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Water sensitivity and context specificity – concept and context in Water-Sensitive Urban Design for secondary cities

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ABSTRACT

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

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Introduction

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

Urban areas worldwide are also facing the climate crisis, with longer and more irregular and unpredictable periods of extreme precipitation or heat resulting in hazards like droughts, flooding, and mudslides, among others. Its impacts, however, are arguably driven in a similar way by urbanisation-driven modifications to land cover and subsequent abruptions in the hydrological cycle. In urban areas, the effects of these modifications are most impactful to human lives. With rapid urbanisation in secondary cities, these modifications occur expeditiously. In intertropical African cities, for instance, urban floodplains are commonly claimed for activities like sports facilities, garbage dumps, or urban agriculture without sufficient infrastructure to prevent flooding (Douglas 2018), or themselves functioning as obstructions in the hydrological system, causing flooding. In Dar es Salaam, Tanzania, the rapid and uncontrolled growth of informal settlement in such hazardous areas is a principal cause of increased flood risk (Mguni, Herslund, and Jensen 2015). In addition to human and hydrological systems, climatic changes negatively affect terrestrial and marine ecosystems; numerous species of flora and fauna face increased risk of extinction (IPCC 2022), in turn affecting the urban and natural environment.

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

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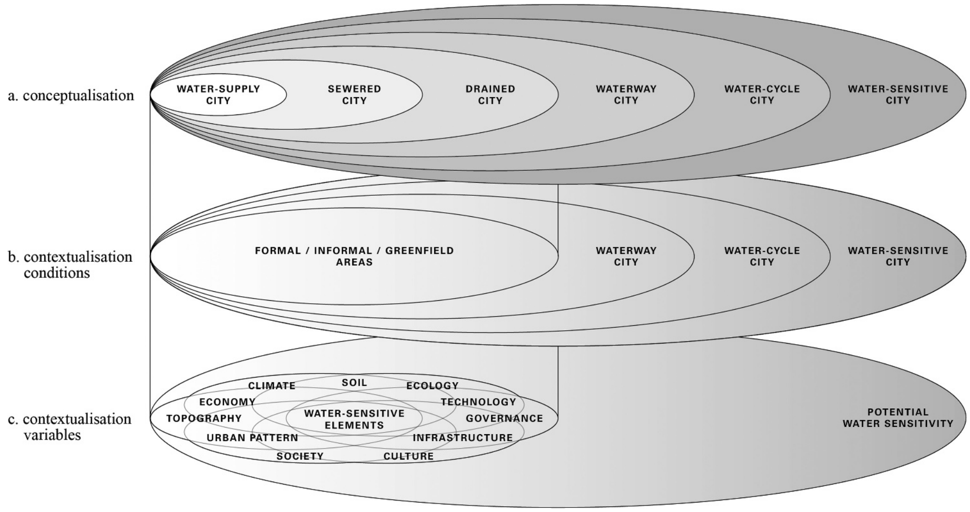

Figure 1. (a) The conceptual UWTF (adapted from Brown, Keath, and Wong 2009); (b) the contextual UWTF with coexisting urban conditions (adapted from Fisher-Jeffes, Carden, and Armitage 2017); and (c) the mutually influencing context variables describing a context, including current water-sensitive elements, informing reachable potential water sensitivity.

changing contexts of secondary cities, more research is warranted on WSUD implementation that takes into account local development processes and contextual conditions (Rashetnia et al. 2022).

Methodology

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

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

Water-Sensitive Urban Design

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

As a theoretical framework accompanying the WSUD concept, the Urban Water Transitions Framework (UWTF) (Brown, Keath, and Wong 2009) (Figure 1(a)) was established to evaluate the state and progress of urban water management transitioning toward the 'water-sensitive city'. Although WSUD can be considered independent of the UWTF, the framework has become a frequent companion, informing assessments of urban development and potential progress in terms of water sensitivity, and visualising foreseen transitions. Despite the fact that there are no fully transitioned water-sensitive cities in the world to date, the UWTF presents its systematic underpinning by defining different temporal, technological, and ideological city states, with the accompanying socio-political drivers and delivered services, through which cities should transition when pursuing a sustainable future. In this light, the UWTF describes the 'road' to the water-sensitive city 'destination', whereas the WSUD concept regards everything that process entails (Fletcher et al. 2015). Toward the ideal of the water-sensitive city, cities are said to first transition through the 'water-supply city', 'sewered city', 'drained city', 'waterways city', and the 'water-cycle city'. In the urban design process, the water-sensitive city ideal provides design criteria as a guiding design concept with three key pillar principles for practice: 1) to use cities as water supply catchments with diverse fit-for-purpose water sources and centralised and decentralised infrastructures; 2) to provide ecosystem services; and 3) to build socio-political capital for sustainability and water-sensitive behaviour (Wong and Brown 2009). As opposed to the guiding design concept, WSUD literature refers to best-practice and illustrative reference projects (Wong and Brown 2009), accompanied by assessment tools and indices as concrete instruments for practice, informing urban planning and design decisions and trajectories (Lerer, Arnbjerg-Nielsen, and Mikkelsen 2015; Rogers et al. 2020).

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

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

Transferability concerns

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

Transferability concerns regarding the UWTF

The cumulative nature of the UWTF fails to recognise regular coexistence of multiple city states within the administrative boundaries of a single city or natural boundaries of its catchment area (Fisher-Jeffes, Carden, and Armitage 2017), which follow distinct rates of change and requiring simultaneous retrofitting and development, instead of only new development as the literature suggests (Rashetnia et al. 2022). The UWTF may give the suggestion (Figure 1(a)) a city can exclusively be a water-supply city, or a drained city, whereas in fact these states coexist or are fluid, and a city is rather in a state of transition, polarised into formal and informal built-up or greenfield areas (Figure 1(b)) (Fisher-Jeffes, Carden, and Armitage 2017), as is the case in secondary city contexts with differently established hydro-social contracts and high speed of change.

However WSUD and the UWTF being in theory free-standing (i.e. the UWTF frames the 'steps' to the water-sensitive city objective, the WSUD concept refers to everything that process entails (Fletcher et al. 2015)), the UWTF gives reason for transferability concerns of WSUD as it became a common aid to WSUD in identifying a city's urban development needs and potential progress towards water sensitivity. Differing sets of context-specific needs in urban areas can best be illustrated by distinguishing two perspectives on adaptation. Cities with developing hydro-social contracts, like many secondary cities, frequently require adaptation to deficits in infrastructures that in less pressured cities or cities with more developed water management infrastructure are already adequate or close to adequate. This is referred to as type I adaptation, characterised by urgency, addressing current shortcomings or absences. Additionally, all cities require adaptation due to local social, economic, and especially climatic changes. This is referred to as type II adaptation, characterised by uncertainty, addressing long-term changes (Burton 2004; Radhakrishnan et al. 2017). In practice, when both types are required, they often interfere (Brown 2011), leading to additional expenditure, inefficiency, or other unforeseen consequences (Bichai and Cabrera Flamini 2018) as adaptation demands for water management are often addressed separately or sequentially instead of in an integrated manner. The drainage plan for a secondary Vietnamese city, Can Tho, for example, recommends future climate measures (type II adaptation) that may be ineffective without addressing current deficits (type I adaptation) (Pathirana et al. 2018a). At the same time, proposed urban developments in Can Tho, such as road improvements and new dike rings (type I adaptation), are path-dependant and unsuitable for addressing sudden or uncertain future changes (type II adaptation) (Patharina et al., 2018b2018a).

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

Transferability concerns regarding green-blue infrastructure

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

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

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

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

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

Transferability concerns regarding data

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

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

Data relevant to WSUD include parameters prescribing the resistance overland and groundwater flow experience when moving through space. Such climatic, topographic, ecologic, and soil variables shape the impedance a water flow encounters within and around urban environments. Additionally, urban patterns of built-up elements and infrastructure, related open spaces, their densities, and the networks within them can be observed as elements of possible friction for water flow in the urban environment. Such elements and infrastructure introduce changes in the physical properties of the pre-urban natural environment, affecting the hydrological cycle in the way they cover or are imposed on soil and topography (Bacchin et al. 2011). However elementary, objective, observable, quantifiable, or known these variables and their global variability may be, their precise local susceptibility to differences and diverging spatial and temporal deviation determine, or are determined by, the unique local speed and magnitude of changes, and can drastically alter local hydrological processes. Sufficiently high-resolution data on all scales and resources to update data at the frequency required to keep pace with such dynamics, however, are consistently lacking (Lindley et al. 2018).

The diverse nature and angles of transferability concerns (i.e. theoretical and assessment frameworks, assets and interventions, data and data resources) arise the moment the WSUD concept lands in a context different from the one it was conceptualised in. Transferability concerns originate both from prior conceptualisation (e.g. unfit and non-inclusive understanding) and during contextualisation (e.g. local limitations, conditions, and unintentional effects) (Table 1), highlighting the local context sensitivity for operationalisation of WSUD and how alternative and potential water sensitivity is context- and culture-bound and brings up the question what is challenging the suitability of WSUD and how water sensitivity, urban design, and context relate to one another.

Cornerstones of WSUD

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

Table 1. Examples from literature of transferability concerns arising from conceptualisation or contextualisation.

	framework	means	instruments
	Urban Water Transitions Framework	green-blue infrastructure	data
	transferability concerns and references	transferability concerns and references	transferability concerns and references
conceptualisation	- unfit cumulative nature; - overlooking joint need for retrofit and development (Fisher-Jeffes, Carden, and Armitage 2017)	- benefit inequity (Mguni, Herslund, and Jensen 2016); - extraneous attributes, colonial (Da Cunha 2019; Ignatieva and Stewart 2009; Shackleton and Gwendla 2021); - ecosystem disservices (Roy et al. 2018; Schröter et al. 2014); - beautification/luxury (Drosou et al. 2019; Herslund et al. 2018; Lindley et al. 2015)	- data-intensive, incomprehensive (Lerer, Arnbjerg-Nielsen, and Mikkelsen 2015; Poustie et al. 2015; Zogheib et al. 2018); - restricted to niche practitioners, limiting interdisciplinary process (Bacchin et al. 2011)
contextualisation	- coexisting city states (Fisher-Jeffes, Carden, and Armitage 2017); - adaptation urgencies/uncertainties (Burton 2004; Radhakrishnan et al. 2017); - varying/high rate of change (Lindley et al. 2018)	- ecosystem service dependency/vulnerability to ecosystem service decrease (Abo-El-Wafa, Yeshitela, and Pauleit 2018); - discrimination (Anand 2017, 35–36); - inequality (Anguelovski et al. 2021; Shackleton and Gwendla 2021 ; Venter et al. 2020)	- limited data resolution/availability/reliability, limited data collection resources (Lindley et al. 2018); - limited data sharing/management/accessibility (Plengsaeng, Wehn, and Van der Zaag 2014; Sharma et al. 2019; Water4Change Forthcoming); - unjust mobilisation of exclusive data (O'Leary 2018; Zogheib et al. 2018); - varying/high rate of change (Lindley et al. 2018)

specificities of a context as three cornerstones of the spatial manifestation of WSUD.

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

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

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

Discussion

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

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

Water sensitivity as context is influenced by, yet depends on more than the sum of observable parameters. The gaze of urban design, which WSUD operationalises, when reading context and projecting change, focuses on patterns and rates of change of physical aspects (e.g. climatic, topographic, ecologic, soil, urban, infrastructural) unique to each context, yet additionally, considers the relation and interaction between them and the intangible cultural, social, and economic structures in place. With the possible absence of data for such parameters, this intangible yet equally dynamic dimension underlines the complexity and context specificity of WSUD. Observed in local climate change awareness and anticipation, ecosystem (dis) service inequity, and the way in which urban space through which water passes is used, valued, and perceived, this intangible dimension further informs and constrains an alternative consideration and potential of water sensitivity and its qualities. Transformation and production of space is namely, intentionally or not, driven and confined by spatial patterns of everyday human behaviour and practices (De Jong 2015). The continuity and recognisability of urban spatial patterns enable place attachment (Meyer, Hoekstra, and Westrik 2020). Space plays an important role in construction of a spatial and cultural identity, especially in the public sphere, enabling appropriation and development of social capital, closely linked to community acceptance, which is particularly key for WSUD approaches (Leonard et al. 2019). Socially produced physical arrangements of space can differ within a polarised urban environment, resulting in different levels of service provision, community awareness, and social vulnerability that ultimately shape the degree of potential resilience of its users and inhabitants (Bacchin 2015).

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

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

Conclusion

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

From an urban design perspective, the use of a utopian water-sensitive city ideal in the UWTF (Figure 1(a)) is recognised as a valid guiding concept, common to the urban design process. The cumulative nature of the UWTF, however, does not seem to consider how technological and sociocultural conditions and city states can coexist within an urban environment or a water catchment, as would be the case with greenfield developments or informal settlements (Figure 1(b)). In most cases, the route to water sensitivity will be nonlinear and context variables, rate of development, and influential local dynamics differ greatly, both between cities and within cities. Thus, water sensitivity as a guiding concept does not always provide sufficient support to practice WSUD, in spite of prioritisation of water in urban design and planning agendas, whereas context becomes the evenly, or more, informative support for potential water sensitivity in these agendas. In this article the link between the WSUD concept and the UWTF is regarded as important because the cumulative framework does not consider that city states can already be somewhat water-sensitive, as with ancient or local water practices and cultures. With this understanding, water sensitivity is a part of past, present, and future contexts, as are other context variables (Figure 1(c)). As such, water sensitivity is both a concept and context in the urban design process; the concept provides direction in addressing a particular context and stimulates water-sensitive development. Through polarised contextual conditions (e.g. formal and informal built-up areas, infrastructural deficits, steady or rapid social, economic, and climatic changes, lacking or ample awareness) and context variables (e.g. climatic conditions, topographic configurations, soil typologies, local ecosystems, urban patterns), however, a particular context dictates and confines the degree of eventual water sensitivity and the scope of challenges and opportunities for urban design. Instead of projecting the same and similarly achievable water-sensitive city goal in each context, the present and reachable water sensitivity varies per context without implying they are suboptimal. Present and reachable water sensitivity must be reviewed per context in close connection with local urban design to determine to what extent urban conditions can be identified to potentially or alternatively be identified as water-sensitive.

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

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

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