 3.2), videos, and written notes to inform the drawing of a series of sections and descriptions as a uniform (visual) urban design language. However ephemeral the act of walking, such documentation preserves the transects and, as sections, they can map lived space in a representational format relevant to hydrological processes. Beyond documentation in response to data deficiency (i.e., spaces that have never before been documented in terms of land use, land cover, outlook, ownership, maintenance, etcetera), the aforementioned forms of representation allow for documentation with intention, and in this case, with the intention of becoming sensitive to the water of the specific context. Drawing becomes a documentation tool that reinforces the accuracy of observations during walks and is able to feed the imagination and provide local values, references, and concepts for design (Moorhouse, 2002).

FIG. 3.2 Selection of fieldwork photographs used to collect and document observations during walked transects and site visits as material to inform post-fieldwork forms of representation.

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3.4 Kozhikode - Rain on an undulating terrain

Kozhikode (its anglicised name is Calicut) is the seat of the headquarters of the district government of the same name in the state of Kerala, on the west coast of the Indian peninsula along the Arabian Sea. The coastal city is positioned at the downstream end of a large watershed that consists of both an undulating coastal plain and the steep Western Ghats mountains, with heights of up to approximately 2500 m, within a stretch of just 80 km. Located in a tropical monsoon climate, orographic precipitation of the Southwest Monsoon winds encountering the Western Ghats in the period between June and September is predominant. Preceded by the Mango Monsoon in April and followed by the Northeast Monsoon between October and November this accounts for a yearly precipitation of 3054 mm on average (IMD, 2015; 2016).

The combination of high annual precipitation averages and the unique landform with an undulating plain adjacent to steep mountains, culminates in challenging stormwater drainage conditions that cause frequent floods and landslides. Extreme monsoon events are difficult to ascribe to the global climate crisis, and the frequency of urban flooding can only be partially attributed to local topographic conditions (Turner, 2017). Changes brought about by urbanisation-driven modifications also increase flood risk. Prior to development, depressions in the undulating terrain facilitated the convergence and deceleration of high stormwater runoff and surface water flows, stimulating percolation. These processes were further enhanced by permeable and culturally embedded land cover and land use types such as forests, wetlands and paddy fields. Besides their value for water cycles, these types of land cover provide many other ecosystem services essential to local communities, ranging from food and shade to recreation, tourism and spirituality. Now, hydrological processes are being pressured by land use and cover change in general, but site-specifically, cultural water artefacts, such as sacred groves, ponds and wetlands, are facing degradation, depletion and reclamation as Kozhikode's urbanisation processes seek space for development, neglecting the contrasting elevations and depressions of the undulating plain. Other local water artefacts, however, follow a similar pattern of inattention: the Conolly Canal, dug in the nineteenth century to transport goods through the calm backwaters before the railways during colonial rule, cuts through depressions and elevations, watersheds and wetlands.

3.5 Fieldwork - Reading water sensitivity

During the 2022 Southwest Monsoon, a series of walks was undertaken along sacred groves, ponds and the Conolly Canal, whose presence was disclosed by prior historical and physiographic desk-based analysis. The canal, a unique piece of water infrastructure that cuts straight through the city, is 11.5 km long and provides an obvious north-south transect along its east and west sides. Ponds and sacred groves are scattered across the coastal plain, calling for a route with targeted visits. In an urban environment dotted with water bodies, these types and particular sites were selected for their exemplarity, historical relevance, the possibility of multiple visits and the probable ability to demonstrate a valuable common principle, as agreed by the local experts consulted.

Monsoon rains orchestrated the pace and rhythm of walks, notes, photographs and videos, requiring intermittent shelter. Such intervals were beneficial to observations, providing time for sketching and writing, and amplifying the details of observation as the rain exposed ephemeral systems of puddles and streams flowing towards the canal, feeding ponds and flooding temple grounds seconds after it commenced. At its peak, the rain halts any type of outdoor activity, causing delays that are reflected in the congestion of vehicular and pedestrian traffic. Seeing and drawing in detail the Conolly Canal, sacred groves and ponds in pre-, mid- and post-rain conditions calibrates prior knowledge and highlights dynamics relevant to WSUD.

3.5.1 Conolly Canal

The Conolly Canal, which links the Korapuzha and Kallayi Rivers, cuts through everything in its path. As you follow the canal, it seems to get deeper, then higher, narrower, then wider. In fact, it cuts through the inconspicuously undulating landscape. Height differences determine the width of the canal, based on the height of the mound it had to cleave when it was dug. Its width now ranges from approximately 4.5 m (Figure 3.3 G-G') to 30 m (Figure 3.3 U-U'). Its profile depth ranges from about 6.5 m (Figure 3.3 G-G') to 0 m, where it floods the banks when heavy rainfall raises the water table (Figure 3.3 S-S'). Stormwater runoff finds its way to the canal following the undulating topography or the imposed road network, at times flooding streets (Figure 3.3 F-F'; S-S'; T-T'; U-U'), at others being diverted into streams below or along the road, occasionally (in)formally covered with concrete tiles by neighbourhood initiatives (Figure 3.3 I-I'; J-J').

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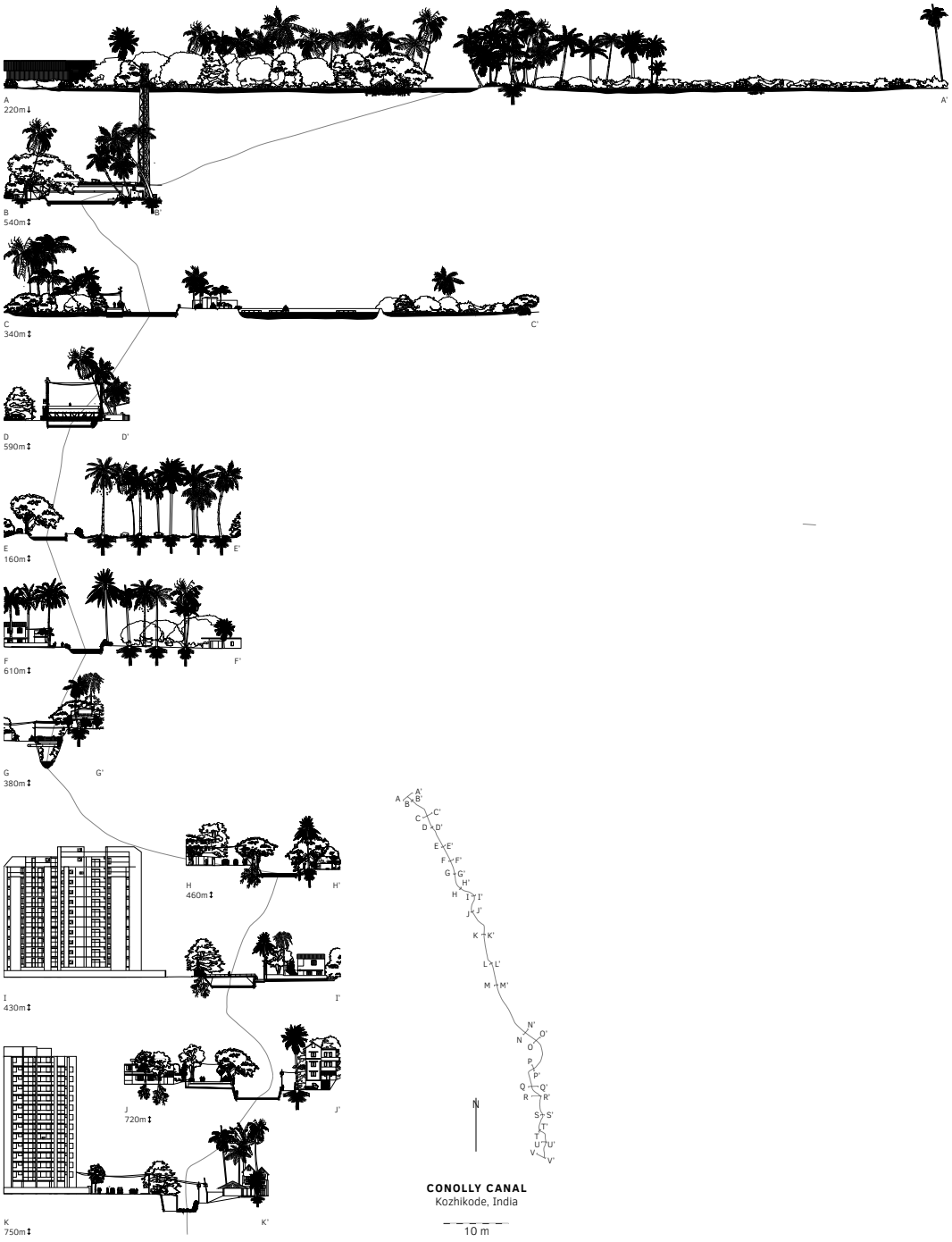
The canal also encroaches on precious wetlands, such as Kottuli, an 87-hectare area adjacent to the city centre of Kozhikode, which has been declared a site of national importance (MoEF, 2019). The city's wetlands are responsible for providing productive ecosystems rich in biodiversity and ecosystem services, water buffers during droughts, and food security and employment for local communities through their use for traditional and communal paddy cultivation. By dividing the wetlands in two, with the embankment-framed canal as an imposed linear element in the middle, the canal introduces harmful non-native weed species and waste water from neighbouring hospitals and commercial and residential areas (Azeez et al., 2008), and causes excessive groundwater and surface water outflow (Bhagyanathan & Dhayanithy, 2023). The wetlands also suffer from, often illegal or unregulated, landfilling for human encroachment (Azeez et al., 2008). Entering Kottuli, the canal is upgraded with 'naturalised' eastern quays, its rock wall edges removed, smoothed and greened, positioning the canal as another body of water in the Sarovaram Biopark, an urban park that occupies part of the landmark wetland (Figure 3.3 N-N'; O-O'). The park is a meeting place and refuge for many young lovers, its dense flora providing privacy. Another wetland, Perunthuruthi, is home to a fish farm and, at times without rain, locals cast their own lines from the canal banks to catch fish for supper (Figure 3.3 C-C').

Few infrastructural artefacts remain from its days as a cargo route, such as lift, pipe and pedestrian bridges (Figure 3.3 D-D'; O-O'; T-T'). The Kalpurath lift bridge now functions as a midday meeting place for nearby workers (Figure 3.3 D-D'). Around the bridge, the Conolly Canal is at its most picturesque, with dramatically overhanging palm trees providing a postcard-like scene. There are plans to deepen, widen and reactivate the canal for cargo and public transport and to improve stormwater drainage. Further deepening, however, would increase groundwater and surface water outflow, accelerating the loss of wetlands (Bhagyanathan & Dhayanithy, 2023).

Where the canal approaches the urban core of Kozhikode, the embankments have become critical parts of the city's road network, which has sought space for road widening by encroaching into the canal (Figure 3.3 K-K'). By providing a framework between the sea and the canal for the city to territorialise, the canal and its adjacent roads have been crucial to the city's urban growth and form (Bhagyanathan & Dhayanithy, 2023). Towards the urban core, like the roads, the buildings equally grow in size and formality. From scattered private residences occupying lush grounds between vacant wet plots with grazing oxen and wilder vegetation (Figure 3.3 E-E'; F-F'), to gated apartment towers (Figure 3.3 I-I'; K-K'; M-M'), culminating in the Gokulam Galleria shopping mall, the Baby Memorial Hospital and the KB tower construction site with multiple bridges crossing the canal to connect the two sides (Figure 3.3 P-P'). Informality, however, is never fully eradicated along the entire length of the canal, with recurring small-scale commercial or residential settlements. At one point, the granite boulders of the quayside were even used for improvised housing (Figure 3.3 H-H').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540m
B'
C
340m
C'
D
590m
D'
E
160m
E'
F
610m
F'
G
380m
G'
H
460m
H'
I
430m
I'
J
720m
J'
K
750m
K'
CONOLLY CANAL
Kozhikode, India
10 m

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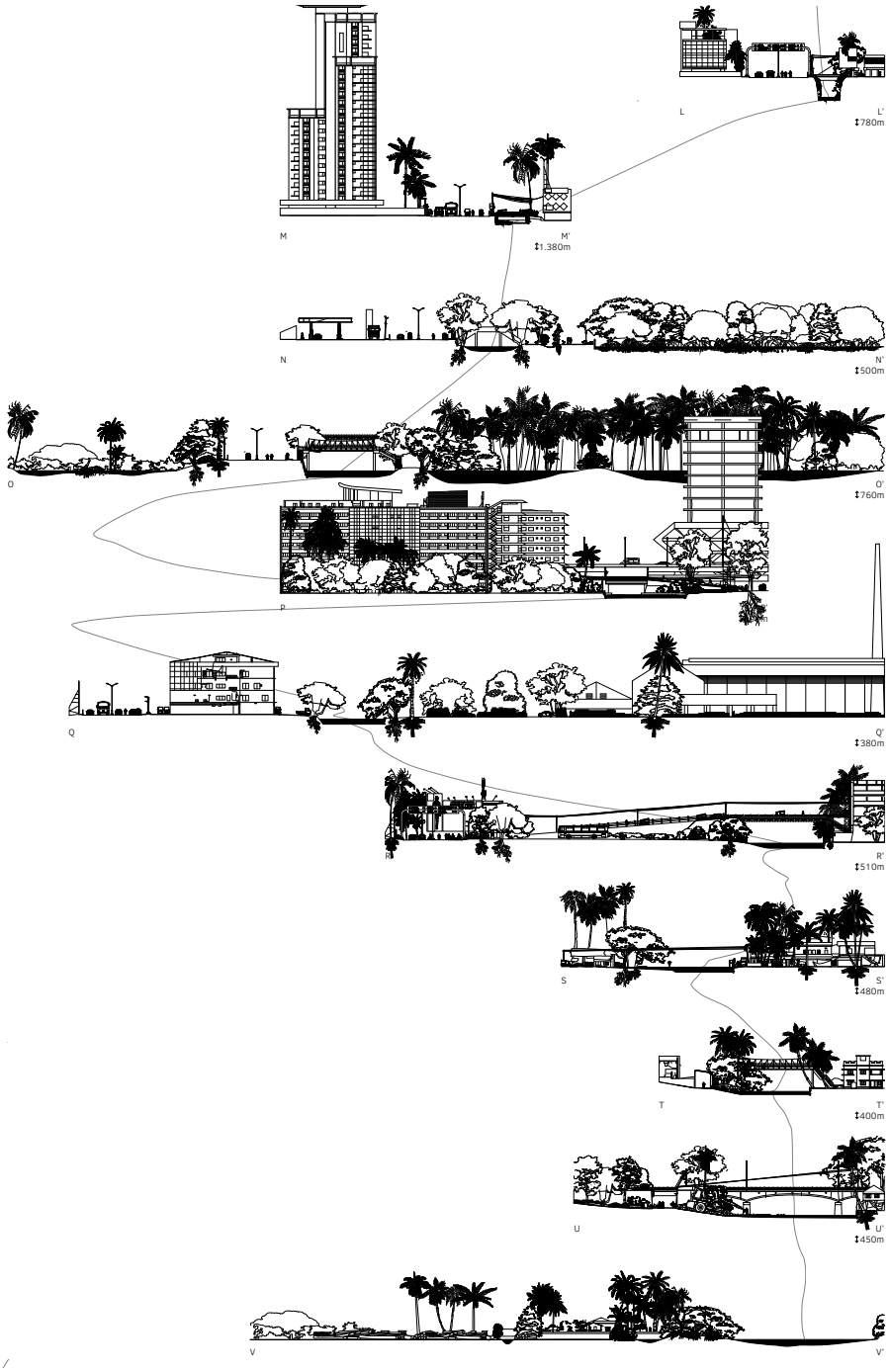

FIG. 3.3 Post-fieldwork illustrations of cross-sections cutting the transect walked along Conolly Canal.

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Near the urban centre, the canal's flow direction shifts from north to south. Due to the reduced flow rate, the canal is covered with water hyacinths, completely obscuring the view of the water surface (Figure 3.3 L–L'). Along the full length of the canal, the banks are covered with dense vegetation. Three municipal workers were seen landing their ladders at the bottom of the canal to carry out the incessant task of clearing the vegetation from the rocky surfaces of its banks (Figure 3.3 J–J'). Further south, the density, size and formalities of the buildings decrease again, making way for industries that leave their mark on the canal and its banks. A landmark tile factory colours the east side of the canal bright orange (Figure 3.3 Q–Q'). Most striking, however, are the floating logs that mark the timber processing industries on the west side of the canal (Figure 3.3 S–S'; T–T'; U–U'; V–V'). The logs could be transported by water, but trucks are currently more efficient. Specialised cranes lift logs into the water to 'water' them: a process that takes months or years to dissolve minerals in the wood, improving its quality. Filled with floating logs, the Conolly Canal gradually widens at its southern end into the Kallayi River (Figure 3.3 V–V'), contrasting with the stark incision at its northern end (Figure 3.3 A–A').

3.5.2 Sacred groves

Sacred groves are patches of virgin forest protected and worshipped by indigenous communities for their high cultural and spiritual values (Bhagyanathan et al., 2017; 2018). Now embedded in residential areas, these remnants of original vegetation could be found on Google Maps and accessed by navigated walks and auto-rickshaw rides. All of the surrounding areas were home to middle- to upper-class communities with mostly freestanding gated private residences, sometimes interspersed with less formally constructed dwellings. Hidden in patches of tropical vegetation between fenced properties, sacred groves in Kozhikode are used to worship the Mother Goddess, the Hindu deity Shiva, his son Kartikeya, the serpents they are associated with, or the adjacent trees or nature. They manifest with varying degrees of green lushness and number of built elements. Ranging from only 40-cm-tall shrines in a 30 x 30-m patch of untamed forest, like Avilery Moorthi Kaavu (Figure 3.4 3–3'), to 25 x 35-m paved openings in forest or wetland with decorated temple pavilions, such as Puliyankil Peralankavu Shiva Temple (Figure 3.4 5–5'). Irrespective of the present structures and degree of territorialisation, all the sacred groves visited offered a sense of wilderness, surrounded by dense tropical forest vegetation, inhabited by local fauna, providing shade, and silencing urban noise.

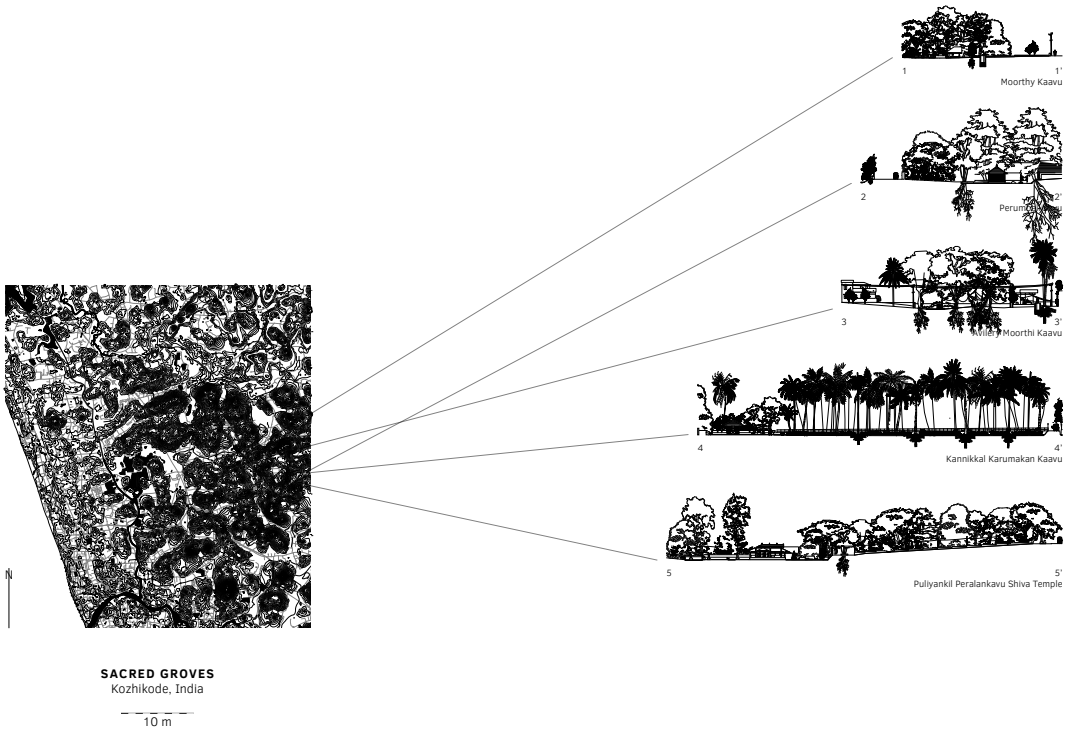

FIG. 3.4 Post-fieldwork illustrations of cross-sections of the visited sacred groves, showing the position and perviousness influencing hydrological processes around the cultural and spiritual sites.

Although the sacred groves visited were found to be occupied by a single person or no one at all, their current active role in the community was recognizable by their well-maintained condition and burning lamps that withstood the rains. Wells adjacent to some sacred groves indicate past communal services (Figure 3.4 1-1'; 3-3'; 5-5'). However, after the post-independence yearning for modernity, domestic piped water supply systems have led to a decline in traditional and communal water supply and a steady increase in water consumption and inequalities between supplied and unsupplied communities. Nevertheless, wells remain the city's main source of water supply - estates adjacent to the sacred groves now all have private wells behind their fences - and are now the cause of over-exploitation of increasingly contaminated groundwater sources.

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There is a pattern in the geographical locations of sacred groves in depressions in the undulating terrain of Kozhikode (Bhagyanathan et al., 2017; 2018). The concave position of sacred groves was only faintly noticeable during site visits by the subtle downward slopes of paths towards central shrines or their submerged state after rains (Figure 3.4 1-1'; 3-3'; 4-4'). Nevertheless, as a system of traditional ecological knowledge (Berkes et al., 1995), sacred groves, along with other remaining forest patches, safeguard biodiversity, percolation and groundwater flows to downstream agricultural fields, and the landscape's resilience to perturbations (Bhagyanathan et al., 2018). The undulating, but relatively flat terrain now facilitates urban sprawl in all directions inland, until the foot of the mountains and sacred groves in proximity to urbanising areas are eradicated or reduced to miniscule shrines or solitary trees (Bhagyanathan et al., 2018). The increasing imperviousness of the coastal plain limits percolation and infiltration processes, resulting in increased runoff and flood risk (Alberti, 2008). Groundwater recharge is consequently reduced, as is the flushing capacity of the monsoons (Powis, 2021), enabling saline seawater intrusion. Both are detrimental to urban water cycles and compromise their utilisation, especially in a rain-fed city like Kozhikode.

3.5.3 Ponds

Kozhikode is short on public spaces but rich in ponds. Despite being man-made interventions in the urban landscape, ponds share communal, cultural, spiritual, and hydrological roles and values with sacred groves and wetlands (T&CDP, 2017). The fieldwork set course for five of them, three of which are among the most-visited landmarks in the city. The small spaces the ponds leave between themselves and the surrounding roads and buildings allude to their origins in a time before car traffic and Kozhikode's growing population. Their maturity resonates in the rooted spiritual or communal uses of the ponds and the corresponding adjacent buildings that adorn them.

Mananchira (*'chira'* is Malayalam for pond) has provided Kozhikode with fresh drinking water since the fourteenth century and is, with its 150 x 150 m, Kozhikode's largest pond. Due to its drinking water provision purposes, the pond is fenced off. Its circumjacent park, once a maidan used to display colonial superiority with policy parades, is now designed to accommodate groups of children with benches, gazebos and an open-air theatre around a monumental ancient tree (Figure 3.5 I-I'). Kuttichira is said to have been dug to provide material for the foundation of the neighbouring fourteenth-century Miskhal mosque. To this day, the pond serves its surrounding Muslim community for washing and bathing, and continues to activate and connect them through organised swimming lessons (Figure 3.5 II-II').

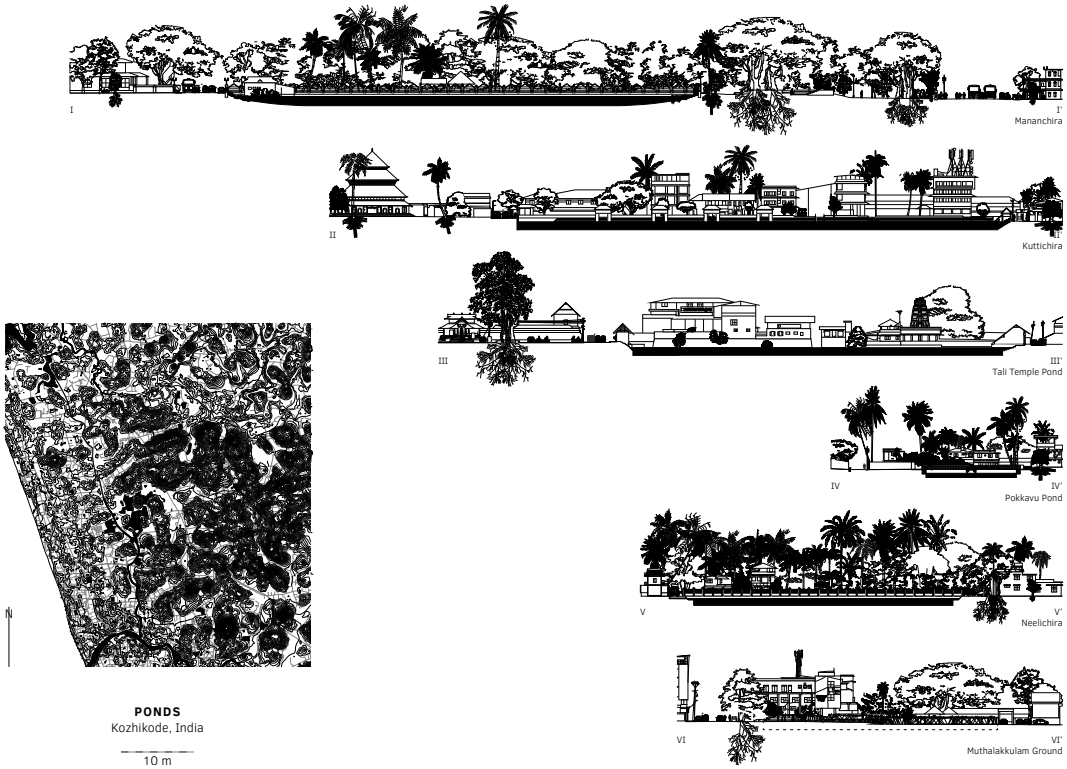

FIG. 3.5 Post-fieldwork illustrations of cross-sections of the visited ponds, showing the position of the man-made water bodies in relation to neighbouring land uses and communities.

The Tali temple pond accompanies the fourteenth-century Shiva temple of the same name and has dedicated roofed ghats for Hindus to bathe (Figure 3.5 III-III'). Both Kuttichira and the Tali temple pond have recently been restored and the adjacent public space has decorative plaques explaining their history. Public spaces around all three ponds are popular meeting places, drawing crowds to their surrounding benches or steps, regardless of religious origin and use. Their popularity is only exceeded by Kozhikode's beach.

To the south of the city centre and the Kallayi River, two other visited ponds have been appropriated and are fenced off, Pokkavu pond for recreational purposes, Neelichira for conservation purposes, after clearing the pond from landfill. The 25 x 25-m Pokkavu pond has been transformed into a public swimming pool and is open at fixed hours. Its traditional steps are still recognizable, but have been provided with chrome railings and painted bright blue to resemble a sports pool (Figure 3.5 IV-IV'). Although the pond is fenced off, Neelichira encourages public use with a sign

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encouraging people to walk around the pond at set times for different age groups. A public water tower next to the pond provides water pressure for nearby households (Figure 3.5 V-V').

A guided tour led to a sixth pond. One that is no more. Muthalakkulam, which means crocodile pond, is now called Muthalakkulam Ground after its reclamation, and represents dozens of others that have been reclaimed for development and lost their role in cooling the city and maintaining groundwater levels (Mushthari, 2016). Mathalakkulam is now used as a drying ground by laundry communities, who fill the lines between rows of elaborate triangular structures with laundry when the rains stop and empty the lines when the rains return (Figure 3.5 VI-VI'). The community is now being targeted for relocation to make way for development.

3.6 Discussion - Exposing a hydro-cultural dimension

Through the observations made during the walked transects, a pre-existing and context-specific water sensitivity is brought to light and captured in forms of representation, in contrast to the UWTF which presents water sensitivity as an end goal. For example, the ways in which water bodies and wet spaces in Kozhikode provide a meeting place, communal activities, a sense of care and belonging, while contributing to urban water management. But it also reveals the juxtaposition of colonial and indigenous water bodies, their hydrological implications, and contrasting images of modernity and tradition. As such, the fieldwork method and design approach amplify the physical hydrological processes in the urban landscapes around water bodies with a hydro-cultural dimension of everyday life and use, which advances the understanding and perception of territorial landscape scales and can inform design processes. The hydro-cultural dimension extends the hydrological indicators commonly considered in WSUD by representing cultural or historical characteristics associated with urban water. These are often implicitly represented or even not considered in conventional WSUD, but have an impact on its suitability for a context. In Kozhikode, the appropriateness of WSUD would benefit from, or even depend on, the design acts of getting to know the characteristics of the hydro-cultural dimension in particular. Uncovering this dimension through fieldwork and representation and respecting its qualities can facilitate the enhancement of situated water sensitivity.

Additional design principles can draw on and reflect findings from the hydro-cultural dimension to further link hydrology and culture in WSUD, such as landscape intensity, potential and mosaics. 'Landscape intensity' and 'landscape potential' are key hydrological indicators for analysing the landscape and its coherence and change, distinguishing land use and land cover and their associated imperviousness from landform and soil patterns and their capacity to manage water flows (Mander et al., 2010). The 'versus' – the relationship between the two – points to the correspondence between land use and cover and the underlying natural and hydrological conditions and processes, ultimately highlighting the suitability of land use (Tveit et al., 2006). However, the fieldwork observations highlight that consideration of this relationship is cultural. Just as administrative boundaries are not acknowledged by water flows, culture does not recognise the relationship between landscape potential and landscape intensity. Designing and planning urban and water infrastructure in contexts like Kozhikode therefore require insight into both physical-hydrological and sociocultural dimensions (Everyday City Lab, 2019), and WSUD has the potential to respond to this call (Coyne et al., 2020).

As population densities rise and urban areas expand, the value and eco- system services that ponds, sacred groves and even the Conolly Canal (can) provide to local communities are becoming increasingly important. Expanding the integral management, protection and conservation of urban water bodies and flows, as proposed by WSUD, keeping in mind the implicit local knowledge, practices and cultural water artefacts represented by the hydro-cultural dimension, as exhibited in sacred groves, would secure their ecosystem service provision and be a highly valuable local asset for WSUD performance (Bhagyanathan et al., 2018). Cultural artefacts, which are already recurring elements in India across neighbourhoods with diverse urban fabric and site-specific characteristics (Keswani, 2017), could be considered as small environmental resource patches in a matrix from a landscape mosaic perspective (Forman, 1995). The conservation of a network of hydro-culturally active green-blue patches with a redeeming potential for expansion in the depressions of Kozhikode's undulating landscape would stress their ecological value and facilitate regaining their contributing role in storage, conveyance and discharge of monsoon rains and groundwater flows (Azeez et al., 2008). Consideration of such a network of spatial and hydro-cultural patches broadens the application of WSUD. Where WSUD generally identifies areas and spaces to be retrofitted with suitable green-blue land uses, land cover, or built- and smaller-scale interventions that maximally approximate or enable natural and hydrological processes, this approach can now be extended to identify cultural areas and spaces and their potential hydro-cultural contribution. Further research should be directed at how systemic considerations of the hydro-cultural dimensions could be integrated into local urban design and water management practices, which are often influenced by informality.

3.7 Conclusion

WSUD focuses on hydrological processes and land use suitability across scales to pursue water sensitivity as a goal, currently primarily informed by infrastructural principles. WSUD lacks design guidance to consider and respond to the specificities of the contexts in which it is implemented (Rashetnia et al., 2022) and to acknowledge the cultural connections between people and natural spaces (Coyne et al., 2020). To discuss the promising yet data-intensive WSUD in the context of Kozhikode, a context with unique water cultures and implicit knowledge, relatively high magnitude and speed of change, yet lacking data availability, the study introduces a fieldwork methodology as a part of a situated and culture-inclusive design process to document, represent and become acquainted with undocumented spaces. Situated design processes are concerned with a defined context, use a visual language and are influenced by guiding concepts and frames of reference (Van Dooren et al., 2014). The use of fieldwork in dynamic contexts with unique site characteristics, such as Kozhikode, identifies the suitability of the guiding concept and frame of reference and the dimensions, knowledge and elements offered by a context to enhance the context specificity of design processes.

Without opposing the basic principles of WSUD (Wong & Brown, 2009), this article emphasises its initial intention to operationalise urban design with a fieldwork method that proposes a complementary perspective and qualitative design approach to WSUD, in light of the transferability concerns that WSUD faces. One that focuses on a small and cultural scale of inquiry that is not accounted for in WSUD, yet is capable of rooting and advancing a landscape and territorial scale of understanding of dynamic urban contexts. The techno-centric nature of WSUD usually suggests studies of hydrological systems and physical elements, often conducted remotely and with big data. However, in contexts such as Kozhikode, any effort at urban design requires an understanding of both the physical-hydrological and social-cultural systems in place (Everyday City Lab, 2019). Particularly in contexts rich in unique water cultures and lacking in data resolution and management, WSUD can benefit from including an overlapping hydro-cultural dimension. This dimension represents the cultural characteristics of a context that influence the manifestation of local water sensitivity and the appropriateness of WSUD for a context. By (the act of) exploring and visualising the hydro-cultural dimension through design-based fieldwork and forms of representation, opportunities for engaging with water cultures and shifting away from water management premised on disconnecting the hydro-cultural dimension are highlighted (McLean et al., 2018).

Focusing additionally on the hydro-cultural dimension, spatially manifested in residual water artefacts or intangibly in related practices and knowledge, allows one to perceive an alternative kind of water sensitivity. Contrary to what the UWTF suggests, this is a kind of water sensitivity that can already be present despite infrastructural deficits. A water sensitivity that is not concerned with an ideal future performance of urban environments. Instead, it is recognised in the qualities of past and residual water artefacts and practices, and brings to light design opportunities to reclaim or emphasise these qualities. As such, the fieldwork not only locates design processes, but also succeeds in locating water sensitivity, making it a site-specific variable that can be reinforced, enhanced or intensified, just as variables such as permeability can be.

Findings from the hydro-cultural dimension can be used in the implementation of WSUD. For example, considering water artefacts as elements in a hydro-cultural network allows them to be respected as infrastructural vernacular water management, maintained and expanded as such, and the various ecosystem services they provide to be enhanced. Introducing a hydro-cultural dimension into a systemic understanding of urban landscapes can promote the establishment of an Indian urban design idiom that is useful for WSUD (Everyday City Lab, 2019). As such, the approach contributes to the decolonisation of design by enabling stronger links to local culture and knowledge, and facilitating the local appropriation of WSUD necessary to engage local practitioners and unlock further application and uptake worldwide (Schultz et al., 2018). Decolonizing design is an imperative of increased contextual focus and unlearning and critically situating familiar design approaches that all design endeavours must be guided by.

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4 Reviewing historic urban water transitions to advance WSUD for Bhuj, India

Van der Meulen, G.J.M., Mishra, G., Van Dorst, M.J., Iyer, M., & Bacchin, T.K. (2023). Reviewing Historic Urban Water Transitions to Advance Water-Sensitive Urban Design for Bhuj, India. *Land, 12 (10)*, 1938. DOI: 10.3390/land12101938.

This chapter is published in Land as referenced above. However, the titles of chapter 4.2 and 4.4 have been changed to match the other chapter titles of the dissertation. 4.2 'Methodology - Reviewing history' is called 'Methods' in the journal and 4.4 'Discussion - Drivers and barriers of water sensitivity' is called 'Discussion of drivers and barriers of water sensitivity' in the journal. Furthermore, the distribution of figures has been altered for layout purposes.

ABSTRACT

In rapidly growing urban contexts, water plays a pivotal role in the transitions the urban environment goes through to sustain the quality of life of its population. Spatial planning and design are essential for the facilitation and manifestation of such transitions. Focusing on Bhuj, a rapidly growing Indian city in a hot arid desert climate, its crucial yet changing sensitivity to urban water flows over time is assessed. The concept of water sensitivity is coined as a goal to pursue by the Water-Sensitive Urban Design approach. In India, however, much of the urban design and development processes are of an unplanned and informal nature, seemingly inhibiting the water sensitivity of urban transitions. Reviewing spatial planning paradigms and their manifestation in space in Bhuj over time, however, brings to light a pre-existing water sensitivity. Yet it also shows a shift from the supply security-oriented ingenious watershed expansion to catastrophe-steered and urban expansion-driven water system negligence. Review and discussion of past and

present urban water transitions and management points out drivers, barriers, and their interrelationships, to enable and advance water-sensitive urban development tied to local history, traditional knowledge, and context specificities.

4.1 Introduction

Urbanisation, alongside the climate crisis and accompanying shifting societal values, drastically pushes for transitions in urban environments. Contrary to prevalent perception, absolute growth of urban populations and intensity of socio-economic changes is highest in smaller and less-studied secondary cities. Especially in India, where population growth contributes most to the urban increment, with its level of urbanisation doubled and its population tripled since 1950 and the increase ongoing (UN DESA, 2019). Commonly characterised by a lack of infrastructure, service provision, and planning (Huang et al., 2018; Maru et al., 2021; Pathirana et al., 2018; Roberts, 2014), secondary cities undergoing sustainable transitions would have substantial collective environmental impact.

To secure the sustainability of transitions, water demands a central role. Of all urban water cycles, hydrological and natural processes (e.g., stormwater drainage, groundwater recharge) are the foundational ones facilitating others (e.g., supply, sewerage, navigation). Water-Sensitive Urban Design (WSUD) is a concept and intention that calls for joint management of all such urban water cycles and the built environment while protecting and conserving aquatic environments in urban areas by operationalizing the collaborative and multidisciplinary nature of urban design and spatial planning (Wong, 2006). Accompanying WSUD, the Urban Water Transitions Framework (UWTF) (Brown et al., 2009) assists in the evaluation of the progress of urban transitions toward 'water sensitivity' as an ultimate goal for cities to pursue. The framework presents theoretical cumulative stages of transitions to water sensitivity, each underpinned with hydro-social contracts consisting of intrinsic expectations and values of society on how water is managed.

Conceptualised in Australian academia and applied in the country's primary city context, WSUD faces knowledge gaps regarding its applicability in urban contexts in countries like India (Bichai & Cabrera Flamini, 2018) and concerns regarding its transferability have been raised (Van der Meulen et al., 2023a). Furthermore, for secondary cities, a knowledge gap can be perceived in the form of the availability of data, with WSUD being data-intensive (Sharma et al., 2019) and secondary

cities portrayed as data-lacking. Necessary formal data sets can be unavailable, outdated, inaccurately scaled, or uncoordinatedly stored while resources to produce data consistently fail to keep pace with high secondary city dynamics (Lindley et al., 2018), whereas emphasis on and recognition of context specificity of water sensitivity is required (Mungekar et al., 2023; Van der Meulen et al., 2023a).

It is this call for context specificity and the knowledge gaps between the secondary city context and the WSUD concept that define the specific direction of the theoretical framework of this study. Beyond the limitations a secondary city context poses to WSUD, as scoped above (Bichai & Cabrera Flamini, 2018; Lindley et al., 2018; Sharma et al., 2019; Van der Meulen et al., 2023a), the article addresses possible pitfalls of WSUD. Being an act of design (Van Dooren et al., 2014), the suitability of universal water sensitivity as a guiding concept, the frame of references, and other aspects considered or presupposed in design processes can be questioned when addressing secondary cities. Urban environments do not transition homogeneously, instead, they know coexisting conditions and states of development within administrative boundaries, such as built-up and greenfield or formal and informal areas (Fisher-Jeffes et al., 2017). With the primary idiom of urbanisation being informal, WSUD approaches in contexts like India should adjust to local spatial planning and urban design discourses (Kumar et al., 2023) and move beyond its techno-centred nature to acknowledge the role and value of cultural and historical connections between people and hydrological processes or urban water cycles (Coyne et al., 2020). Valuable achievements in WSUD approaches in other contexts continue to call for more research on design guidance of WSUD implementation considering local conditions, such as Indian secondary city dynamics (Rashetnia et al., 2022). However, by deploying WSUD based on accustomed design principles from a specific context, in a contrasting one, the global uptake of WSUD also appertains to the greater project of 'decolonizing design' (Schultz et al., 2018), calling for unlearning and context specificity in all design approaches.

Motivated to inquire into design mechanisms for a WSUD approach better capable of facilitating sustainable secondary city transitions, this article visits Bhuj, India. Located in a hot arid desert climate, water bodies and streams commonly run dry, which, together with limited data or documentation about them, contributes to a certain invisibility of crucial urban systems. Confronting the theoretical UWTF and its hydro-social contracts with Bhuj's remarkable urban water transitions contributes to closing the perceivable data gap with a chronicle of the city's water-linked urban development. The inquiry looks for promising combinations of WSUD and water sensitivity in Bhuj's particular context. Rather than constructing missing data sets, the historical account is used as a necessary design action and method of reading space to develop an understanding of urban water management processes beneficial

to water-sensitive urban development. Rather than positioning water sensitivity merely as a goal that may remain unachievable in certain contexts, water sensitivity is, in this historical account, recognised as a variable of context (Van der Meulen et al., 2023a) and distilled as such from each period discussed. This approach and understanding of water sensitivity seeks answers to the questions: what aspects have enabled and halted water sensitivity in Bhuj's past urban water transitions? And what is the relevance of those aspects to ongoing and future transitions in Bhuj? To do so, this article reviews past and ongoing transitions and underlying local practices, communities, infrastructures, knowledge, and their urban footprint and influence on hydrological processes, as drivers and barriers of water sensitivity. Knowing the transitions through which Bhuj reached its current state, planning for future transitions can be informed (Raman, 2014). This study aims to contribute to promoting context-specific water sensitivity and urban design methods for urban transitions to advance the sustainability of its outcome with insights of value to local spatial planning practice.

4.2 Methodology - Reviewing history

As a secondary city, much knowledge of Bhuj exists in stories passed on within communities and families, whereas formal documentation or data sets are lacking. To construct the city's historical narrative, answering the necessity of describing and writing down its development over time, the research elaborated a review of the existing literature with additional qualitative methods. Field visits were carried out in June-July 2022, February 2023, and July 2023 to conduct workshops, interviews, and fieldwork. In addition, field visits were also carried out in January-March 2018 for preliminary research work and documentation of participatory water management practices. Three formal workshops, within the framework of Water4Change (i.e., a collaborative research program between India and the Netherlands) and with up to twenty attendees, addressed urban water challenges, water-sensitive visions, and barriers in Bhuj. In the workshops, representation of civil society was higher compared with public agencies, which inclined focus group discussions to demand management, participation, and traditional knowledge. The inquiry therefore followed with multiple semi-structured interviews, with fourteen different participants, equally concentrated on developments of urban water challenges and their management. Thus, while focus group discussions through workshops brought together diverse viewpoints of actors, interviews provided in-depth narratives around Bhuj's urban water transition.

Participants of the workshops and interviews included five members from public agencies, six from NGOs (one interviewee was both active in public service and an NGO), one from academia, and one from design and planning practice, yet each simultaneously represented local communities and residents of Bhuj. Narratives of workshop participants and interviewees were triangulated to derive "meaning out of analysis" (Denzin, 1978). The process of triangulation is essential to identify convergence and divergence of various viewpoints and ensures and provides validation and stronger substantiation of viewpoints, constructs, and arguments (Eisenhardt, 1989; Hesse-Biber, 2010) by improving confidence in collected qualitative data or narratives of people while minimising biases. As such, these insights contributed significantly to constructing the synopsis of Bhuj's urban development.

With a double perspective of spatial planning and urban design, emphasis was placed on dissecting planning paradigms and the spatial manifestation or performance of such plans. Spatial manifestation can contrast with plans in a context in which development recurrently takes place in a partially unplanned, informal, or organic manner (Kumar et al., 2023). To provide a spatial planning perspective at Bhuj, a two-step approach and a related set of methods were applied. At first, all three Development Plans (DPs) (e.g., 1976, 2011, and 2025) for Bhuj were chronologically reviewed to reflect on changing land use patterns and processes. Subsequently, interviews with experts and practitioners from government and non-government sectors were conducted alongside secondary research of media articles and reports, among others, to identify drivers behind changing land use over the past five decades (since the formation of the first DP). Further, direct and indirect observations were made through field visits to map the current status of water bodies and surrounding settlements. This also supported the urban design perspective which deployed immersive designerly fieldwork methods, such as walking, drawing, photography, mapping, and interviews, focusing on physical components and documenting small-scale observations in space with the aim of advancing the understanding of landscape- and urban-scale processes of interest and associating social and cultural dimensions of such processes (Van der Meulen et al., 2023b).

Insights collected from workshops, interviews, and fieldwork are the basis of both context description and discussion in this article. An elaborate description of the context and review of its history was, instead of being part of the introduction, a fundamental part of the research's methodology of unfolding Bhuj urban water systems by compiling information collected on-site and through a literature review. In fact, a review of historical context is one of the key domains of the situatedness of urban design processes (Van Dooren et al., 2014), yet is not formalised in

WSUD, despite its call to operationalise urban design approaches. Processing the description as data in the discussion provides for a dialogue on drivers and barriers of water sensitivity in past urban water transitions and the relevance of those insights for potential water-sensitive urban development in Bhuj.

4.3 Urban development and water transitions of Bhuj

Reviewing Bhuj's urban transitions in hindsight directs focus to pivotal paradigms in between them. Paradigms are, in their turn, demarcated by the city's key disruptive events. Firstly, the city's foundation in 1510 and the developments that followed until the 19th century. Secondly, the arrival of the British in 1819 and developments in the colonial period under British rule until 1947. Thirdly, the departure of the British and consecutive Indian Independence in 1947 and developments in the post-colonial period until the end of the 20th century. Fourthly, the Bhuj earthquake in 2001 and the emergency-steered reconstructions and developments that followed. At last, the article discusses the present situation and offers a look ahead. Each paradigm reviews the spatial planning of the time and how such plans manifested in space to construe the periodic urban development logic. At the end of this chapter, Table 4.1 provides a summary of spatial planning and its spatial manifestation per period. Figures 4.1, 4.2, and 4.3 provide fieldwork mappings as an overview of the mentioned locations.

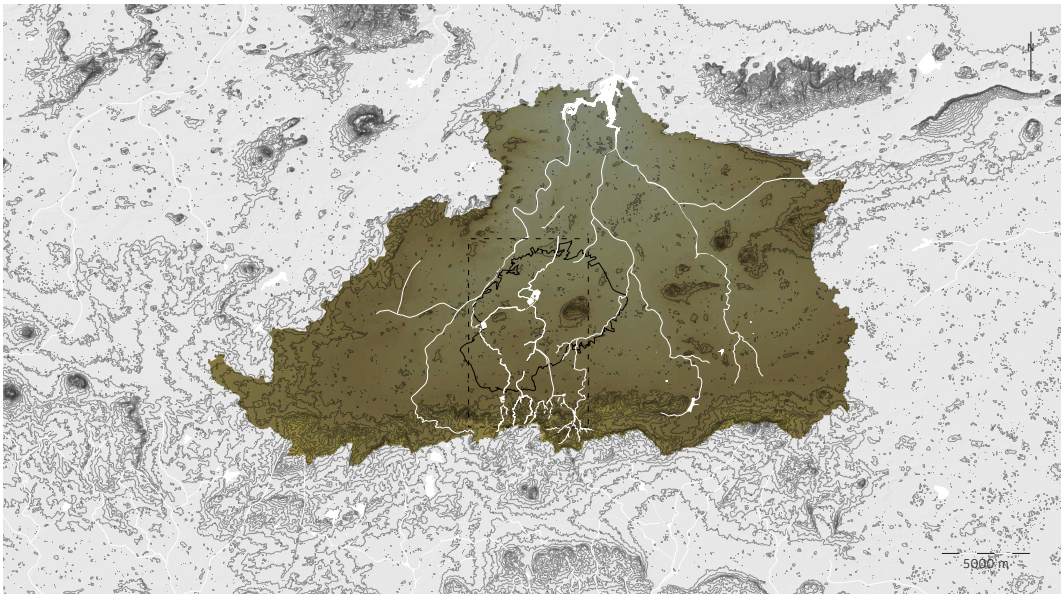

FIG. 4.1 Bhuj's location in the watershed.

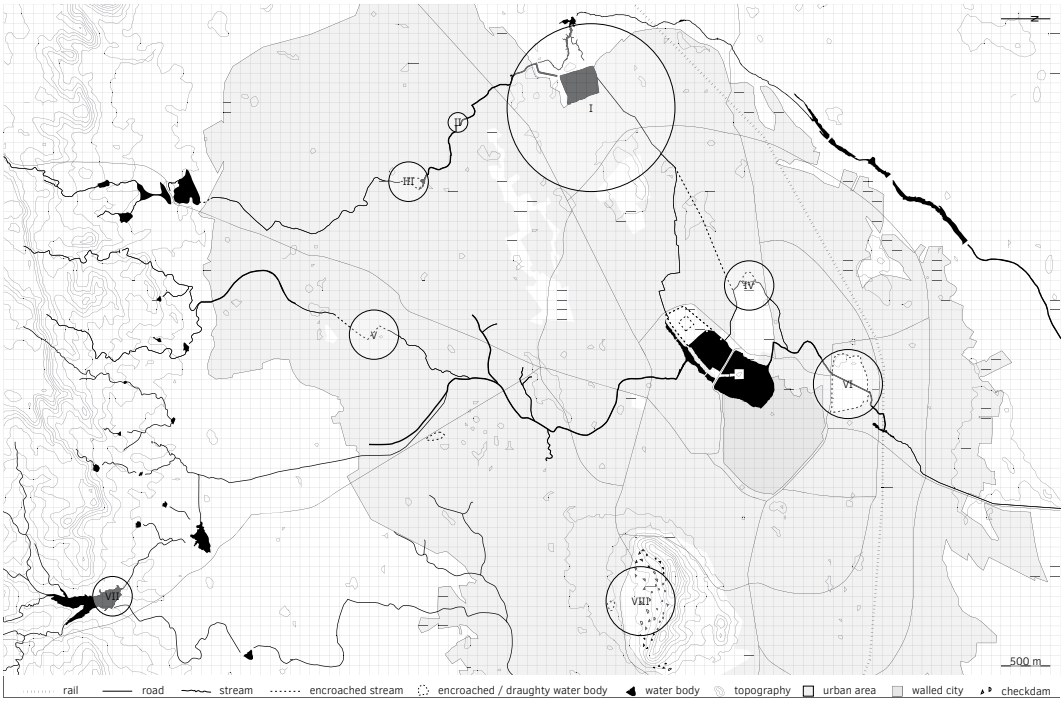

FIG. 4.2 Fieldwork mapping of the traditional water system.

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I Mochirairakhal talav / 24 wells

II encroachment - tech company

III encroachment - orchard

IV encroachment - Romaniya talav

V encroachment - Kachchh University

VI Pragsar

VII Dhunaraja dam

VIII Bhujiyo Dungar hill / Smritivan Earthquake Memorial

FIG. 4.3 Fieldwork mapping projected on Google (n.d.) Earth satellite imagery.

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4.3.1 Foundation of Bhuj, 1510 - 19th century

Founded by King Maharao Hamir in 1510, the city of Bhuj was positioned on a plain amidst modest hills. One of which - Bhujiyo Dungar hill, home to Bhujang the great serpent according to mythology - provided an efficiently defensible location for a fort adjacent to the walled city and gave the city its name (Iyer et al., 2022). King Hamir's son and successor, Khengarji I, made Bhuj the capital of the state of Kutch in 1549, followed by an increasing population (Gazetteer of the Bombay Presidency, 1880). Kutch means 'intermittently changing from dry to wet', referring to the condition of its seasonal salt marsh (i.e., Rann of Kutch). Furthermore, the state has no perennial rivers, low rainfall, high evaporation rates, few surface water resources, no recharge potential from neighbouring areas, and salinisation due to its adjacency to the sea.

To sustain a growing city in this circumstance and the hot arid desert climate and fulfil the needs of its inhabitants, local hydrogeological comprehension was imperative. The establishment of a water system to efficiently capture the little rain the area receives and recharge the landmark human-made Hamirsar Lake adjacent to the city at the beginning of the 16th century highlights the traditional mastery of hydrology. Consisting of separate areas for people, animals, and washing, Hamirsar provided water to all. Despite the city's ruling being passed on over time, a series of complementary ingenious interventions in the following three centuries continued to connect neighbouring watersheds and deviate water flows toward the central lake, enhancing water provision to the city (Bharwada & Mahajan, 2002). By digging the Haripar canal and constructing the Dhunaraja dam, water from the Hamidrai, Dhunaraja, Lakki, and Tapka catchments was redirected to Hamirsar Lake instead of flowing around Bhuj on its east side (Figure 4.2.VII; 4.3.VII). A qanat system of 24 wells connected to an underground canal funnelled water from a reservoir, named both Umasar Lake and Mochirairakhal talav, through a hill separating the Mirzapar catchment from Hamirsar Lake instead of water flowing around Bhuj on its west side (Sheth & Iyer, 2021) (Figure 4.2.I; 4.3.I; 4.4). Such water works, deepening of water bodies, and maintenance of the system were carried out collectively by employing the local population, who were paid in cash or in kind (Bharwada & Mahajan, 2002).

The interventions upscaled the catchment which discharges to Hamirsar from 7 to 35 km^2. At the time, the lake was three times the size of the walled city, securing water supply and preventing droughts and famines which did strike surrounding villages in the region (Bharwada & Mahajan, 2002; Sheth & Iyer, 2021). At disintegrated locations, the unique system remains in place and contributes to the establishment of an urban water culture in the water-scarce region. The rare occasion when the water level of Hamirsar reaches the feet of two wall sculptures of decorated elephants on each side of an *'aaro'* - an accessway on the lake's east side - is celebrated with a holiday, rituals, and community dinners to this day (Tyabji, 2006) (Figure 4.5).

FIG. 4.4 A 500 m long drain discharges water from Umasar Lake toward the qanat system of 24 wells (left), of which two are depicted in the right image, to transport the water underneath a hill toward Hamirsar.

FIG. 4.5 Hamirsar Lake access with elephant sculpture marking the celebrated water level of the lake during low water levels in early July 2022 (left) and in Late July 2023 with the lake almost filled until the marking (right) (right photo by Gargi Mishra, 2023).

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4.3.2 British rule, 1819 - 1947

Located on fault lines, the Kutch area and Bhuj have a history of earthquake disasters. 1819, the year in which British armed forces attacked Bhuj and took over the Kutch government, was additionally marked by the 1819 Rann of Kutch earthquake which caused significant loss of life and building damage. The shocks altered the routes of water flow, cutting off some of Bhuj's important water supply sources. Nevertheless, Bhuj's population rapidly continued growing as a British military post (Gazetteer of the Bombay Presidency, 1880) (Figure 4.6). The colonial rule introduced the position of a District Collector responsible for land revenue collection and partition of land holdings. Like in many colonial cities in India, the British imported and imposed their spatial planning, water management, and other infrastructural approaches (Raman, 2014). Managed by engineers unaware of traditional water knowledge, new infrastructure, such as dug wells, seaports, public transport, and air services (Tyabji, 2006), addressed the short-term needs of elite minorities (Hazareesingh, 2001), especially following the 1844 earthquake which triggered novel British technology-laden reconstructions. Perception of water provision and practices of water collection shifting away from Hamirsar set off the neglect of the unique local water system, affecting vulnerable hydrological processes in the scarce region and resulting in recurring water shortages (Sheth & Iyer, 2021).

The 1947 Indian Independence Act brought the rule of the British Crown to an end and the princely State of Kutch merged into the Union of India. Under the rulers of the latter, throughout colonial occupation and the imposition of alternative systems, traditional water system knowledge was passed on to successive generations. This bequest of knowledge continued until the ruler's entitlements were abolished in 1971. Half a century later, there is a struggle to sustain the bequest of water system knowledge, which results in neglect. Post-colonial India today still knows 'internal colonisation' (Calvert, 2001) in which colonial legacies of hierarchy and extraction and its associated knowledge and value systems continue to prevail, overruling its indigenous equivalents and building up ecological degradations, yet admired and pursued as modernity (Gandy, 2023; Mungekar et al., 2023; Sultana, 2023).

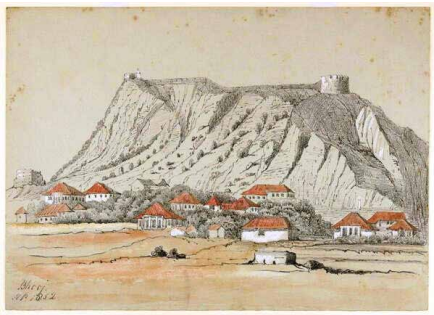

FIG. 4.6 British army camp bungalows and Bhujiyo Dungar hill. Pencil and watercolour by Harriet Parr (partner of a British army official) (1852)

4.3.3 Post-colonial period, 20th century

Post-independence, Bhuj had a palimpsest-like landscape of imposed water systems which would fall under the responsibility of Bhuj Nagar Palika (BNP) (or Bhuj Municipality), an elected urban local body, and Kutch district and Gujarat state-level authorities. Builders of modern India focused on modernisation and centralisation, further concealing traditional knowledge and systems (Bharwada & Mahajan, 2002; Raman, 2014) while shifting to real-estate-demand-driven urban development. Like many Indian cities, Bhuj experienced historical financial neglect due to the colonial period and lacked inclusive or suitable investments (Kumar et al., 2023), drawing up the adaptation urgencies in post-colonial Bhuj.

Although it is located in the area comprising 15% of Kutch known as the 'tubewell zone' and on a sponge-like cretaceous sandstone (Iyer et al., 2022), the city's traditional hybrid natural-artificial water system failed to provide water security due to impacts of imposed foreign infrastructure. Supply failures and public health concerns surrounding waterborne diseases pressured the introduction of piped water provision in 1968, which would increase domestic water usage and demand. Bhuj now became dependent on sources up to 11 km outside of the traditionally connected water catchments while groundwater tables dropped due to rising water extraction with developing technologies (Bharwada & Mahajan, 2002; CEPT, 2017; Sheth & Iyer, 2021).

National land surveys under ongoing government centralisation in the 1970s, which visited the arid region in a time of drought, failed to recognise temporarily dry or ephemeral water bodies and assigned the status of 'wasteland' to many of them. However, stemming from the colonial project, wasteland was at the time, in fact, a modern concept to characterise indigenous land use as inefficient in the spatial logic of modernity (Gandy, 2023). On that account, surveyors drew boundaries and edges

ambiguously in the context of 'fluid' systems, yet also where they are unnecessary constituents of cultural imagination (Mathur & Da Cunha, 2007). Traditional knowledge of the water system and bodies, concurrently, continued to fade through redistribution of management and maintenance responsibilities and a general lack of documentation. After subsequent years of drought, dry grounds of water bodies would unwittingly be encroached. With new and more formal legal status documentation rescinding previous documents, water bodies were lost on paper and, instead, development on them would now become permitted and facilitated. Bhuj's first DP in 1976 (Figure 4.12), following the state's first urban development act of the same year, on the other hand, failed to regulate urban growth altogether (Byahut & Mittal, 2017). Devoid of details, the 1976 DP incorporated the bare minimum aspects of land use planning, only including zoning principles to roughly color code parts of town into residential, commercial, agricultural, and institutional uses, among others.

Equally lacking physiographic and hydrological details on aspects like topography, drainage, and the aquifer, engagement of the DP in urban water system management or planning was limited to marking main city-level water bodies and surrounding land uses. Despite many of the city's water bodies rarely conveying or retaining water, the negligence new developments and encroachments would have of their collective contribution to water drainage and groundwater recharge would drastically alter Bhuj's hydrology. Due to such changes, in 1959 the city suffered a severe flood after heavy rainfall. To facilitate stormwater drainage and mitigate future flood events, Hamirsar was equipped with an additional channel from the qanat wells and an overflow going around the Sharad Baug royal palace grounds to a depression and impermanent water body, called Romaniya talav. Both interventions were dug to connect to the west side of the lake but would soon be encroached upon after a few years without heavy rainfall or flood events and remain inhabited to this date (Figure 4.2.IV; 4.3.IV; 4.7). The current inhabitants of Romaniya talav encroachment interviewed are not aware of the water body in which they reside, exemplifying the general perception of the droughty water system.

FIG. 4.7 Encroachment of Romaniya talav: the drainage stream can be recognised flowing through the neighbourhood's main road (left) and the stream is used to dump waste (right).

4.3.4 Post-Bhuj earthquake, 2001

On the morning of 26 January 2001 an earthquake hit Kutch with its epicentre only 60 km east of Bhuj. Despite the existence of local seismic building codes, their lack of enforcement had resulted in weak building constructions, in some cases with rooftop water tanks, around narrow streets in the dense and organically evolved walled city. This combination would lead to grave destruction of buildings and supply systems and severe loss of life in the city, followed by limited reachability for emergency workers.

With national and international humanitarian and financial aid for large-scale redevelopment works in the months after, the Gujarat state government established frameworks for reconstruction and mitigation. Instead of relocating Bhuj to a non-earthquake-prone area, the city was "built back better" on its original grounds around Hamirsar. Spatial planning was key in reconstruction processes, under pressure by trade-offs between time required, quality of work, and level of public participation (Balachandran, 2017). The Bhuj Area Development Authority (BHADA) was established to supervise the set-up of a revised second statutory DP (Figure 4.12). BHADA is chaired by the District Collector whose role continues to

exist to organise and collect land revenues. The DP had a timeline until 2011 and was assembled within 11 months after the earthquake in an attempted comprehensive and participatory manner (Byahut & Mittal, 2017). Besides the rehabilitation of affected communities, the DP aimed to focus on trade, commerce, and tourism. Prioritising the preservation of culture, identity, and economy, the DP directed that focus to rapid reconstruction of the walled city through limited application of micro-level Town Planning Schemes (TPSs).

TPSs deploy a model of land pooling, readjustment, and reconstitution. By appropriating private land for public purposes and utilising space formed by collapsed structures, streets were widened, new ones were created, and cul-de-sacs and bottlenecks, which caused much harm during the earthquake, were removed (Figure 4.8). By doing so, the DP identified growth areas and locations for infrastructure (Mahadevia et al., 2018). With 12,000 land plots, 24,000 properties, and 30,000 ownership claims within the 1 km^2 walled city, the execution of TPS was highly complex (Balachandran, 2017; HCP, 2004). At the time, it was assumed that micro-level plans would only provide structural building design inputs. Outside of the walled city, no part of town, to date, has been planned at this micro-scale. With a new road network, land use zoning, and allocation of relocation areas, the DP further utilised macro-level planning, again limited to zoning. In terms of infrastructure development, the DP only highlighted the need to have centralised water supply, drainage, and sewerage networks with efficient treatment to improve the quality and quantity of water.

To promptly respond to the disruption of water supply from remote sources, Bhuj tapped into the more remote Narmada canal supply (Sheth & Iyer, 2021) (Figure 4.9). Transporting water from the Sardar Sarovar Dam in the Narmada River via hundreds of kilometres of its main canal and Kutch branch, the Narmada canal connection controversially increased the distance between Bhuj and its water source seventy-fold, from 11 km to over 700 km, amplifying the unwieldiness of 77% of the city's dependency. A total of 23% of the city's water remains locally sourced from sumps and borewells (CEPT, 2017; Iyer et al., 2022). For water provision, the state nowadays enforces BNP to focus exclusively on the development of the Narmada supply, most of which is destined for industries it aims to attract, increasing dependency.

FIG. 4.8 Town Planning Scheme (TPS) with road network adjustments by land pooling for the walled city of Bhuj: (left) the road network of the walled city before the TPS; (right) the new road network with higher road density and reduced block sizes after the TPS (HCP, 2004).

As a planning approach reactive to catastrophe, developed under the pressure of the emergency situation, the DP focused on built development. With micro-level focus limited to the walled city and macro-level planning indifferent to catchment-level issues, the DP's recommendations failed to discuss ecological disruptions caused by the earthquake. Hydrological features of the urban landscape were insufficiently taken into consideration or ignored and short- and long-term consequences of the rapid developments, particularly on the catchment and natural drainage system, were disregarded. With the catastrophe striking in a dry period, water bodies standing dry were obvious locations for the disposal of rubble from earthquake destruction. In particular, Pragsar, a dried-out depression north of Hamirsar was nearest to the debris from the walled city (Raman, 2014). The rubble was eventually flattened by bulldozers, reducing the depth of the water body (Figure 4.2.VI; 4.3.VI). The locations of relocation sites were assigned regardless of the subtle watersheds in the plain and disturbed natural drainage patterns and traditional water system infrastructure. The westernmost Rawalvadi relocation site (Figure 4.9) was constructed on top of the droughty stream constructed after the 1959 flood as an extension to the city's ingenious ephemeral water system. Instead of connecting to Hamirsar, the historic system is now obstructed and provides water to a private commercial orchard encroaching on the connection and benefitting from the water supply (Figure 4.2.III; 4.3.III). Encroachment on Bhuj's temporary water streams from orchards to secure their water supplies is occurring more frequently.

FIG. 4.9 The location where Narmada water reaches Bhuj and is stored (left). Rawalvadi relocation site (right) (right photo via BHADA, 2016a).

Advocating systemic preservation of the built environment while paying little to no attention to identifying and addressing ecological and water-sensitive issues is concerning for an arid city like Bhuj in which susceptibility to earthquakes is joined by an ongoing vulnerability to water scarcity. With changes in global precipitation patterns and encroachment on drainage systems, the city faced major waterlogging and flooding in 2006. Both in response to the 2001 earthquake and the 2006 floods, from within the community, numerous NGOs and other civil society organisations were established to collectively complement and inform reconstructions and developments. Efforts included sensitising and capacitating people to promote traditional earthquake-resistant construction techniques, traditional management of waste and livestock, decentralisation of governance and water management, and revival of water bodies, among others.

4.3.5 Present Bhuj

With Kutch becoming the most invested-in district of India, its capital attracts industries and faces urban growth, with its population doubling to approximately 200,000 in the last 20 years (Doshi et al., 2020), calling for necessary developments. Hesitant to live in multilevel buildings due to earthquake risks, urban sprawl spreads following the major national and state highways connecting Bhuj, rapidly expanding the city's spatial footprint in the plain. Counting 1 km^2 in surface area in 1950, the city nowadays covers 48.6 km^2 (Iyer et al., 2022). Both planned and informal settlements on vacant plots inside this footprint continue to encroach on dry water bodies and streams (Raman, 2014) and contribute to increasing the invisibility of the system, which, in turn, expedites further encroachment (Figure 4.2.II; 4.3.II). Invisibility, furthermore, contributes to a general indifference and loss of water system knowledge.

Krantiguru Shyamji Krishna Verma Kachchh University was constructed in the droughty wetland of the Tapka catchment in 2007 (Figure 4.2.V; 4.3.V). Disregarding the recommendation of a 7 m wide drain to compensate for the campus' encroachment by only installing a 0.45 m wide drain resulted in flooding of the campus in the following years, after which the drain was widened to a meagre 2 m (Figure 4.10). While other floods on campus may have been prevented, floods downstream in Bhuj's centre intensified (Iyer et al., 2022; Raman, 2014) (Figure 4.10). In 2022, the drain was blocked by a newly constructed fence but re-opened after public opposition. An opposite example is Pragsar, which was controversially sold by BNP in 1979 (Iyer et al., 2022; Raman, 2014), yet designated as public and police cricket grounds. As a frequented public space it may be considered to fend off encroachment and flooding and secure stable space for future water retention (Figure 4.2.VI; 4.3.VI). Local water scarcity is attributed to the failure of rains, whereas, in fact, this emanates from traditional systems being replaced by unregulated drainage and groundwater exploitation beyond rechargeable limits (Bharwada & Mahajan, 2002).

FIG. 4.10 The new 2 m drain to compensate for constructing the university campus in a droughty wetland (left). Urban flooding after heavy rain in July 2022 (right) (right photo by Taneha Kuzniecow Bacchin, 2022).

The only ongoing effort to revive the ancient water system lies with NGOs, such as Arid Communities and Technologies (ACT). Since 2006, ACT has initiated awareness generation projects around the traditional system, such as hosting educational tours and cleaning activities, disseminating informative posters and newspaper articles, and carrying out revival works (Sheth & Iyer, 2021) (Figure 4.11). The value of their efforts to map the system is frequently underestimated and disregarded in BHADA's spatial planning and BNP's drainage and supply maintenance. The lacking formality of the documentation and availability of staff might be a justification. BHADA and BNP currently have limited capacity to (train to) use GIS applications, as BHADA's spatial planning responsibilities are conducted by only one planner, and BNP's numerous drainage and supply maintenance tasks are performed by only one engineer, working around the clock. Nevertheless, the value of maintaining accurate maps is recognised (Balachandran, 2017) and the present BHADA planner is invested in formalising existing maps and using them in their current development control regulations (GDCR, 2016), such as permitting development only at 9 m distance from the edge of streams and water bodies which appear in government documents.

FIG. 4.11 Hydrological models at ACT to increase awareness (left). A neglected decentralised wastewater treatment plant project from 2006 (right).

Bhuj's history in communal water system mastery can, conceivably, be recognised in the relatively high level of active participation in water governance, however sporadic and inconsistent at times (Mungekar et al., 2023). National and state-level actors provide for funding, monitoring, and evaluation of projects and frameworks. Local-level stakeholders aim attention at the preparation and implementation of urban water management. The well-networked group of local NGOs and citizen groups ensures water remains a priority in urban development and initiates rainwater harvesting, groundwater recharge, wastewater reuse, waterbody cleaning, and educational projects (Iyer et al., 2022; Mungekar et al., 2023; Sheth & Iyer, 2017). The citizen group Jalstrot Sneh Sanvardhan Samiti (JSSS) succeeded in discontinuing a BNP beautification project of Hamirsar that endangered the lake's bed and biodiversity (Times of India, 2021). Continuity of other such efforts or interventions, however, is lost the moment maintenance responsibilities and costs are passed on to alternative local communities or authorities (Figure 4.11). Furthermore, the network suffers from a lack of funds, and consultation and collaboration between NGOs and local authorities is limited (Mungekar et al., 2023).

Most urban water redevelopment projects in town focus on the revitalisation of water bodies, yet deliver only beautification, deteriorating the water system (Iyer et al., 2022). Epitomising the loss of traditional or general water system knowledge is perhaps the Smritivan Earthquake Memorial Museum and park, completed in

2022. However deserving the commemoration of the more than 13,000 victims of the 2001 Bhuj earthquake, the location, configuration, and materialisation of the pilgrimage heavily affect local water flows. Located on 470 acres of the Bhujiyo Dungar hillslopes, fifty half-round or triangular stepwell-shaped check dams and a network of broad walkways to connect them serve as a memorial park, yet obstruct the drainage of the hill and recharge of the downhill Shrijinagar Lake (Figure 4.2.VIII; 4.3.VIII). In fact, in the context of arid Bhuj and the moderate, yet landmark, Bhujiyo Dungar hill, the dimensions and quantity of the check dams and the choice of the stepwell-shaped check-dam typology are profoundly out of place and the project could be considered as an example of populist architecture (Müller, 2023). Moreover, tickets to enter the museum are too costly for many of Bhuj's inhabitants.

4.3.6 Future Bhuj

As emphasised in previous periods, the DP is the most important legal spatial planning tool to guide future development and provides a look ahead for Bhuj. Again, with a delay in preparation and a large gap of 18 years after the sanction of the previous DP, the 2025 DP (Figure 4.12) was sanctioned in 2019 to be prepared by BHADA and its appointed external consultant, Nascent Technologies. A DP generally consists of three parts: a report with existing situation analysis and recommendations, a land use or zoning map, and development control regulations consisting of building bylaws. In Bhuj, however, DPs are repeatedly sanctioned by the state without report, which implies that future development of Bhuj will be solely based on a land use map and the state's development control regulations (GDCR, 2016) to guide land uses. A DP report is crucial for providing information on longer-term projections and gaps in existing infrastructure, especially considering soaring global climate change impacts, such as longer periods of drought and intensified precipitation events frequently flooding the city's centre, a population projected to cross 450,000 by 2050 (CEPT, 2017), and urban sprawl expected to expand the city's current footprint of 48.6 km^2 to 75.6 km^2 by 2035 (Iyer et al., 2022). The lack of capacities within BHADA and the private consultant was reported to be the primary reason for the absence of this DP report. Consequently, failure in the identification of future projects in a statutory DP provides room for ad hoc or needs-based development in Bhuj, often driven by political needs until the sanction of the next DP. Outcomes of this gap in envisioning the long-term needs of the city include the ambitious and costly 24 × 7 Narmada water supply, which is driven by the state's development agenda for the district, however, it is unmentioned in the DP.

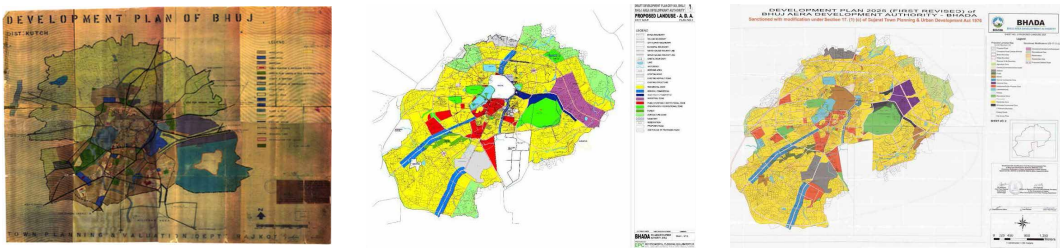

FIG. 4.12 Bhuj Development Plan (DP) 1976 (left) (Balachandran, 2017); DP 2011 (middle) (BHADA, 2016b); and DP 2025 (right) (BHADA, 2016c).

Progress, however, is seen in the growing influence and effect of local citizen groups on enhanced water sensitivity of spatial planning agendas. After their successful efforts to discontinue a municipal beautification project, the JSSS members continue to push for the identification and demarcation of lost water bodies and their inclusion in revenue records and DP 2025. For example, Umasar Lake, part of the traditional water system, is among five newly recognised water bodies in the latest DP. Despite the acknowledgment of such inputs, collaboration between BHADA and citizen groups or NGOs remains non-formalised. Pressure is then, for example, exerted through a public interest petition filed at Gujarat High Court by JSSS, successfully resulting in a High Court order to the District Collector and municipality to include all 25 currently unregistered lakes in prompt restoration efforts (Divya Baskar, 2023).

TABLE 4.1 Spatial planning and its spatial manifestation in Bhuj per period.

Period	Spatial Planning	Spatial Manifestation
Foundation of the city, 1510 - 19th century	– Foundation of the city; – Construction of a defensible walled city; – Designation as capital; – Provision of water security in water scarce region	– Water infrastructure (i.e., canals, dams, qanat system) to supply to Hamirsar Lake; – Population growth; – Urban water culture (i.e., water security celebration)
British rule, 1819 - 1947	– Designation as a military post; – Provision of water security after first water shortages; – Housing growing population; – Reconstruction with novel British technologies after the 1844 earthquake	– Altered water flows after the 1819 earthquake partially cutting off the water supply; – Oscillating population (20,000 in 1818; 30,000 in 1837; 24,000 in 1872 (Gazetteer of the Bombay Presidency, 1880); 26,000 in 1901; 19,000 in 1921; and 26,000 in 1951 (Census of India, 2011)); – Exogenous water infrastructure (i.e., dug wells) imposition on traditional water infrastructure; – Bequest of water system knowledge via the royal family and local communities
Post-colonial period, 20th century	– Modernisation of urban life; – Centralisation of urban water services; – Provision of water security after ongoing water shortage; – Provision of water supply infrastructure after perceived health concerns; – Execution of national surveys; – First Development Plan, 1976; – Real-estate demand-driven development following nationwide liberalization	– Concealment of traditional water infrastructure, systems, and knowledge; – False recognition of (droughty) water bodies as wasteland; – Encroachment of the water system, mostly due to new market-centric urban development; – Urban flooding due to reduced drainage; – Expansion of the traditional water infrastructure system; – Dropping groundwater tables with the advancement of extraction technologies; – Water supply dependency from remote sources (11 km away); – Population growth (136,000 in 2001 (Census of India, 2011))
Post-Bhuj earthquake, 2001	– Reconstruction and relocation after the 2001 Bhuj earthquake; – Second Development Plan, 2001–2011; – Town Planning Schemes for land pooling and road widening in the walled city; – Provision of urban water infrastructure due to infrastructural deficits; – NGOs and citizen groups capacitating people and promoting local means for reconstruction and decentralisation	– Rubble riddance in a dry water body; – Reconstruction of the destroyed walled city; – Relocation sites encroaching on the natural and traditional water systems; – Water supply dependency (77%) from Narmada canal (700 km away); – Urban flooding due to reduced drainage

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TABLE 4.1 Spatial planning and its spatial manifestation in Bhuj per period.

Period	Spatial Planning	Spatial Manifestation
Present Bhuj	– Investments in Kutch district; – NGOs and citizen groups capacitating people and securing priority of water in urban development; – Lacking documentation, staff, and expertise to conduct advanced spatial planning; – Earthquake memorial; – Housing growing population;	– Population growth (188,000 in 2011 (Census of India, 2011); approximately 200,000 in 2020 (Doshi et al., 2020)); – Urban sprawl (avoiding earthquake-sensitive high-rises); – Invisible (droughty) water system; – Encroachment on the water system; – Urban flooding due to reduced drainage and precipitation intensified by climate change
Future Bhuj	– Third Development Plan, 2025 (lacking report); – Housing growing population (450,000 projected for 2051 (CEPT, 2017)); – Increased identification of water bodies	

4.4 Discussion – Drivers and barriers of water sensitivity

This historical account provides insight into the urban development of Bhuj in relation to hydrological processes and urban water cycles. Historic events determine shifting hydro-social contracts, urban water management regimes, and urban transitions. Spatial elements and cultural aspects of previous urban water arrangements, however, do not disappear when the urban environment has transitioned. Remaining as artefacts, ongoing development settles on them. Ongoing developments are rooted in, or originating and evolving from, these artefacts as a previous establishment. In this discussion, these lost and remaining spatial elements and cultural aspects of urban water transitions are reviewed as fragments with the potential to understand or capacitate local water sensitivity and seek promising combinations with WSUD. Highlighting the contextual specificity of water sensitivity, this discussion is organised around two evident barriers due to Bhuj's arid and earthquake-prone surroundings.

4.4.1 Arid Bhuj

A constant objective - from the establishment of the walled city, during the period as a British military post, to modern times - is to provide the city in an arid region with water security. Tangible artefacts in space, once controlling flow directions and capturing water of the natural drainage system, underline how water security has been fundamental to securing and expanding the local power systems and its accompanying urban settlement. Provision and perception of water security, however, can be achieved using methods that may differ per ruling authority. Intangible urban water culture underlines how water security is still perceived as a cornerstone of arid urban life. Development of the urban environment, however, no longer sets conditions for how water security is achieved, while relative and absolute demand grows.

The transition from water-centric to land-centric development is attributed to the adoption of new water management technologies (Iyer et al., 2022). Additionally, the introduction of different technology interlinks with shifting hydro-social contracts as novel technology alters hydro-social contracts while upcoming hydro-social contracts also call for modern technology. Both are the case in Bhuj, where exogenous British water infrastructure and water service expectations imposed new value systems and reshaped local views regarding how water should be managed and provided. In later periods, modernising perceptions of water health and assumptions of water availability in the arid region challenged local resource dependency and appealed to infrastructure to deliver solutions. While demanding ongoing modernisation, Bhuj's urban population increases, adding to the water demand. Securing the image of modernity by reproducing exogenous water resource management routines may, however, carry coloniality forward (Mungekar et al., 2023). Interlinkage of technology and hydro-social contract particularly becomes a threat the moment the deployed technology or prevalent contract disregards or affects local hydrological processes while the tech-contract relation and dependency strengthen. Besides decreasing awareness of hydrological processes and the traditional water network, this threat is invigorated by the invisibility of these flows due to the aridness.

Besides being a barrier, the arid context does provide drivers for water sensitivity by challenging urban development and urban water management. One of the key principles for practice underpinning WSUD in fact calls to use cities as water supply catchments with a diversity of infrastructures (Wong & Brown, 2009). Unlike the formation of most cities - in which water was initially imported into town to exploit and be disposed of out of town when polluted - Bhuj's foundational layout and infrastructure had already been conceived to maximise efficient capture and use of

water. However, suffering from encroachment and reduced visibility and performance of the traditional water system interventions, many elements of the system remain in place as a network, still recognizable in the city's urban form, waiting to be re-operationalised (Van der Meulen, 2022) in line with the city's persisting urban water culture.

Another key principle for WSUD practice calls upon the city's communities and institutional capacity for water-sensitive decision making and behaviour (Wong & Brown, 2009). The citizens' care for Hamirsar and other water bodies (e.g., by JSSS and ACT) alludes to a potential upscaling toward the historic water system. A barrier to overcome is the lack of collaboration between local planning and development authorities and NGOs and citizen groups. The increased identification of water bodies can then be advanced to active protection and conservation and include consideration of water bodies as an interconnected system to the same degree as traditional watershed management succeeded to do in previous centuries.

4.4.2 Earthquake-prone Bhuj

Detrimental features of Bhuj's urban development history and logic are its earthquake susceptibility, recurring earthquake events (i.e., 1819, 1844, 1956, and 2001), and reconstructions in response. Earthquake-pressured decision making for urban redevelopment commonly fails to use the opportunity to avert vulnerabilities, yet it entails the establishment of additional or alternative ones (Balachandran, 2017). Many of Bhuj's interventions or developments insensitive to water should today be seen in light of its post-2001 Bhuj earthquake emergency context in which priority to water (sensitivity) was considered unaffordable. Nevertheless, as a piece of history unfortunately repeating itself, the earthquakes, interventions, and their effects in Bhuj make up the current and future agenda of urban water management challenges.

At the same time, earthquake incidents and their repercussions have given rise to awareness of the inhabitants of the region regarding water and heritage. By uniting in NGOs and citizen groups, inhabitants put their awareness into practice to compliment, encourage, or critique government initiatives and further its dissemination (Iyer et al., 2022). Efforts have been directed at participatory urban water management and the traditional water system (e.g., by ACT), as well as traditional earthquake-prone construction practices and use of local construction materials (e.g., by the Hunnarshala Foundation) and halting encroachments (e.g., by JSSS). It suggests citizen-instigated care for heritage and tradition for which the 2001 earthquake can be considered a turning point, following an era of insensitivity

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and abuse of the traditional system by development authorities (Iyer et al., 2022). Local authorities, however, continue to lack independence from district or state-level authorities to join the approach of comprehensive heritage conservation. Despite earthquake risk calling for decentralising urban water infrastructure – in fact, re-operationalizing the city's traditional system (Van der Meulen, 2022) – authorities at multiple levels continue to opt for a centralised focus on Narmada and miss opportunities for drainage and recharge.

Weak governance of water service provision and spatial planning in countries like India recurrently challenges water-sensitive urban development as responsible authorities operate in silos (i.e., scalar and disciplinary) and obstruct integration and collaborative policy establishment (Kumar et al., 2023). Planning in Bhuj inclines to address short-term targets motivated by urgencies ordered by its earthquake history. The city's spatial planning is, furthermore, limited to macro-level zoning efforts, whereas alternative or additional micro-level and catchment-level focus on water bodies and hydrological processes would enable water sensitivity.

Water-sensitive intentions do exist among Bhuj's local officials, resulting in improved documentation of the water system, an increased number of water bodies featured in DPs, and their inclusion in development permits. Yet the prevalence of short-term strategies and the lack of capacities in terms of finance, skill sets, staff, and knowledge impede formalisation, upscaling, and enforcement of this intention and obstruct it from becoming an integral enabler of water sensitivity. The city's network of NGOs and citizen groups face similar limitations. Its emergence, however, highlights the major potential to leverage local values toward water sensitivity (Mungekar et al., 2023).

4.5 Conclusion

WSUD succeeds in tapping into past urban water transitions of the world's primary city contexts and guiding their future transitions sustainably toward water sensitivity as a goal. The city of Bhuj, however, exemplifies a secondary city with a remarkably rich water history defining its urban development and different urban conditions coexisting within the city, notably differentiating it from cities in which WSUD has been conceptualised. Water sensitivity can, in Bhuj, instead be recognised in past and present practices and infrastructures, yet it is at times challenged by current transitions rather than improved. Rapid urbanisation, short-term spatial planning, aridity, and perceived data deficiency are among the context specificities raising concerns regarding the suitability and transferability of the WSUD approach to the alternative urban conditions.

To go deeper into design mechanisms behind WSUD and context-specific opportunities and obstacles for water sensitivity – highlighting promising combinations of established WSUD and local water sensitivity – this article deploys a set of qualitative methods. Through a literature review, interviews, workshops, and fieldwork, a historical narrative of Bhuj's urban development and water transitions was constructed, chronologically arranged in six periods from its foundation to its future, focusing on spatial planning and its spatial manifestation. The historical account of Bhuj's context serves as an analysis to cast light on its effects on hydrological processes and urban water cycles as drivers and barriers of water sensitivity. As such, the article deploys a design act of reading and describing space and reviewing historical context, common to situated urban design processes (Van Dooren et al., 2014), yet unaccounted for in WSUD. Two prominent context specificities organise the discussion that follows: the city's aridness and earthquake risk. The inventory around these context specificities provides answers to the research question on both enablers and disablers of water sensitivity in past urban water transitions. Despite the fact that these context specificities generally encumber water-sensitive urban development, ingredients for water sensitivity seem to gravitate around them.

Triggered by earthquake vulnerability, they include a general citizen awareness for and cultural and historical connection to geophysical systems, care for heritage, well-networked NGOs and participatory citizen groups engaged in local water resource conservation, and a strong argument for decentralisation of water systems. The arid context, additionally, provides a pursuit for water security to be a part of the city's urban water culture and is represented in remaining artefacts. Furthermore, the

city and district are subject to large investments. Yet at the same time, barriers to the operationalisation of these potentialities remain and require to be overtaken. Despite the natural argument for decentralisation, local authorities opt for centralisation fitting their short time frames, immediate needs, and availability of funds. These often align with the central government's urban development agenda. Investments fail to reach or engage urban local bodies, NGOs, and other citizen groups. Without additional resources, local authorities and citizen groups lack collaboration and the development of skills to succeed in operating in a transdisciplinary manner. Various capacities for water sensitivity may be present, yet remain sporadic, inconsistent, and selective (Mungekar et al., 2023). Manifesting in response to catastrophic events, an ad hoc approach can be recognised in contemporary spatial planning in Bhuj. Short-term targets dictated by an emergency state hinder envisioning long-term goals and accounting for ecology and hydrological systems.

The descriptive narration of a context and its history has provided insight into barriers and drivers of water sensitivity. That description and review as a design act, however, contribute to redefining notions of relevance to WSUD and the role of spatial planning and urban design. Context specificities, like aridity and earthquake risk, seemingly inhibit sustainable urban water transitions in Bhuj as proposed by WSUD theory. The city's infrastructural deficits may imply a long way to go for Bhuj to develop into the ideal water-sensitive city (Van der Meulen, 2022). Yet by using insights acquired through design action, into history, context specificities, traditional knowledge, and the state of infrastructure and framing and reviewing them as an existing water sensitivity in place, sustainable urban transitions can potentially be unlocked. As such, this approach responds to the question of the relevance of the gained insights for ongoing and future urban transitions in Bhuj. This article does not intend to offer a framework or principles for locating drivers and barriers or unlocking sustainable transitions, nor does it intend to answer the formulated research questions exhaustively or once and for all. Instead, it showcases how furthering the intention to operationalise urban design and spatial planning processes to fuller extents and more consciously (e.g., by review of historic development) can improve the capacity of WSUD to understand ongoing urban transitions and facilitate sustainability of future ones. Collaboration between urban design and spatial planning fields provides a double perspective on real development means, motivation, and logic of an urban environment in which entry points for WSUD and sustainable transitions reside. Furthermore, by focusing on urban design mechanisms, WSUD can embrace the complex reality of urban environments rooted in multilayered past developments and the open-endedness and uncertainty that apply to planning transitions for such contexts. It is in this manner that questions inquiring into barriers and drivers of water sensitivity and their relevance to ongoing and future transitions are addressed.

Centring drivers and barriers of context-specific water sensitivity through emphasised urban design approaches allows us to challenge current efforts of modernisation and urban development and its roots in colonial values. By acknowledging stronger ties to local history, traditional knowledge, and the influence of context specificities in ongoing urban processes, this study is part of a greater project of 'decolonizing (urban and water infrastructure) design' (Schultz et al., 2018). As an imperative to which all acts of design should be oriented (Abdulla et al., 2017), decolonizing design entails an enhanced focus on the context to be addressed by design acts and unlearning and reconsidering the roots of accustomed design approaches. By considering water sensitivity as present throughout the histories of cities like Bhuj and as a variable that can be strengthened, WSUD can facilitate context specificity and improve the sustainability of future urban transitions. Toward furthering the decolonisation of design, future research should be directed at making alternative readings of urban environments, such as historical accounts, and at making those readings systemic, acknowledged, and engaged in by local spatial planning, water management, urban design, and urban development practices, each represented by their complete fields of stakeholders, especially concerning contexts where such practices are influenced by informality.

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TOC

5 Promises and perils of water sensitivity as a new hydro-social imaginary for Kozhikode, India

Van der Meulen, G.J.M.*, Silva, R.H.*, Zwarteveen, M.Z., Stead, D., Van Dorst, M.J., & Bacchin, T.K. *Promises and perils of water sensitivity as a new hydro-social imaginary for Kozhikode, India.* (under review).
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This chapter is currently under review for publication. However, the titles of chapter 5.1, 5.2, and 5.3 have been changed to match the other chapter titles of the dissertation. 5.1 'Introduction - Kozhikode "needs" water sensitivity' is called 'Introduction or Kozhikode needs water sensitivity' in the manuscript, 5.2 'Theoretical framework - Decentring and resituating water sensitivity' is called 'Decentring and resituating water sensitivity' in the manuscript, and 5.3 'Methodology - Researching urban water transitions through contested hydro-social imaginaries' is called 'Researching urban water transitions through contested hydro-social imaginaries' in the manuscript.

ABSTRACT Water-Sensitive Urban Design (WSUD) proposes integrating the management of urban water cycles into urban planning and design as a strategy to better respond to water challenges in the urban environment. Proposed frameworks try capturing urban water sensitivity in terms of generic, transferable, principles. In this article, we trace the water history of Kozhikode in India to make a plea for a more contextually specific definition of water sensitivity, one that recognises how the quality and direction of contemporary urban water flows are the outcome of particular - (post-) colonial, neo-liberal - histories. We mobilise insights from political ecology to do this. Concepts like waterscapes and hydro-social imaginaries help recognise

that waters and cities co-evolve to create often highly uneven waterscapes. This usefully denaturalises and thereby politicises urban water sensitivity, giving much-needed prominence to the 'who' questions: who will benefit (most), and who will stand to lose? For Kozhikode, with its fishing enclaves, sacred groves, ponds, and a colonial canal crossing its coastal plain, treating water sensitivity as a mere techno-managerial question risks reinforcing middle-class dominance and aspirations, while also provoking ecological decay.

5.1 Introduction - Kozhikode "needs" water sensitivity

Growing awareness of conventional infrastructure's failure to ensure sustainable water use in cities, combined with emergence of ecological water management paradigms, has given rise to the concept of water sensitivity. Water sensitivity stems from Water-Sensitive Urban Design (WSUD), an approach that seeks to manage all water cycles (i.e., stormwater drainage, water supply, wastewater sewerage) in integration with protection and conservation of aquatic environments through urban design processes (Wong, 2006). Key principles of this approach include circularity in terms of water, providing ecosystem services, and building socio-political capital for sustainability (Wong & Brown, 2009). Beyond technical innovation, WSUD theorists focus on how such urban water transitions require a new set of agreements among communities, governments, and businesses on how water should be managed (Brown et al., 2009). Water sensitivity, thus, emerges as an 'imaginary' that carries a particular conceptual framing and system of meanings related to urban environments (Gabriel, 2014) that treat cities as bounded ecosystems. We approach imaginaries and the concept of water sensitivity in this paper through capacities of collectives to circulate, normalise, or contest such ideas (Davoudi & Machen, 2022). In urban design processes, collective imaginaries translate to guiding concepts and intended set of qualities determining one's frame of reference in design, planning, and management (Van der Meulen et al., 2023a).

Investigation on how imaginaries play a role in shaping cities' socio-nature through uneven processes of urbanisation has been taken up in the field of urban political ecology (UPE), particularly in studies of waterscapes (Swyngedouw, 2004; Gandy, 2004). Such investigations have established that, as waterscapes, the unequal socio-ecological relations of cities are influenced by ideologies and narratives that

compose urban imaginaries. For example, colonial states transferred European urban imaginaries of a modern and hygienic city to colonised geographies, like India, where centralised piped networks brought during British rule replaced existing traditional infrastructures of supply to distinguish the coloniser's quarters from native towns (Gandy, 2004; 2008; Mann, 2007; Sharan, 2014). Recent developments in UPE call scholars to take emerging urban environmental imaginaries such as water sensitivity equally seriously in their capacity to produce new socio-ecological relations at the expense of multiple cultural erasures (Gabriel, 2014; Zimmer et al., 2020). In the context of emerging claims for ecological recovery in cities, more recent ideas put forward by Gandy (2023) elucidate how there are different conceptualisations of what exists, what is worth saving, and the potential role of non-human agency. For scholars in the field of WSUD this means questioning how particular imaginaries and associated hydro-social relations are promoted over others, to whom do they belong, and what kinds of waterscapes they produce. Such questions help explain processes of unjust urbanisation whereby local knowledge of residents is often disregarded by planners and decision makers while international consultancies use their privileged positions to increasingly exert material and immaterial power over urban environments globally (Anguelovski et al., 2020). In an increasingly 'evidence-driven' urban policy setting, it is imperative to pay explicit attention to whose experiences, knowledges, and expertises are considered a valid source of evidence and data, and whose are excluded, when it comes to establishing the nature of water challenges and the role of WSUD in cities (Mabon et al., 2022). This requires urban designers and water managers to look for theories and methods beyond – or alongside – those of the science of ecology and engineering when analysing and designing transformations of waterscapes (Silva et al., 2024).

In response to concerns regarding the way WSUD intervenes in urban water cycles irrespective of historical or political context and fear it may therefore reinforce uneven urbanisation, we set out to learn from the urban water transitions of Kozhikode, India, to propose a possible re-orientation of WSUD. We intend to promote an application of WSUD that starts by exploring diverse urban conditions which define water sensitivity as a part of a present context rather than a goal. We do this by looking specifically at the contested imaginaries that have produced diverse, unequal, and often incomplete water supply, sewerage, and drainage infrastructures in the city. Instead of approaching diverse forms of access to these services as a result of inherent social inequality, we explore how these very inequalities are a product of planning, design, and management. Our analysis of how pipes, sewers, treatment plants, ponds, and canals are built, maintained, re-worked, or erased from waterscapes through time builds on UPE theorisations. Therefore, we understand that intensely political socio-ecological processes shape how water flows and is metabolised in cities. We find this particularly relevant in the context of WSUD

knowledge transfer as we identify growing international support for planners and designers to build networks capable of influencing how urban water is managed. Our concern is particularly focused on what types of water-sensitive projects global-urban networks of expertise conceive and justify in Southern cities (i.e., term from urban theory for cities in the 'Global South' yet distancing them from a North-South divide or an exemplary global city (McFarlane, 2008)), where environmental urgency finds its most dramatic experiences, and to whom they serve.

Such concern was triggered by previous research on the application of water sensitivity in Indian cities. Researchers have indicated that, after landing in urban India, such discourses can converge with ideas of achieving slum-free cities and, thus, displacement (Arabindoo, 2011; Baviskar, 2020; Baviskar & Ray, 2011; Coelho & Raman, 2010; Ghertner, 2011). Both planning imaginaries aim to create a competitive edge for Indian cities to attract private investment, producing incoherent scenarios such as public housing on endangered wetlands or eco-parks on dying estuaries (Coelho & Raman, 2013). Within this planning discourse in Indian cities, poorer groups are, at times, blamed for polluting, overcrowding, and clogging urban water systems (Rao, 2010), perpetuating a discriminatory approach to planning. To address these issues, a design perspective focused on ecology was intertwined with the conceptual approach of UPE to cast light on Kozhikode's urbanisation in three sections. Prior to our analysis, we start with a presentation of the analytical framework with theories (Chapter 5.2) and methodologies (Chapter 5.3) from the fields of political ecology and urban design. In the analysis (Chapter 5.4), we look at successive moments of urban water transitions in Kozhikode and their associated imaginaries, water structures, and contestations related to water-supply, wastewater, and surface water changed over time. Questions that guided our analyses were: 1) Where do imaginaries that form plans and designs come from, to whom do they belong, and what are their guiding assumptions?; 2) How and who are the multiple actors colluding to mobilise and promote such imaginaries?; 3) What happens when imaginaries become operationalised in actual projects? Finally, from the analysis, the conclusion (Chapter 5.5) draws up learnings to alert urban development practice and associated water-sensitive imaginaries and helps us identify new pathways for socially just WSUD.

5.2 Theoretical framework - Decentring and resituating water sensitivity

Water sensitivity is a concept that emerged to express an intention of water managers to fuse and prioritise management, protection, and conservation of water in urban design and planning agendas. Scholarship advocacy for WSUD gained institutional legitimacy in various countries in the global north, each operationalizing the concept differently in urban design and water management practices (Brown & Clarke, 2007; Cook et al., 2019). Despite concerns regarding the relevance of WSUD in the global south (Bichai & Cabrera Flamini, 2018), its following grows as its successes are proclaimed by advocates from academia and policy making. Such international trajectory of design and planning steers imaginations regarding the positive role of WSUD universally. However, we see water-sensitive knowledge systems and technologies as situated, coming from specific places, and embodied, belonging to certain groups of people. We understand that the growing following of WSUD deserves attention considering how the history of water management is marked by unjust processes of recognition and subjugation of socio-ecological relations (e.g., Zwarteveen & Boelens, 2014).

The Urban Water Transitions Framework (UWTF) developed by WSUD scholars (Brown et al., 2009) is an example of how water managers create universal theories about urban water systems, emphasising a need to transition towards one 'water-sensitive city' ideal. The UWTF informs assessments of a city's urban water management performance by formulating cumulative 'city states'. Organised in a linear manner as such, each city state is considered to influence and shape the successive state (Wong & Brown, 2009). As such, the UWTF falls short in representing the diversity of ways in which historical hydro-social arrangements have produced urban contexts with coexistence of multiple, fragmented, or alternative city states. By employing hydro-social contract theory, the UWTF describes the history of water use as a progressive utilisation of a society's water resources by means of engineering dominance and state provision (Meissner & Turton, 2003). With the uptake of WSUD, the concept of water sensitivity becomes definitive and increasingly inspires urban design practice and designer's frame of references (Van Dooren et al., 2014). Determining factors are formulated to track an urban environment's suitability to receive WSUD and its potential efficiency and effectiveness (Kuller et al., 2017).

WSUD's way of analysis and knowing the urban water environment risks creating a scientific discursive genre separating issues of water from those of culture. For example, by considering cultural and habitat functions through separate sets of indicators, WSUD readings fail to recognise that nature and culture literally flow into each other and can exist without clear boundaries. It is because of these effects that we are concerned that WSUD in its current form may perpetuate unevenness in cities. Current WSUD frameworks give the impression that manifestation of water sensitivity should be the same and similarly achievable in each context and, if not, the context is suboptimal. We argue that such a framing justifies inclusions and exclusions of hydro-social relations without problematizing questions of socio-ecological justice.

We identify a potential for WSUD to investigate urban territories not as fixed entities containing water but rather as socionatures (Swyngedouw, 1996), as waterscapes produced through different hydro-social imaginaries. To decenter the model of development represented in the UWTF, we re-theorise urban water transitions through the experience of Kozhikode. By using the term decentering, we aim to complicate existing WSUD scholarship by challenging the universality of its theories derived from experience in Northern cities and by displacing the centrality of its associated artefacts (e.g., bioswales or constructed wetlands) from a position of determinacy (Furlong & Kooy, 2017). We employ the notion of hydro-social imaginaries to highlight how urban water management develops in ways that escape understandings of the UWTF. Imaginaries are understood here as collectively held and performed visions of a desirable future and are a powerful cultural resource to respond to urban challenges (Davoudi et al., 2018; Jasanoff & Kim, 2013). Theories about hydro-social imaginaries describe how more diverse and divergent actors – beyond engineers and bureaucrats – seek to imagine and materialise different forms of water practices that suit their interests. They constitute important elements of waterscapes in cities as they offer an idea of its ideal state and way of becoming and reflect collective forms of imagination that give groups of people a sense of how to live together (Davoudi et al., 2018), which may diverge. As such, imaginaries percolate into urban design and planning processes to shape guiding concepts and objectives, influencing urban development and management in practice. Theories of hydro-social imaginaries, however, highlight how unequal powers among actors in society do not allow all collective forms of imagination to materialise (Duarte-Abadía & Boelens, 2016).

Imaginaries belonging to communities of urban designers and planners percolate the values, interventions, or frameworks of WSUD, including the UWTF, influencing and steering the politicised terrain of urban development. As water-sensitive urban imaginaries emerge in attempt to reconfigure existing hydro-social relations, the concept of ecological decay, introduced by Gandy (2023), brings to attention

how such water-sensitive reconfigurations also work in erasure of non-dominant water cultures that may be associated with biodiversity protection in urban areas. Concepts of waterscapes and hydro-social imaginaries are mobilised for a more context specific WSUD. One which puts 'who' questions explicitly on the agenda, with attention to whose identities and whose experiences are included in the process of framing problems and proposing solutions. Rather than a goal, we re-consider water sensitivity as part of an existing context, for example recognisable in traditional practices, and as a context-specific variable whose potential is defined by diverse urban conditions without that making a context less successful (Van der Meulen et al., 2023a). Towards decentering universalised notions of WSUD, we proceed to situate water sensitivity by understanding how it manifests in the context of Kozhikode's contested imaginaries and shifting hydro-social relations. We employ the introduced theoretical constructions from UPE related to waterscapes, hydro-social imaginaries, and ecological decay and we take water infrastructures of the supply, sewered, and drained city, as prescribed by the UWTF, as the scale and focus for our analysis.

5.3 Methodology - Researching urban water transitions through contested hydro-social imaginaries

Our research was based on qualitative methods. Our interest in hydro-social imaginaries emerged from our experience as scientists from a technical university in the Netherlands hired to contribute in the production of a framework and roadmap to achieve a vision for water-sensitive cities in India. The assignment is part of a research project that required us to host stakeholder workshops in three Indian cities, one of them being Kozhikode. The project's aim was to integrate research findings and stakeholder perspectives to: understand opportunities and barriers for WSUD; develop contextualised visions for water sensitivity; and create pathways for each city to transition towards water sensitivity. During our visits to Kozhikode, we interacted with a diverse set of actors and followed how they mobilise different knowledge about water to justify and give coherence to their judgements of present water sensitivity and their imaginations towards a better future. Divergence among actors in relation to what water sensitivity is, how it should be achieved, and by whom, made the role of contestations around hydro-social imaginaries visible to us.

The research involved two occasions of qualitative fieldwork by the first two authors. One month in July-August 2022, during the Southwest Monsoon, and two weeks in March 2023. As part of the research project, three stakeholder workshops were held in Kozhikode to achieve the project's aims, one online and two on-site, and each involving up to 80 attendees. Participants in workshops were civil servants, residents, activists, designers, scholars, and politicians. It is important to highlight here the diplomatic nature of bi-lateral academic collaboration as it conditions research projects, thereby shaping workshops' design and selection of participants. In this sense, stakeholder workshops can be a way to decide what and whose discourses to put centre stage in participatory forms of academic knowledge production and may, as such, define imaginaries without participation being representative of the population. In the case of the workshops in Kozhikode, workshop design was bound by the necessity of Indian academic partners to strengthen relationships with politicians and bureaucrats associated with local ruling regimes.

In this context, therefore, qualitative semi-structured interviews with 58 key informants, realised in the period after the workshops, were essential, as this exercise allowed us to encounter actors, mostly residents and activists, that either were not present in workshops for diplomatic reasons or did not feel comfortable or safe enough to speak up. During such encounters, we listened and learned from counter-narratives about Kozhikode's urban water challenges and who is responsible for or contributes to degradation and preservation. Data from interviews and workshops was recorded and transcribed, yet will not be directly quoted to secure anonymity. Additionally, field visits provided in-situ and small-scale observations and validation of processes of interest. Instead of commonly used big data site analysis in urban planning, creative documentation methods (e.g., walking, drawing, mapping, photography, videography, writing) were employed to provide and enhance accuracy of observations, uncover local dynamics and conditions, and advance understanding of the urban landscape and developments at community scales (Van der Meulen et al., 2023b).

5.4 Learning from transitions in Kozhikode's waterscape

This section presents a historical account of how Kozhikode's waterscape was transformed through different expressions of water-society relations through time. A historical reading of the city helps to unpack how specific territories within the waterscape become sites for construction of subjectivities and identities that have important consequences in the unfolding of urban life. Taking the conceptualisation and materialisation of urban water transitions (i.e., water-supply city, sewered city, and drained city) in Kozhikode as our starting point, we question which strategies were adopted, by whom, and to whose interests they served. To learn from Kozhikode's urban water transitions, thus, means to see waterscapes as constantly under a process of renegotiation, subject to shifting symbolic and cultural dominance of perceptions and, thus, landscapes of power.

5.4.1 Becoming a water-supply city as Kolikkod, Calicut, and Kozhikode

Pre-colonial narratives of Kozhikode emphasise its importance as a centre of maritime trade and prosperity under the rule of Zamorin kings. Prior to their tenure, the marshy coastal area had belonged to the Chera Empire, one of the major powers of Southern India, from approximately the 3th century onwards (Bhagyanathan & Dhayanithy, 2023). In the beginning of the 11th century, Cola rulers annexed the area now known as Kerala and constructed Kolikkod (Ayyar, 1976) or Koyilkotta (Ayyar, 1938), signifying 'fort built by Colas', at the mouth of the Kallayi river. Kolikkod's hinterland was characterised by a strikingly undulating coastal plain, dotted with wetlands and marshlands in its depressions which were cultivated with paddies and worshipped as sacred groves, until the foot of the steep Western Ghats (Figure 5.1). Within the coastal settlement, the pattern of water bodies was mirrored with human-made ponds exposing high groundwater levels. These ponds served adjoining religious communities or families with water for washing, ceremonial bathing, besides being the main source of water supply. For example, the Muslim quarter of Kuttichira earns its name after the pond adjacent to the mosque built by a shipowner and merchant in the 14th century. In a similar way, under Zamorin command, the Tali Shiva Hindu temple was adjoined by a pond and Mananchira was constructed as a bathing pool and source of drinking water.

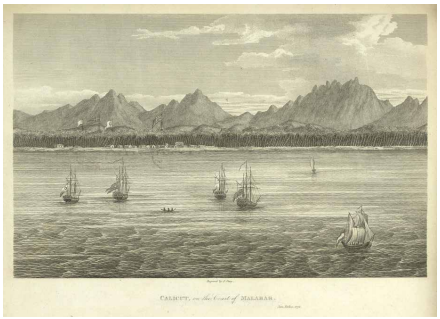

FIG. 5.1 View from sea at Calicut with its undulating landscape and the Western Ghats in the background. Engraving by J. Shury after the 1772 James Forbes' drawing published in his 1813 Oriental Memoirs (Forbes, 1813).

The centuries following Vasco da Gama's landing just north of Kolikkod in 1498 were characterised by wars to expel Portuguese, Dutch, and neighbouring local rulers, eventually resulting in the surrendering of the Zamorin kingdom to the British (Ayyar, 1976). The British had arrived in the region in 1615 and would, in the 19th century, make the city their district capital for its spice and teak extraction and trade missions, under the name Calicut. The establishment of the colonial government meant imposition of new operations and reorganisation of urban space to accommodate the economy and civic life of colonial settlers. Striking artefacts of water-supply, such as the city's ponds and associated open spaces, were appropriated and reworked by colonial administrators into a new typology of public space that sought to impose the cultural values and practices of British settlers. The public space around Mananchira came under the control of the District Collector (i.e.,a position created during British administration to collect revenue and keep peace by, for example, directing police work). The waterbody was to become a 'maidan', an open ground where colonial power and superiority could be displayed, for example, through police parades, while also providing space for leisurely walks, coach rides, and cricket and football matches (Jidhu, 2014).

Pre-colonial uses, such as performances, ceremonies, and celebrations were increasingly perceived as out of place by European residents. In an attempt to turn Mananchira into a manageable public realm, such uses were framed by colonial settlers as threats to public health in what they conceived to be a sanitised neighbourhood. This resonates in Acharya's (2023) account of how colonial science influenced public health departments to keep people away from ponds in the Bengal delta. In response to angry letters and petitions from European residents, the Collector in charge agreed to define a set of rules and conditions for anyone using the Mananchira ground to obey (Anima, 2012a). However, the fact that colonial infrastructure can be held responsible for contamination due to fragmentation of natural drainage (Acharya, 2023), highlights how planner's imaginaries may originate from discriminatory misconceptions. Such colonial conceptualisation

and materialisation of the city's public space associated with ponds did not land in Calicut without controversy as subsequent efforts to turn Mananchira ground into a green park were met by contestations (Anima, 2012b).

After Indian Independence in 1947, the state of Kerala was established and, in 1957, its first Communist-led government was elected. The new political and institutional landscape resulted in reduced income inequalities and increased health care and literacy rates in the renamed city of Kozhikode. Economic growth and a growing middle class further amplified demand for water while, simultaneously, conversion of land use related to urbanisation processes increased impermeability. With an increasing number of household wells delivering the communal supply services of ponds at a private level, groundwater resources were overexploited to levels that disturbed urban water cycles. Along the most densely populated coastal area, wells and ponds suffered from contamination due to rising numbers of household septic tanks, while in inland areas with lower densities, wells and ponds faced depletion (Vinod Kumar et al., 2020). Such supply insecurities were responded to with centralised water-supply schemes introduced by the Public Health Engineering Department (PHED) created in the 1950s under the National Water Supply Programme.

Notions of Western imaginaries were carried over to contemporary urban development by builders of modern Kozhikode to secure post-colonial visions of urban modernity and growth. This longing is linked to the city's rapid economic shift from primary and secondary to tertiary sectors (Bhagyanathan & Dhayanithy, 2023) and accompanying growing middle class and elite. Associated rising urban development pressures and surging land values are additionally instigated and invested in by remittances from Non-Resident Indians (NRI) – mostly from the Gulf region – that push consumerist activities and touristic and infrastructural developments, remaking Kerala's culture, real estate, and landscape, with consequential social exclusions (Jaffe & Doshi, 2017; Mannathukkaren, 2022). This scopes the aspirations of more hygienic surroundings in urban environments. Yet, by leaving certain areas suffering from problems of water shortage and underserved through implementation of un-metered stand posts by the PHED between 1964 and 1974 (ADB, 2005), realisation of an imagined order in the urban fabric continued to be challenged by the city's socio-economic and cultural diversity. 1980s state induced expediting urbanisation pushed the shift in water-supply management from decreasingly reliable wells to seemingly infinite piped supply. Under the centralised management and maintenance plans of the Kerala Water Authority (KWA), an agency founded in 1984 through a conversion of the erstwhile PHED, the water-supply system was upscaled with upstream dams and reservoirs. In 1997, the first of three loan agreements between the Japan International Cooperation Agency and the Government of India was signed to develop water-supply and sanitation systems in Kerala under the execution of the KWA.

The urban ideal of fully connected water systems in Kozhikode was conceived by KWA engineers in the same ostensible technical and managerial simplicity that architects, engineers, and planners sought to re-work chaotic and disconnected nineteenth-century European towns into modern cities (Gandy, 2004). With financial support from international donors, imaginaries of effective functioning urban water systems were conceptualised for Kozhikode through the institutional capacity of KWA. In practice, however, the relationship between social and technological urban water systems is far more complex than the KWA's engineers and the Kozhikode corporation's planners continue to assume. In the case of Southern cities, water-supply networks often are diverse and not always concern unequal access to an incomplete 'universal infrastructural ideal' as citizens may have good reasons for choosing alternative options to centralised systems (Furlong & Kooy, 2017). The choice for development of a centralised model of water supply with its hidden pipes, private household taps, and meters rests on a broad misconception that all citizens would ultimately conform to becoming piped water consumers. Instead, open and bore wells for drinking water and other domestic purposes continue to be a common practice in Kozhikode to this day. Many households choose to avoid economic burdens of paid water services by maintaining irregular non-metered connections, using public taps, or resourcing groundwater for their daily use. Not accounting for such practices in planning and designing urban water supply results in revenue loss for the KWA posing a significant fiscal challenge for the corporation to sustain access to reliable drinking water to the population of Kozhikode. Given these challenges, the district's Irrigation Department expands its role from solely supporting agricultural activities to indirectly supplying water in urban areas. It does so through maintenance of Kozhikode's secondary canal system to enable recharge of groundwater tables that allow abundant water at household wells. The same system is connected to the larger colonial Conolly Canal system which, controversially, causes excessive water outflow lowering groundwater tables.

5.4.2 Communities and areas bearing the weight of the sewered city

Accompanying the rise of private household wells, in the field of wastewater management the growth of economy, urbanisation, and middle class materialised in private household septic tanks. Lacking awareness or regulations regarding risks of contamination, tanks were often constructed in close proximity to drinking water wells at one's own or neighbouring property grounds, leading to severe health risks of the consumer. Other significant health risks were incurred by those maintaining septic tasks through manual scavenging work. For this reason, the practice was banned by the Kerala government in 1982 and again, nationwide, in 2013 through the Prohibition of

Employment as Manual Scavengers and their Rehabilitation Act. Enforced by the orders, communities engaged in manual scavenging became adopted as contingency workers by the Kozhikode Municipal Corporation (KMC) as sweepers or sanitation workers. Under these different titles, however, the practice continued, yet now facing arrests and access to rehabilitation measures taken from them. KMC, in fact, denies the existence of remaining manual scavengers altogether and further threatens their livelihoods by investing in robots to clean manholes instead of rehabilitation (Fathima, 2022).

Under KWA's 1980s centralisation efforts, the city's first sewerage infrastructure project was inaugurated to replace onsite sanitation methods and manual scavenging. The sewerage plan was abandoned midway due to shortage of funds resulting in an incomplete transition in the city's wastewater system. Toilet wastewater continues to be disposed through septic tanks and soak pits, while greywater from kitchen and bathroom use is directly discharged into stormwater drains without any treatment. Onsite sanitation methods are still managed through private parties with limited involvement of local urban administration in sewage management. More recently, ecological conceptualisations of water systems, mobilised through the National Green Tribunal (NGT), additionally demanded new sewerage technologies to prevent pollution of water bodies. Following directions of the NGT to ensure scientific interventions to treat sewage, the KWA responded by setting up a separate entity exclusively for preparations of sewage infrastructure.

Interestingly, the same ecological reasoning that led the NGT to call for appropriate treatment of sewage was later mobilised in a case, under the same tribunal, to halt implementation of a proposed sewage treatment plant (STP) under the justification that its location, the Kottuli wetlands, covering 87 hectares directly adjacent to downtown Kozhikode, are an ecologically protected area. This scenario leads to high levels of bacteriological contamination in Kozhikode's water system, aggravating health hazards for household use of groundwater through public and private wells. The Conolly Canal, as main drainage to the city's water system and recipient of sewage from direct discharge and connected water channels, for example, shows high levels of pollution which indicates contamination of the wider surrounding system.

A Muslim coastal fishing community – carrying the name of its adjacent stream, Avikkal Thodu – faces chronic water pollution from convergence of upstream discharges. Explained through technical and 'expert' vocabulary, the area was selected as alternative recipient of the city's STP for its low lying characteristics, maximising gravity flows of wastewater to reduce costs of pumping towards the treatment station. In fear that the project will affect their livelihoods, residents have organised a series of protests against implementation of the STP that have been met by police violence and custody of activists (Figure 5.2).

FIG. 5.2 Fishing community Avikkal Thodu. On the left, police surveillance at the proposed sewage treatment plant (STP) implementation site with an inverted wooden boat with the inscription 'Please let us live: children of the sea'. On the right, women of Avikkal Thodu gather to discuss strategies and coalitions for the anti-STP movement (photos by Raquel Hädrich Silva, 2022)

FIG. 5.3 Palayam vegetable market. On the left, a sign says 'Vegetable market traders and workers are in protest: keep the vegetable market where it is; preserve the heritage of the vegetable market' (photos by Raquel Hädrich Silva, 2023).

FIG. 5.4 Work of washer community at Muthalakulam. On the left, a man fetches water from the well to wash clothes and, on the right, linen from customers are put to dry (left photo by Raquel Hädrich Silva, 2023).

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Regardless of technical justifications, informal settlements in Kozhikode, constitute a 'matter out of place' or 'nuisance' in emerging urban imaginaries linked to ideas of environmental improvement (e.g., Baviskar & Ray, 2011; Ghertner, 2013). In Kozhikode's most recent Master Plan, a number of 'pockets of decay' are identified in the city that, according to planning discourse, contribute towards unhealthy conditions and squalor in the city (T&CPD, 2017), while municipality turns a blind-eye to middle-class households disposing garbage and sewage into drains, frequently ending up in poor household areas downstream. As such, communities, like Avikkal Thodu, are identified as unhygienic and blamed for the polluted conditions of the neighbourhood's stream and groundwater. The fishing community faces a combination of discursive and material discrimination that becomes normalised in the name of cleaning the city's water system through the technology of sewage treatment. Similarly, the city's most significant open air fruit and vegetable market, Palayam (Figure 5.3), and washer community ground at Muthalakkulam (Figure 5.4), are some of the targeted areas proposed to be relocated for developments. The associated communities, however, have responded in a similar way as the fishers of Avikkal Thodu fighting against the STP by resorting to public protest to effectively make their opinion against the proposals to be considered, claiming that the shift is not in advantage of their operations.

5.4.3 Drained city sprawling in the undulating coastal plain

Prior to urbanisation in the colonial and post-colonial periods, scarce inhabitation of the undulating inland plain secured drainage of seasonal monsoon rains. This equilibrium was additionally maintained by local water practices and knowledge, for example, spatially manifested in sacred groves. Study of terrain attributes of these virgin forest patches by Bhagyanathan et al. (2018) shows how they encourage deceleration and percolation of water securing groundwater tables. As such, cultural and spiritual values overlap or interlock with natural and hydrological processes, securing their protection through worship and maintenance by indigenous communities. The British rule introduced water infrastructure that would leave a permanent mark on the city and landscape. To facilitate transport between plantations and ports, a system of Conolly Canals, named after its initiator and the region's Collector, was dug in 1848. Common to European water management and industries, canals were designed in Calicut for extractive practices. By cutting through elevations and depressions, the canal initiated an irreversible process of excessive groundwater and surface water outflow, turning wetlands brackish, lowering water tables, and increasing wetland fragmentation (Bhagyanathan & Kasthurba, 2013) (Figure 5.5).

FIG. 5.5 Landform of Kozhikode and Kottuli wetland-loss (modified from Bhagyanathan & Dhayanithy, 2023) after completion of the Conolly Canal.

Besides culminating in major wetland area loss, this imposed water infrastructure triggered road developments along its embankments. The rectangular frame-like canal drew an outer ring for the city to grow into, territorializing wetlands in the frame's interior (Bhagyanathan & Dhayanithy, 2023). After India's independence, the city within the rectangular frame densified and the relatively flat coastal plain outside of the frame permitted urban sprawl in all directions landinward, filling up wetlands (Figure 5.6). Land cover changes and accompanying road network and sewage discharge diminished hydrological functioning of remaining wetlands and marshlands and affected associated biodiversity and communities and their water practices (Bhagyanathan & Dhayanithy, 2023), at the cost of other imaginaries.

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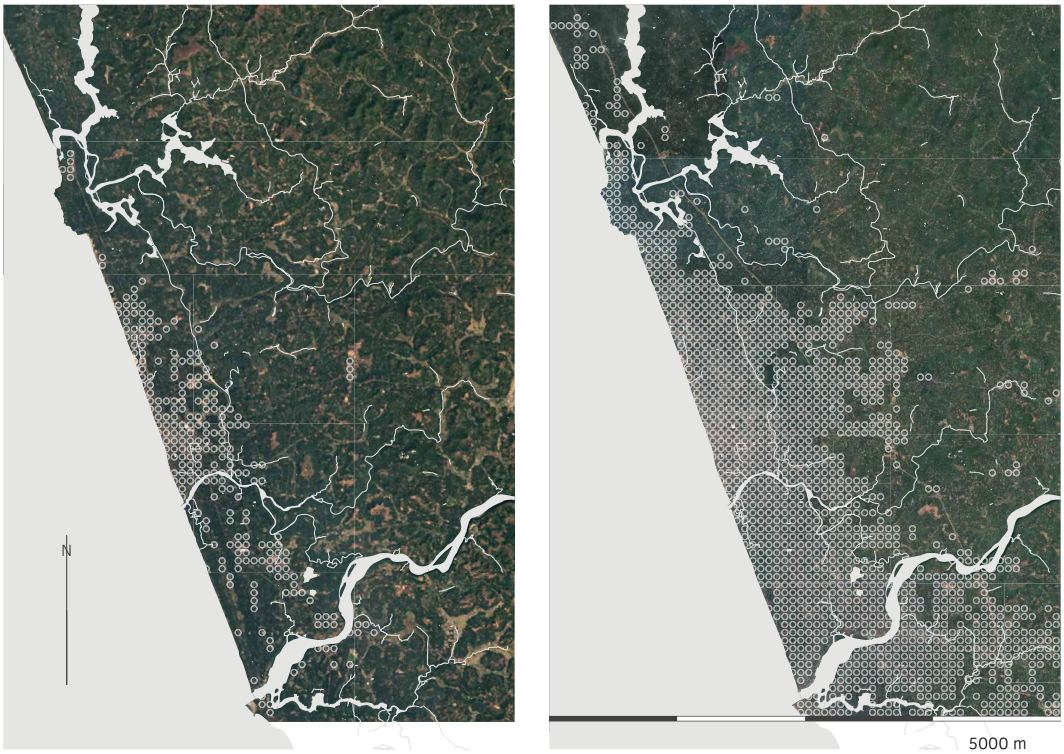

FIG. 5.6 Sprawl of Kozhikode 1992 - 2020 (modified from Defourney et al., 2023) projected on Google (n.d.) Earth satellite imagery.

After one and a half centuries of suffering from superfluous surface and groundwater outflow, wetland fragmentation, and saline intrusion caused by the insertion of the Conolly Canal, Kottuli became the axis of conservation efforts. India's consolidation and amendment of laws related to nature conservation in Kozhikode emerged in response to urbanisation-driven pressures on wetlands. This resulted in the designation of Kottuli as wetland of national importance in 2007 (MoEF, 2019), followed by a statewide act for conservation of paddy- and wetlands in 2008 (Government of Kerala, 2008). In Kozhikode, 200 acres of wetland would now enjoy the protected ecologically-sensitive status. An area which equals only 13 percent of the wetlands remaining after the wetland loss induced by the Conolly Canal.

Assigning a protected status to a portion of the wetlands, enables the dangerous assumption, among inhabitants and developers in the area, that the 43 percent of unprotected remaining wetland does not require preservation and can be developed upon. A destiny which has yet been ordained to 44 percent of the remaining area that has been filled and encroached (Bhagyanathan & Dhayanithy, 2023).

During field visits, such practices could be observed, as encroachment takes place in plain sight at numerous occasions and both at small and large scales. Luxury villa complexes, seeking proximity to natural tranquillity of wetlands, are constructed in them or encroach their edges. Widening and heightening of a national highway is currently underway within unprotected wetlands, further aggravating wetland fragmentation (Bhagyanathan & Dhayanithy, 2023) (Figure 5.7). Being low lying areas, these developments result in aggravated flooding, stormwater drainage obstructions, and reduced groundwater recharge opportunities, all of which are crucial to flood risk and groundwater security. It shows how ecological conservation planning agendas introduce flexible conceptualisations and interpretations of what exists and what is worth preserving (Gandy, 2023).

Amidst pressured development agendas, Kozhikode suffers the threat of a gradual disintegration of its socio-ecological relations. Inauguration of land as a form of property in the colonial period, for example, has led to delegitimisation of non-monetizable values of ponds and sacred groves. These water bodies and forest patches came to be perceived by land owners as prospective commercial value, prompting processes of land reclamation and encroachment for new constructions. Many smaller ponds are on private properties belonging to family residences or temple grounds and lack documentation, limiting possibilities for preservation. Sacred groves and associated ponds used to be located within forests, as worshipped gods are associated with nature and should be out in the sun and get wet in the rain. However, as part of an ongoing cultural homogenisation following India's independence, pan-Indian Hindu deities substitute local folk deities. This process of, so-called, Sanskritisation entails mobilisation of sacred groves as cultural symbols of a coherent nation. Within modernising urban cultures, this shift implies that paved surfaces and temple structures associated with classical Hinduism increasingly cover permeable grounds of sacred groves, undermining their nature conservation potential (Bhagwat & Rutte, 2006; Bhagyanathan & Dhayanithy, Forthcoming; Ormsby, 2011). In other cases, ponds, sacred groves, or its hydrological role is erased completely to make way for construction work (Figure 5.8). The more impermeable the urban landscape becomes, the less capable it is to deploy monsoon precipitation for groundwater recharge.

FIG. 5.7 Encroachment of Kottuli wetland, on the left, by construction of Promenade Villas, on the right, by widening of the national highway 66 bypass.

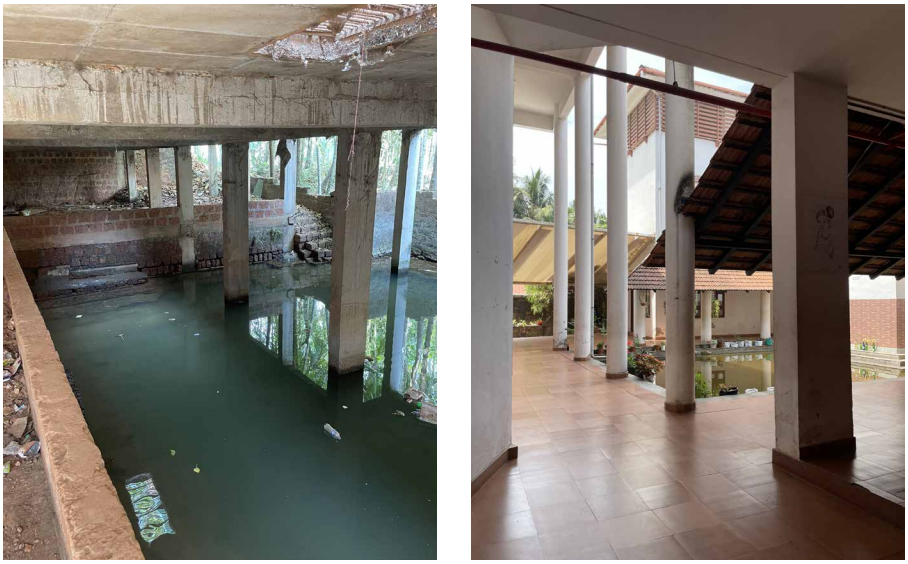

FIG. 5.8 Encroachment of ponds, on the left, covered by a road at Kattukulangara Mosque and, on the right, closed in by the Anakulam Samskarika Nilayam cultural centre.

FIG. 5.9 Kottuli wetland. On the left, the Kerala Water Authority stores pipe material in wetland area. On the right, flooded walkways in the Sarovaram Biopark.

Prohibitions and exemptions of the national Coastal Regulation Zone (CRZ) also result in similar discrepancies in Kozhikode and Kerala. In the remaining Kottuli wetland area subject to conservation with legal protection, conservation is adopted by the Government of Kerala, under its Tourism Resorts Kerala Limited enterprise, as opportunities for development and ecotourism. Without opposing CRZ limitations, a public urban park, called Sarovaram Biopark, was constructed within the wetland in 2013 (Azeez et al., 2008), prioritising labour provision and awareness of nature conservation, above conserving nature in itself. Here, scientific aspirations to manage ecology denote a particular aesthetic value in its imagination that caters to middle-class uses (D'Souza & Nagendra, 2011) in detriment of other cultures and relations to nature (Gandy, 2023). Alongside ongoing park maintenance, which differs from nature conservation, ecotourism requires walkways, parking spaces, and public amenities, eventually harming the wetland area. At plots adjacent to the park, South India's largest convention centre is currently under construction and the KWA has its base here, using conserved wetland area to store pipe material (Figure 5.9). Beautification and use of urban nature in Kozhikode emerges as a symbol of modernity associated with the shift towards middle-class cultural values. For example, key ponds in the city have been restored with decorative plaques depicting Zamorin heritage and the beach adjacent to the city centre has been designated as 'cultural beach' and encroached with a boulevard, square, and an arrangement of monolithic walls commemorating freedom fighters.

In 2018, the rain-fed landscape of Kerala was incapable of processing the abnormally high rainfall during monsoon season, resulting in severe flooding and loss of life and property in all districts of Kerala, affecting in total 5.4 million people. In Kozhikode city, flood levels started to rise when upstream dam shutters were opened, inundating roads and neighbourhoods, especially around Conolly Canal (Cherian & Sahasranaman, 2018). Floods polluting wells and damaging pumps and STPs subsequently led to

drinking water crisis in the state. Heavy intensity rainfall patterns repeated in following years (DoECC, 2022). As a result, local communities and their traditional practices around wetlands are both at risk of being pressured or pushed out by urban and real estate developments, as well as at risk of flooding by reduced drainage and retention capacity and ecological harm these developments entail.

5.5 Conclusion

Ways in which Kozhikode's waterscape came into being through deeply interlinked and co-evolving societal and natural processes, highlight the need for more contextualised and politicised readings of urban water transitions to inform ongoing urban planning and water management. In this article, we have shown how design, planning, and production of Kozhikode's contemporary waterscape can be linked to dominant hydro-social imaginaries belonging to middle-class cultural values. Such water management processes are marked by historical injustices that result from spatial production of urban nature through foreign concepts and capitalist relations. Middle-class imaginations of hydrological components of the urban landscape lead to a planning discourse that increasingly disintegrates socio-ecological relations which deviate from new ideas about waterscapes in cities. Despite constitutional efforts to widen political representation of diverse actors in Indian democracy, middle classes claim a strong position in creation of the public realm. Their stance, consequently, takes the lead in discussions and decision-making about what is worth saving, and what is considered nature in water-sensitive transitions. In this context, imaginaries of 'water-sensitive cities' are attempts to discipline nature and society through WSUD that reflect an urban aesthetics and politics linked to middle-class values, partly inherited from the British colonial period. A key problem is that poorer groups' socio-ecological relations are not recognised as contributing to water-sensitive transitions imagined by middle classes. On the contrary, as we have seen in the case of Kozhikode, they are more likely to be blamed for water problems perpetuating a discriminatory approach to planning.

In response to these complexities, we advocate for WSUD scholars to engage more closely with insights from political ecology when reviewing urban water transitions, as we do so in this article, and particularly when acting upon them. Challenging the current position of WSUD, which assumes water to be graspable in established hydrological processes and urban water cycles, we emphasised that water should be

understood as a critical dimension to the social production of space. By mobilising the idea of waterscapes, that sees no dichotomy between water and culture, we argued that WSUD should rather regard present-day Kozhikode as home to a multitude of hydro-social imaginaries. Each offers alternative ways of perceiving, knowing, and managing water, some of which manifest or root in artefacts and practices currently present in the city's waterscape. Such a framing is fit to address the described discrepancies regarding service provision and nature conservation in which interventions, perceived as infrastructural improvements by one community, are prioritised over and at the cost of ecological systems, other communities, or their practices, places, values, or visions. It would give the 'who' questions in WSUD their due prominence, making explicit whose knowledge and interests are considered and whose might be disregarded. Only then can the concept of water sensitivity be repositioned as being present in past and current conditions, rather than being an ideal universal future state, as framed by the UWTF.

Conventional WSUD projects that have gained international status as exemplary water management, such as the Dutch Room for the River scheme or Rotterdam's water squares, are considered "attractive" precisely because they are remodelled for international consulting purposes. Such technical solutions and the processes through which they are established are decontextualised and, thus, made generic, transferrable, and a-political to circulate more or less 'freely' across cities, establishing new imaginaries of water sensitivity globally. Practising conventional WSUD entails tapping into the frame of references of best practice of such generic water management and urban design solutions. These best practices, however, are derived from conditions which fail to be representative and valid for all contexts (Furlong & Kooy, 2017). Its roots on a technocratic approach neglect the politics of their governance and the connection of imaginaries to values and interests of more powerful actors. In the context of urban India, Room for the River has the risk of facilitating a 'politics of cleansing' that enables mass evictions of poor families but does not erase or impede forms of encroachment by the rich (Gandy, 2023). More recently, the EU subsidised collaboration between Rotterdam and Surat, aiming to take the experience of the Dutch city to construct seven water squares in its Indian 'sister-city' (Municipality of Rotterdam, 2022), demonstrates transfer of foreign water sensitivity schemes to India and indicates the relevance of our concern.

Moving beyond such generic operationalisations, we argue that WSUD should include practices uniting people, nature, and artefacts and engage with ecological connections that local communities may have to water and waterscapes (Coyne et al., 2020; Furlong & Kooy, 2017). We understand that our contextualised version of WSUD is much less mobile, and will therefore probably be less attractive to international consultants and donor projects. To create a circuit for our proposed

version of WSUD to travel and have equally renowned international status, we propose longer-term alliances of designers with partners on the ground that actively decenter conventional best practices. Engagement in WSUD, therefore, should entail activism, being political and taking a position towards just water-sensitive responses (Silva et al., 2024). Such political WSUD makes place for valuing local practices and knowledge and seeing people's roles in waterscapes as infrastructure (Simone, 2004). On top of that, we endorse McCann et al. (2013)'s call for centering Southern cities as unique nodes of relevance to urban theory beyond their stereotypes like 'slum-ridden' megacities. Instead, in fact, traditional knowledge or local practices embedded in slums or carried by other communities in Southern cities deserve recognition and can be learned from globally. How residents of Southern cities make a place in the world should, therefore, be centred rather than understanding them in contrast and comparison to imposed visions or desires of a world-class city.

Cities like Kozhikode can contribute to understanding, not just Southern waterscapes, but add to development of discourses of research and international practice on urban design, urban water management, and fields alike. Sacred groves, ponds, and manual scavenging are among Kozhikode's artefacts and knowledge around which WSUD theory and practice can be rethought, developed, and disseminated, no different than dikes, wadis, and green roofs do in and for other contexts. Realising that water sensitivity should and will inevitably manifest differently depending on conditions of a context enables decentering urban theory, frames of references, and imaginaries from the contexts in which WSUD has been conceptualised and centering their local equivalents. To ultimately see them as equal and for WSUD to be able to serve contexts and its communities equally.

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6 Discussion and conclusion

In order to provide an urban design perspective on Water-Sensitive Urban Design (WSUD), enabling investigation of its current and potential context specificity, the research is guided by three research questions, whose answers are explored over four chapters. At first, within WSUD the role of urban design mechanisms and the concept of water sensitivity in contextualisation of the approach was investigated by means of transferability concerns of WSUD to certain contexts. Based on these findings, a reconceptualisation of water sensitivity was developed and repositioning of urban design suggested (Chapter 2). Secondly, the reconceptualisation was tested by situating it in two secondary case study cities by means of different urban design analysis methods. The methods included fieldwork (Chapter 3 and 4) and historical analysis and interdisciplinary actor consultation (Chapter 4 and 5). These explorations contributed to understanding the value of urban design in improved contextualisation of WSUD. At last, the reconceptualisation of water sensitivity and the contributions of urban design were used to challenge principles of WSUD with the complex reality of a secondary city context. The critical review of the agency of WSUD results in pathways for the account of context specificities, beyond the call to include proper urban design processes in WSUD (Chapter 5).

The following sections will be used to reflect on, synthesise, and discuss these findings of the previous chapters. A reflection combining the findings from the case studies with literature presents procedural and context-specific findings. The theoretical synthesis critically underpins WSUD with urban design process theory, acts, and agency. The conclusion provides the learnings and scientific contributions and responds to the research questions. Which is followed by a disquisition of the research limitations and suggestions for future research.

6.1 Reflection - Findings from Indian secondary cities

The research findings from the Indian secondary cities, reinforce the hypothesis that conventional WSUD, as currently appropriated in a widening range of contexts, including Indian secondary cities, is often operationalised without sufficient consideration of relevant specificities of those contexts. The main finding connecting this hypothesis to the dissertation's aim of enhancing the context specificity of WSUD, is the contribution of the selected urban design acts. The urban design acts discussed in this research are not exhaustive, but highlight a few ways to prove how context matters (Kahn & Burns, 2021) and should matter to design approaches, like WSUD. Furthermore, it shows how centring urban design and making it instrumental in WSUD is essential for the approach to respond to local water sensitivity. Observations during fieldwork, historical analysis, and actor consultation are the methods used in this dissertation, enriching their vocabulary for WSUD. Considering urban design is an embodied field of work, these methods are thus executed as personal acts by a researching individual. The use of other urban design methods or execution of the same methods by others, therefore, may result in other findings or areas of focus. The result of enhanced context specificity, however, will be shared.

Immersive fieldwork in India provided novel ways of seeing and reading the landscape to WSUD. Fieldwork functions as sampling the case studies, providing samples characterising the urban contexts with context knowledge. Walking allows for observations to gather context knowledge on hidden and physical forces of spatial regimes (Staničić, 2023), while drawing these observations amplifies the accuracy of these observations (Moorhouse, 2002). Translating observations in drawings in a representational format of relevance to hydrological processes, and thus to WSUD, contributes to intensifying context specificity of WSUD by visualising cultural and societal ties. As such, fieldwork is capable of gathering a wide variety of valuable context knowledge, as well as developing meaningful novel narratives (Velevski et al., 2023) (Chapter 3). Fieldwork in India, furthermore, provided evidence of how the case study city contexts of Bhuj and Kozhikode, at present, maintain water sensitivity, when its regard moves beyond water management. By disclosing societal and cultural dimensions at the intersection with hydrology, urban design equally represents origins, guiding assumptions, and values of types of usage and management of water and space throughout spatial scales in its analysis. For example, the ways in which traditional practices, like sacred grove worship, within the networks of water bodies and wet spaces within Kozhikode's catchment provide for a communal sense of care and belonging and secure maintenance, while complementing urban water management purposes, such as water retention and infiltration.

Historical analysis explored such contextual water sensitivity of the case study cities over time. As an extension of the immersive fieldwork, it provided for additional deeper-rooted context knowledge, relating the past to the present and anticipating the future and identifying changeable and unchanging elements in space (Kimic, 2023). Furthermore, it provided for documentation of systems and spaces never documented before. It highlights how, in the case of the Bhuj and Kozhikode, past and present conditions of water sensitivity are, in fact, entangled in complex histories of power, extraction, and inequality, among others. Water service provision has been locked into pathways of development and modernisation through infrastructures used (Graham & Marvin, 2001), with significant impacts on the use, perception, and imaginaries of water and space, yet insufficiently documented as such. Kozhikode's water supply, for example, is divided into contradicting practices originating from pre-, intra-, and post-colonial periods. Attempts at sewerage systems have been made at the cost of both natural areas and communities. Drainage and retention of stormwater in the coastal plain is hindered by colonial canal infrastructure and urban sprawl which both link to a pursuit of growth, modernity, and extraction (Chapter 5).

Moving beyond fieldwork as passive observation, reviewing history and studying the landscape in contexts deficient of documentation entailed understanding mechanisms by consultation of actors and engaging with its residents and communities, making it also a collective exercise (Velevski et al., 2023). As such, the research explored interdisciplinarity of urban design (Hooimeijer et al., 2022). The primary idiom of urbanisation in the Indian case study cities being informal called attention to the necessity to include not only specialist disciplinary knowledge, but also local, indigenous, or traditional knowledge, to enhance context specificity. Conventional WSUD is an example of an approach in which a certain form of knowledge prevails. Knowledge which may be technocratic, data-heavy, and originating from the contexts in which WSUD is developed. Through actor engagement and interdisciplinarity, urban design facilitates articulation of more diverse knowledge to understand systems and can excel despite absence of data. For example, urban design acts of fieldwork and historical analysis in collaboration with local actors in Bhuj located and documented parts of the city's traditional water drainage system. Its whereabouts and connectivity were only known and passed down by the shrinking group of locals. Despite being united in an NGO, their knowledge is currently not included in local urban planning and water management (Chapter 4). General loss of such local knowledge can, in Bhuj - following Blaikie et al. (1997)'s identification of challenging circumstances - be explained by their history of disruptive earthquakes, droughts, oscillating population numbers, colonial occupation, and current investments for development in the region.

Insights into the culture and history of Bhuj and Kozhikode facilitate a better reading of their urban environments. Urban design acts contributed in assessing the validity of universalised WSUD concepts and its frame of references for the two urban contexts while bringing to light local alternatives or equivalents whose qualities could be regained or stressed. Through such opportunities, the case study research strengthens context-specific ties between the fields of water management and urban design in contexts in which the uptake of the intended union of the fields in WSUD is only starting. Likewise, it exposes how conventional WSUD risks overlooking local conditions decisive for its suitability or resulting in adverse effects, in general, for a specific group, area, or in a later period.

6.2 Theoretical synthesis - Generalisation of findings

The critical evaluation of WSUD as an urban design approach and a critical positioning of its contribution for secondary cities, in general, responds both to reports in literature announcing the value and uptake of WSUD (e.g., Abbott et al., 2013; Cook et al., 2019; Fletcher et al., 2015; Kuller et al., 2017; Wong, 2006), as well as gaps reported in literature regarding the validity of those values in certain contexts (e.g., Bichai & Cabrera-Flamini, 2018; Fisher-Jeffes et al., 2017; Rashetnia et al., 2022). An entry point of the research was the definition of water sensitivity which WSUD promotes. Water sensitivity has acquired specific meaning within the water management field. In relation to WSUD, originating from the field of water management, the literal meaning of sensitivity (e.g., qualities of being aware and understanding of needs, carefulness, having a strong physical reaction, responsiveness, needing to be treated with care, being easily affected) is quickly reduced to its connotation of a state of an urban environment and focus on water as a detached element. This limited understanding of water sensitivity in WSUD stems from the UWTF, which presents the water-sensitive city as a uniform ideal and goal and mostly reflects on the associated water services to be expected and delivered (Brown et al., 2009). This understanding is fundamental for the established project culture of WSUD which represents the norms, values, and assumptions of conventional water sensitivity. These, however, may not always match the complexity of its project in all contexts.

A second entry point of the research was the urban design process, used to reflect upon WSUD and refine the concept of water sensitivity, the role of context, and their mutual relations. The urban design process is characterised by: 1) explorative processes of developing alternatives, 2) following guiding concepts, 3) its own visual language, 4) being highly contextualised (i.e., designing for a specific location and collecting and using context knowledge from that location when designing), and 5) happening with a relevant frame of reference in mind (Van Dooren et al., 2013; 2014). By overlapping these process characteristics of urban design with conventional WSUD (Table 6.1), the research highlights that the context knowledge it intends to collect (Sharma et al., 2019) may not be available at all contexts or representative for the full urban environment (Fisher-Jeffes et al., 2017). Furthermore, success of conventional WSUD resulted in 'best practice' examples (Cook et al., 2019) shaping and affirming its universal frame of references without sufficient consideration of their relevance and suitability for all contexts equally.

When reflecting on WSUD with the urban design process characteristics, it becomes clear that water sensitivity plays a double role. Literature shows that the utopian water-sensitive city, as presented as the goal of the UWTF (Brown et al., 2009), may be a valid guiding concept inspiring WSUD processes and delivers prioritisation of water in urban design agendas (Brown & Clarke, 2007). However, through the urban design perspective, water sensitivity could equally be framed as part of past, present, and future context. This framing suggests water sensitivity is a context variable which, as such, is highly intertwined with other context variables and thus will materialise differently in each location without implying these locations are unsuitable or suboptimal because of such different materialisation. One could consider a gradient of water sensitivity, whose reach and manifestation are determined by context. Being both a guiding concept and context knowledge in the urban design process, water sensitivity as a concept mostly provides direction in addressing a context, while the present or potential degree of water sensitivity of a context, among other context variables, is fundamental to the realisation of the concept (Table 6.1).

TABLE 6.1 Overlay of Van Dooren et al. (2013; 2014)'s characteristics of the urban design process and Water-Sensitive Urban Design (WSUD).

Urban design process characteristics	Used for improvements to WSUD as follows:		
	WSUD theory	WSUD methods	WSUD and context
1) Explorative process of developing alternatives	For future research		
2) Guiding concepts	Water-sensitive city ideal	Identifying past and present water sensitivity	Local potential and manifestation of water sensitivity
3) Visual language	N/A	Drawing and other forms of representation	Documentation of the context
4) Contextualisation	Water sensitivity as context variable influencing and influenced by other context variables	Urban design methods: immersive fieldwork, historical analysis, and actor consultation	Local, communal, traditional, or indigenous knowledge and its associated artefacts
5) Frame of references	Assumed validity and universality of WSUD 'best-practice' and resulting transferability concerns	Decentring of WSUD 'best-practice' and retrieving and centring local equivalents instead	Awareness of validity of WSUD 'best-practice' and value of local equivalents locally and to global discourse

Operationalisation of the reconceptualisation of water sensitivity in the urban design process, or WSUD, is done by creating thorough understanding of the context through immersive fieldwork methods, like walking and drawing (e.g., Schultz, 2014), as well as historical analysis (e.g., Kimic, 2023; Kostov, 1991), that are part of the analysis of the urban design process, yet novel to WSUD (Table 6.1). Bernardo Secchi (late renowned urban planner, designer, theorist, and professor) declared walking as fundamental to urban planning and design, remarkably stating "L'Urbanistica si fa con piedi" ["Urban planning and design is done by foot"] (Fini, 2014). Walking, supported by drawing, are used as observation methods to gather context knowledge, capable of understanding urban and hydrological processes through spatial and temporal scales, including people's perspectives and practices otherwise left unnoticed, and, as such, connecting a community's culture to its territory (e.g., Rolando, 2020; Velevski et al., 2023).

Elaborating fieldwork with historical analysis to gather context knowledge responds, not only, to the data deficiency commonly suffered in secondary cities as when compared to other cities globally (Roberts, 2014; Roberts et al., 2022), but simultaneously succeeds in including neglected local data and insights, like

indigenous knowledge. Iteration of fieldwork and consultation of historic material and consultation of actors led to the retracing and documentation of traces of history, retrieved from the landscape as useful active or inactive parts of the past (Descombes, 2016). As artefacts in the urban landscape, with a permanence determined by space and time, they are essential to urban design, and thus to WSUD, and require full understanding of their impact on and potential for future development (Rossi, 1982). Following the metaphor of a palimpsest (Corboz, 1983), the context holds multiple layers of valuable information, both physical and intangible, at times imposed on each other to obscure or rework previous layers. The framing over time suggests a 'Longue Durée' (Braudel, 1958) of the concept water sensitivity, providing a historical perspective focusing on changeable and unchanging elements in space (Kimic, 2023) shaping the relation between people and its environment. Perceptions of water, motivations of water management, and degrees of water sensitivity evolve and diverge. Such changes can be explained by circumstances which commonly challenge bequest of local knowledge: 1) rapid population growth; 2) rapid immigration and shifting socio-economic structures; 3) disaster events and their response; 4) environmental changes challenging resilience and adaptability of communities; and 5) rapid commercialisation or globalisation (Blaikie et al., 1997).

Fieldwork and historical analysis facilitate connecting multiple spatial and temporal scales (e.g., Bacchin, 2015) and physical and intangible dimensions of the urban environment. Characteristics from the multiscalar intersection of culture and water - the hydro-cultural dimension - are, for example, often only implicitly considered or unaccounted for in WSUD (Coyne et al., 2020). Overlooking such cultural dimensions, however, leads to maladaptive outcomes of climate change adaptation, whereas methods inquiring into culture and context-specific qualitative data provide ways to engage with cultural dimensions of environmental change (Adger et al., 2013). As opposed to the disconnect between a context's data deficiency and WSUD data needs (Sharma et al., 2019), urban design methods are qualified to address such contexts by rather focusing on understanding mechanisms with other information available or inquired into. Another contribution of urban design methods is the inclusion and consultation of actors representing specialist disciplinary knowledge, making the process interdisciplinary, which is key to urban design (Hooimeijer et al., 2022). By equally articulating local, communal, or traditional knowledge in urban design, interdisciplinarity is amplified, as perception or knowledge from within an indigenous community may coexist or contradict with the knowledge framework and frame of references from the context from which the urban design approach originates (Akama et al., 2019).

At last, the perceived universality and transferability of WSUD, water sensitivity as goal of the UWTF, and the agency of WSUD as such, is confronted with the complex reality of a secondary city context. It finds that a city's urban water system emanates from interlinked societal and natural processes. Conventional WSUD analysis of such contexts, however, risks separating issues of water from issues of culture. Water sensitivity, as defined by conventional WSUD, belongs to certain groups of people and certain contexts and can, therefore, be considered as an urban environmental imaginary (Gabriel, 2014) shaping contesting roles and perceptions of nature or water in cities and carrying pervading values and implicit agreements on how water should be managed and the infrastructures or designs used. Mobilisation of WSUD may, therefore, be part of past and ongoing exclusive and unfit water management and uneven urban development agendas. For example, assigning protected status to certain sites as conservation may enable displacement of communities or suspension of traditional practices, while assumptions that other areas of urban nature do not require preservation facilitate real estate development. The concept of ecological decay (Gandy, 2023) regards how such reconfigurations of hydro-social relations entail erasure of non-dominant water cultures or practices, for example because they are not recognised as contributing to water sensitivity as imagined by an influential community or set of actors.

Situating water sensitivity and enhancing context specificity of WSUD is achieved through properly making urban design mechanisms instrumental for WSUD. However, the study goes further by pointing out the necessity for an increased awareness of the agency of design. The study suggests to 'decentre' (Furlong & Kooy, 2017) the universalised development model of the UWTF and its theories, values, and interventions, while actively centring context knowledge, gathered through urban design analysis, instead (Table 6.1). Prior to design – in what could be called the metaproject (De Moraes, 2010) of WSUD – the contents of the project culture and the 'design of the design' can be reflected upon: WSUD should regard water as a critical dimension in the social production of space (Gandy, 2004), regard cities as waterscapes (Swyngedouw, 2004) without dichotomy between water and culture and home to a multitude of valid imaginaries, and be able to regard people's roles and practices in such waterscapes as infrastructure (Simone, 2004). Such WSUD could identify the ways in which context-specific water sensitivity may manifest in an Indian or Southern city, as well as the ways this manifestation can equally contribute to development of urban design theory and practice worldwide, rather than in just Southern cities (McCann et al., 2013) (Table 6.1).

6.3 Conclusions

The scientific contributions and learnings of this research are threefold: theoretically, methodologically, and contextually and respond to the first, second, and third research question, respectively. Deploying the urban design perspective to WSUD, the research delivered a theoretical contribution to the field of urban water management by enriching WSUD with actual urban design theory and methods. WSUD is a valuable effort to unite water management and urban design to address climatic and urbanisation challenges. However, despite its call for water circularity and waterway protection, the context knowledge considered in conventional WSUD testifies to a systemic and water service-oriented view of urban contexts. Within this incomplete view, WSUD is an approach which is situated and embodied. This implies it comes from a specific context and belongs to a specific group of people, respectively, and proves it is therefore not fit for all purposes. Practising such unfit WSUD, entails a pursuit or superimposition of an exclusive water sensitivity representing contested values and agreements of urban water management originating from conventional WSUD and the contexts of its initial application (Chapter 5).

The advice from the theoretical contribution is to operationalise urban design analysis to broaden the view of WSUD to include the complexities introduced by the intersection and coexistence of water service or infrastructure with water culture, practices, and histories. Urban design analysis contributes as the necessary calibration of collected knowledge and deployed concepts. The research proposes a reframing of the concept of water sensitivity in which it no longer is regarded merely as a goal or ideal and guiding concept to urban design processes, but rather as an adjective and part of an urban context's past or present condition. As such, water sensitivity is a context variable and influences and is influenced by other context variables. Water sensitivity will thus materialise differently depending on the context, evolve over time, and be perceived differently among groups or communities within a shared urban environment (Chapter 4 and 5). This provides the answer to the first research question; *What role do the concept of water sensitivity and urban design methods play in the distinct operationalisation that WSUD requires per context?* In the urban design process, water sensitivity is both guiding concept and context knowledge. As context knowledge it is decisive to the manifestation of the concept. As a guiding concept it provides focus on how to address the context (Chapter 2). This reframing of water sensitivity was contextualised in the secondary Indian cities Kozhikode (Chapter 3 and 5) and Bhuj (Chapter 4).

In line with the theoretical contribution, the methodological improvement of WSUD comes from an urban design perspective and attention to context specificity. This implied an emphasis on the role of urban design mechanisms and analysis methods, and fieldwork in particular, to instrumentalise in WSUD. The review of a context and gathering of context knowledge, through walking and forms of representation, and reading and describing space and its histories was leveraged as a common act of design, yet unaccounted for in WSUD, despite its inceptive intention to operationalise urban design (Chapter 3 and 4). The research contributes to enriching the vocabulary of these acts with regards to WSUD, in particular their capability to gather, include, and connect context knowledge from multiple associated and non-associated spatial and temporal scales and physical and intangible dimensions, such as the intersection of hydrology and culture. This connecting ability of urban design is the answer to the second research question; *What contribution do urban design methods provide to situating the concept of water sensitivity?*

Inclusion of these additional scales and dimensions, ultimately, resulted in a call on WSUD for decentring its implicit notions, theories, and values, whose universality is unrightfully assumed (Chapter 5). Beyond knowledge-gathering, the design analysis processes in this research thus provide ways to articulate specific knowledge. Decentring assumptions from conventional WSUD and articulation of local equivalents is the answer to the third research question; *How can context specificities be accounted for in WSUD?* With context knowledge gathering and articulation, focus of the research was on design as minimal intervention, proposing emphasis on analysis of context characteristics, relational thinking, assessment of the validity of certain design concepts, and retrieving local qualities to regain or stress. In line with the research aim, the answers to the research questions enhance context specificity of WSUD as they each shift primary focus of the urban water management and design approach from general principles of water systems and service provision to what defines a specific context for WSUD to address.

Finally, the research - being oriented at enhanced context specificity and making use of case study cities - automatically delivered scientific contributions about these urban contexts. This is worth mentioning in light of the secondary, and therefore understudied, nature of the case study cities, Kozhikode and Bhuj. Not only does the dissertation deliver a disquisition of concerns regarding WSUD transferability to these contexts (Chapter 2) to underline the urgent need for context specificity. The research has also provided scientific accounts, by means of documentation and historical review, on relevant exemplary urban contexts and urban elements about which scientific and non-scientific literature or documentation was limited or even non-existing (Chapter 3, 4, and 5). Beyond the novelty of these contextual contributions, as findings from the two Indian case study cities, the research urges to use their contributions for development and understanding of the urban design discourse worldwide, with Southern or Indian cities as equally relevant nodes to develop urban theory (Chapter 5).

6.4 Limitations

For research with Indian case study cities conducted from the Netherlands, the most influential imposed limitation was the global Covid-19 pandemic, which struck the Netherlands and India two months after the start of the research. Travel restrictions during more than half of the planned duration of the research, ruled out fieldwork in that period and shifted methods to elaborate remote literature review and focus on theory. The fieldwork approach targeted at context specificity would have benefitted from more sequential visits to allow for repetition of the methods, validation of findings, and tracking of relevant processes on ground over time (Wijnbelt, 2023). The intended focus on less-documented secondary cities complicated the matter, having less data available for desk research. Implications of the pandemic had its effects on numerous other aspects of the research. As the research and the pandemic progressed side-by-side, surrounded by major unprecedented uncertainties, many implications were difficult to anticipate.

More general limitations are to be found in the conducted qualitative fieldwork methods. Walking and drawing (Chapter 3 and 4) and semi-structured interviews and workshops (Chapter 4 and 5) may be valid analytic methods, at the same time they involve bodily and personal experiences influenced by someone's bias or prior knowledge and are therefore open to intersubjective scrutiny (Schultz & Van Etteger, 2017). The dissertation strived to secure accessibility of the methods and traceability of their execution. Yet, when carried out by other researchers, the same methods can result in other findings or other urban design methods can be selected which may also result in alternative sets of findings. However, the benefits of qualitative methods for the topics and aims of interest, such as exposing the intersection of culture with hydrology and its spatial relevance (Chapter 3) or consulting actors on perception of water and water sensitivity (Chapter 4 and 5), cancelled out quantitative methods for this study.

At the intersection of the methods of fieldwork and actor consultation and the Indian case study context, noteworthiness of positionality comes to the fore. The author is aware of the influence that aspects of an outsider identity may have had both on this research as well as within the Indian-Dutch research consortium of Water4Change. Representing a technical university from a country known for its frontrunning water management required going against the flow of the common direction of solution provision - coming from the Netherlands - in order to focus on context specificity for the Indian case study cities. It is also for this reason that the research did not intend to deliver a design but instead focus on design (analysis) as minimal

intervention and critically reflect upon and unlearn Western design processes to voice local knowledge, highlight underexposed local water-sensitive practices, and limit having to make assumptions about experiences of insiders of the Indian context. Despite collaboration and engagement with local researchers, stakeholders, and communities, the research, nevertheless, remains an outsider account which surely has had constraints on data collection (e.g., language barriers, overlooking data sources) or depths of its findings (e.g., incomplete image of the cities, limited personal connection to the cities) and, therefore, on the local contribution of its conclusions (e.g., incomplete representation of the cities' population, inability to inform local design and planning practice). Furthermore, it exposed a separation of academic cultures in terms of accessible and preferential sources for dissemination and the associated audiences, doctoral research trajectories, and their influence on the nature of the research.

In terms of content, the construction of the findings in the research is based on two case study cities. Both of them being Indian and both being particularly rich in water culture limits the scope of the research. Kozhikode and Bhuj are nearly 1,500 km apart and do show major climatic contrasts, being located in different climatic zones belonging to different climatic groups according to the Koppen-Geiger climate classification (i.e., tropical monsoon climate and hot desert climate, respectively) (Beck et al., 2018). However, such contrasts, among other differences, could have been further amplified by selecting other or additional case study cities in different regions of India, different countries, or different continents to validate and enforce the findings, if the research would have been independent of the Water4Change framework.

6.5 Future research

This research did in no sense intend to deliver closing findings. Instead, the findings of the research and lines of reasoning could be continued in a multitude of directions in the fields of water management, urban design, and design science to critically review its theories and methods. This should be done through repetitive (Wijnbelt, 2023) explorations and reviews of a wider variety of contexts and diversity of local climates and cultures. In the field of urban design, focus should be on alternative sets of methods to deploy to further develop the argument and enrich its vocabulary for WSUD, as well as engaging in the explorative projecting design processes of developing alternative scenarios (Table 6.1). Participatory urban design and planning processes (Dyer et al., 2017; Nisha & Nelson, 2012) notably hold potential to articulate and centre local knowledge by involving and literally voicing local communities and stakeholders (CTM, 2024). Furthermore, disciplines such as governance, social sciences, and engineering, among others, could provide relevant reflections on the findings of this research.

Considering the two contexts studied in this research, Kozhikode and Bhuj, India, but also a potential wider variety of (international, intercultural, inter-climatological) contexts where to explore context specificity, a more specific suggestion for future research would be to conduct a comparative multiple case study city analysis (Yin, 2018). Such analysis could allow in depth investigation of a phenomenon, like context-specific water sensitivity, within determined real world contexts and develop a better understanding of context specificity and water sensitivity. How it materialises and is influenced, perceived, and evolved over time. Studying multiple cases allows for comparison, finding representatives of climatic or cultural situations, and drawing cross-case conclusions to facilitate validation and improvement or adjustment of the findings.

This research underscored Bichai and Cabrera Flamini (2018)'s recognised gaps in literature regarding WSUD applicability in developing contexts and Rashetnia et al. (2022)'s call for design guidance on implementation and consideration of context specificities for WSUD. The ways it emphasised these appeals, concerns, or necessities, is munition for further interdisciplinary endeavours uniting fields and methods of water management, urban design, and beyond. The goal is to continue to fill the aforementioned gaps and, ultimately, develop such design guidance in a collaborative, participatory, and inclusive manner with room for context-specific appropriation per context.

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Acknowledgements

I wish to express my gratitude to the team members and collaborating institutions of the Water4Change research programme (W4C). Among them, my thanks in particular goes out to Gargi, my Indian counterpart in W4C. Despite the 6,522 km and confusingly shifting time differences between us, collaboration with her was smooth as if she was sitting next to me. I want to thank her, Sameer, Siddh, and Mona, for instantly making me feel at home at their CEPT University in Ahmedabad and for the generous sharing of their network and experience in Bhuj. I will not soon forget my motorbike ride with sir Kantibhai from Arid Communities and Technologies, to whom I owe a lot of the insights on Bhuj in this dissertation and for which I am very grateful.

Another 1,219 km further away, I would like to thank Navaneeth and the team at CWRDM for their hospitality in Kozhikode. To Anjana, Deepak, Vasu, and Hari, thank you for becoming my Kozhikode-family, welcoming me in your home, and sharing both your knowledge and warmth. In part thanks to the people mentioned above, Bhuj and Kozhikode have become places very dear to me.

Back 'home' in Delft, special thanks goes out to Raquel, for being the necessary lifeline and best friend in this process. How we laughed! Even during the most intense moments and craziest Zoom calls. Thank you to Fransje for securing an easy final sprint and helping me 'put the dots on the i's', to Machiel for keeping the research simultaneously fun and sharp and teaching me how to master it, and to Taneha for inspiring me and literally making it all possible and adding beautiful India to our long track record of ventures. These four are among many BK colleagues who make the faculty feel like a home to me, but I especially want to extend my thanks to those from the Urban Design section and Urbanism secretariat.

I will forever be indebted to Cem, Daphne, Elise, Joppe, Marloes, Robert, Tijs, and Co. for being there and helping me through when things got tough. But also for all the endless fun making things light. To my parents, thank you for believing in me unconditionally. Your support, together with Joris, Christel, and Jorrit, means the world to me. And in closing, thank you dear Stan, for everything. My biggest motivation was that I got to celebrate PhD milestones with you.

TOC

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2014 - 2014	Minor Museology *University of Amsterdam* *Faculty of Humanities*
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Working experience

2024 - present	Senior advisor *Rijkswaterstaat*
2018 - present	Researcher and educator *Delft University of Technology* *Faculty of Architecture and the Built Environment* *Department of Urbanism*
2014 - present	Founder *Day Cityguides*
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Dissemination

Peer-reviewed articles

Van der Meulen, G.J.M., Bacchin, T.K., & Van Dorst, M.J. (2023). Hydro-cultural Dimension in Water-Sensitive Urban Design for Kozhikode, India. *Journal of Landscape Architecture, 18 (2-3)*, 22-33. DOI: 10.1080/18626033.2023.2347142.

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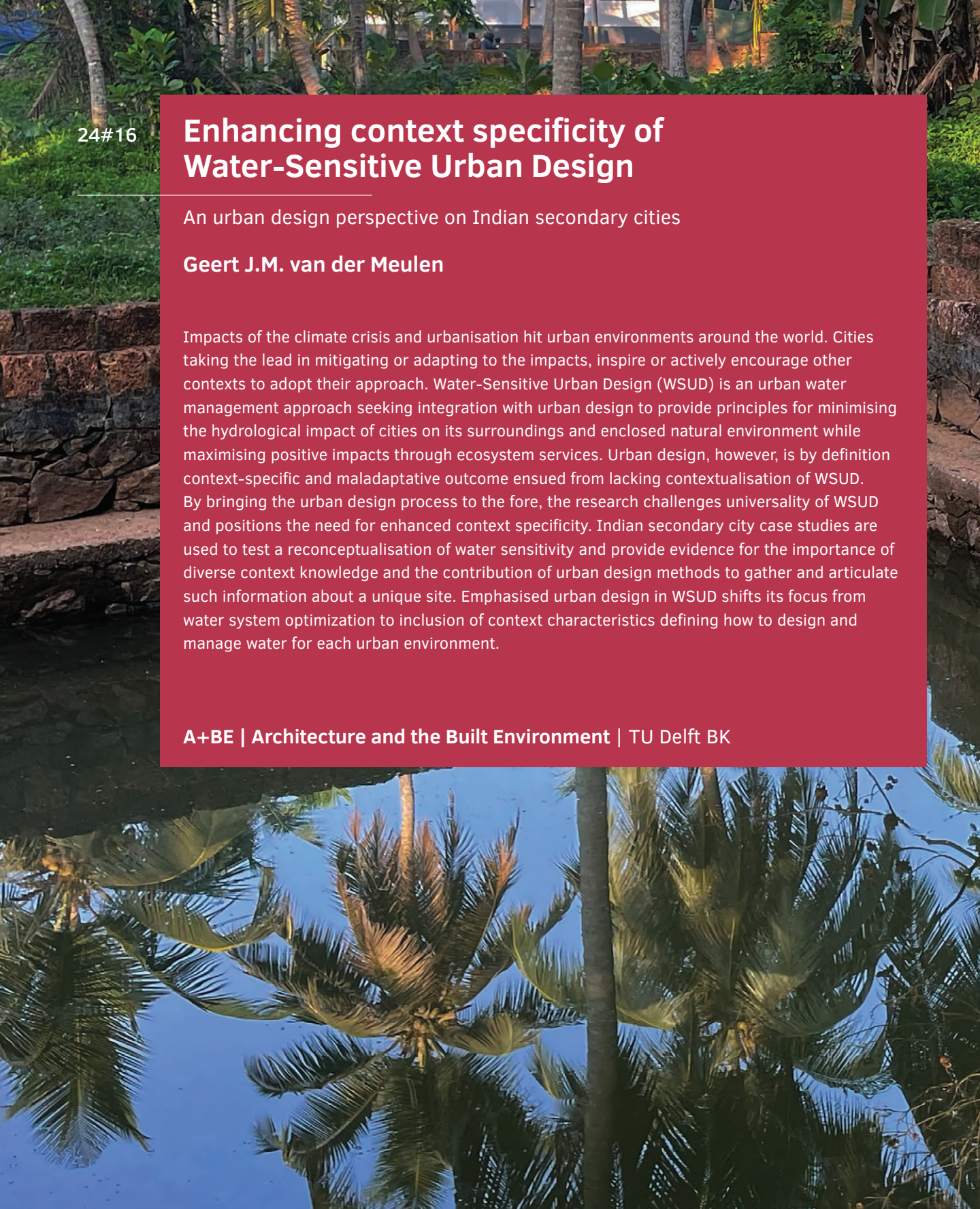

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Enhancing context specificity of Water-Sensitive Urban Design

An urban design perspective on Indian secondary cities

Geert J.M. van der Meulen

Impacts of the climate crisis and urbanisation hit urban environments around the world. Cities taking the lead in mitigating or adapting to the impacts, inspire or actively encourage other contexts to adopt their approach. Water-Sensitive Urban Design (WSUD) is an urban water management approach seeking integration with urban design to provide principles for minimising the hydrological impact of cities on its surroundings and enclosed natural environment while maximising positive impacts through ecosystem services. Urban design, however, is by definition context-specific and maladaptative outcome ensued from lacking contextualisation of WSUD. By bringing the urban design process to the fore, the research challenges universality of WSUD and positions the need for enhanced context specificity. Indian secondary city case studies are used to test a reconceptualisation of water sensitivity and provide evidence for the importance of diverse context knowledge and the contribution of urban design methods to gather and articulate such information about a unique site. Emphasised urban design in WSUD shifts its focus from water system optimization to inclusion of context characteristics defining how to design and manage water for each urban environment.

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