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Towards water resilience through Nature-based Solutions in the Global South? Scoping the prevailing conditions for Water Sensitive Design in Cape Town and Johannesburg

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ABSTRACT

Water Sensitive Design (WSD) is gaining attention as a Nature-based Solution (NbS) to urban water problems. It incorporates green infrastructure with engineered urban water systems through innovative design of the built environment and urban landscape. In Africa, Johannesburg and Cape Town are two cities engaging with WSD at a policy level. This paper uses the Strategic Niche Management (SNM) approach in a comparative analysis of ongoing engagement with WSD in Johannesburg and Cape Town. We explore the extent to which this engagement signals the launch of the transition towards water resilience. WSD represents a niche that is in synergy with the visions of sustainable urban (water and environmental) management in both cities. Results indicate a progressive engagement with WSD by different actors at regime and niche levels. However, the lack of coordination and capacity deficiencies due to limited social networks and higher order learning are challenges that constrain take-off and further consolidation of the WSD approach in the transition towards water resilient futures. Furthermore, we find urban governance practitioners struggle with reconciling the pursuit of visions of sustainability to be realised through nature-based urban development with the pressing infrastructure deficits that persist in most African cities.

1. Introduction

Cities around the world are facing persistent environmental problems such as climate change, pollution, biodiversity loss and resource depletion (Steffen et al., 2015). Within the urban water sector, there are concerns about the ability of conventional water systems to adequately meet current and projected challenges such as rapid urbanisation, water scarcity and climate change impacts Grigg, 2019(Hoffmann et al., 2020). Thus, the idea of Water Sensitive Design (WSD) has gained purchase as a suite of complementary Nature-based Solution (NbS) to conventional water management systems, and as one way of transitioning towards water resilient futures (Albert et al., 2019; Radcliffe, 2019; Zevenbergen et al., 2018). WSD emphasises total water cycle management, the use of Sustainable Drainage Systems (SuDS) and green infrastructure (GI) to store, convey, treat, and infiltrate rain and stormwater (see Fletcher et al., 2015; Lennon et al., 2014; Cousins, 2018).

Several cities around the world have begun integrating WSD as part of their water supply and stormwater management e.g., in Australia, Sweden, and UK, however progress towards large-scale retrofitting remains slow (Mukhtarov et al., 2019; Brown et al., 2013; Radcliffe, 2019; Trapp et al., 2017; Furlong et al., 2017). For cities of the Global South, infrastructure deficits, continued deterioration of existing water infrastructure coupled with pressures from climate change and deepening inequality make the leapfrog over incomplete infrastructure configurations, towards less path-dependent approaches such as WSD, critical for attaining the Sustainable Development Goals (Mguni et al., 2015; Poustie et al., 2016; Bichai and Cabrera Flamini, 2018)). As such, WSD is

Abbreviations: NbS, Nature-based Solutions; WSD, Water Sensitive Design; SNM, Strategic Niche Management.

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gaining attention in Africa, where it is seen as a possible approach to remedying colonial infrastructural legacies whilst addressing climate change impacts and resource scarcity (Armitage et al., 2014; Mguni et al., 2016; Fitchett, 2017; Herslund et al., 2018; Mulligan et al., 2020; Lottering et al., 2014).

While the potential for African cities to integrate WSD as a resilience-building option is receiving increased consideration, there has been little empirical mapping and analysis of on-going sociotechnical transitions towards water resilience through WSD in the African context, partly because of the lack of substantive exemplars of WSD implementation, save for South African cases (Cilliers and Rohr, 2019; Fisher-Jeffes et al., 2017; Madonsela et al., 2019; Carden et al., 2016; Carden and Fell, 2021). This paper seeks to contribute to this gap by asking, "What is the current scope for the transition towards water resilient futures through WSD in Johannesburg and Cape Town?" We use the Strategic Niche Management (SNM) approach's niche development processes i.e., (i) *articulation of expectations and visions,* (ii) *social network formation* and (iii) *mutual learning processes* (Schot and Geels, 2008), to explore the extent to which prevailing conditions in the urban water and environmental management regimes in Johannesburg and Cape Town may constitute the possible launch of the transition towards water-resilient futures through WSD. Such an assessment of the socio-technical systems' readiness for transformative change is important for catalysing sustainability transitions, as well as for building the evidence base for NbS in the Global South (Kabisch et al., 2016; Loorbach et al., 2017; Maas et al., 2018; Frantzeskaki et al., 2019).

2. Exploring the conditions and possibilities for take-off in the transition towards water resilient futures through WSD

2.1. Dynamics of sustainability transitions at the urban scale

African cities are currently faced with the challenge of mainstreaming NbS like WSD in pursuit of water resilient futures whilst confronted by the "[…] *stubborn realities of both a material and discursive nature […]*" such as infrastructural deficits and rising inequality (Watson, 2013)(Watson, 2006). The envisaged shift from conventional pipe-based drainage systems towards hybridised green-grey infrastructure approaches like WSD is framed as a 'socio-technical sustainability transition challenge' of moving towards more sustainable urban water management (Brown et al., 2009; de Haan et al., 2015; Domènech et al., 2015; Hoffmann et al., 2020).

In urban water sustainability transitions research, the take-off or launch phase of the sustainability transition (see de Haan and Rotmans, 2011; Frantzeskaki and de Haan, 2009; Loorbach and Rotmans, 2006) towards water resilient urban futures through NbS requires the emergence of nature-based innovations in small niches, supported by the concurrent build-up of processes and conditions that support the emergence of more sustainable businesses models; user practices, policies as well as the entry of new actors into the urban water and environment sector (de Haan et al., 2015; van der Jagt et al., 2020; Markard et al., 2020). As such, an understanding of the conditions for the successful launch towards more water resilient cities through NbS remains a crucial gap in knowledge which constrains urban stakeholders who are keen to drive and scale up NbS in their cities, especially in the Global South (Frantzeskaki et al., 2018b; Herslund et al., 2018).

Sustainability transitions in diverse socio-technical sectors are understood as resulting from the dynamic interplay of different levels of societal organisation and contexts; conceptualised as the Multi-Level Perspective (MLP) (Geels, 2005; Hodson et al., 2017). The MLP posits that for sustainability transitions to occur, three processes are necessary: niche-innovations such as WSD build up enough momentum to challenge the regime; changes at the landscape level such as climate change and rapid urbanisation exert pressure on the regime; and finally, stress within the regime creates windows of opportunity for the uptake of niche-innovations (Geels, 2014; Loorbach et al., 2017).

While the breakthrough of niche-innovations is considered imperative for the transition of socio-technical systems, studies have shown that at the urban scale, sustainability transitions are likely the result of incumbent governance regimes taking the lead as initiators and enablers of urban experimentation wherein the city is seen as a 'transitionscape' (Grin, 2020; Köhler et al., 2019; Kronsell and Mukhtar-Landgren, 2018; Frantzeskaki et al., 2018a). Within regime-driven transitions incumbent actors use internal resources to consciously direct transition trajectories and practices towards more sustainable directions by adopting symbiotic niche-innovations such as WSD (de Haan et al., 2015; Quitzau et al., 2013; van de Meene et al., 2011). Thus, incumbent regime actors enact the often-incremental transition process and drive transformation by performing strategic work that establishes and nurtures sustainability niches (Geels, 2014; Quitzau et al., 2013; Turnheim and Geels, 2019; Sengers et al., 2019). It is this kind of endogenous regime transformation which is most relevant for the analysis of the integration of alternatives like WSD in on-going urban transitions towards sustainability and resilience, as actors within urban infrastructure regimes make efforts to adapt to climate change (Bulkeley et al., 2014; Quitzau et al., 2013).

2.2. Strategic niche management: exploring social learning, expectations, and social networks in regime-driven transitions

Within transitions studies, Strategic Niche Management (SNM) scholarship provides a useful approach to investigating the conditions under which niche approaches like WSD may be mainstreamed, as well as possible measures that may modulate emerging windows of transition opportunities in the regime (Grin, 2020; Schot and Geels, 2008; Stiles, 2020).

2.2.1. Alignment of expectations and visions

One of the criteria for the successful development of a radical niche is the *articulation of specific and high-quality expectations and visions* (Schot and Geels, 2008). Expectations and visions are critical for providing direction and depth to learning processes as well as mobilising resources (Raven, 2012; Dóci et al., 2022). Within regime-driven transitions, visions of sustainable futures afford regime actors a "*horizon of expectations*" for the niche's development (Grin, 2020). Expectations are most effective when they are tangible, realistic and shared by an increasing number of actors (van der Laak et al., 2007). When held by many actors, expectations provide a structuring role in niche development processes, allowing actors to draw on them for legitimation and alignment of their work (Bakker et al., 2012; Yang et al., 2020). However, recent literature on urban transition initiatives points to the prevalence of unmet expectations and the difficulties of achieving visions of sustainability due to implementation gaps between long-term sustainability visions and the short-term initiatives needed to achieve them (Huxley et al., 2019).

This may be partly because even those actors who are committed to sustainability transformations remain governed by the 'logics inscribed by incumbent infrastructural histories' (Arapostathis and Pearson, 2019; Grin, 2020). For instance, the pursuit of the 'modern infrastructure ideal' persists in the urban water management sectors of developing cities and may constrain the consideration of visions of nature-based urban development (Herslund and Mguni, 2019; Jaglin, 2014; Mguni et al., 2020). This renders the decision-making process of incumbent actors pursuing nature-based alternatives highly contingent, as practitioners struggle to shake off the overdeterminacy of material histories and their manifestation as environmental injustice (Arapostathis and Pearson, 2019; Grin, 2020; Rodina, 2019a). As such, an awareness of 'policy-relevant histories' is recommended for sustainability transition processes, as is sensitivity to the persistence of structural disparities likely in socio-technical transformations (Akallah and Hård, 2020; Arapostathis and Pearson, 2019).

2.2.2. Development of broad and influential social networks

Another condition for the success of niches is the *building of broad and*

influential social networks which help in enroling a constituency behind alternatives such as WSD, mobilising resources and driving social learning (Dignum et al., 2020; Meckling et al., 2017; Raven, 2012). Coordinating these dynamics remains a governance challenge for supporting the launch of transitions towards sustainability as innovations like WSD require the alignment of multiple policies, actors and governance structures (Grandin and Sareen, 2020). The lack of a platform to which dispersed stakeholders may come together to develop a shared understanding of the transition challenge confronting their cities remains a key challenge for many urban sector regimes pursuing sustainability transitions, as does the absence of procedures for collective reflection and sense-making (Frantzeskaki et al., 2018a; Mukhtarov et al., 2019; Dóci et al., 2022).

In regime-driven transitions, some regime actors may exercise individual agency and act as 'policy entrepreneurs' or 'champions' seeking to influence the adoption of NbS like WSD by pursuing experimentation, whilst activating and securing the space for social networking and learning (Mukhtarov et al., 2019; Habtemariam et al., 2019; Pesch et al., 2017). The activities of champions include nurturing social capital, building trust, developing a shared vocabulary and leadership, all of which can serve to keep new approaches like WSD visible within city departments and to other stakeholders (Mukhtarov et al., 2019). However, there is concern that so-called champions and the networks around them may suffer from elitism and lack legitimacy if not sufficiently inclusive (Nastar et al., 2018; Wittmayer and Loorbach, 2016).

Regime outsiders are crucial to regime-driven transitions as they translate landscape pressures and highlight alternatives in their criticism of the regime (Geels and Schot, 2007). Thus, the activities of intermediary actors alongside regime insiders within a sustainability-oriented social network is seen as key in transition processes (Hamann and April, 2013; Manders et al., 2020; Bos et al., 2015). Intermediaries such as academics, consulting firms and civic groups act as facilitators of cross-scale systemic change as they help monitor on-going initiatives whilst accumulating and circulating knowledge through workshops, conferences etc, thus supporting social learning (Geels and Deuten, 2006; Gliedt et al., 2018; Seyfang et al., 2014). Finally, regime-driven transitions are subject to contestation as there may be little consensus between actors over the directionality, content, and necessity of/for change (Smith et al., 2005; Yuana et al., 2020). Therefore, there is a need to protect niche development within the regime (Grin, 2020; Raven, 2012), as well as to understand and attend to the potential winners and losers in transition processes (Markard et al., 2020; Pereira et al., 2015; Avelino and Wittmayer, 2016).

2.2.3. Learning

Thirdly, social *learning processes* are seen as a critical condition for successful niche development (Bos et al., 2013; Luederitz et al., 2017). Learning is instrumental for niche development, benefitting from the political will and knowledge produced in social networks (Matschoss and Repo, 2020)(Wolfram, 2019). *First-order learning* is concerned with facts, i.e., data and technical performance of socio-technical systems, resulting in regulations and rules (Smith, 2007). *Second-order learning* expands on the alternative solutions available by questioning the tacit assumptions within a socio-technical system (Geels and Raven, 2006; Hoffmann et al., 2020). In the longer term, *third order learning* is important as it enables changes in the cognitive frames and underlying assumptions on which the incumbent socio-technical system is constructed, leading to coalition-building and deepening social networks (Hoffmann et al., 2020; Smith, 2007).

Such higher-order learning is conducive to deeper structural change and is accompanied by the 'unlearning' of obsolete practices and most likely happens in open, inclusive social networks (van Mierlo and Beers, 2020; Bos and Brown, 2012). Learning processes may impart reflexivity into niche development processes by further informing expectations and visions and creating a broader range for agency (Raven, 2012; von Wirth et al., 2019). Furthermore, there is a need to encourage "process learning" in sustainability transitions i.e., by empowering regime insiders to learn to experiment more effectively as well as to translate and embed new insights into regime processes and urban transformation (Dóci et al., 2022). However, learning is still poorly conceptualised and implemented in urban sustainability experimentation in general, and in the WSD field more specifically (Beukers and Bertolini, 2021; Dóci et al., 2022; Mukhtarov et al., 2019; Bulkeley et al., 2019). Even where learning processes are designed for urban sustainability transitions, Dóci et al. (2022) find that third order learning is hampered by a lack of knowledge integration. Moreover, even when higher-order collaborative learning is present it may not translate into implementation of WSD approaches like SuDS unless it is supported by stronger sustainability-inclined institutional frameworks at local and national levels of governance (Mukhtarov et al., 2019).

3. Methodology

Cape Town and Johannesburg were chosen as illustrative case cities for exploring transitions towards water resilience as both cities have begun engaging with WSD to address climate change and water security challenges. Both cities serve as frontrunners in urban Sub-Saharan Africa with their policy interest in Nature-based innovation for addressing the impacts of climate change, rapid urbanisation, biodiversity loss and socio-economic challenges. Beyond both cities' engagement with WSD, Cape Town was chosen as a case due to its embedding in several international municipal networks e.g., the 100 Resilient Cities Network, which make it a strategic landing ground for key global change constructs about sustainable urban development such as WSD (Enqvist and Ziervogel, 2019).

This paper draws on fieldwork conducted in June and October 2019 as well as in March 2020 in Johannesburg and Cape Town. It is also informed by earlier research conducted in 2013/2014 in Johannesburg, which provided background for the current study (Mguni, 2015). Primary data was collected through sixteen semi-structured interviews with twenty-one interviewees. Interviewees consisted of four officials at the City of Johannesburg (CoJ), four officials at the City of Cape Town (CoCT) and three officials working on Water Sensitive Design project at the provincial Gauteng Department of Agriculture and Rural Development (GDARD) as well as one official from the Gauteng City Region Observatory.

Furthermore, interviews were conducted with two academics working on WSD in Johannesburg, officials from an international NGO in Cape Town and the provincial water utility in Johannesburg. Five experts serving as consultants from the engineering and landscape architecture fraternities in both Cape Town and Johannesburg were also interviewed. These interviewees were included as they act as intermediaries to the NbS activities undertaken in both cities, providing knowledge, expertise in the design, assessment and implementation of WSD. All interviews were conducted in English and duration ranged between 30 and 60 min. The aim of the interviews was to explore how WSD is framed and understood by different stakeholders, what roles the interviewees and their departments play in the WSD space, and how far WSD-related initiatives constitute a coherent move towards water resilient futures within each city. The interviewees and their responses are referred to by alphabet codes that were randomly assigned to preserve the anonymity of the interviewees.

Two workshops were held in Cape Town and Johannesburg in June 2019 to assess the WSD-related research needs in the cities from the perspective of twenty-four public and private sector practitioners. Secondary data gathering consisted of a desktop study of policy documents from the City of Johannesburg (CoJ), the City of Cape Town (CoCT), the Gauteng City-Region Observatory (GCRO) and the Gauteng Department of Agriculture and Rural Development (GDARD) among others. An analysis of emergent themes was informed by the Strategic Niche Management's (SNM) three niche development processes of (i) *social network formation*, (ii) *articulation of expectations and visions,* and (iii)

mutual learning processes (Schot and Geels, 2008) was performed.

4. Prevailing narratives on Water Sensitive Design in the water and environmental management spheres of Cape Town and Johannesburg

4.1. Visions and expectations of WSD

4.1.1. Visions of water sensitive futures in Cape Town and Johannesburg

For the City of Cape Town (CoCT), the 2015–2019 Drought was a key landscape factor that accelerated the city's rethinking of water as it was confronted by the spectre of running out of water for its 4 million residents (CoCT, 2019b; Rodina, 2019b; Wolski, 2018). According to interview respondents, the Drought forced most stakeholders to "[…] frame water as a primary consideration […]" for the city and its survival (Respondent, R). It also opened the space for the regime's consideration of alternatives such as Managed Aquifer Recharge and greywater reuse. Furthermore, the CoCT's policies have long offered a foundation for water-sensitive planning e.g., the 'Catchment, Stormwater and River Management Strategy (2002–2007)' and the 'Stormwater Impacts policy (2009)'.

With the Drought, the city sought to further consolidate water sensitive development through the Cape Town Water Strategy and the Cape Town Resilience Strategy (CoCT, 2019a, 2019b). The Water Strategy commits to attaining a water sensitive city by 2040 through the diversification of water resources and infrastructure. In the same strategy, the CoCT integrated the responsibilities for the different aspects of water management under one authority, i.e., the City's Water and Sanitation Department. Indeed, there was consensus among respondents that the drought led to clearer intent across the CoCT's departments to integrate WSD aspects into the city's development and management.

Currently, three initiatives highlight the CoCT's on-going engagement with visions of WSD. The CoCT is piloting the 'Source-to-Sea' and the 'Liveable Urban Waterways' projects that bring together city and civil society stakeholders to collaboratively address water issues at catchment and city scales to support biodiversity, build resilience, improve water quality and supply as well as socio-economically strengthen local communities. Additionally, the CoCT and the Western Cape provincial government are collaborating on the 'Development and application of a benchmarking tool and implementation strategy for the transition towards a Water Sensitive City for the City of Cape Town' project (CRC for Water Sensitive Cities, 2020).

Although the Drought has brought the conversation and intent around WSD to the fore, most interviewees felt WSD has not yet been mainstreamed in the CoCT and that its integration into city projects and initiatives remains ad-hoc. This is not unique to Cape Town, as confirmed by Grandin and Sareen (2020) (p. 72) who found local climate change adaptation initiatives in general to be "frequently impermanent and iterative". Thus, while the CoCT's efforts to incorporate WSD principles are embedded in policy, implementation has yet to catch up (Respondents O & S). Furthermore, the city practitioners interviewed seemed mindful of holding to an official narrative around water which may indicate attempts to align statements and frames with dominant narratives in a contentious context. This may not be conducive to prompting the deeper, integrative conversations that are necessary for experimenting with WSD within the regime.

The Drought has also shone a light on how water remains a divisive political subject that is fraught with distrust and a lack of effective communication between stakeholders in the CoCT; a finding consistent with Lang (2018), Enqvist and Ziervogel (2019) and Rodina (2019b). For example, the water demand management devices installed in poor neighbourhoods around the city before and during the Drought are thought to have further deepened the vulnerability of poor households' access to water and sanitation (Mahlanza et al., 2016; Lang, 2018; de Groot and Lemanski, 2021). As such, water and its management remain loaded with contestations about historical dispossession, inequality and injustice in the post-apartheid city; presenting a key challenge to resilience-building efforts (Lang, 2018; Ziervogel et al., 2017).

For the City of Johannesburg (CoJ); (1) recurrent droughts e.g., 2014–2015, (2) increased incidence of flooding due to climate change impacts and infrastructure deficits, and (3) the lack of nearby water resources are the main landscape factors affecting the city. The capping of the Lesotho Highlands Water Project (LHWP) transboundary transfer scheme, which is the main water supply for the city, adds to the pressure of supplying water to the city's growing 5.3 million residents until the second phase of the LWHP is completed (GCRO and GDARD, 2019). The CoJ's Growth and Development Strategy 2040 as well as other policy documents such as the Spatial Development Framework have served to articulate prevailing and expected landscape factors that confront the urban management regime. These policies emphasise the expectations and visions of Johannesburg attaining liveability, resource resilience and equitable socio-economic growth by 2040.

Some interviewees in the CoJ highlighted that, unlike in the CoCT where WSD now features prominently in policies, WSD is often implicit in similar CoJ policies (Respondents B, E & V). Still, these policies have been translated by regime and niche actors in a way that mobilises some momentum around WSD as an urban water management option such as the Johannesburg Roads Agency's On-Site Stormwater Attenuation policy, the CoJ's Stormwater Bylaws (2009) and the Stormwater Design Manual (2019). Some interviewees felt the CoJ could benefit from a universal water-specific vision within which WSD could be detailed, different actors enroled and the diverse initiatives currently underway in the city coordinated - all contextualised to the specificities of Johannesburg. In both cities the narrative and understanding around WSD is gaining ground, however implementation of WSD projects by city authorities is limited to pilot projects whilst the bulk of the scant-yet-increasing implementation is done by property developers following city policies and regulations.

4.1.2. "Taps and toilets" as an anti-vision

One narrative that emerged as constraining the horizon of expectations and visions around WSD in both cities is that of the housing, water and sanitation infrastructure deficits. This narrative is directly tied to the landscape factor of both Cape Town and Johannesburg having at least 20% and 21% of the households, respectively, living in informal settlements (HDA, 2013; Rodina, 2019a). For most of the respondents, the applicability of WSD to the South African city context must contend with the reality of long-standing infrastructure deficits borne out of the apartheid era and continuously fed by rapid urbanisation and deteriorating legacy infrastructures (de Groot and Lemanski, 2021; Ziervogel et al., 2017).

As one CoCT official highlighted, "*I don't think we as a city have grasped how we are going to make the city water sensitive […] it's about taps and toilets most of the time […] So, it's like we are trying to force a very First world concept into a situation where we've got bigger challenges than that.*" (Respondent P). This raises two issues which represent the primary dilemma of pursuing WSD in a developing context, first is the problem of poor stormwater quality as also found by (Enqvist and Ziervogel, 2019; Fisher-Jeffes et al., 2017). WSD assumes the quality of urban stormwater runoff to be suitable for non-potable uses.

Secondly, interviewees in both cities are apprehensive about committing to what many think is a 'First World' idea like WSD i.e., an idea more suitable to developed cities with adequate infrastructures and resources; whilst the housing and sanitation deficits persist and remain a priority in their respective cities. This is also highlighted by Mulligan et al. (2020) (p. 11) who find a case of "green aspirations, grey realities […]" in a Kenyan case where practitioners considered SuDS for addressing water and sanitation challenges but had to reckon with contextual resource, time and capacity constraints. As such, regime actors in both the CoCT and the CoJ continue to be keenly aware of the logics inscribed by Apartheid as a material history of and in their cities (Arapostathis and Pearson, 2019; Grin, 2020). They remain governed by

obligations of addressing Apartheid's attendant consequences of environmental and socio-political injustice in South African cities.

4.1.3. Expectations of declining city revenues

In the CoCT, most interviewees questioned the sustainability of the city's current revenue model if household water consumption was to be reduced through decentralisation and hybridisation of water management systems as envisaged by the WSD approach (Respondents T, N, S & O). Currently, the city approaches the WSD conversation from a city/catchment-scale question of how to augment water supply through groundwater development and the re-use of treated sewage effluent. The systematic decentralisation and hybridisation of water and sanitation systems at household scale is still an unresolved question (from revenue and public health liability aspects). The CoCT's Resilience and Water Strategies both highlight the same reservations, *"The sustainability of municipal revenue is a constant challenge and is impacted upon by City resource constraints, technological change and rapid urbanisation. Off-grid water and energy solutions, which are desirable for the purposes of enhancing household and business resilience reduce revenue streams to the City."* (CoCT, 2019a). While the declining revenue dilemma may seem to be a constraint in the CoCT, it is also evidence of how far the conversation around WSD in the city has permeated. In contrast, the declining revenues narrative in the CoJ and its likely impacts was only highlighted by two interviewees pointing to the emergent state of the conversation around WSD in the CoJ.

4.2. On the building of social networks to support WSD in Cape Town and Johannesburg

The CoCT's recent integration of water functionaries under the new Water and Sanitation Department has led to the emergence of the director of this new unit as a key champion for the WSD agenda in the city. Respondents also highlighted that for the WSD concept to be mainstreamed in CoCT there is a need for a policy entrepreneur who can act across city departments. This emergent state of the social network around WSD in the CoCT could be the result of the politicised nature of water in the city as well as the information, mandate and implementation silos that persist in the city's structures despite efforts at integration.

As a result, interviewees highlight that WSD-related knowledge and action remain tacit and diffused across the city's structures without a mechanism for knowledge harvesting. Yet, a strong social network is a pre-condition for translating and transferring tacit knowledge through sustained interaction (Dóci et al., 2022). For now, the integration of WSD into projects and initiatives in the CoCT remains ad-hoc at best and confined to *"[…] a small water-related group of practitioners across the city's departments."* (Respondent R). So, while there may be a constituency behind the WSD concepts, regime incumbents in the CoCT still need to activate the collective agency required to craft a binding narrative and build a platform for learning about and driving WSD in the city.

The institutional work involved in pushing the WSD agenda in the CoJ can be traced to the agency of one incumbent regime actor (Respondent B), functioning as a WSD champion as highlighted by other interviewees. However, participation in a social network around WSD within Johannesburg remains limited. While there are WSD-related activities by actors spanning both the niche and regime levels, these actors seem to be dispersed, and as in Cape Town, lacking a platform for engagement. As Respondent B highlighted: "*In Johannesburg a lot of energy is lost in brokering and negotiating for the planning and implementation of [WSD], because mandates related to [WSD] lie within different entities.*" In the absence of such a platform, WSD initiatives by different actors in Johannesburg presently lack coordination. Likewise, there is no shared understanding of what WSD means for Johannesburg's varied urban forms (formal and informal development); nor is there a shared vocabulary with which to engage in collective sense-making (Garud and Gehman, 2012) as also highlighted by Mukhtarov et al. (2019) in the case investigating learning around WSD in Leicester.

With the practitioner championing the idea of WSD within the CoJ due to retire in 2022, the dependence of the WSD agenda in the CoJ on the agency of a single champion puts its future into question. With no solid platform for coordination of the WSD agenda and social network in the CoJ, it is unclear who may emerge as a champion for WSD within Johannesburg currently. A social networking platform around WSD in both cities would ideally facilitate support the development of a WSD-related vision by giving actors with different agendas and expectations a space for dialogue and alignment of activities and policies. Moreover, the coordination accompanying such engagement could foster higher-order learning processes between actors.

Interviewees in the CoJ also identified young practitioners across the private and public sectors of engineering, landscape architecture and environmental compliance as promising in terms of opportunities for widening the social network around WSD in the city. These practitioners are seen as more receptive to the WSD approach as highlighted by one interviewee, "*[…] the younger generation of engineers and practitioners is a lot more open to this kind of thing [WSD]… a lot more comfortable with applying technologies […] and with the concept of modelling, which the older generation generally isn't.*" (Respondent E).

While the conversation around WSD in Johannesburg is yet to gain momentum and is behind that of Cape Town, there have been noteworthy cross-scale network building activities that support WSD in the city and Gauteng province. The provincial Gauteng Department of Agriculture and Rural Development (GDARD) and the Gauteng City-Region Observatory (GCRO) have each contributed to the advancement of the WSD agenda by commissioning and performing research into water security and WSD in the province. GDARD and the GCRO have released policy documents such as the 'SuDS Implementation Manual' (GDARD, 2020; Culwick et al., 2019; GCRO and GDARD, 2019) which are complimentary to the CoJ's WSD policies. However, these network activities in Johannesburg remain at the policy level, as incumbent regime actors like the CoJ and GDARD continue to be limited to policy development and monitoring roles. As such, it seems the pathway for WSD implementation currently relies on developers and landowners complying with the CoJ's Stormwater By-Laws (2009) and the GDARD's environmental compliance requirements, by enlisting consultants to design and implement brownfield and greenfield developments according to the CoJ Stormwater Design Manual's (2019) and GDARD's specifications.

Lastly, the persistence of siloes and lack of collaboration between departments relevant for WSD remains a challenge in the transition towards water sensitive futures in the CoJ and CoCT as also found by Rodina (2019a) and Enqvist and Ziervogel (2019) for CoCT, as well as by Mukhtarov et al. (2019) for Leicester and Bush (Bush, 2020) for Melbourne. In Cape Town, while the recent restructuring has integrated most water-related units under one entity, the collaboration with other departments, necessary for achieving nature-based urban development, remains low. Respondent R also emphasises this by highlighting that in the CoCT, "*[…] there is no systematic mechanism for [the] day-to-day integration across departments […].*" In the CoJ, interviewees also identified the lack of coordination as a pressing challenge (Respondents B, C, K, L & V). Siloes in the city are budget-induced and tied to linear, disparate mandates resulting in the lack of the integration necessary for implementing WSD.

4.3. On social learning around WSD in Cape Town and Johannesburg

While existing WSD-related initiatives in the CoCT and CoJ have formed the basis for increased learning about WSD, most respondents in both cities highlighted the lack of capacity and knowledge about WSD as the biggest barrier to the approach's institutional embedding. First, respondents had differing definitions and understandings of what WSD is when interviewed, indicating the lack of a shared cognitive frame with which to understand the WSD approach. This was also found by

(Washbourne, 2022) concerning the differing understandings about green infrastructure in the CoJ and CoCT.

In Johannesburg, despite city-mandated training for practitioners, respondents highlighted that it was still to be seen if practitioners would be able to use the new Stormwater Design Manual (2019) for ensuring compliance with the Stormwater By-Laws (2009). Some CoJ respondents highlighted that the new Stormwater Design Manual (2019) itself is a challenging document to read and understand, let alone apply in daily practice. However, the Stormwater Design Manual (2019) is intended to be a 'living document' (Respondent E), that CoJ practitioners and stakeholders can add to and re-work as experience with WSD implementation gathers momentum in the city and insights concerning WSD in the Johannesburg context are (collaboratively) distilled. Indeed, the accessibility of policy documents for effectively conveying information encouraging WSD implementation is an important aspect in the take-off of the transition towards water sensitive futures for cities. Mukhtarov et al. (2019) also stress the critical role played by the simple, well-illustrated SuDS Guidance document in enroling developers and city practitioners to the idea of SuDS in Leceister.

Another common theme identified by interviewees in both cities was that practitioners remain tentative about implementing WSD. For instance, respondents B and E in Johannesburg highlighted the lack of hydrogeological knowledge and modelling skills as likely impediments to the uptake and mainstreaming of WSD by practitioners. This type of knowledge is considered critical, considering Johannesburg's notoriously complicated geology and the heightened risk of acid mine drainage, borne out of the city's mining history (GCRO and GDARD, 2019). However, this is not unique to Johannesburg. Capacity and skills related to modelling and information processing especially for understanding the impacts of WSD-related installations present a problem for other cities as well. Dadson et al. (2017), Mukhtarov et al. (2019) and Dóci et al. (2022) all highlight that the deficiencies in knowledge and skills for understanding and learning about transitions present a significant barrier to WSD-related implementation, and to urban sustainability transitions in general, leading to a paucity of evidence that can support better decision-making in UK and Swedish cities.

Another reason for the lack of confidence in abilities to implement WSD was the lack of harvesting lessons and best practice examples from past and on-going WSD initiatives, which remains a key constraint in boosting the momentum for mainstreaming WSD in both cities (Respondents S, T, N, R, & E). Respondent T highlighted that, *"We do not, in the city, go back and learn from what we've done. It's the weakest point, in my opinion."* Respondent R also suggested that with WSD interventions there was a need to *"[…] demonstrate success to be able […] to roll the thing out, to scale it up and go different places."* Respondents suggested several ways of remedying this, one being the compilation of case studies assessing and evaluating WSD initiatives in South Africa as a way of demonstrating what works, how and what does not (Carden et al., 2016).

Due to the lack of skills and capacity, both the CoJ and CoCT depend on engineering, landscape architecture and environmental consultants for the conceptualisation and implementation WSD projects. However, post-implementation operation and maintenance remains a problem for both cities' entities due to a lack of 'green engineering' capacities as well as the lack of coordination of siloed mandates across departments. In terms of the depth of learning, though the WSD-supporting policies in the CoJ and the CoCT are a positive step in the NbS direction, they are nonetheless an indication of the prevalence of first-order individual learning. There remains a need to encourage second and third-order learning which would lead practitioners to question the frames that underpin urban water management practice in their cities.

5. Concluding discussion – on the conditions for nature-based transformation towards water resilient futures in Cape Town and Johannesburg

Nature-based Solutions are gaining ground as potentially transformative means of pursuing pathways towards water resilient futures. In this paper we contribute to the growing compendium of studies addressing the potential that NbS like WSD hold for cities in the Global South by qualitatively scoping the prevailing conditions for transitioning towards water sensitive cities in Cape Town and Johannesburg. We have employed Strategic Niche Management (SNM)'s niche development criteria, to assess the prevailing conditions for transitioning towards water-resilient futures through WSD in Cape Town and Johannesburg. Our analysis has given a view into the dynamics and narratives that currently characterise the WSD space in the two cities.

By using the SNM framing to explore the conditions for sustainability transitions through WSD, our paper has built on an intersection of various bodies of literature including social learning, sustainability transitions in the Global South and literature on the applicability of NbS such as WSD and green infrastructure in urban resilience-building pathways. However, our approach is not without limitations. By concentrating on the urban water governance regimes' efforts to integrate WSD as a synergistic niche, we have not given due attention to WSD activities outside the regime by niche-level actors. These niche-level activities by property developers and other regime-outsiders are central to both cities' WSD implementation pathways as identified earlier, and we believe they deserve full attention separately.

Overall, we find that the conditions for launching the transition towards water resilient futures based on NbS such as WSD in Cape Town and Johannesburg are (for now) insufficient and the transition remains emergent; nonetheless with strong impetus from WSD-linked policies, benchmarking processes and landscape pressures. Cape Town is further along the process than Johannesburg, perhaps due to having to address the protracted Drought of 2015–2018 with policy and practical responses that clearly support WSD. Our analysis points to several dynamics and narratives as characterising this emergent state of affairs. First, for both cities, WSD remains mainly in visions and policies whilst implementation by city entities lags behind; characterised by ad-hoc pilot projects. In the policies, both cities have sought to articulate the landscape pressures they face, as well as their subscription to normative visions of Nature-based urban development through WSD, as one approach to remedying water and environmental management problems.

Secondly, approaches like WSD currently present regime incumbents in South African cities (and other African cities) with several dilemmas. Due to infrastructure deficits, urban practitioners are confronted with the need for balancing aspirations of attaining water resilient futures through WSD with priorities for providing safe housing as well as access to water and sanitation services for the urban poor - whose vulnerability has been further deepened by the COVID-19 pandemic (de Groot and Lemanski, 2021). Unlike in the Global North where NbS are gaining momentum as a climate governance response, this points to the need to problematise NbS approaches in the Global South as highly contingent on the infrastructural logics, realities of deficits and resource constraints, which are based on the environmentally unjust material histories of post-colonial cities.

Indeed, this dilemma raises questions of the very 'sustainability' of solutions put forward by concepts such as WSD in such contexts of deep socio-economic and infrastructural inequality. While nature-based approaches such as WSD may satisfy the environmental aspects of sustainability, care is needed in their introduction and implementation so as to address the socio-political and economic aspects of their sustainability. Our paper thus corroborates the caution urged by other authors including Cousins (2021), (Dorst et al., 2021; Sekulova et al., 2021), Dorst et al. (2021) and Tozer et al. (2020) on the need to ensure that the policies supporting the implementation of NbS such as WSD do not

further entrench neoliberal processes of green rent-seeking, exclusion and gentrification thus further alienating the urban poor.

As such, one implication of our findings that emerges when looking at the integration of NbS such as WSD in the Global South is the need to address how WSD can be strategically linked to the water supply and sanitation (WASH) agenda in a way that simultaneously addresses current infrastructural deficits and resilience-building needs as also found by Mulligan et al. (2020) and Poustie et al. (2016). Addressing the critical and ongoing agenda of providing water and sanitation access in a water sensitive manner would help support developing cities to tackle the 'Just Transition' challenge of ensuring transformations which are committed to justice, human well-being and environmental sustainability in the Global South (Swilling, 2019).

Additionally, both the CoCT and CoJ cases (to different extents) point to another dilemma of the expected decline in municipal revenues vis-à-vis the implementation of decentralised WSD installations at household scale, in line with municipal concerns in other parts of the world as seen in Bush (2020). Furthermore, the two cases illustrate the challenge of facilitating sustained learning and social networking about/around NbS as key factors in the emergent state of the transition towards water resilience in the views of regime incumbents in the CoCT and CoJ. This points to the need for a binding narrative or WSD-specific vision on which to build the coherence and collective agency necessary for launching the transition towards water resilient futures. The 'ephemerality' of governance attempts at NbS policy integration and implementation in Cape Town and Johannesburg are characteristic of the difficulty of deploying embedded, collective agency in mobilising and sustaining transformative change at a local scale as identified in recent transitions literature e.g., in Grandin and Sareen (2020).

In both cities there are NbS-aligned initiatives taking place, however coordination between relevant regime stakeholders remains problematic and little has been done to harvest, understand and build on the impacts of such activities as also highlighted in other contexts by Albert et al. (2019), Mukhtarov et al. (2019); Bush (2020) and Dignum et al. (2020). Our paper also highlights the inherent linkages between the three SNM niche development processes as our findings point to the importance of a social network formation around WSD for the emergence of higher order social learning processes as emphasised by other authors including Mukhtarov et al. (2019) and Dóci et al. (2022). Without a collective social networking platform for developing common cognitive frames for understanding what NbS is for their respective cities; whilst lacking the skills for hybridised water management models; and without case studies detailing past NbS initiatives, most regime incumbents in the CoCT and the CoJ still lack the confidence to pursue the systematic integration of NbS into governance and operational structures.

Thus, intermediaries such as universities, environmental consultants as well as international organisations like ICLEI and the World Resources Institute have emerged as important stakeholders in supporting sustainability transitions through NbS in cities of the Global South. Apart from providing impetus for the consideration of WSD, these intermediaries also engage in policy development support, facilitation of workshops as well as providing skills for the implementation of NbS-linked activities. However, like Nastar et al. (2018), we find there remains a need to widen the social networks around WSD to become more inclusive and empowering of previously excluded actors such as communities, whose experiential knowledge of living in the post-colonial city are frequently disqualified.

By scoping the conditions for the take-off of the transition towards water resilient futures through NbS like WSD in Cape Town and Johannesburg, we have found that the regime-driven transition impetus of mainstreaming WSD via policies, benchmarking processes and regulation points to an emergent yet tenuous pathway towards water resilient futures in both cities. Indeed, more research is needed that can anticipate the risk of system lock-ins or regressive transitions in the socio-technical systems Pel, 2021 such as potentially found in African cities, as urban managers struggle to provide basic services to their citizens whilst attending to climate change impacts. Finally, additional studies are needed to investigate what it takes to 'do' sustainability in professional practice in a developing city i.e., by developing a better understanding of the social learning and networking challenges that confront urban stakeholders pursuing transformative change in post-colonial cities.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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