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The hydro-cultural dimension in Water-Sensitive Urban Design for Kozhikode, India

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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 conceptualized. 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 operationalized, 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.

Implicit knowledge / Landscape-informed fieldwork / Secondary cities / Water cultures / Water sensitivity

Introduction

Cities around the world are facing climate and urbanization 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 conceptualized[1] (for instance, in Australia in the 1990s by local academics and urban drainage professionals).[2] 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 pressurized urban water cycles.

This study responds to WSUD by elaborating on its intention to operationalize the integrative and multi-scalar nature of urban design.[3] 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 emphasized for WSUD to be appropriate to secondary urban contexts.

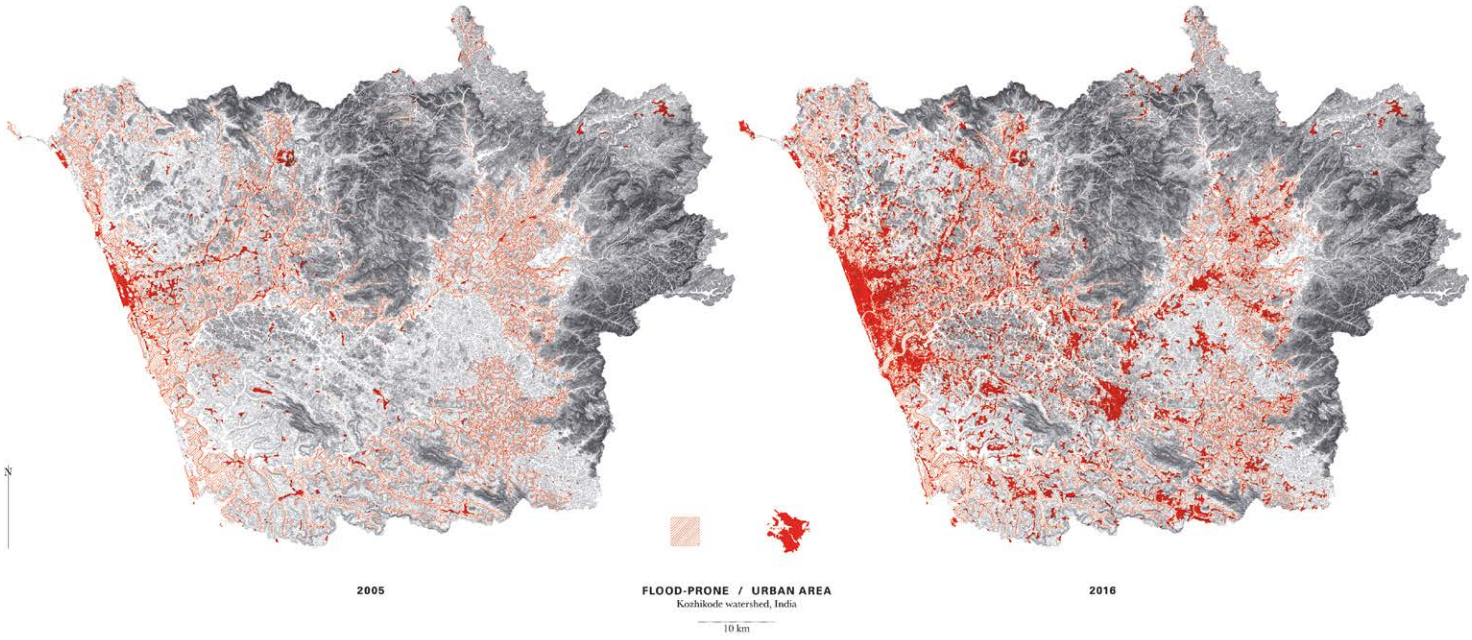


Figure 1 Overlay mapping of urbanization and flood prone area in 2005 and 2016 in the watershed in which Kozhikode is located, showing the rapid and hazardous urban sprawl in the undulating coastal plain up until the Western Ghats mountains.

Source: urbanization adapted from: National Remote Sensing Centre (NRSC), *Land Use / Land Cover database on 1:50,000 scale, Natural Resources Census Project* (Hyderabad: NRSC, 2019); flood prone area adapted from: National Centre for Earth Science Studies, *Flood Susceptibility Zones of Districts of Kerala* (Thiruvananthapuram: Kerala State Disaster Management Authority, 2010).

On WSUD:
The concept and its secondary city contextualization

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.[4] 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.[5] The emphasis here is on WSUD because of its intended holistic approach to urban water management and the operationalization of urban design.

In the context of developed cities across the globe, the WSUD concept has been successfully operationalized 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.[6] However, there is a lack of design guidance for WSUD that takes into account context specificities or for its implementation in unplanned developing cities.[7] 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 conceptualization of WSUD in approaching the transition to this ideal performance.[8]

WSUD is accompanied by the Urban Water Transitions Framework (UWTF),[9] 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 centralized and decentralized infrastructure, the provision of ecosystem services, and sociopolitical capital for sustainability.[10] 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 urbanization 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.[11] '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.[12] 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.[13] This occurs under increasing pressure of rapid urbanization without extensive urban planning[14] or data

collection resources sufficient to keep up with the speed of change.[15] On the other hand, the article addresses secondary cities as cities that are less known and unrecognized 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 urbanization has doubled.[16] Apace with Kozhikode's urbanization and in combination with its striking topographic and climatic conditions, the city and its environs face major urban water challenges, including flooding (Fig. 1), landslides, the encroachment of water bodies, water scarcity and pollution. Additionally, these challenges increase inequality as certain communities are struck more by the negative effects of these challenges than others. WSUD offers opportunities for the spatial organization of dynamic urban environments and their water management, such as water-related recreation, water harvesting and reuse, and flood control,[17] 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.[18] 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 emphasized for water-sensitive development.

On 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.[19] 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,[20] examining possible, probable and desirable futures for a context.[21] 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 conceptualized, 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 urbanization 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.[22] 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,[23] 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.[24] Deviations encourage this by allowing for investigations physically adjacent to and thematically related to the transects walked and sites visited.[25] 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.[26] 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.[27]

Observations are collected and mapped through sketches, photographs (Fig. 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 (that is, spaces that have never before been documented in terms of land use, land cover, outlook, ownership, maintenance, et cetera), 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.[28]

Figure 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.

On Kozhikode: Rain on an undulating terrain

Kozhikode (its anglicized 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.[29]

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.[30] Changes brought about by urbanization-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 urbanization 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.

On 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.

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 (Fig. 3, G-G') to 30 m (U-U'). Its profile depth ranges from about 6.5 m (G-G') to 0 m, where it floods the banks when heavy rainfall raises the water table (S-S'). Stormwater runoff finds its way to the canal following the undulating topography or the imposed road network, at times flooding streets (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 (I-I', J-J').

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.[31] 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,[32] and causes excessive groundwater and surface water outflow.[33] The wetlands also suffer from, often illegal or unregulated, landfilling for human encroachment.[34] Entering Kottuli, the canal is upgraded with 'naturalized' 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 (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 (C-C').

Few infrastructural artefacts remain from its days as a cargo route, such as lift, pipe and pedestrian bridges (D-D', O-O', T-T'). The Kalpurath lift bridge now functions as a midday meeting place for nearby workers (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.[35]

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 (K-K'). By providing a framework between the sea and the canal for the city to territorialize, the canal and its adjacent roads have been crucial to the city's urban growth and form.[36] 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 (E-E', F-F'), to gated apartment towers (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 (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 (H-H').

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 (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 (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 (Q-Q'). Most striking, however, are the floating logs that mark the timber processing industries on the west side of the canal (S-S', T-T', U-U', V-V'). The logs could be transported by water, but trucks are currently more efficient. Specialized 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 (V-V'), contrasting with the stark incision at its northern end (A-A').

Sacred groves

Sacred groves are patches of virgin forest protected and worshipped by indigenous communities for their high cultural and spiritual values.[37] 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 (Fig. 4, 3-3'), to 25 x 35-m paved openings in forest or wetland with decorated temple pavilions, such as Puliyankil Peralankavu Shiva Temple (5-5'). Irrespective of the present structures and degree of territorialization, 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.

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 (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.

There is a pattern in the geographical locations of sacred groves in depressions in the undulating terrain of Kozhikode.[38] 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 (1-1', 3-3', 4-4'). Nevertheless, as a system of traditional ecological knowledge,[39] 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.[40] 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 urbanizing areas are eradicated or reduced to miniscule shrines or solitary trees.[41] The increasing imperviousness of the coastal plain limits percolation and infiltration processes, resulting in increased runoff and flood risk.[42] Groundwater recharge is consequently reduced, as is the flushing capacity of the monsoons,[43] enabling saline seawater intrusion. Both are detrimental to urban water cycles and compromise their utilization, especially in a rain-fed city like Kozhikode.

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.[44] 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 (Fig. 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 organized swimming lessons (II-II'). The Tali temple pond accompanies the fourteenth-century Shiva temple of the same name and has dedicated roofed ghats for Hindus to bathe (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 (IV-IV'). Although the pond is fenced off, Neelichira encourages public use with a sign 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 (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.[45] 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 (VI-VI'). The community is now being targeted for relocation to make way for development.

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

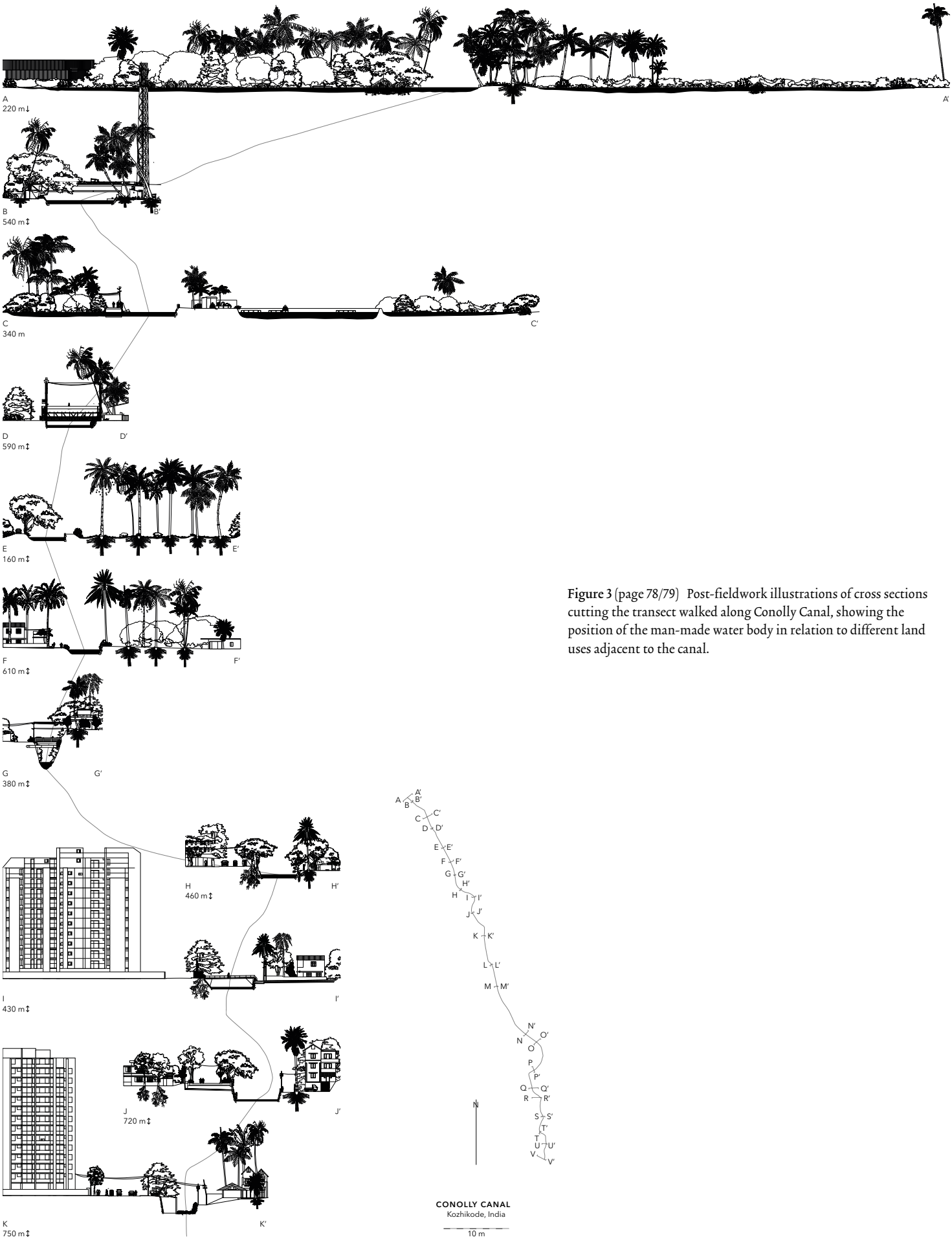
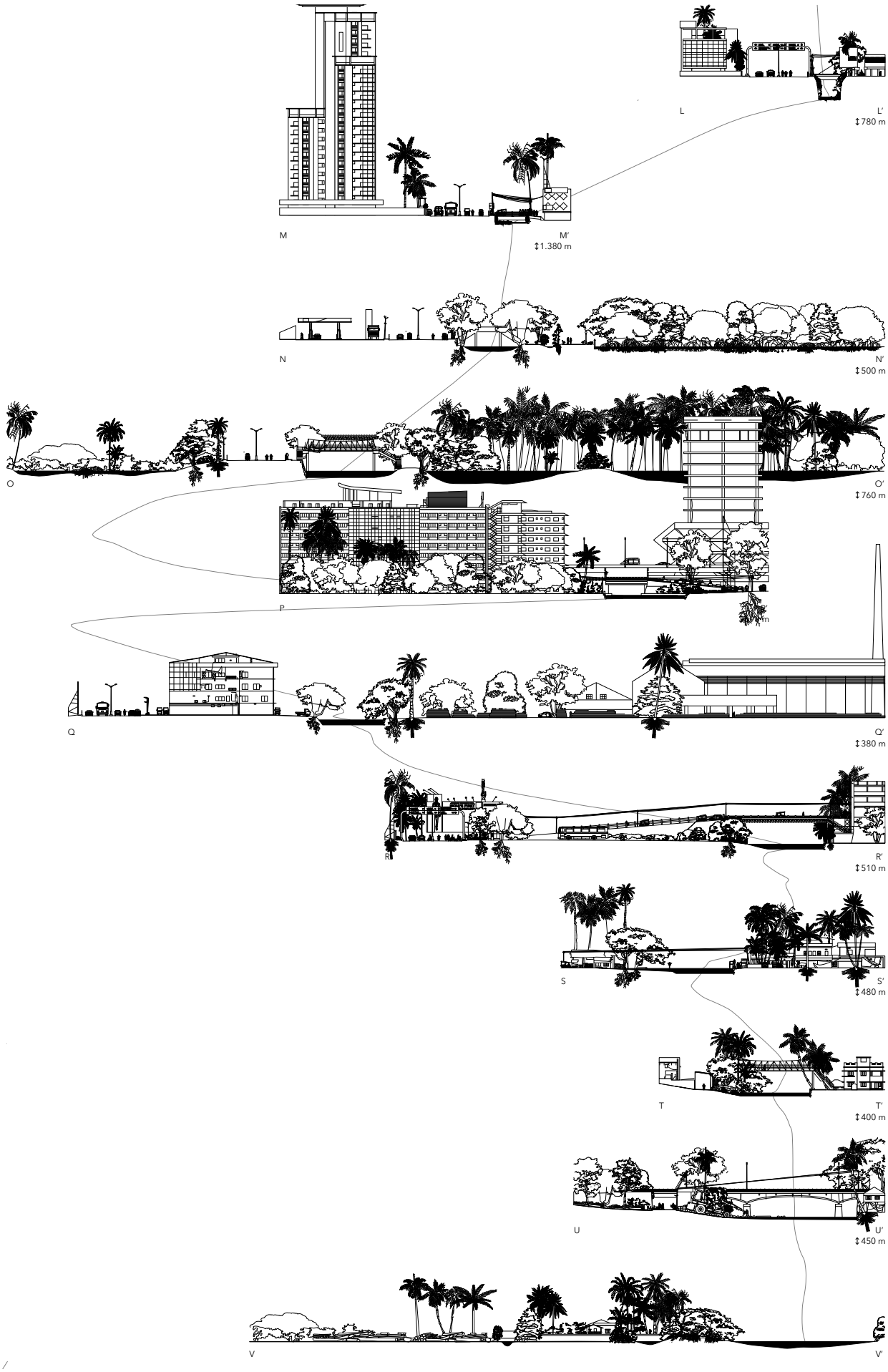


Figure 3 (page 78/79) Post-fieldwork illustrations of cross sections cutting the transect walked along Conolly Canal, showing the position of the man-made water body in relation to different land uses adjacent to the canal.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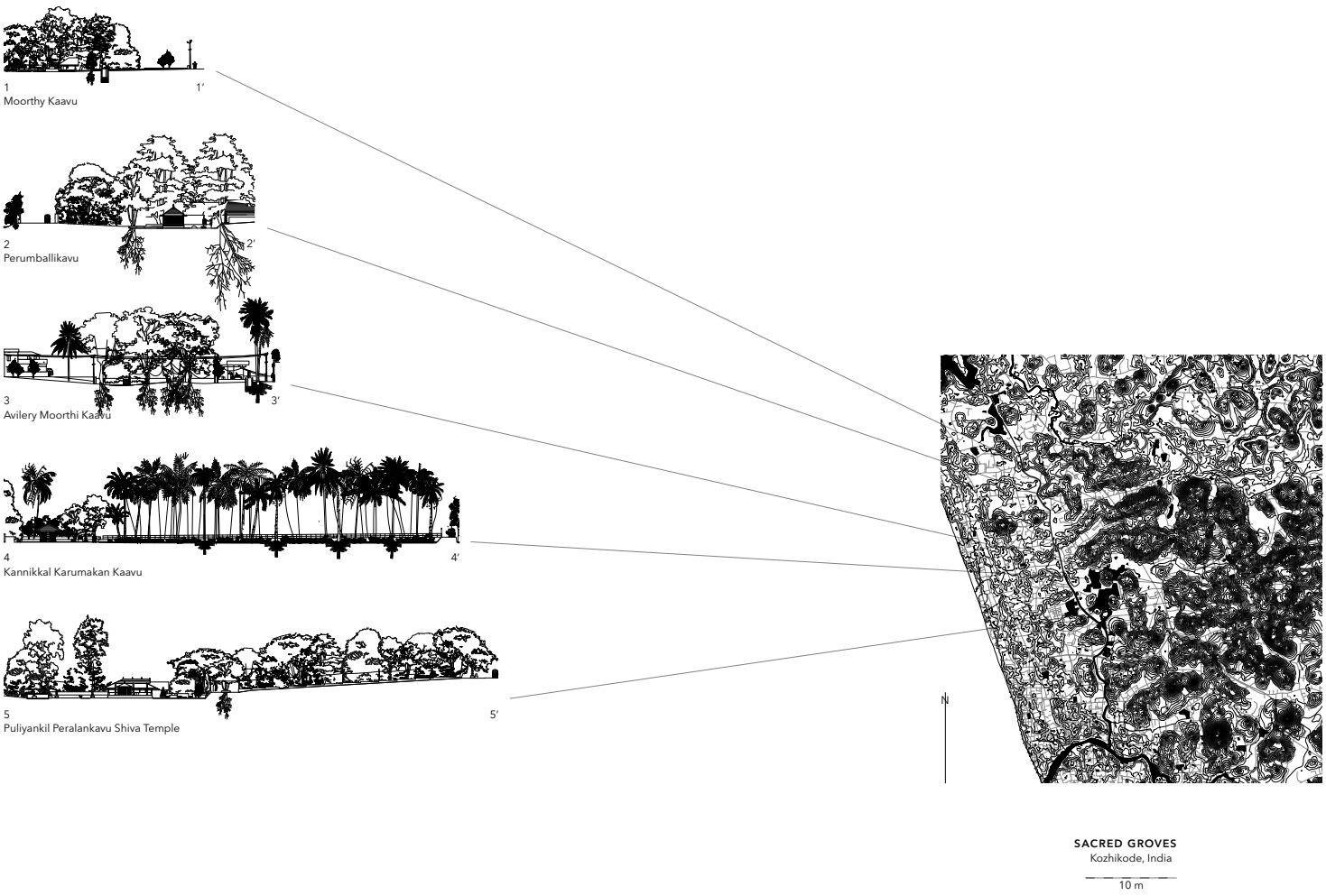

Figure 4 Post-fieldwork illustrations of cross sections of the visited sacred groves, showing the position and perviousness influencing hydrological processes around the cultural and spiritual sites.

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.[46] 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.[47] 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 recognize 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,[48] and WSUD has the potential to respond to this call.[49]

As population densities rise and urban areas expand, the value and ecosystem 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.[50] Cultural artefacts, which are already recurring elements in India across neighbourhoods with diverse urban fabric and site-specific charac-

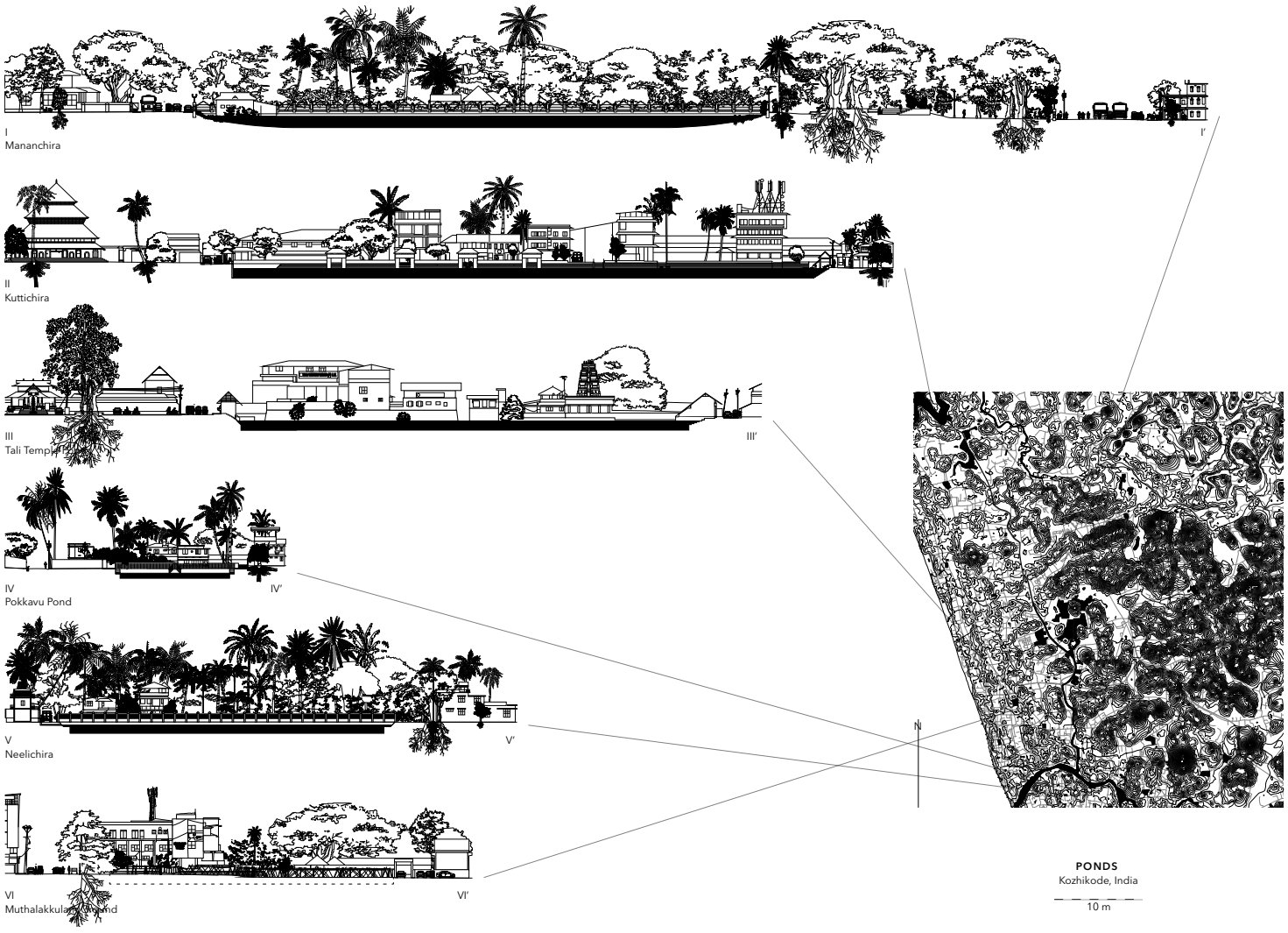

Figure 5 Post-fieldwork illustrations of cross sections of the visited ponds, showing the position of the man-made water bodies in relation to neighbouring land uses and communities.

teristics,[51] could be considered as small environmental resource patches in a matrix from a landscape mosaic perspective.[52] 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.[53] 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.

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[54] and to acknowledge the cultural connections between people and natural spaces.[55] 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.[56] 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,[57] this article emphasizes its initial intention to operationalize 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.[58] 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 visualizing 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.[59]

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 recognized in the qualities of past and residual water artefacts and practices, and brings to light design opportunities to reclaim or emphasize 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.[60] As such, the approach contributes to the decolonization 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.[61] 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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