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Blue-Green Acupuncture: Transforming Stormwater Ponds into Multifunctional Green Infrastructure in Cape Town

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ABSTRACT

In post-apartheid Cape Town, urban green space and ecological functionality remain starkly unequal across socio-economic gradients, giving rise to conditions described as “Green Apartheid” on the Cape Flats. Within this context, over two hundred and fifty mono-functional stormwater detention ponds situated above the Cape Flats Aquifer present untapped potential for Nature-based Solutions as Blue-Green Infrastructure. These sites can advance water resilience through Managed Aquifer Recharge while helping address spatial and ecological deficits in historically marginalized areas. However, these engineered ponds are frequently perceived as neglected or vacant spaces, obscured by dumping, litter, or informal occupations that compromise flood protection functions and limit public recognition of their value. Drawing on a five-year longitudinal case study in Mitchells Plain, this paper employs Situational Analysis grounded in Critical Realism to document the transformation of a mono-functional stormwater pond into multifunctional green infrastructure. Through low-cost, co-created retrofits – including an infiltration trench, indigenous Strandveld planting, community murals, a multifunctional weir, and stepping-stone bollards – the project created physical and social “cues to engage”. The interventions generated measurable ecological recovery, alongside new community activations and educational awareness. Building on these empirical findings, the paper introduces Blue-Green Acupuncture as a theoretical framework structured around three core processes: (1) *Puncturing* (strategic, low-cost ecological interventions); (2) *Curating* (re-framing “cues to care” into “cues to engage”); and (3) *Linking* (connecting ponds as catchment scale ecological stepping stones while accommodating informality and local green economy opportunities). Grounding green infrastructure in spatial justice and local urban realities, this framework provides a

practical model for adapting mono-functional stormwater infrastructure to support water-sensitive development in resource constrained cities of the Global South.

Keywords: Biodiversity; Blue Green Infrastructure; Nature-based Solutions; Parks; Spatial Equity; Stormwater Ponds; Urban Landscape; Global South

HIGHLIGHTS

- Activating Nature based Solutions (NbS) as Blue Green Infrastructure (BGI) using a conceptual acupuncture framework.
- Recognising dual-purpose landscape elements within NbS as cues to engage people.
- Merging stormwater pond and park roles to link engineered infrastructure with environmental conservation.
- Recognising context as a critical informant for where BGI that uses NbS could be used.
- Scalability of a process at catchment scale that provides ecological stepping stones.

INTRODUCTION

Cape Town, South Africa experienced a severe drought from 2016 to 2018 with water scarcity reaching its peak in March 2018. The prospect of 'Day Zero', when dams supplying water to the city would run dry, almost occurred, with the city's inhabitants facing the unnerving prospect of having to collect water daily from tanker points across the city. Since then, the City of Cape Town Municipality has developed a Water Strategy that sets out its approach to achieving water resilience to mitigate against similar future scenarios (City of Cape Town, 2020). This includes the adoption of a Water Sensitive City (WSC) vision by 2040, where water is managed in a sustainable manner, contributing to urban resilience by embracing water sensitive strategies that include the diversification of water resources and the optimal use of stormwater and green infrastructure.

In this context, however, stormwater ponds are disproportionately located within neighbourhoods that have historically experienced environmental injustice and limited access to quality public open space. Their transformation therefore represents not only an ecological intervention, but also an opportunity to address inequities in access to biodiversity, recreation, environmental education and climate resilience.

Suited to the achievement of the WSC vision are some two hundred and fifty stormwater ponds located above the Cape Flats Aquifer that form part of a stormwater management infrastructure system originally engineered to control flooding. Using Nature based Solutions (NbS), these ponds could potentially augment the city's water supply as part of Managed Aquifer Recharge (MAR) strategies, whilst also serving as multipurpose green landscapes (Mauck, 2017; Okedi, 2019; Rohrer, 2017). In its current state though, this stormwater pond infrastructure is invisible and generally not recognised by many residents for its flood prevention functions nor as a beneficial public open space resource with environmental conservation potential, despite being zoned for these purposes. Many of these ponds are vacant, covered in litter and used as dumping sites. Others have been occupied with informal housing, compromising their functionality. This has consequences not only for the maintenance and management of the stormwater flood protection system, but also for the future augmentation of the city's water supply using MAR.

These ponds need to be understood in the context of the development of Cape Town's Cape Flats area, with much of this urban growth resulting from the combined ideologies of modernist town planning and the South African system of apartheid in the mid-20th Century. Separate racial development forced the relocation of people of Colour from their homes, communities and livelihoods in other areas in Cape Town, to its outskirts, the Cape Flats. What has resulted is a landscape characterised by urban sprawl, separation and fragmentation associated with high levels of poverty, unemployment and inequality. These conditions are exacerbated by the existing settlement structure that restricts access to opportunity and resources, with people having further to travel to find work and education opportunities (Dewar, 2016). Furthermore, studies have recorded a

decrease in biodiversity across a transect of the city, from wealthier formerly white only areas down to poorer areas on the Cape Flats. This corresponds with reduced ecological functionality across the socio-economic gradient (Anderson et al., 2020). Access to biodiversity is itself an equity concern.

Another study records many of the areas across the Cape Flats having not only less biodiversity but also very little vegetation, referring to this phenomenon as a "Green Apartheid" (Venter, Shackleton, Van Staden, Selomane, & Masterson, 2020). This is the context in which NbS is being considered for application; where nature and natural processes are mimicked to enable the infrastructure's optimal functioning (UNWWAP, 2018).

Krauze & Wagner conceptualize the "*implementation instrument for NbS*" as Blue Green Infrastructure (BGI) (2019, p. 698). BGI, recognised as an urban strategy for water sensitive stormwater management by Stovin & Ashley (2019), is defined as an interconnected network that includes both natural and designed open green spaces, with permanent or temporarily inundated water bodies (O'Donnell, Netusil, Chan, Dolman, & Gosling, 2021). There is a wealth of literature that serves to illustrate the practical implementation of BGI that uses NbS and its numerous benefits as part of urban public space, with Kimic & Ostrysz (2021) providing a detailed assessment of these. Furthermore, Pereira & Baro (2022) recognise the potential of BGI to improve ecosystem services and environmental sustainability by enhancing biodiversity. What is less obvious is how cities of the Global South, characterised by a variety of social, economic and political challenges, could practically implement this approach and scale up urgent interventions to deal with water scarcity. Available literature provides general strategies but also recognises context-specific solutions (Ahmed, Meenar, & Alam, 2019; Castaldo, Nocentini, Lemes de Oliveira, & Mahmoud, 2025; Drosou et al., 2019).

This paper presents a Cape Town case study set in a resource-poor and socio-economically challenged area of the Cape Flats of the southeast Metropolitan Area. Recognising the numerous environmental, ecological, social and economic benefits, it explores the practical transformation of a mono-functional stormwater pond into biodiverse, multi-functional BGI. The Methods section provides details of the research work carried out, detailing the interventions - indigenous planting,

habitat enhancement, interpretive signage, public art, pathways, stepping-stone bollards, and a multifunctional weir structure. The Results and Discussion sections elaborate on a transitional framework of Blue Green Acupuncture, envisaging how similar pond infrastructure could be transformed within the varied contexts of the Cape Flats. It concludes with a recommendation that stormwater ponds as hybrid stormwater parks could provide a voice for this currently silent infrastructure: biodiverse, multi-functional BGI can provide educational as well as recreational uses within the urban landscape whilst also enhancing biodiversity at a catchment scale through functioning as valuable ecological stepping stones.

METHODS

The Pathways to water resilient South African cities (PaWS) project (2019 to 2025) was a transdisciplinary collaboration between the University of Cape Town's Future Water Institute in South Africa and the University of Copenhagen in Denmark [funded section removed for peer review]. In consultation with the City of Cape Town's Catchment, Stormwater and River Management (CSRM) Branch, their groundwater consultants, Umvoto, and residents, the PaWS research team selected a stormwater pond as an experimental study site (Figure 1). The pond, hereafter referred to as the study site, is located along Fulham Road, Rondevlei, in a low-to-middle income neighbourhood within Mitchells Plain, a residential area in the Cape Flats, conceived in the 1970's according to apartheid spatial planning ideologies.



Figure 1. Location of study site (Source: Google Earth).



Figure 2. The study site prior to retrofitting works, with the neighbouring school on the right and single-storey residential housing in the background. (Source: PaWS Research Project, 2019)

It is important to recognise the context for this research, as the relationships people have with this infrastructure contribute to how it is used or perceived. The study site lies in a single-story residential neighbourhood, mostly on small plots (~300m²) with two primary schools, one of which it borders (Figure 2). There is a doctor's clinic as well as small informal commercial enterprises in the residential area. Private garages, for instance, have been converted into tuck shops or cafés while a house advertises traditional sweet delicacies for sale and a car mechanic runs his business from home with cars for repair parked outside. Like many other areas across the Cape Flats, the neighbourhood is characterised by limited access to formalized public recreational or green spaces.

The stormwater pond study site has been engineered into the urban landscape as a detention pond to prevent localised flooding from predominantly winter rainfall in what is a relatively flat area. It is almost 3m deep in parts with sloped embankments in which two concrete stormwater inlets and one outlet can be found. These are connected to an underground piped stormwater network. The design is meant to ensure that, during storm events, run-off is detained in the pond for a few hours and slowly released to the downstream pipe system. Prior to the research work, the site varied in seasonal appearance from knee-high grasses and exposed sandy patches during hot, dry summers to becoming a reed-covered basin in winter. Contractors, engaged by the

City of Cape Town's CSRM Branch, mowed the pond on a biannual basis, cutting down all vegetation to a few centimetres above ground.

Situational Analysis (SA) was employed as a qualitative research method informed by the meta-theoretical lens of Bhaskar' Critical Realism (CR). SA was selected due to its suitability for a broad analysis of the stormwater pond study site situation across macro, meso and micro scales (Clarke, Friese, & Washburn, 2015) whilst the metatheoretical lens of CR enabled an in-depth exploration and examination of events and activities to be conducted. SA as a research method, offered a postmodern Southern turn approach considered appropriate for this work as it enabled acknowledgement and the seeking out of the situational differences and complexities, using a broad range of data sources (Clarke, 2003). Rooted in grounded theory, Clarke refers to the need to identify the concept of situation. At the study site, the "*fundamental unit of analysis*" (Clarke et al., 2015, p. 99) was the stormwater pond situation, with the retrofitting process itself becoming the product of SA.

Retrofitting the mono-functional stormwater pond study site into BGI

Residents interviewed in the early stages of the research project were largely unaware of the study site's role as a detention pond and part of a stormwater management system to protect the neighbourhood from flooding. Instead, they perceived it as vacant land with some using it for dog-walking while local children used it as an informal play area. Some residents also referred to the neighbourhood protecting the site from 'outsiders' wanting to erect informal housing on it. Observations of building rubble and other rubbish in the study site by the research team suggested that it was also used as a convenient location for dumping.

Initial research activities involved drilling monitoring wells to test water quality as well as constructing a sandbag wall and infiltration trench. The infiltration trench was designed and implemented along the contour in front of the stormwater inlets to the pond to evaluate the potential for aquifer recharge from the neighbourhood stormwater run-off as well as the potential for water quality improvement using this type of infrastructure retrofit (McLachlan et al., 2023). Included as part of the retrofit work process was a Spring Planting Day, facilitated by a local

environmental activist-conservationist. Adopting the theme, 'Restoration in Progress', it focused on the value of wetland habitats and involved planting seedlings indigenous to the area's vegetation type, the Cape Flats Dune Strandveld. Residents as well as children from the neighbourhood schools, helped with the planting, while the activist spoke about the value of the plants, their propagation and watering needs.

Interviews with some of those involved in the Spring Planting Day suggested that this had causal powers and served as a generative mechanism altering their perception of the pond and thus seeing it as part of nature that needed protection for future generations rather than as empty space. Other respondents acknowledged a new recognition of nature at the pond, posting pictures of dragonflies, frogs and lizards, amongst others on the research team's WhatsApp group. Some described it as a wetland and acknowledged the value of these natural systems for water while others referred to the wetland zone of the study site as being equivalent to our 'living bodies' and looking forward to seeing the seasonal flowers appearing.

While the 'Restoration in Progress' planting activity in the spring of 2021 was not the ideal planting time due to the long, dry summer ahead, it did appear to serve as an engagement catalyst with a few of the residents starting to define and protect the wetland zone by laying rocks and rubble along its perimeter. Thus, although participation in advertised community events aimed at building interest in the pond was not particularly high, what emerged in the process was a recognition of the pond landscape itself influencing perceptions. This offered an opportunity to consider how the stormwater pond landscape study site could be physically transformed as part of the transitioning process from mono-functional infrastructure to BGI that uses NbS.

Strategic retrofits and enhancements have since been made over a period of 5 years at the study site. These retrofits have worked within the City of Cape Town's zoning policy for the use of these areas as public open space and environmental conservation whilst also ensuring that the primary flood protection function of the stormwater pond has not been compromised. The retrofits

and rehabilitation to transform the landscape of the study site are elaborated on in sequence of implementation.

Mural Painting Events

A mural painting capturing the environmental role of stormwater ponds in the Cape Flats was completed over the course of 2022, with locals contributing their ideas, drawings and later, helping to paint the exterior of house boundary walls lining a portion of the study site (McLachlan et al., 2023). An eco-friendly South African produced paint (ProNature) was used to create the mural of approximately 35m in length and 2.1m high (Figure 3). The mural underwent a touch-up process with some repainting in late 2025 to coincide with the finalisation of the project.



Figure 3**.** A portion of the completed mural overlooking the pond, 2022 (Source: GoogleMaps Street View)

Winter Rehabilitation Planting

A plant workshop was conducted in May 2023. Plant samples brought to the study site to ascertain the extent of recognition and knowledge of locally indigenous plants in the neighbourhood suggested that much of this plant knowledge has disappeared. Respondents were familiar with exotic commercial plants, like tulips, or sunflowers, but unable to identify locally indigenous plants that are adapted to the conditions of the area. To build on the accessibility of these plants to the neighbourhoods, as well as the biological diversity of the pond, FynbosLIFE was approached to assist in additional planting at the study site. FynbosLIFE (where LIFE stands for 'Locally Indigenous Fynbos Education') is a Cape Town based wildlife charity and non-profit organization run by botanists,

ecologists and horticulturalists focused on the protection and promotion of the highly threatened lowland fynbos biodiversity found within the region. They sourced a diverse selection of plants from the locally indigenous Cape Flats Dune Strandveld vegetation type and propagated around 800 plants in their nursery for later planting at the pond.

The winter rehabilitation planting was concentrated on the southern boundary of the study site where it bordered the neighbouring school with rock-lined paths defining walkways and protecting new planting. Planting was done according to zones – dry edible, aromatic, medicinal Strandveld, ecological habitat and seasonal wetland – with residents invited to help. This involved digging holes within the existing vegetation layer of the study site to limit the disturbance of this layer and allow what was there previously, whether seeds, mowed vegetation, etc. the chance to grow (Figures 4a and 4b).



Figure 4a and 4b. Planting Day in July 2023 showing rock-lined paths demarcating planted zones and holes being dug by locals for new plants within existing vegetation to maintain seed bank (Source: Authors, 2023)

Planting in cooler wet months was also intended to help plants establish themselves before the hot dry summer. Hand-sized river boulders marked the pathways while ten A3 size signs were installed to provide information about the pond functions and the locally indigenous plants using ABS boards nailed to two 40mm thick timber poles with signs placed so that they would not obstruct

the view of the landscape. In winter of 2024, the vegetation in the planted area around the pond was further augmented with an additional 100 plants selected for their water-wise capabilities.

Weir Wall Retrofit

To facilitate the measurement of water flowing from the pond to the local drainage system, a Perspex and plywood weir structure was originally installed in 2021 at the study site's outlet, but this was subsequently damaged. In 2024, and again using local labour, a more substantial concrete weir with a V-notch was constructed to assist in the collection of further data on water volumes and flows. The design of the weir considered both the needs of the water experiment as well as its potential as a pedestrian crossing point across the outlet channel (Figure 5a and 5b).



Figure 5a and 5b. The deep outlet channel in 2019 before the weir installation (left) and the completed concrete V-notch weir (right) damming up water (Source: PaWS Research Project)

Bollard-Stepping-Stones Retrofit

In December 2023, a municipality-contracted tractor mowed across a portion of the wetland zone. This incident prompted the installation of more permanent bollard demarcations to protect the wetland area of the study site whilst also providing a stepping-stone path. A local eco-friendly building contractor, Natural Homes, was appointed to assist in the casting of 250 bollards using lightweight bio-cement, 300mm x 300mm x 470mm in size and each weighing 46kg. The concrete used incorporated recycled plastic and paper as well as alien invasive shrubs and trees to provide

lightweight aggregate. A team of 4 residents was employed to assist in the installation of these bollards around part of the study site, joining to the existing sandbag wall and the concrete weir structure to complete a path around the wetland area (Figure 6). As the area is sandy, no foundations were required with just an excavation of a hole to accommodate at least one third of the bollard and tamping down of the base. The excavated sand was scattered around to avoid a build-up over existing vegetation and loose stones from the spoil were placed to fill in gaps in the existing stone-lined paths.



Figure 6. Installation of concrete bollards in May 2025 to physically demarcate and protect the wetland zone while creating stepping-stone path (Source: Natural Homes).

Conducted between 2019 and 2025, the research project adopted a longitudinal case-study approach that captured the evolving transition of the study site from mono-functional stormwater infrastructure to multifunctional BGI. Data were generated through multiple sources, including semi-structured interviews, participant observation, community workshops and planting events, field notes, project records, and photographic documentation. These data informed the Situational Analysis mapping process and supported the identification of relationships, activities and emerging patterns across social, ecological and infrastructural dimensions of the study site. Together, they

provided the empirical basis for understanding a participatory transitioning process and green governance approach for developing the conceptual framework of Blue-Green Acupuncture.

RESULTS

Results from the various retrofits of the study site, co-created with local community members, are categorised as follows.

Enhancing biodiversity

In previous years, the whole study site was mowed biannually by city contractors as part of stormwater maintenance and management regimes. The 'Restoration in Progress', Spring Planting Day resulted in some community members identifying a significantly sized 'living wetland' zone within the site and protecting it by laying rocks and rubble to demarcate to city contractors where they should not mow. This initial gesture by a few community members not only allowed plants within the wetland zone to grow but also suggested an approach for further enhancement of plant biodiversity at the study site with the Winter Planting event. Following this planting it was observed that many of the plants successfully adapted and established themselves without irrigation despite long hot summers. The strategy to limit the disturbance of the existing vegetation layer to allow what was there previously, whether seeds, mowed vegetation, etc. the chance to grow also ensured that embankments remained intact during the heavy winter rains, with existing plant roots binding the sandy soils together.

Without maintenance however, planting on the upper embankments appeared unkempt and susceptible to fires in the dry summer seasons. The planting within the wetland area was considered more successful, growing and blending in well with the existing vegetation with diverse species being identified. Residents and researchers have remarked on the distinctive calls of the Clicking Stream Frogs (Strongylopus grayii) they now hear each winter coming from the wetland, whilst birds like pin-tailed whydah (Vidua macroura) and black winged kite (Elanus caeruleus) have also been observed. A critically endangered fynbos plant, Psoralea glaucina (*blouteebossie*) was identified as well as patches of Imperata cylindrica (sword grass) that are critical hosts in the life cycle

of the highly threatened Barber's Cape Flats Ranger Butterfly. The caterpillar lays its eggs in the spear-like grass but mowing activities by City of Cape Town maintenance teams destroy these eggs; the objective is therefore to protect a larger area of this particular grass habitat.

At the time of writing a biodiversity assessment is being conducted to identify and list the various plant species occurring at the study site. Further research is also required to determine the extent to which the engineered infiltration trench and sandbag wall have altered the hydrology of the pond to assist in its greening and biodiversity or whether restricting mowing and allowing locally indigenous plants to grow has influenced the behaviour of the wetland.

Curating 'cues to care'

Strategic mowing is recognised as beneficial in providing 'cues to care' (Nassauer, 1995) for the pond, with community members commenting on the pond subsequently looking attractive, neat and tidy. The City of Cape Town's appointed maintenance teams cooperated with the PaWS research team to restrict mowing within parts of the pond and encourage biodiversity. Recent findings however indicate that the non-indigenous kikuyu grass grows rapidly, and more frequent and strategic mowing interventions of areas outside of the wetland zone may be required that speak to the different needs and uses of the pond as well as its appearance. This and the build-up of rubbish between scheduled maintenance visits by the appointed municipal maintenance teams remains a challenge.

Attempts made by the research team to encourage residents to form a group that could seek funding and/or support for, amongst others, more regular maintenance and mowing activities at the pond, and provide potential employment opportunities, have not materialized. Further studies would be required to establish reasons for this; potentially attributed to the pond not yet being recognised for its usefulness within the neighbourhood or because an intermediary organization such as a nature education and conservation NPO would be required to facilitate and guide this maintenance on a monthly, weekly or daily basis.

Recognising 'cues to engage'

Various elements introduced into the landscape have been recognised as 'cues to engage'. The grass-sod covered sandbag wall, introduced as an engineered element to retain stormwater in the infiltration trench, has evolved as a path; community members and research team members alike use this element to walk around the wetland above the damp areas. The sandbag wall path now connects to a rock-lined pathway, installed during the first winter planting season and which serves to designate a clear route through the planted zones. Though many of the hand-sized rocks have been either dislodged or removed, the paths have endured, suggesting that they are still serving as cues to how members of the community engage with and move through the pond.

A concrete V-notch weir, constructed as part of the hydrological experiment to measure outflows from the pond has also provided 'cues to engage' with the pond. Whilst the concrete weir forms a narrow crossing point over the almost 1m deep outlet channel it also creates an opportunity for the local children to observe frogs or wildlife. The quality of the water remains a concern though, particularly during the dry summers when there is a build-up of rubbish and unpleasant smells. Concrete bollards link to the V-notch weir bridge, completing a circuit path around the wetland. Feedback from some residents has been positive with a recent neighbourhood WhatsApp post showing morning dog-walkers using these stepping-stones to walk around the site (Figure 7).

The sand-bag walls, rock-lined paths, V-notch weir and concrete bollards can all be recognised as infrastructure that creates opportunities for cues to engage. The bollards have also provided a level of guidance and spatial demarcation for maintenance teams on where not to mow.



Figure 7. Overall picture of the site complete with stepping stones (Source: Authors, 2025)

Communicating a Blue-Green message

Information conveyed in signage across the site has had variable impact. The large mural painted on the walls of several houses has helped to distinguish the study site, but it has proven less effective in aiding the engagement of residents with the pond, although a few did start to place more plants below it at one point. Signage installed during the winter planting to provide information on the role of the stormwater pond and the plants appeared to have initial success with schoolteachers from the adjoining school taking their learners to look at them. Many of these signs were subsequently vandalized or removed however, and a decision was taken to install more durable A3 sized Perspex signs and place them on longer wooden poles. Within a day of installation, the poles were stolen, though several of the A3 Perspex signs were found by a local resident and returned to the research team. It was assumed that the poles were taken as they were easy to remove and considered useful. The recovered A3 Perspex signs have subsequently been fixed to concrete blocks and installed as part of the concrete bollard pathway and appear to be more visible and less susceptible to vandalism.

Engagement opportunities with the stormwater pond study site

The research at the study site has highlighted that whilst the involvement of residents in the actual installation or retrofit as BGI is considered necessary, how people identify opportunities for the use

of the pond after the event is key. Consequently, the research asks, *how can stormwater ponds become equitable forms of Blue Green Infrastructure in historically underserved communities*?

Our evaluation of the success of the pond elements has been informed by not only observing their use, such as children playing at the weir or using the sandbag wall as a path, but also by the interest it has generated in NPOs and municipal officials with a similar nature-based agenda who see it as an example of an approach they could apply to their own projects and for future planning or projections for public open spaces. Visitors to the study site have included a Cape Flats based NPO, interested in seeing how to transform a similar stormwater landscape for the growing and harvesting of locally indigenous medicinal plants, amongst others. City of Cape Town River Wardens as well as Educational Officers from nearby nature reserves have also visited the site and commented on the potential use of these as part of a city-led aquifer management education program (Strandfontein Aquifer Park, Cape Flats Aquifer).

The neighbouring school has also identified opportunities for its use. Following mowing, the school made enquiries to use a section of the pond for an end of year function. 'Guardians of the Pond' educational workshops – using educational workbooks designed and printed by the research team - have also been held, following a suggestion by the principal from the neighbouring Primary School who recognised the potential of the pond as a learning opportunity for grade 7s, (12-year-olds) (Figure 8). Further discussions are continuing to establish how this could be turned into an annual event and offered to other educational institutions in the area. It has therefore been recognised that whilst BGI that uses NbS can be easily retrofitted into these ponds using cost-effective, low-tech solutions, it is essential to consider the activation in context for its long-term sustainability, by providing for instance, outdoor classroom opportunities or even green economy learning opportunities. In this regard, the rehabilitation using locally indigenous planting complemented by the dual-purpose landscape elements such as concrete weirs and protective stepping stone bollards has helped to complement the BGI using an NbS vision for these ponds by curating engagement opportunities.



Figure 8. Study site in use as 'Guardians of the Pond' nature education workshop for primary school children (Source: Authors, 2025)

DISCUSSION

Reframing BGI in the Global South

The transformation of Cape Town's ~250 mono-functional, engineered stormwater infrastructure must be understood within the historical and spatial trajectory of the Cape Flats, where apartheid policies and modernist town planning forcibly relocated communities of Colour to the urban periphery. Designed primarily as mono-functional, sloped basins to manage seasonal winter flood risks, these sites are legally zoned for public open space. In daily practice, rigid institutional boundaries and socio-spatial marginalisation have rendered this infrastructure largely invisible to surrounding residents. At the scale of the Cape Flats, these engineered solutions have created an expansive, fragmented and undervalued green landscape. Crucially, these structural inequalities extend directly into the ecological realm. This systematic ecological "Green Apartheid" (Venter et al, 2020) leaves marginalized communities with severely diminished access to vegetated, functional public open space with biological and socio-economic value.

Work at the study site suggests that, from a Global South city perspective, transforming a landscape with NbS requires not only enhancing the biodiversity but also creating recognisable engagement opportunities that can in turn, contribute to the transition of mono-functional stormwater pond infrastructure into BGI. It requires recognising links in the urban landscape between, firstly, BGI as a

406 water sensitive stormwater strategy that uses NbS, and secondly, acknowledging people as part of
407 this infrastructure.

408 *Blue-Green Acupuncture*

409 Adopting Krauze & Wagner's conceptualization of BGI as the "*implementation instrument for NbS*"
410 (2019, p. 698) we liken the transitional process to transform Cape Town's monofunctional
411 stormwater pond infrastructure as 'Blue-Green Acupuncture'; regarding BGI as conceptual
412 powerlines, and nature and NbS as the potential power that courses through it to provide numerous
413 multifunctional environmental, ecological, social and economic benefits.

414 This Blue-Green Acupuncture framework strategy builds on Lerner (2014) and the urban
415 acupuncture concept. It refers to an active, rather than purely passive engagement focus for these
416 stormwater ponds, imagining a diversity of relationships being punctured through between natural,
417 urban and cultural systems, and the co-creation of landscape elements that could build on the notion
418 of cues. The framework is process rather than product driven, where the framework:

419 - imagines resilience as an interconnected system that encompasses all non-living and living
420 networks, recognising people and ponds as part of these systems;
421 - acknowledges that nature cannot be re-created in the urban landscape, but that it is possible
422 to physically shape and create opportunities for engagements and relationships with natural
423 systems;
424 - proposes bringing critical functionality back into the urban landscape to provide landscapes
425 that work both ecologically and as part of urban green space; and
426 - recognises their potential to enhance biodiversity whilst also providing educational, cultural
427 and economic opportunities in the urban landscape.

428 The Blue-Green Acupuncture conceptual framework envisages several key ideas and
429 interventions and relies on processes of *puncturing*, *curating* and *linking*, described in the following
430 sections and illustrated diagrammatically in Figure 9.

Puncturing processes: Enhancing Biodiversity in Ponds

The intervention as part of this research focuses on the conceptual 'puncturing' of the surface of a stormwater pond as part of its transition into BGI to enhance the biodiversity of the landscape surface. Puncturing is not about implementing expensive landscaping features but rather, as in 'acupuncture', releasing the power of stormwater ponds within the urban landscape using minimal but strategic interventions. This process recognises opportunities as well as limitations from a natural, social and economic context and is informed by the need for cost effective, contextual strategies.

It firstly envisages, based on the retrofitting at the study site, the physical puncturing of the landscape to promote infiltration of stormwater and enhance biodiversity with the focus on improving ecosystem stability in the face of growing climate change concerns. Rather than recognising biodiversity benefitting *from* BGI, it specifically focuses on planning and providing biodiversity *for* BGI using NbS (Molné et al., 2023).

Secondly, the puncturing intervention recognises that biodiversity cannot exist without considering the role of people in these urban landscapes. BGI that incorporates enhanced biodiversity might well have the potential to provide numerous environmental, ecological, social and economic benefits, but these might be perceived as indirect and less tangible to those who live within the vicinity of these systems. This has consequences for their sustainability in the short and long term. People are part of this infrastructure; they can enhance it or they can damage and destroy biodiversity, with socioeconomic rather than socioecological agendas often driving how people engage with natural systems (Balbi et al., 2019; Cumming et al., 2014). The research at the study site supports the assertions of Ernstson and the need for innovative approaches and a "*new way of knowing and being in relation to urban green spaces*" (2013, p. 5) to enhance and protect biodiversity that contributes to BGI. Findings at the study site support the need for intermediary organizations that can assist with the sharing of knowledge and skills, hosting educational workshops, providing locally indigenous planting, as well as stewarding and maintaining these

457 landscapes (Ernstson, 2013). This is the puncturing process, envisaging people entering the pond
458 landscape to engage with it while acquiring knowledge and skills specific to it.

459 *Curating processes: Creating Cues to Engage*

460 Curating in this context refers to the processes within these stormwater pond landscapes to create
461 conditions and cues for engagement with the locally indigenous vegetation that might otherwise be
462 associated with the untended or neglected empty sites.

463 Participation in BGI that uses NbS requires a relational consideration between the pond
464 landscape and people, co-creating and transforming the landscape to create recognisable
465 engagement opportunities that contribute to the transition of mono-functional stormwater pond
466 infrastructure into multi-functional BGI. In his paper, 'The Landscape of Things', Kullmann (2018)
467 considers how the concept of landscape has changed from being an active agent in cultural practice
468 to being viewed as a physical 'thing' or an object. Acknowledging that it is unlikely that "*landscape-*
469 *thingness*" (2018, p. 66) can be revived or recreated, landscapes can however still serve as catalysts
470 or generative mechanisms with causal powers in how people interact with them. While the
471 landscape itself is not an actor, we as agents can shape it to communicate, as Barthel & Isendahl
472 (2013) suggest, using landscape elements as mnemonic prompts. In Messy Ecosystems, Orderly
473 Frames, Nassauer refers to "cues to care" (1995, p. 167) and the consideration of the appearance of
474 these ecological landscapes, that visually demonstrates a human intention to care for them. In these
475 landscapes, 'cues to care' can also become 'cues to engage' that can vary depending on the
476 objective.

477 The research at the study site has demonstrated how stormwater pond infrastructure
478 comprising engineered elements such as inlets and outlets within basins could be retrofitted using
479 NbS without compromising their functionality, to also create experiential, educational or cultural
480 engagement opportunities. Water-related features such as weirs where water can be dammed can
481 create diverse habitats and provide areas of interest, whilst perimeter protection concrete bollards,

designed as stepping-stones can also provide social-ecological mnemonics and 'cues to engage' whilst contributing to a particular pond infrastructure materiality.

Linking processes: Recognising inter-relationships with urban context

Linking recognises that converting mono-functional stormwater ponds into locally indigenous biodiverse multi-functional BGI requires the acknowledgement and accommodation of a variety of inter-relationships that flow across the ecosystem as green landscapes. Stormwater ponds across the Cape Flats vary in size, from large to small, and in function (detention or retention) with each having different hydrogeological conditions that can influence how they perform at the local and catchment scale. Their urban context will vary too: a stormwater pond located near a busy commercial centre requires a different response to a pond embedded in a neighbourhood made up of many communities driven by a variety of agendas and with differing opinions on how ponds might be used. For example, a pond located in close proximity to a nature reserve would require different consideration to ponds in a dense urbanised setting.

Stovin & Ashley (2019) refer to a land-use planning approach to spatially integrate the water sensitive resource management capacity of BGI into settlements. This land-use approach is problematic though as it focuses on the separation of land use and urban activities. It ignores the role of context and is considered partially responsible for many of the problems on the Cape Flats that include a fragmented green landscape with high levels of poverty, unemployment and inequality (Dewar, 2016). Furthermore, the land-use approach is limiting especially in recognising the multiple uses of BGI in isolation from their surroundings, particularly when there are so many variables.

Ahern, Cilliers, & Niemelä (2014) motivate for the planning and design of multi-functional landscapes to meet both the conservation of biodiversity whilst addressing significant social development issues (Anderson et al., 2020). This however requires recognising not only a pond's potential to contribute to enhancing locally indigenous biodiversity in relation to its location but also recognising its urban location and its potential to create and enable access to opportunities that might complement its biodiverse landscape. Instead of separating land-use and activities, the linking

process seeks to reconcile them. As these stormwater ponds can differ in shape, size, function and location, it proposes specific principles to guide their potential roles.

The first principle recognises stormwater ponds and their associated catchments, working together as a connected network that is focused primarily on ensuring the ecological functioning of these locally indigenous biodiverse landscapes in relation to existing 'reserves of nature'. For example, stormwater ponds could contribute as an ecological network of biodiverse stepping stones across the urban green landscape, connecting to larger nature reserves (Dramstad, Olson, & Forman, 1996).

The second principle recognises stormwater ponds and their associated catchments, working together as a connected network at micro, district and city scale. It recognises the design device of urban structure to enable the organization of activities; hierarchy of movement correlates with the hierarchies of public open space as green infrastructure. More important public open spaces therefore correspond with movement routes connecting more neighbourhoods (Dewar, 2016; Dewar & Todeschini, 2004).

The third principle proposes that these stormwater ponds be identified for their specific ecological role that could complement the local urban context and be stewarded in addition to being maintained. This presents an opportunity for what Marin & de Meulder (2018) refer to as the regenerative resource landscape. Acknowledging and stewarding these ponds in this manner could also contribute to enhancing the green economy; plant cuttings could be used for traditional herbal remedies or even to supply nursery stock.

The fourth principle sees the accommodation of informality as being key in the associated social, economic, educational and cultural opportunities these landscapes might provide (Rodina, Harris, Ziervogel, & Wilson, 2024). Stormwater ponds, transformed as part of BGI that uses NbS have the potential to serve numerous uses - for mental and physical health benefits such as recreation, nature play, nature education and community gathering, amongst others. Accommodating informality and permitting a level of flexibility of uses that complement BGI could

provide greater access to opportunities. Suggestions at the study site perimeter included its occasional use as a market space, or as a temporary nursery.

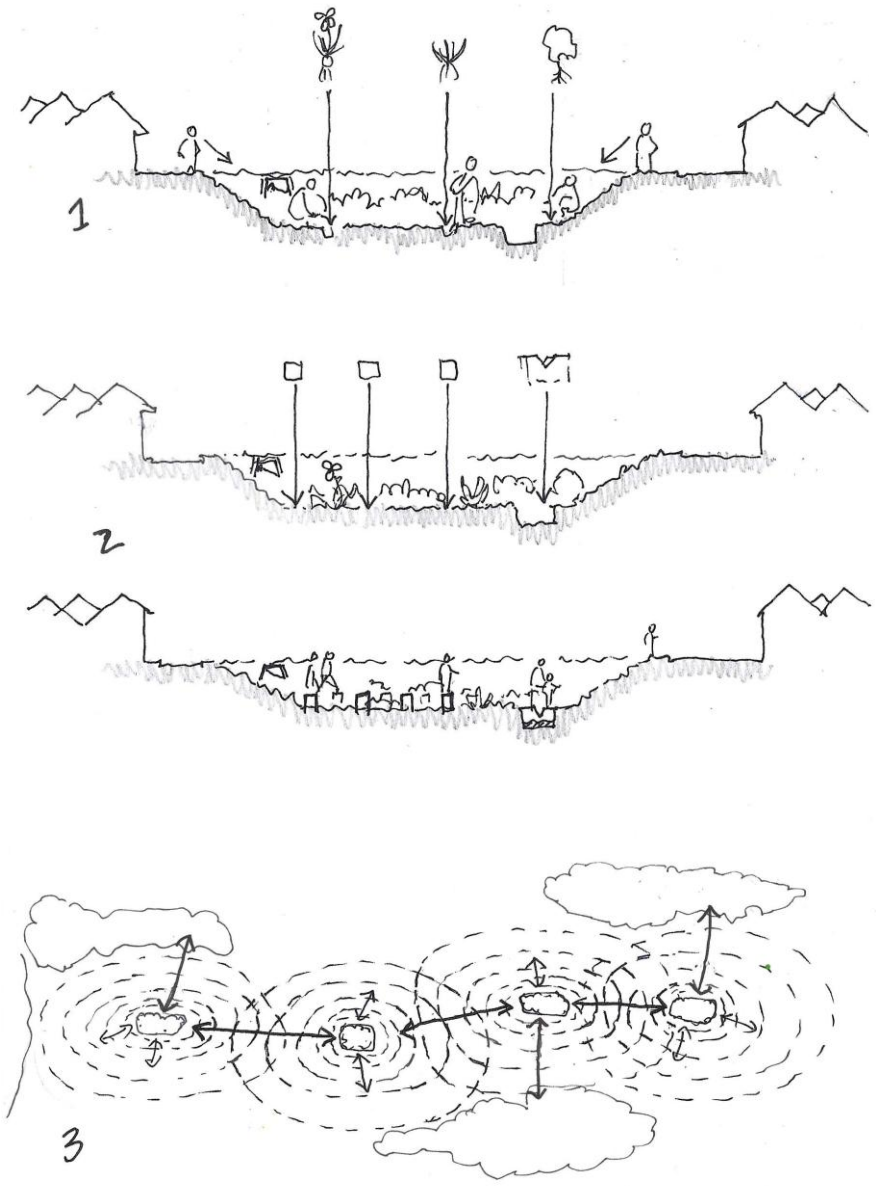


Figure 9: Blue-Green Acupuncture Conceptual Framework Diagram illustrating: 1 – Puncturing, 2 – Curating, and 3 – Linking, processes

CONCLUSION

Cape Town's ambition to implement a Water Sensitive City vision by 2040 requires the embracing of water sensitive strategies that include optimising the use of green infrastructure towards SDG 11 (Sustainable Cities and Communities). Beyond their hydrological function, stormwater ponds

546 represent an underutilised public asset capable of supporting more equitable access to biodiversity,
547 environmental education and climate resilience. The Blue-Green Acupuncture framework
548 demonstrates how strategic implementation can transform overlooked or silent infrastructure into
549 multifunctional landscapes that generate ecological, social and civic value in historically underserved
550 urban communities. Guided by this, the PaWS research team implemented a series of low-cost,
551 context-sensitive interventions over a five-year period at a study site in Mitchells Plain. Involving
552 local stakeholders, interventions included the construction of an infiltration trench, the enhancement
553 of habitat biodiversity using locally indigenous planting, public art, interpretive signage, pathways, a
554 multifunctional weir structure and stepping-stone bollards to transform a mono-functional
555 stormwater pond landscape.

556 Findings indicate that these interventions enhanced biodiversity, increased awareness of the
557 pond's environmental functions, and created new opportunities for community engagement and
558 stewardship. Key to the implementing of NbS, and the delivery of ecological and social benefits as
559 part of a BGI strategy, was however the co-creating of these landscapes to reveal the hidden
560 infrastructure within the stormwater pond. This meant recognising biodiversity but also,
561 importantly, the opportunities for recognisable engagement opportunities within this NbS landscape,
562 such as a multi-functional weir structure and stepping-stone bollard retrofits that provided cues to
563 engage and played an important role in the transition of this mono-functional stormwater pond
564 infrastructure into BGI.

565 Further research is required to measure the actual enhancements to biodiversity, associated
566 decreases in maintenance costs, potential savings from mowing and the possible regenerative
567 resources, such as medicinal plants, floriculture, and so on, that these landscapes could offer in their
568 urban context. The concept of Blue-Green Acupuncture however provides a framework for
569 transitioning stormwater ponds into multifunctional green landscapes. It offers a practical approach
570 for adapting existing mono-functional stormwater infrastructure to support water sensitive urban
571 development using NbS approaches in resource-constrained cities of the Global South.

572 **REFERENCES**

573 Ahern, J., Cilliers, S., & Niemelä, J. (2014). The concept of ecosystem services in adaptive urban
574 planning and design: A framework for supporting innovation. *Landscape and Urban Planning, 125*,
575 254-259. doi:10.1016/j.landurbplan.2014.01.020
576 Ahmed, S., Meenar, M., & Alam, A. (2019). Designing a Blue-Green Infrastructure (BGI) Network:
577 Toward Water-Sensitive Urban Growth Planning in Dhaka, Bangladesh. *Land, 8*(9).
578 doi:10.3390/land8090138
579 Anderson, P., Charles-Dominique, T., Ernstson, H., Andersson, E., Goodness, J., & Elmqvist, T. (2020).
580 Post-apartheid ecologies in the City of Cape Town: An examination of plant functional traits in
581 relation to urban gradients. *Landscape and Urban Planning, 193*.
582 doi:10.1016/j.landurbplan.2019.103662
583 Balbi, S., Selomane, O., Sitas, N., Blanchard, R., Kotzee, I., O'Farrell, P., & Villa, F. (2019). Human
584 dependence on natural resources in rapidly urbanising South African regions. *Environmental research*
585 *letters, 14*(4), 44008. doi:10.1088/1748-9326/aafe43
586 Barthel, S., & Isendahl, C. (2013). Urban gardens, agriculture, and water management: Sources of
587 resilience for long-term food security in cities. *Ecological Economics, 86*, 224-234.
588 doi:10.1016/j.ecolecon.2012.06.018
589 Castaldo, A. G., Nocentini, M. G., Lemes de Oliveira, F., & Mahmoud, I. H. (2025). Nature-based
590 solutions and urban planning in the Global South: Challenge orientations, typologies, and viability for
591 cities. *Land use policy, 150*. doi:10.1016/j.landusepol.2024.107439
592 City of Cape Town. (2020). *Cape Town Water Strategy*. City of Cape Town
593 Clarke, A. E. (2003). Situational Analyses: Grounded Theory Mapping After the Postmodern Turn.
594 *Symbolic interaction, 26*(4), 553-576. doi:10.1525/si.2003.26.4.553
595 Clarke, A. E., Friese, C., & Washburn, R. (2015). *Situational Analysis in Practice: Mapping Research*
596 *with Grounded Theory*: Left Coast Press.

Cumming, G. S., Buerkert, A., Hoffmann, E. M., Schlecht, E., Von Cramon-Taubadel, S., & Tscharntke, T. (2014). Implications of agricultural transitions and urbanization for ecosystem services. *Nature (London), 515*(7525), 50-57. doi:10.1038/nature13945

Dewar, D. (2016). A Transformational Path for Cape Town, South Africa. In A. G. Piller, R. Mahayni, & F. Wagner (Eds.), *Transforming Distressed Global Communities* (1 ed., pp. 231-244). United Kingdom: Routledge.

Dewar, D., & Todeschini, F. (2004). *Rethinking Urban Transport After Modernism: Lessons from South Africa* (1 ed. Vol. 1): Routledge.

Dramstad, W. E., Olson, J. D., & Forman, R. T. T. (1996). *Landscape ecology principles in landscape architecture and land-use planning*. U.S: Harvard University, Graduate School of Design.

Drosou, N., Soetanto, R., Hermawan, F., Chmutina, K., Bosher, L., & Hatmoko, J. U. D. (2019). Key Factors Influencing Wider Adoption of Blue–Green Infrastructure in Developing Cities. *Water, 11*(6). doi:10.3390/w11061234

Ernstson, H. (2013). *Re-translating nature in post-apartheid Cape Town : The material semiotics of people and plants at Bottom Road*. Paper presented at the Centre for Development Informatics Institute for Development Policy and Management, SED University of Manchester, Arthur Lewis Building, Manchester, M13 9PL, UK. http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-145917

Kimic, K., & Ostrysz, K. (2021). Assessment of Blue and Green Infrastructure Solutions in Shaping Urban Public Spaces—Spatial and Functional, Environmental, and Social Aspects. *Sustainability (Basel, Switzerland), 13*(11041), 11041. doi:10.3390/su131911041

Krauze, K., & Wagner, I. (2019). From classical water-ecosystem theories to nature-based solutions — Contextualizing nature-based solutions for sustainable city. *The Science of the total environment, 655*, 697-706. doi:10.1016/j.scitotenv.2018.11.187

Kullmann, K. (2018). The landscape of things. *Journal of Landscape Architecture, 13*(1), 58-67. doi:10.1080/18626033.2018.1476033

Lerner, J. (2014). *Urban acupuncture*. Washington [D.C: Island Press.

623 Marin, J., & De Meulder, B. (2018). Urban landscape design exercises in urban metabolism:
624 reconnecting with Central Limburg's regenerative resource landscape. *Journal of Landscape*
625 *Architecture, 13*(1), 36-49. doi:10.1080/18626033.2018.1476031
626 Mauck, B. A. (2017). The capacity of the Cape Flats aquifer and its role in water sensitive urban
627 design in Cape Town. In: University of Cape Town.
628 McLachlan, J., Tanyanyiwa, C. T., Schneuwly, R., Carden, K., Armitage, N. P., Abrams, A., Mguni, P., &
629 Herslund, L. B. (2023). Pathways to water resilient South African cities – from mono-functional to
630 multi-functional stormwater infrastructure. *Scientific African, 20*. doi:10.1016/j.sciaf.2023.e01674
631 Molné, F., Donati, G. F. A., Bolliger, J., Fischer, M., Maurer, M., & Bach, P. M. (2023). Supporting the
632 planning of urban blue-green infrastructure for biodiversity: A multi-scale prioritisation framework.
633 *Journal of environmental management, 342*, 118069. doi:10.1016/j.jenvman.2023.118069
634 Nassauer, J. I. (1995). Messy Ecosystems, Orderly Frames. *Landscape journal, 14*(2), 161-170.
635 doi:10.3368/lj.14.2.161
636 O'Donnell, E. C., Netusil, N. R., Chan, F. K. S., Dolman, N. J., & Gosling, S. N. (2021). International
637 Perceptions of Urban Blue-Green Infrastructure: A Comparison across Four Cities. *Water (Basel),*
638 *13*(4), 544. doi:10.3390/w13040544
639 Okedi, J. (2019). *The prospects for stormwater harvesting in Cape Town, South Africa using the*
640 *Zeekoe Catchment as a case study.* (Doctor of Philosophy (PhD)). University of Cape Town,
641 Pereira, P., & Baro, F. (2022). Greening the city: Thriving for biodiversity and sustainability. *Sci Total*
642 *Environ, 817*, 153032. doi:10.1016/j.scitotenv.2022.153032
643 Rodina, L., Harris, L., Ziervogel, G., & Wilson, J. (2024). Resilience counter-currents: Water
644 infrastructures, informality, and inequities in Cape Town, South Africa. *World Development, 180*,
645 106619. doi:https://doi.org/10.1016/j.worlddev.2024.106619
646 Rohrer, A. R. (2017). *The viability of using the stormwater ponds on the Diep River in the Constantia*
647 *Valley for stormwater harvesting.* (Master of Science in Civil Engineering MSc. (Eng)). University of
648 Cape Town,

649 Stovin, V., & Ashley, R. (2019). SuDS/BMPs/WSUD/SCMs: convergence to a blue-green infrastructure.
650 *Urban Water Journal, 16*(6), 403-403. doi:10.1080/1573062X.2019.1685229
651 UNWWAP. (2018). *The United Nations World Water Development Report 2018: Nature-based*
652 *Solutions for Water*: UN.
653 Venter, Z. S., Shackleton, C. M., Van Staden, F., Selomane, O., & Masterson, V. A. (2020). Green
654 Apartheid: Urban green infrastructure remains unequally distributed across income and race
655 geographies in South Africa. *Landscape and Urban Planning, 203*.
656 doi:10.1016/j.landurbplan.2020.103889.