



Delft University of Technology

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

Silva, Raquel H.; van der Meulen, Geert J.M.; Zwarteveen, Margreet Z.; Stead, Dominic; van Dorst, Machiel J.; Bacchin, Taneha K.

DOI

[10.1016/j.envsci.2025.103985](https://doi.org/10.1016/j.envsci.2025.103985)

Publication date

2025

Document Version

Final published version

Published in

Environmental Science and Policy

Citation (APA)

Silva, R. H., van der Meulen, G. J. M., Zwarteveen, M. Z., Stead, D., van Dorst, M. J., & Bacchin, T. K. (2025). Promises and perils of water sensitivity as a new hydro-social imaginary for Kozhikode, India. *Environmental Science and Policy*, 164, Article 103985. <https://doi.org/10.1016/j.envsci.2025.103985>

Important note

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

Copyright


Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

Takedown policy

Please contact us and provide details if you believe this document breaches copyrights.
We will remove access to the work immediately and investigate your claim.



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

Raquel H. Silva^{a,1,2}, Geert J.M. van der Meulen^{a,*,1,3} , Margreet Z. Zwarteveen^{b,c,4},
Dominic Stead^{a,d,5}, Machiel J. van Dorst^{a,6}, Taneha K. Bacchin^{a,7}

^a Delft University of Technology, Faculty of Architecture and the Built Environment, Department of Urbanism, Delft, the Netherlands

^b University of Amsterdam, Faculty of Social and Behavioural Sciences, Group of Governance and Inclusive Development, Amsterdam, the Netherlands

^c IHE Delft, Department of Water Governance, Delft, the Netherlands

^d Aalto University, Department of Built Environment, Espoo, Finland

ARTICLE INFO

Keywords:

Hydro-social imaginaries
Urban political ecology
Waterscapes
Ecological decay
Water-Sensitive Urban Design
Epistemic justice

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 epistemic justice and context-specificity in the definition of water sensitivity, recognizing how the quality and direction of contemporary urban water flows are the outcome of particular – (post-)colonial, neo-liberal – histories. We mobilize insights from political ecology to do this. Concepts like waterscapes and hydro-social imaginaries help acknowledge that waters and cities co-evolve to create often highly uneven waterscapes. This usefully denaturalizes and thereby politicizes 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.

1. Introduction or 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 and 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

* Correspondence to: Delft University of Technology, Faculty of Architecture and the Built Environment, Julianalaan 134, Delft, BL 2628, the Netherlands.

E-mail addresses: R.HadrichSilva@TUDelft.nl (R.H. Silva), G.J.M.vanderMeulen@TUDelft.nl (G.J.M. van der Meulen), M.Zwarteveen@UN-IHE.org (M.Z. Zwarteveen), D.Stead@TUDelft.nl (D. Stead), M.J.vanDorst@TUDelft.nl (M.J. van Dorst), T.K.Bacchin@TUDelft.nl (T.K. Bacchin).

¹ equal contribution

² <https://orcid.org/0000-0002-0100-755X>

³ <http://orcid.org/0000-0002-0705-5763>

⁴ <https://orcid.org/0000-0001-7169-1337>

⁵ <https://orcid.org/0000-0002-8198-785X>

⁶ <http://orcid.org/0000-0001-5555-9803>

⁷ <http://orcid.org/0000-0002-2160-735X>

<https://doi.org/10.1016/j.envsci.2025.103985>

Received 25 April 2024; Received in revised form 16 December 2024; Accepted 2 January 2025

Available online 10 January 2025

1462-9011/© 2025 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

circulate, normalize, or contest such ideas (Davoudi and 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., 2023).

Investigation on how imaginaries play a role in shaping cities' socio-nature through unjust processes 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 colonized geographies, like India, where centralized piped networks brought during British rule replaced existing traditional infrastructures of supply to distinguish the colonizer's quarters from native towns (Gandy, 2004; 2008; Sharan, 2014; Mann, 2007). 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 conceptualizations 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 the role of power and knowledge when certain conceptualizations of water sensitivity gain traction in urban agendas. From the perspective of epistemic justice (Fricker, 2007; 2017), this involves asking how particular knowledge systems, and associated imaginaries and hydro-social relations are promoted over discrimination of others, to whom do they belong, and what kinds of waterscapes they produce. Such questions help elucidate processes of unjust urbanization 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 expertise 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).

In response to concerns regarding the epistemic violence that international knowledge transfers on WSUD may perpetuate and fear it may therefore reinforce local socio-ecological injustices, we set out to learn from the urban water transitions of Kozhikode, India, to propose a possible re-orientation of WSUD. 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 analyzing and designing transformations of waterscapes (Silva et al., 2024). By doing so, professionals should take epistemic justice into consideration; that is, utilize such theories and methods to recognize and uncover local spatial knowledge and experiences. 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 guided by technocratic epistemologies. 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 theorizations. Therefore, we understand that intensely political socio-ecological processes shape how water flows and is metabolized 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 (Coelho and Raman, 2010; Ghertner, 2011; Baviskar, 2020; Baviskar and Ray, 2011; Arabinndoo, 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 and 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 of discriminatory epistemic injustice in WSUD, a design perspective focused on ecology was intertwined with the conceptual approach of UPE to cast light on Kozhikode's urbanization in three sections. Prior to our analysis, we start with a presentation of the analytical framework with theories (Section 2) and methodologies (Section 3) from the fields of political ecology and urban design. In the analysis (Section 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 mobilize and promote such imaginaries?; 3) What happens when imaginaries become operationalized in actual projects? Finally, from the analysis, the conclusion (Section 5) draws up conclusions for unlearning urban development practice with entrenched water-sensitive imaginaries and relearning new pathways for socially just WSUD.

2. Decentering and relearning water sensitivity for epistemic justice

Water sensitivity is a concept that emerged to express an intention of water managers to fuse and prioritize 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 and Clarke, 2007; Cook et al., 2019). Despite concerns regarding the relevance of WSUD in the global south (Bichai and 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 (see Zwarteveen and 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, emphasizing 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'. Organized in a linear manner as

such, each city state is considered to influence and shape the successive state (Wong and Brown, 2009). As such, the UWTF falls short in representing the diversity of ways in which historical hydro-social arrangements have produced physical urban contexts with coexistence of multiple, fragmented, or alternative city states, as well as their associated diverse social classes, communities, and cultures. By employing hydro-social contract theory, the UWTF describes the history of water use as a progressive utilization of a society's water resources by means of engineering dominance and state provision (Meissner and 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 recognize 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 discriminatory hydro-social imaginaries and produces inclusions and exclusions of hydro-social relations without problematizing questions of epistemic and socio-ecological justice.

We identify a potential for WSUD to investigate urban territories not as fixed entities containing water but rather as socationatures (Swyngedouw, 1996), as waterscapes produced through different hydro-social imaginaries. To decenter the model of development represented in the UWTF, we re-theorize 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 artifacts (e.g., bioswales or constructed wetlands) from a position of determinacy (Furlong and 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 (Jasanoff and Kim, 2013; Davoudi et al., 2018). Theories about hydro-social imaginaries describe how more diverse and divergent actors - beyond engineers and bureaucrats - seek to imagine and materialize 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, even within a single social class. 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 materialize (Duarte-Abadía and 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 politicized 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 mobilized to offer an alternative and more

context-specific approach for WSUD theorists and practitioners concerned with the inter-relations between epistemic justice; that is, justice related to knowledge production, and unequal production of waterscapes in cities. Such an approach 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 recognizable 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., 2023). In post-colonial urban contexts, such recognition of plurality in local water practices gains additional relevance as it means unlearning conventional, or even colonial, ways of managing water and enables reparation for water sensitivity (Mungekar et al., 2023). Towards decentering universalized notions of WSUD, we proceed to relearn 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, sewerage, and drained city, as prescribed by the UWTF, as the scale and focus for our analysis.

3. 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 contextualized 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 mobilize 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 center stage in participatory forms of academic knowledge production and may, as such, legitimize 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, realized 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.

4. Relearning transitions through 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 conceptualization and materialization 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.

4.1. *Becoming a water-supply city as Kolikkod, Calicut, and Kozhikode*

Pre-colonial narratives of Kozhikode emphasize its importance as a center 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 3rd century onwards (Bhagyanathan and 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 characterized by a strikingly undulating coastal plain, dotted with wetlands and marshlands in its depressions which were cultivated with paddies and worshiped as sacred groves, until the foot of the steep Western Ghats (Fig. 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.

The centuries following Vasco da Gama's landing just north of Kolikkod in 1498 were characterized by wars to expel Portuguese, Dutch, and neighboring 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 re-organization of urban space to accommodate the economy and civic life of colonial settlers. Striking artifacts 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 sanitized neighborhood. 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 conceptualization and materialization 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. The associated growing middle class also entailed a more heterogeneous middle class ranging from urban vulnerable to affluent. Along with economic growth these citizens further amplified demand for water while, simultaneously, conversion of land use related to urbanization 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 centralized 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

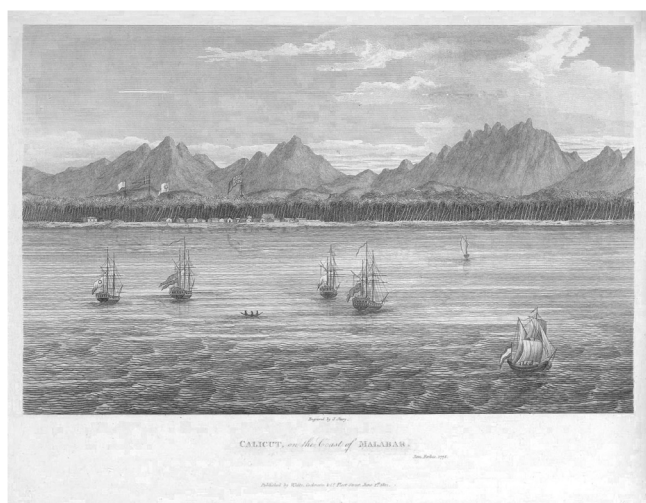


Fig. 1. View from sea at Calicut with its undulating landscape and the Western Ghats in the background. Engraving by J. Shury after the 1772 James Forbes' drawing published in his 1813 *Oriental Memoirs* (Forbes, 1813).

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 and Dhayanithy, 2023) and accompanying growing 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 and Doshi, 2017; Mananthukkaren, 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 (Asian Development Bank, 2005), realization 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 urbanization pushed the shift in water-supply management from decreasingly reliable wells to seemingly infinite piped supply. Under the centralized 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 conceptualized 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 centralized systems (Furlong and Kooy, 2017). The choice for development of a centralized 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.

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, urbanization, and middle class materialized 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 neighboring property grounds, leading to severe health risks of the consumer. Other significant health risks were incurred by those maintaining septic tanks 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 centralization 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 conceptualizations of water systems, mobilized 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 mobilized 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 ha 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, maximizing gravity flows of wastewater to reduce costs of pumping towards the treatment station. In fear that the project will affect their livelihoods, residents have organized a series of protests against implementation of the STP that have been met by police violence and custody of activists (Fig. 2).

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 (see Baviskar and 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 (Town and Country Planning Department Government of Kerala, 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 neighborhood's stream and groundwater. The fishing community faces a combination of discursive and material discrimination that becomes normalized in the name of cleaning the city's water system through the technology of sewage



Fig. 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 (authors, 2022).

treatment. Similarly, the city's most significant open-air fruit and vegetable market, Palayam (Fig. 3), and washer community ground at Muthalakkulam (Fig. 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.

4.3. Drained city sprawling in the undulating coastal plain

Prior to urbanization 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 and Kasthurba, 2013) (Fig. 5). 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 and 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 (Fig. 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 and Dhayanithy, 2023), at the cost of other imaginaries.

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 urbanization-driven pressures on wetlands. This resulted in the designation of Kottuli as wetland of national importance in 2007 (Ministry of Environment, Forest, and Climate Change, 2019), followed by a state-wide 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 and 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 tranquility 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 and Dhayanithy, 2023) (Fig. 7). Being low lying areas, these developments result in aggravated flooding, stormwater drainage obstructions, and reduced groundwater recharge opportunities, all of



Fig. 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' (authors, 2023).



Fig. 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 is put to dry (authors, 2023).



Fig. 5. Landform of Kozhikode and Kottuli wetland-loss (modified from Bhagyanathan and Dhayanithy, 2023) after completion of the Conolly Canal (authors, 2023).

which are crucial to flood risk and groundwater security. It shows how ecological conservation planning agendas introduce flexible conceptualizations 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

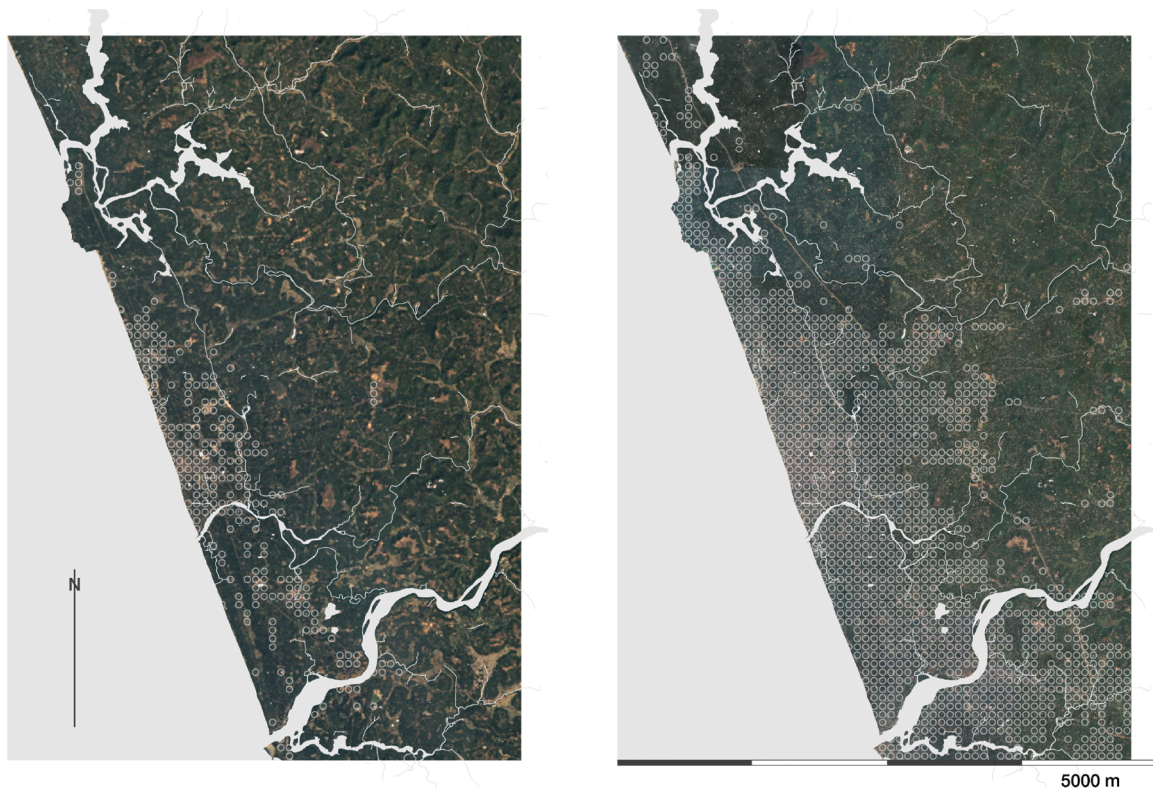


Fig. 6. Sprawl of Kozhikode 1992 - 2020 (modified from Defourny et al., 2023) (authors, 2023).



Fig. 7. Encroachment of Kottuli wetland, on the left, by construction of Promenade Villas, on the right, by widening of the national highway 66 bypass (authors, 2022; 2023).

of land as a form of property in the colonial period, for example, has led to delegitimization of non-monetizable values of ponds and sacred groves. These water bodies and forest patches came to be perceived by landowners 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 worshiped 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 homogenization following India's independence, pan-Indian Hindu deities substitute local folk deities. This process of, so-called, Sanskritization entails mobilization of sacred groves as cultural symbols of a coherent nation. Within modernizing 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 and Rutte, 2006; Bhagyanathan and Dhayanithy, Forthcoming; Ormsby, 2011). In other cases, ponds, sacred groves, or its hydrological role is erased

completely to make way for construction work (Fig. 8). The more impermeable the urban landscape becomes, the less capable it is to deploy monsoon precipitation for groundwater recharge.

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), prioritizing labor 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 general middle-class uses (D'Souza and 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



Fig. 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 center (authors, 2023).

center is currently under construction and the KWA has its base here, using conserved wetland area to store pipe material (Fig. 9). Beautification of urban nature in Kozhikode emerges as a symbol of modernity associated with the shift towards general 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 center 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 neighborhoods, especially around Conolly Canal (Cherian and Sahasranamam, 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 (Directorate of Environment and Climate Change, 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. 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 contextualized and politicized 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 general middle-class cultural values. Such values are enforced by techno-managerial water management processes that risk resulting in discriminatory epistemic injustices through spatial production of urban nature by means of

borrowed foreign concepts and capitalist relations. As such, middle-class imaginations of hydrological components of the urban landscape are interlinked with a planning discourse that increasingly disintegrates socio-ecological relations which deviate from new ideas about water-scapes in cities. India’s constitutional efforts to widen political representation in democracy and Kerala’s participatory planning structure (e.g., open general forums called *gram sabhs*) and legacy of pro-democracy movements allow for many grassroots organizations in Kozhikode to link lower-class and ecological demands to policy-making arenas. Yet despite instances of participation in the city’s institutionalized planning, there is no guarantee it will effectively influence decision making, limiting its redistributive effects (Heller, 2005).

Under neo-liberal urban governance, symbolic inclusion through participation and material exclusion through extractive urban development may happen simultaneously when discussing and deciding 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 interlinked with general middle-class values, partly inherited from the British colonial period. A key problem in this, is that poorer groups’ socio-ecological relations are not recognized as contributing to water-sensitive transitions by increasingly technocratic governance structures. On the contrary, as we have seen in the case of Kozhikode, they are more likely to be blamed for water problems perpetuating epistemic violence and injustice in planning. At the same time, the uniform middle class which water-sensitive transitions intend to cater is not representative of Kozhikode’s heterogeneous middle class and multitude of hydro-social imaginaries, established after centuries of intricate coexistence, friction, and development of communities and cultures.

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 emphasized that water should be



Fig. 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 (authors, 2022; 2023).

understood as a critical dimension to the social production of space. By mobilizing 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, varying among communities and even within broad social classes instead of being uniform. Each imaginary offers alternative ways of perceiving, knowing, and managing water, some of which manifest or root in artifacts 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 prioritized over and at the cost of ecological systems, other communities, or their practices, places, values, or visions. It can highlight how social form and demographics affect the kind of policy decisions which ignore everyday infrastructure-making, such as manual scavenging and their rights. 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 remodeled for international consulting purposes. Such technical solutions and the processes through which they are established are decontextualized and, thus, made generic, transferrable, and a-political to circulate more or less 'freely' across cities, establishing new imaginaries of water sensitivity globally. Practicing 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 and 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 reproducing epistemic violence by 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 subsidized 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 operationalizations, we argue that WSUD requires unlearning by including practices uniting people, nature, and artifacts and engaging with ecological connections that local communities may have to water and waterscapes (Coyné et al., 2020; Furlong and Kooy, 2017). We understand that unlearning and decentering WSUD makes it 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 and social form 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 centered rather than understanding them in contrast and

comparison to imposed visions or desires of a world-class city.

Cities like Kozhikode can contribute, not just to understanding 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 artifacts 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. Realizing that water sensitivity should and will inevitably manifest differently depending on conditions of a context enables unlearning and decentering urban theory, frames of references, and imaginaries from the contexts in which WSUD has been conceptualized and centering their local equivalents. To ultimately see them as equal and for WSUD to enable epistemic justice by serving contexts and its communities equally.

Funding

This work was supported by the Dutch Research Council (Nederlandse Organisatie voor Wetenschappelijk Onderzoek - NWO) [grant number W 07.7019.103] and the Indian Government Department of Science & Technology (DST) [grant number DST-1429-WRC]. The funding sources had no involvement in any part of the establishment of the article.

CRediT authorship contribution statement

Raquel Hädrich Silva: Writing – original draft, Validation, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Geert Johannes Maria van der Meulen:** Writing – original draft, Visualization, Validation, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Margreet Zwaantje Zwartveen:** Writing – review & editing, Supervision, Conceptualization. **Dominic Stead:** Writing – review & editing, Supervision. **Machiel J. van Dorst:** Writing – review & editing, Supervision. **Taneha Kuzniecowa Bacchin:** Supervision, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Raquel Hädrich Silva and Geert van der Meulen report financial support was provided by Dutch Research Council. Raquel Hädrich Silva and Geert van der Meulen report financial support was provided by India Ministry of Science & Technology Department of Science and Technology. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This article was established in the framework of the Water4Change (W4C) research program under the Cooperation India – The Netherlands program. The authors wish to express their gratitude to the team members and member institutions of the W4C program.

Data Availability

The data that has been used is confidential.

References

- Acharya, A., 2023. *Memories of Water. Places J. April*.
- Angelovski, I., Brand, A.L., Connolly, J.J.T., Corbera, E., Kotsila, P., Steil, J., GarciaLamarca, M., Triguero-Mas, M., Cole, H., Baro, F., Langemeyer, J., Del Pulgar, C.P., Shokry, G., Sekulova, F., Argüelles Ramos, L., 2020. Expanding the boundaries of justice in urban greening scholarship: toward an emancipatory,

- antisubordination, intersectional, and relational approach. *Ann. Am. Assoc. Geogr.* 110, 1743–1769. <https://doi.org/10.1080/24694452.2020.1740579>.
- Anima, P., 2012a. When circuses were not fun. *Hindu* 23. November.
- Anima, P., 2012b. The battle for the maidan. *Hindu* 21. December.
- Arabindoo, P., 2011. City of sand': stately re-imagination of Marina Beach in Chennai. *Int. J. Urban Reg. Res.* 35, 379–401. <https://doi.org/10.1111/j.1468-2427.2010.00943.x>.
- Asian Development Bank, 2005. Kerala Sustainable Urban Development Project - Final Report, City report Kozhikode. Asian Development Bank, Manila.
- Ayyar, K.V.K., 1938. The Zamorins of Calicut. Norman Printing Bureau, Kozhikode.
- Ayyar, K.V.K., 1976. The Importance of the Zamorins of Calicut. In: *Proceedings of the Indian History Congress*, 37. Indian History Congress, Aligarh, pp. 252–259.
- Azeez, P.A., Bhupathy, S., Raj, N., Chandra, R., 2008. Conservation of Kottuli Wetlands. Sálím Ali Centre, Coimbatore.
- Baviskar, A., 2020. *Uncivil city: Ecology, equity and the commons in Delhi*. Sage Publications, Thousand Oaks.
- Baviskar, A., Ray, R., 2011. *Elite and everyman: the cultural politics of Indian middle classes*. Routledge, New Delhi.
- Bhagwat, S.A., Rutte, C., 2006. Sacred groves: Potential for biodiversity management. *Front. Ecol. Environ.* 4 (10), 519–524. [https://doi.org/10.1890/1540-9295\(2006\)4\[519:SGPFBM\]2.0.CO;2](https://doi.org/10.1890/1540-9295(2006)4[519:SGPFBM]2.0.CO;2).
- Bhagyanathan, A., Dhyanithy, D., 2023. A canal, urban sprawl and wetland loss: the case of Kozhikode, India, from colonialism to climate change era. *Area* 55 (3), 435–446. <https://doi.org/10.1111/area.12875>.
- Bhagyanathan, A., Kasthuba, A.K., Thampi, S.G., Dhyanithy, D., 2018. Terrain attributes of sacred grove locations point towards conscious spatial delineation. *Curr. Sci.* 114 (5), 957–959. <https://doi.org/10.18520/cs/v114/i05/957-959>.
- Bhagyanathan, A., Dhyanithy, D., Forthcoming. Water gods of sacred groves: spatially explicit conservation for watershed management.
- Bhagyanathan, A., Kasthuba, A.K., 2013. Maintenance of Water Depth in Navigation Canals Versus Wetland System Loss - The Case of Canoly Canal, Calicut, Kerala, India. In: *The Asian Conference of Sustainability, Energy & the Environment*, Official Conference Proceedings, Osaka, Japan, 6–9 June 2013, pp.234–246. International Academic Forum, Osaka.
- Bichai, F., Cabrera Flamini, A., 2018. The Water-Sensitive City: Implications of an urban water management paradigm and its globalization. *WIREs Water* 5, e1276. <https://doi.org/10.1002/wat2.1276>.
- Brown, R.R., Keath, N., Wong, T.H.F., 2009. Urban water management in cities: historical, current, and future regimes. *Water Sci. Technol.* 59 (5), 847–855. <https://doi.org/10.2166/wst.2009.029>.
- Brown, R.R., Clarke, J., 2007. The transition towards Water Sensitive Urban Design: a socio-technical analysis of Melbourne, Australia. In: *Proceedings of Novatech 2007 - 6th International Conference on Sustainable Techniques and Strategies in Urban Water Management*, Lyon, France, 25–28 June 2007, pp.349–356. GRAIE, Villeurbanne.
- Cherian, J., Sahasranamam, S., 2018. Ground report: Kerala's Kozhikode is barely hanging on as floodwaters rise and losses mount. *Scroll* 17. August.
- Coelho, K., Raman, N.V., 2010. Salvaging and scapegoating: slum evictions on Chennai's waterways. *Econ. Political Wkly.* 45 (21), 19–23.
- Coelho, K., Raman, N.V., 2013. From the frying pan to the floodplain: negotiating land, water, and fire in Chennai's development. In: *Rademacher, A., Sivaramakrishnan, K. (Eds.), Ecologies of Urbanism in India*. Hong Kong University Press, Hong Kong, pp. 145–168.
- Cook, S., Van Room, M., Ehrenfried, L., Lagro, J., Yu, Q., 2019. WSUD "Best in Class" - Case Studies From Australia, New Zealand, United States, Europe, and Asia. In: *Sharma, A.K., Gardner, T., Begbie, D. (Eds.), Approaches to Water Sensitive Urban Design*. Elsevier, Amsterdam, pp. 561–585. <https://doi.org/10.1016/B978-0-12-812843-5.00027-7>.
- Coyne, T., De Lourdes Melo Zurita, M., Reid, D., Prodanovic, V., 2020. Culturally inclusive water urban design: a critical history of hydrosocial infrastructures in Southern Sydney, Australia. *Blue-Green. Syst.* 2 (1), 364–382. <https://doi.org/10.2166/bgs.2020.017>.
- D'Souza, R., Nagendra, H., 2011. Changes in public commons as a consequence of urbanization: the Agara Lake in Bangalore, India. *Environ. Manag.* 47, 840–850. <https://doi.org/10.1007/s00267-011-9658-8>.
- Davoudi, S., Crawford, J., Raynor, R., Reid, B., Sykes, O., Shaw, D., 2018. Policy and practice spatial imaginaries: tyrannies or transformations? *Town Plan. Rev.* 89 (2), 97–124. <https://doi.org/10.3828/tp.2018.7>.
- Davoudi, S., Machen, R., 2022. Climate imaginaries and the mattering of the medium. *Geoforum* 137, 203–212. <https://doi.org/10.1016/j.geoforum.2021.11.003>.
- Defourny, P., Lamarque, C., Brockmann, C., Boettcher, M., Bontemps, S., De Maet, T., Duveiller, G.L., Harper, K., Hartley, A., Kirches, G., Moreau, I., Peylin, P., Otlé, C., Radoux, J., Van Bogaert, E., Ramoino, F., Albergel, C., Arino, O., 2023. Observed annual global land-use change from 1992 to 2020 three times more dynamic than reported by inventory-based statistics. *European Space Agency Climate Change Initiative*, Paris.
- Directorate of Environment and Climate Change, 2022. Kerala State Action Plan on Climate Change 2023 - 2030. Department of Environment, Government of Kerala, Thiruvananthapuram.
- Duarte-Abadía, B., Boelens, R., 2016. Disputes over territorial boundaries and diverging valuation languages: the Santurban hydrosocial highlands territory in Colombia. *Water Int.* 41 (1), 15–36. <https://doi.org/10.1080/02508060.2016.1117271>.
- Fathima, A., 2022. The invisible manual scavengers of Kerala's Kozhikode. *N. Minute* 12. August.
- Forbes, J., 1813. *Oriental Memoirs*. Richard Bentley, London.
- Fricker, M., 2007. *Epistemic Injustice: Power and the Ethics of Knowing*. Oxford University Press, Oxford.
- Fricker, M., 2017. Evolving concepts of epistemic injustice. In: Kidd, I.J., Medina, J., Pohlhaus Jr., G. (Eds.), *Routledge Handbook of Epistemic Injustice*. Routledge Handbooks in Philosophy. Routledge, London, pp. 53–60.
- Furlong, K., Kooy, M., 2017. Worlding water supply: thinking beyond the network in Jakarta. *Int. J. Urban Reg. Res.* 41 (6), 888–903. <https://doi.org/10.1111/1468-2427.12582>.
- Gabriel, N., 2014. Urban political ecology: environmental imaginary, governance, and the non-human. *Geogr. Compass* 8, 38–48. <https://doi.org/10.1111/gec3.12110>.
- Gandy, M., 2004. Rethinking urban metabolism: water, space, and the modern city. *City* 8 (3), 363–379. <https://doi.org/10.1080/1360481042000313509>.
- Gandy, M., 2008. Landscapes of disaster: water, modernity, and urban fragmentation in Mumbai. *Environ. Plan. A: Econ. Space* 40, 108–130. <https://doi.org/10.1068/a3994>.
- Gandy, M., 2023. Chennai flyways: birds, biodiversity, and ecological decay. *Environ. Plan. E: Nat. Space* 6 (4), 2678–2699. <https://doi.org/10.1177/25148486221142491>.
- Ghertner, D.A., 2011. Green evictions: environmental discourses of a "slum-free" Delhi. In: Peet, R., Robbins, P., Watts, M. (Eds.), *Global Political Ecology*. Routledge, London, pp. 145–166.
- Ghertner, D.A., 2013. The nuisance of slums: Environmental law and the production of slum illegality in India. In: Anjaria, J.S., McFarlane, C. (Eds.), *Urban Navigations*. Routledge, New Delhi, pp. 37–63.
- Government of Kerala, 2008. The Kerala conservation of paddy land and wetland act, 2008. Government of Kerala, Thiruvananthapuram.
- Heller, P., 2005. Reinventing public power in the age of globalization: Decentralization and the Transformation of Movement Politics in Kerala. In: Ray, R., Katzenstein, F. (Eds.), *Social movements in India Poverty, power, and politics*. Rowman & Littlefield, Lanham, pp. 79–106.
- Jaffe, G., Doshi, V., 2017. One of the few places where a communist can still dream. *Wash. Post* 27. October.
- Jasanoff, S., Kim, S.H., 2013. Sociotechnical imaginaries and national energy policies. *Sci. Cult.* 22 (2), 189–196. <https://doi.org/10.1080/09505431.2013.786990>.
- Jidhu, M.U., 2014. Architecture in the urban space: life of the elite in colonial calicut. *New Delhi, India, 28-30 December 2014*. In: *Proceedings of the Indian History Congress*, 75. Indian History Congress, Aligarh, pp. 647–652. New Delhi, India, 28–30 December 2014.
- Kuller, M., Bach, P.M., Ramirez-Lovering, D., Deletic, A., 2017. Framing water sensitive urban design as part of the urban form: a critical review of tools for best planning practice. *Environ. Model. Softw.* 96, 265–282. <https://doi.org/10.1016/j.envsoft.2017.07.003>.
- Mabon, L., Barkved, L., De Bruin, K., Shih, W.Y., 2022. Whose knowledge counts in nature-based solutions? Understanding epistemic justice for nature-based solutions through a multi-city comparison across Europe and Asia. *Environ. Sci. Policy* 136, 652–664. <https://doi.org/10.1016/j.envsci.2022.07.025>.
- Mann, M., 2007. Delhi's belly: on the management of water, sewage and excreta in a changing urban environment during the nineteenth century. *Stud. Hist.* 23 (1), 1–31. <https://doi.org/10.1177/025764300602300101>.
- Mannathukkaren, N., 2022. *Communism, Subaltern Studies and Postcolonial Theory, The Left in South India*. Routledge, Oxon.
- McCann, E., Roy, A., Ward, K., 2013. Assembling/worlding cities. *Urban Geogr.* 34 (5), 581–589. <https://doi.org/10.1080/02723638.2013.793905>.
- McFarlane, C., 2008. Urban shadows: materiality, the 'Southern city' and urban theory. *Geogr. Compass* 2 (2), 340–358. <https://doi.org/10.1111/j.1749-8198.2007.00073.x>.
- Meissner, R., Turton, A.R., 2003. The hydrosocial contract theory and the lesotho highlands water project. *Water Policy* 5 (2), 115–126. <https://doi.org/10.2166/wp.2003.0007>.
- Ministry of Environment, Forest, and Climate Change, 2019. *National Wetland Conservation Programme*. Ministry of Environment, Forest, and Climate Change, New Delhi.
- Mungekar, N., Janssen, A.L., Hölscher, K., Looibach, D., 2023. Decolonizing governance in Indian cities through reparative capacities. Case—Bhuj. In: *Proceedings of the 6th International Conference in Public Policy*, Toronto, Canada, 27–29 June 2023.
- Municipality of Rotterdam, 2022. *Resilient Rotterdam Strategy 2022 - 2027: from risks to resilience*. Municipality of Rotterdam, Rotterdam.
- Ormsby, A.A., 2011. The impacts of global and national policy on the management and conservation of sacred groves of India. *Hum. Ecol.* 39 (6), 783–793. <https://doi.org/10.1007/s10745-011-9441-8>.
- Rao, U., 2010. Making the global city: urban citizenship at the margins of Delhi. *Ethnos* 75 (4), 402–424. <https://doi.org/10.1080/00141844.2010.532227>.
- Sharan, A., 2014. *In the city, out of place: Nuisance, pollution, and dwelling in Delhi, c.1850-2000*. Oxford University Press, Oxford.
- Silva, R.H., Zwarteveen, M.Z., Stead, D., Bacchin, T.K., 2024. Bringing ecological urbanism and urban political ecology to transformative visions of water sensitivity in cities. *Cities* 145, 104685. <https://doi.org/10.1016/j.cities.2023.104685>.
- Simone, A.M., 2004. People as infrastructure: intersecting fragments in Johannesburg. *Public Cult.* 16 (3), 407–429. <https://doi.org/10.1215/08992363-16-3-407>.
- Swyngedouw, E., 1996. The city as a hybrid: On nature, society and cyborg urbanization. *Capital. Nat. Social.* 7 (2), 65–80. <https://doi.org/10.1080/10455759609358679>.
- Swyngedouw, E., 2004. *Social Power and the Urbanization of Water: Flows of Power*. Oxford University Press, Oxford.
- Town and Country Planning Department Government of Kerala, 2017. *Master Plan for Kozhikode Urban Area - 2035*. Town and Country Planning Department Government of Kerala, Thiruvananthapuram.

- 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 J.* 20 (1), 15–25. <https://doi.org/10.1080/1573062X.2022.2153704>.
- Van Dooren, E.J.G.C., Rooij, R.M., Willekens, L.A.M., 2014. Urban and Regional Design Education: Making the Design Process Explicit In: Proceedings of the AESOP annual congress: From Control to Co-Evolution, Turin, Italy, 9-12 July 2014. AESOP, Utrecht.
- Vinod Kumar, T.M., Firoz, C.M., Bimal, P., Harikumar, P.S., Sankaran, P., 2020. Smart Water Management for Smart Kozhikode Metropolitan Area. In: Vinod Kumar, T.M. (Ed.), *Smart Environment for Smart Cities*. Springer, Singapore, pp. 241–306. <https://doi.org/10.1007/978-981-13-6822-6>.
- Wong, T.H.F., 2006. Water sensitive urban design - the journey thus far. *Aust. J. Water Resour.* 10 (3), 213–222. <https://doi.org/10.1080/13241583.2006.11465296>.
- Wong, T.H.F., Brown, R.R., 2009. The water sensitive city: principles for practice. *Water Sci. Technol.* 60 (3), 673–682. <https://doi.org/10.2166/wst.2009.436>.
- Zimmer, A., Véron, R., Cornea, N.L., 2020. Urban ponds, environmental imaginaries and (un)commoning: an urban political ecology of the pondscape in a small city in Gujarat, India. *Water Altern.* 13 (2), 225–247.
- Zwarteveen, M.Z., Boelens, R., 2014. Defining, researching and struggling for water justice: some conceptual building blocks for research and action. *Water Int.* 39 (2), 143–158. <https://doi.org/10.1080/02508060.2014.891168>.