Towards Liveable Neighbourhoods by Redesigning Using Water Sensitive Design

Report to the Water Research Commission

by

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"A Water Sensitive Settlement is one that is steered by a conscious and connected community of people, animals, plants, and organisms. There is a deep reverence shared between communities for the water that flows from the Mountains, nourishing the valley, waiting in the Wetlands and Estuary, and sheltering the Bay. Humankind shows restraint when using gifts from the river and wetland. Water is not wasted. Water is celebrated and respected. Property owners take responsibility in ensuring that the gifts from water bodies are equally shared among all community members. There is a genuine balance of give and take between nature and humans. Human guardians of the river ensure that water bodies stay healthy and always able to regenerate".

Donna Shefer on what a water sensitive settlement can look like in Hout Bay

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Executive Summary

Background and Motivation

This study was executed in Cape Town, a city that is arguably a microcosm of contemporary global challenges. Segregated apartheid colonial planning resulted in an atomised spatial geography. Cape Town's main water sources are far away. The city is water-stressed. This was brought to the world's attention in 2016-2017 with the impeding threat of Day Zero – the day when taps in buildings would run dry. A world class city with massive inequality, Cape Town is home to numerous informal settlements with poor levels of water and sanitation services. The informal settlements are exposed to winter floods and summer fires. Aging and overstrained infrastructure cannot cope with the formal areas, let alone meet new needs in the informal settlements. At current growth rates, water demand is projected to double every 25 years. And according to some estimates, the footprint of the city grows annually by some 650 hectares – destroying rich biodiversity and agricultural lands. Freshwater ecosystems such as rivers and swamps are polluted and pressured by urban development and with global warming, the city's temperature is projected to increase by 1°C by 2050 and by 3°C by 2100.

It is known that Water Sensitive Design (WSD) can regenerate urban catchments to bring multiple benefits, such as enhancing ecological health, securing water resources, increasing recreational opportunities, enhancing ecological and human health, reducing of urban heat island, mitigating floods and offering a range of economic benefits. But how can WSD spatially be integrated in an existing city setting given prevailing constraints? Located in Cape Town, the purpose of this study was to generate spatial WSD proposals that are responsive to the social inequity and informality challenges of a Global South city context.

The empirical context of this study was Hangberg, a low income and informalising neighbourhood located at the edge of a biodiversity conservation area on the slopes of the Sentinel Mountain. Sandwiched between an artificial harbour and the nature reserve, the neighbourhood has limited land for expansion. In Hangberg, the above challenges are heightened, even as population increases naturally and by immigration.

Hangberg neighbourhood is in Hout Bay suburb. The history of Hout Bay suburb is centered around the Hout Bay River. Starting in the 1650s, the natural Hout Bay River Catchment was transformed through farming, lumbering and urbanisation. From the 1930s, advent of the private motorcar made scenic Hout Bay an attractive area for residential development. Hout Bay is today mainly an affluent residential suburb. The fishing, recreation and tourism industries are also important. But the river catchment and the bay are pressured by urban developed. Hangberg and Imizhamo Yethu are two low income enclaves in the otherwise affluent suburb.

Objective

There have been many WSD studies in South Africa. The studies have come up with valuable fit-for-context WSD insights and solutions. But none of the studies have engaged with spatial integration of WSD solutions in a specific urban, environmental, social and legal-institutional context. The goal of this study was to create spatial WSD proposals that are responsive to prevailing contextual factors in a Global South city, including informality. The study intended to generate a set of spatially accurate WSD plans and a set of visualisations for a water sensitive precinct and neighbourhood. The study's target was to formulate compelling and realistic proposals for water sensitive places in Hangberg and Hout Bay.

Key Outcomes

This interdisciplinary study produced mutually supportive packages of knowledge from the fields of anthropology, hydrological engineering, urban planning, urban design and information systems. The study yielded the following key outcomes:

- A hydrological model that demonstrates the flooding mitigating capacity of adding Sustainable Drainage Systems (SuDS) in the Hout Bay Catchment
- A Water Sensitive Spatial Planning (WSSP) proposal for the Hout Bay Subdistrict of Cape Town
- Insights into how low-income residents in Hangberg experience water, space and urban living
- A Water Sensitive Urban Design (WSD) proposal for Hangberg neighbourhood
- An online Decision Support Platform for Water Sensitive Places

Hydrological Study

A hydrological model was used to investigate the feasibility of utilizing SuDS to mitigate flooding in the Hout Bay Catchment. The study made two scenarios: (i) as is (baseline) and (ii) with SuDS. Rainfall and land characteristics were model inputs. The conduits, junctions, storage units and outfalls of the Hout Bay stormwater network were also imputed in the model. Design storms for 5-year, 2-year; 1-year and 6-month return period design storms were simulated. Results indicated a significant flood risk in the Hout Bay River Catchment in the baseline model, especially for 5-year and 2-year design storm events.

In the SuDS Intervention Scenario, 19 swales and 5 detention ponds were introduced in different areas of the catchment. The SuDS greatly reduced the duration of discrete flood events by between 25% (for a 5-year design storm) and 43% (for a 6-month design storm). Moreover, the SuDS improved infiltration and reduced runoff.

Hout Bay Water Sensitive Spatial Planning

The City of Cape Town (CoCT) has started adopting aspects of WSD in its planning at metropolitan scale. But natural areas and water features are scattered on different maps. Moreover, the current land use scheme for Hout Bay omits prominent freshwater ecosystems. On the ground, the public open space in Hout Bay is fragmented and portions of the floodplains are fenced off in private gardens. There is a productive aquifer in Hout Bay catchment which is endangered by insensitive urban development and surface hardening. The catchment is rich in biodiversity in the mountains. But the biodiversity in floodplains, swamps and the estuary biodiversity are under urban development pressure. Contrary to the 2009 Cape Town Floodplain and River Corridor Management Policy, many urban developments in Hout Bay are below the 100-year floodline. In the estuary area, some properties are below the 50-year floodline and there are plans to intensify development.

The study used Water Sensitive Spatial Planning (WSSP) to propose a Hout Bay Subdistrict Spatial Plan (HBDSP) to enhance urban liveability and regenerate nature. The first intervention was a vision for water sensitive Hout Bay:

By 2031 the Hout Bay catchment area will be a healthier and living river that flows from source to sea. Many benefits are provided to the Hout Bay communities through the existence of healthy connected ecosystems. All residents will have access to safe services and infrastructure and reside within a liveable and joyful water sensitive neighbourhood.

The above vision framed WSSP proposals in a set of five maps. The first map proposed realignment of spatial jurisdiction boundaries to bound the entire Hout Bay River Catchment within the Southern District and thus ensure coordinate planning. The second map proposed including the river and its tributaries on the land use map and rezoning to integrate the currently disjointed public open areas. The third map created ecological buffer corridors for the river system, established a protective overlay for swamps and the estuary, and identified the area above the aquifer as a sensitive zone. The fourth map proposed blue-green fingers to extend along the ecological corridors of the river and its tributaries into the mountain.

The fifth map limited development to the existing urban edge. It proposed that the above-mentioned blue-green fingers become multifunctional infrastructure with ecological function, heritage value, public open space, sports fields, recreational areas, tourist attractions and educational opportunities. It further proposed incentivisation of WSD retrofit of existing properties and embedment of WSD solutions in all developments. The map also introduced a Groundwater Sensitive Development Zone. Furthermore, the map proposed that properties near the river and estuary are retrofitted or designed to interact with the water spatially, aesthetically and in ecological function. An Estuary Protected Area was also introduced.

Additionally, the map identified a biodiversity node that is maintained by the Friends of the Hout Bay River (a local community-based organisation) and proposed that it be consolidated. A living lab was proposed within the node to bring together communities and facilitate demonstration, experimentation and innovation of WSD solutions.

Finally, the study developed *Guidelines for Water Sensitive Spatial Planning* that reference the above process and proposals. The guidelines are an 8-step iterative process for planning and implementing solutions for water sensitive cities in the short-, medium- and long terms. Each step is presented graphically and highlights responsible city departments, and fitting roles for community-based organisation and champions. Each step also cites relevant government legislation and helpful literature. The guidelines are framed as an easy-to-use resource for municipal officials, professionals and the general public.

Hangberg Community Voices

Hangberg was established during apartheid. Some Coloured people from Hout Bay were resettled in the Hangberg neighbourhood at the slopes of the Sentinel Mountain in the 1950s. The original residents provided labour to the fishing industry. Expansion of the settlement is restricted by the bay, the Atlantic Ocean and a protected nature area on the steep slopes of the Sentinel. The settlement is separated from the nature protected area by a firebreak which also serves as an important stormwater drain. The genesis of the settlement in forced relocation left an enduring sense of grievance in the community and a distrustful relationship with authorities. Many in the community believe authorities and stifle their initiatives at self-help housing and small-scale fishing.

The natural population of the Hangberg has increased over the years without a commensurate increase in formal housing. The study found that informal shacks are proliferating the area and have been constructed above the firebreak on the steep vegetated slopes. The firebreak is overgrown and ill-maintained. This has exposed the settlement to frequent floods and landslides. In summer, fires are common, and dust is nuisance. Illegal connections to water and sanitation infrastructure overburden the system. Water supply is unreliable and leakage of clean water and sewage occur frequently in the streets.

The study surmised that WSD is an opportunity to regenerate Hangberg into a liveable sustainable neighbourhood. The process should be participatory and place the needs of the most vulnerable first. Government (CoCT) should focus its resources at developing a larger scale catalytic framework for residents to appropriate and develop. The WSD process must not be appropriated by an exclusionary agenda. It must be an opportunity for just urban transitions.

Urban Design

Hangberg mainly contains low-income flats, hostels, and informal shacks. Shacks are encroaching on the ecological areas on the slopes of the Sentinel. There are three urban nodes in Hangberg, but the settlement is not well-serviced by public transport. Pedestrian paths along the steep terrain are improvised and dangerous.

A firebreak ("die sloot") is runs above the 90 m contour line in Hangberg. Informal shacks have infiltrated the environmentally sensitive areas above the firebreak. This endangers biodiversity, renders the settlement prone to floods, landslides, fires and dust. This study recommends that development in Hangberg be limited to the existing urban footprint.

To make proposals for a liveable Hangberg, the study used three urban design strategies: ***connection***, ***place*** and ***resilience.*** The strategies were used to make proposals focused on the performance qualities of equity (access facilities, opportunities and social spaces), balance (between urban needs and environmental needs), integration (between communities and bring nature into urban space), sense of place (enhancing unique qualities of the location), safety and security (tenure, food security, safety from hazards), and efficiency.

The three strategies of connection, place and resilience were used to develop an Integrated Hangberg Urban Design Framework (IHUDF) proposal. The framework thus defined was non-deterministic and was conceived to offer multiple possibilities for the residents of Hangberg to inhabit and develop incrementally. The IHUDF has three key corridors: Harbour Corridor, Green Corridor and Firebreak Corridor. The Harbour Corridor links Hangberg neighbourhood to Hout Bay with a Non-Motorised Transport (NMT) route running from the harbour and penetrating the rest of the suburb along the river. The Firebreak Corridor consolidated the firebreak (die sloot) to protect the nature on the mountain, make the settlement more resilient to floods, landslides, fires and dust. In the Green Corridor proposal, the water in stormwater drain beneath Oude Skip Road was resurfaced to make a bioswale. The bioswale was conceived as a multifunctional piece of WSD infrastructure in Hangberg that connects the biodiversity from mountain to harbour. Along the three corridors, a system of nodes is with positive public spaces was introduced. The final proposal for each Corridor was presented in a map and a creative collage.

A precinct study for the Green Corridor proposed more detailed WSD spatial interventions. Ecological connectivity was enhanced by the bioswale from mountain to sea. And the corridor was designed with welcoming public spaces in the four nodes along it. Each node was illustrated with a collage that suggests options for WSD appropriation by residents.

The above IHUDF and precinct proposals were brought together in new *Guidelines for Water Sensitive Design of a Liveable Neighbourhood*. The step-by-step guidelines are illustrated with the above process and outcomes for a liveable and water sensitive Hangberg. They are resource for urban designs and architects, professionals, city officials and community-based organisations.

Cape Town has embraced aspects of water sensitivity in its spatial plans at metropolitan, district and subdistrict. But this study is the first context responsive study to propose WSD solutions at neighbourhood and precinct scales.

Decision Platform

WSD brings together a diverse range of stakeholders. The stakeholders have varying backgrounds, motives and priorities. This makes communication and attainment of consensus difficult. There is no unified vision for how Cape Town can transition to become a Water Sensitive City. This study designed an online WSD Decision Support Platform to stimulate knowledge exchange and discourse amongst the diverse stakeholder groups in the WSD space. The platform is inclusive, easy-to-use and engaging. It accommodates user-generated content, such as text, images and videos. The platform has the potential to connect stakeholders to evolve a common vision and support communities of discourse and practice for water sensitive living.

Commentary and Recommendations

WSD enhances ecosystems while reconnecting urban spaces and their residents to nature. Water sensitive cities and neighbourhoods offer multiple options for improving urban liveability, including public space, sports fields, recreational areas, tourist attractions, educational opportunities, fresh air and urban cooling.

This study worked within prevailing contextual opportunities and constraints to generate realistic proposals for transitioning Hout Bay Subdistrict and Hangberg into WSD places. Whereas aspects of existing Cape Town policy promote WSD, the study recommends that, to mainstream WSD transitioning in the city, new visionary policy and implementation mechanisms at urban planning and urban design scales must be introduced to complement existing ones.

To speed up WSD uptake, the study further recommends that interdisciplinary and transversal approaches to city planning, urban design and implementation be strengthened. This includes working in the interstitial spaces between institutional departments and involving communities throughout the process.

Furthermore, GIS-bespoke software and data must be utilised to scientifically understand the hydrology of catchments and demonstrate cost-benefit of WSD interventions. In South Africa, many young professionals have been trained in using the above powerful tools for WSD. These young professionals must be employed in consultancies and city departments to inject agility and new life into the drive to water sensitive places.

SuDS are a low-hanging fruit for WSD. The study demonstrated these decentralised nature-based systems have great capacity for flooding. The recommendation therefore is that SuDS be accretionally implemented in neighbourhoods as funds become available. Each SuD system is an excellent opportunity for residents to come together to co-create a piece of green infrastructure that can also be used for recreational purposes.

For water sensitive spatial planning and design, the study recommends four steps: baseline/context study; programme; vision/concept; design/planning. There is no unidirectional cycling through the steps. Rather, the process iteratively shifts between the steps as new information, opportunities and constraints emerge. WSD implementation requires *acupuncture* approach: start with what is possible – however small – but make it impactful and catalytic. A champion is required to coalesce and drive WSD coalitions. The process is not linear – is both reflexive and iterative – meaning an overarching vision, champions who go beyond relatively short-term political cycles.

Maps are a great tool for spatialisation of WSD decisions. City administrative boundaries must be realigned with catchments and micro-catchments to harmonise planning and implementation. Scattered information must be collated in new maps that integrate all freshwater systems and other ecosystems to make visible the interdependencies and how they can inform spatial planning and design. These maps must spatialise natural features, including rivers, wetlands, aquifers, floodplains and estuaries, public spaces and other biodiversity areas. WSD proposals must then be overlaid to protect and boost functioning of these natural ecosystems, while contributing to urban place making and enhancing liveability. Furthermore, the maps must be linked to clear directives and guidelines that articulate responsibilities, funding and enabling legislation in the short, medium and long terms.

Commitment to just transitions requires that WSD works in challenged places like the informalising neighbourhood of Hangberg. Building trust between the community and authorities is a prerequisite for making a broad participatory coalition for transitioning such a place into a liveable neighbourhood that serves residents and in which water and nature are valued and protected. To harness the power of the residents, non-prescriptive WSD spatial frameworks are required at neighbourhood scale. Maps enable spatial precision while

creative collages and three-dimensional compositions free up the residents' imagination to appropriate the framework and implement solutions at the building scale piecemeal.

The decision WSD decision support platform developed in this study is an important resource for bottom-up networking and enhancing conversations and sharing resources and knowledge. The full potential of the platform will only be realised over time. It is therefore recommended that the activating and maintaining the WSD decision support platform is prioritised in the short term.

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List of Acronyms and Abbreviations

CoCT	City of Cape Town
CTMSDF	Cape Town Metropolitan Spatial Development Framework
HBSDP	Hout Bay Subdistrict Development Plan
ICM	Integrated Catchment Management
IHUDF	Integrated Hangberg Urban Design Framework
IUWM	Integrated Urban Water Management
IWRM	Integrated Water Resource Management
LNRP	Liveable Neighbourhood Research Project
NDP	National Development Plan
NSDP	National Spatial Development Plan
PCSWMM	Personal Computer Storm Water Management Model
SDF	Spatial Development Framework
SDSDP	South District Spatial Development Plan
WSC	Water Sensitive City
WSD	Water Sensitive Design
WSSP	Water Sensitive Spatial Planning
WSUD	Water Sensitive Urban Design

Definition of Key Terms

There are two key phrases in this study: (i) water sensitive design (ii) liveable neighbourhood

Water Sensitive Design

Water Sensitive Design (WSD) is "the process of integrating water cycle management with the built environment through planning and urban design. Water Sensitive Urban Design is the process. Water sensitive places are the outcome." (Morgan et al. (2013). This includes water sensitive buildings, water neighbourhoods and water sensitive cities.

Water is a pervasive and omnipresent natural resource that in occurs in the three states of matter at multiple overlapping and nested scales in the global hydrological cycle. Water is indispensable for man's survival and the health of ecosystems (Sanya, 2022).

Sensitive: this alludes to care and responsiveness. The intricate linkages in the hydrological cycle are robust but become fragile in the face of increasing demands from humans, particularly in urban areas where the cycle is disrupted. There is, therefore, a need for humans to interact with water with due care and sensitivity. Contemporary evidence is that the water cycle is susceptible to human interference. Humans must therefore intervene with due care responsiveness in the water cycle.

Design as used in this study mainly refers to spatial-aesthetic fields, specifically urban and city planning and design, architectural design, landscape, urban design; architecture; landscape architecture, etc. This also extended to design an ICTS platform. Understood this way, design is a science and art that fuses formal explicit knowledge with tacit reflexive knowledge in a creative process.

Liveable Neighbourhood

An urban neighbourhood is a distinct geographical area with clear boundaries and with certain shared social and/or urban characteristics within which communal facilities such as schools and recreational areas are provided. A well-designed neighbourhood must respond to nature to enhance sense of place.

Liveability encompasses those qualities that make a city a good place to live, including wellbeing, safety, decent housing, opportunities for employment, good social mix, access to public facilities, multi-modal transport (including public transport), heritage, and respect for nature. A liveable neighbourhood is therefore one with these qualities.

Chapter 1: Introduction

Study Context

Background

Many of Cape Town's contemporary problems are manifest in water stress, inequitable access to water and sanitation services, and degrading natural systems. Segregated apartheid planning resulted in an atomized spatial geography. Cape Town's main water sources are far away. The infrastructure is old, and there are limited resources to maintain, replace and expand it to meet existing needs of the poor and new needs. The threat of Day-Zero during the 2016-2017 was a shock reminder of these issues. Cape Town must use its water resources prudently. This is urgent because climate change will increase the frequency and severity of extreme weather events, including drought. Water Sensitive Design (WSD) can secure water quality and quantity while delivering a multiple range of aquatic ecosystem benefits to people and nature. But most WSD studies originate from the Global North and do not engage with unique challenges of the Global South, such as, informality, constrained financial resources and rapid urbanisation. These unique challenges are reflected in Hangberg, a low-income and informalising enclave in the affluent Cape Town suburb of Hout Bay. Hangberg and Hout Bay were the empirical sites for the study.

Cape Town's water demand growth rate of 3.3% implies doubling of water demand every 25 years. Wasteful water-use patterns predominate. Sewage pollution is also significant problem in the city. For instance, Cape Town discharges partially treated sewage directly into at the sea at Green Point and Hout Bay marine outfalls. The additional capacity required at the wastewater treatment works to accommodate urban growth on the land inside the formal areas is 150 million litres per day. Informal settlements are inadequately serviced. The idea that Cape Town can successfully maintain the currently overstrained infrastructure while doubling infrastructure every 25 years using business as usual centralised infrastructure is not feasible. WSD promotes decentralised and scalable approaches that should become part of the solution (Sanya, 2021).

Cape Town city is currently expanding by 650 hectares annually – destroying habitats and interfering with the natural water cycle. Urban hardening is associated with reduced water infiltration, increased surface runoff and reduced evapotranspiration (Sanya, 2021). This compromises aquatic ecosystems and natural habitats. The increase in amount and speed of surface runoff due to surface sealing increases flood risk in cities. The destruction caused by severe weather events, i.e. loss of life, property and financial losses is usually counted in millions of rands (including disaster preparedness and response, and insurance). The severity and frequency of natural events such as storms and flooding is expected to increase in Cape Town

due to climate change. Surface runoff exacerbates soil erosion and silting of freshwater bodies. Stormwater drainage systems in Cape Town urban areas interfere with natural river profiles. By interfering with evaporation and evapo-transpiration, urbanisation disturbs rainfall cloud formation and rainfall quantity and distribution (Mollison, 1988). Cities are generally warmer than their hinterlands by up to seven degrees because of the urban heat island effect. In Cape Town, there is an expected increase in warming of 1^C by 2050 with potential to increase by 3^C by 2100 (Sanya, 2021).

WSD is a quintessentially interdisciplinary process. The outcome of WSD is Water Sensitive Cities (WSC). WSD aspires to return urban areas to a state that approximates natural water cycles in terms of evapo-transpiration, evaporation, infiltration and runoff. This results in multiple benefits such as: securing water quantity and quality, diversifying freshwater supplies, protecting aquatic ecosystems and biodiversity, improving liveability, increasing flood resilience, reduction of urban heat island.

WSD links to broader umbrellas of Integrated Urban Water Management (IUWM) and Integrated Water Resource Management (IWRM). WSD, IUWM and IWRM cover social, economic and environmental aspects. WSD can be applied to scales of the urban districts, neighbourhoods, precincts and buildings.

This contextually grounded study made WSD proposals for Hout Bay Subdistrict and Hangberg neighbourhood in Cape Town.

State of Knowledge

Motivation

Since the Water Research Commission (WRC) published Water Sensitive Design (WSD) guidelines in 2013 (K5/2071, Armitage et al., 2013), much has been done in terms of context-relevant studies for South Africa. WRC project K5/2412 explored the challenges to and opportunities for the implementation of WSD in South Africa, mainly from single-disciplinary perspectives. The study discovered potentially significant potable water savings using large-scale catchment studies that covered such techniques as rainwater harvesting (RWH) and stormwater harvesting (SWH), sustainable (urban) drainage systems (SuDS), Water Conservation and Water Demand Management (WCWDM), water efficient devices, greywater harvesting, and groundwater use linked to managed aquifer recharge (MAR). Research on individual WSD technologies in South Africa has now achieved a level of maturation. There is a need to extend the above disciplinary perspectives with interdisciplinary investigations into application of WSD in urban space and at scale to (i) meet spatial design targets (ii) fulfil human health and amenity objectives (iii) enhance a full range of ecosystem services (iv) incorporate user-perspectives (v) work within specific contextual spatial

parameters. The main motivation for this study was therefore the need for integrative design research to make spatial WSD proposals for a specific context in Cape Town.

Using an ecosystem services framework, Bhikha (2017) proposed architectural and urban precinct-scale WSD decision-support guidelines for a riverside *greenfield* development. But the current study extended Bhika's guidelines through an interdisciplinary approach with a focus on urban planning and urban design spatial WSD proposals in a *brownfield* site.

WRC study K5/2412 highlighted approval / legislative mechanisms (development approval processes, local government policy and by-laws) as key drivers for WSD in South Africa. For instance, the Cape Town Spatial Development Framework (CTSDF) recognises the need for a shift towards a rationalised, policy-driven land use management system that is more responsive, flexible and policy driven (City of Cape Town – CoCT, 2012). Local spatial land plans should serve as precinct scale mechanisms for safeguarding congruency between new developments on the one hand, and district spatial development plans, by-laws and policies, and zoning schemes on the other. A motivation for this research was therefore to execute designs at district and neighbourhood scales to uncover mechanisms for embedment of WSD in municipal legal, institutional and operational frameworks.

WRC project K5/2412 recognised that ultimately the uptake of WSD is significantly driven by social perceptions particularly around what constitutes acceptable water and sanitation services levels. This highlights the cultural barriers to WSD and alternative water and sanitation systems. For example, changing from a flush to composting toilet may be perceived as taking a step back in development. WSD still operates at the margins of society relative to mainstream engineering approaches. Another motivation was to engage with a local community in a neighbourhood to integrate their perspectives into WSD processes.

Enhancement of WSD and blue-green infrastructure can (but need not) be inconsistent with the urban development objectives of spatial integration, mixed land-use and densification. Historical apartheid spatial imbalances have resulted scattered, segregated, low density urban geographies that are dependent on motorised road travel. The need for spatial integration, densification and mixed-use development in cities is recognised (NSDP, 2006) and the National Development Plan (NDP, 2011). Furthermore, spatial integration, densification, mixed land use, and active street frontages are integral to the CTSDF. Research into how to implement WSD at urban and architectural design levels while simultaneously responding to the objectives of spatial integration, densification and mixed land-use is still needed in the South African context. This study was motivated by the need to contribute to this area of work.

Rationale

Goal

The goal of this study was to create spatial WSD proposals that are responsive to prevailing contextual factors in a Global South city context, including informality. The study intended to generate a set of spatially accurate WSD plans and a set of visualisations for a water sensitive district and neighbourhood. The study's target was to formulate a compelling and realistic vision for water sensitive places in a Global South city. The goal was to articulate possibilities, instigate discourse and guide practice and to attain new insights into WSD for policymakers, practitioners and academics informed by the unique urban contexts of Hangberg and Hout Bay. Furthermore, the study expected to make visual graphic proposals in two- and three-dimensions to demonstrate feasibility of WSD in spatial and functional terms. Additionally, the study intended to develop planning and design WSD guidelines for policy makers, practitioners and academics, Finally, the study intended to develop an online decision-support platform for communities and diverse stakeholders to collaborate and pool available knowledge, skills and resources in the drive for accretional, bottom-up transitioning to water sensitive places.

Objective

The specific objective of the study was to propose WSD spatial interventions that consider urban, biophysical, natural, social and legislative aspects in an existing mixed income location and to develop guidelines for implementation.

Aims

Working in Hout Bay Subdistrict and Hangberg Neighbourhood in Cape Town, the study aimed to

Specific aim 1: Investigate barriers and enablers for WSD within existing legislation, communities, catchments, the built environment and the natural environment.

Specific Aim 2: Make spatial WSD proposals for urban regeneration at precinct, neighbourhood and architectural scales.

Specific Aim 3: Use the spatial proposals to make contextually informed recommendations for policy and practice to drive future WSD uptake.

Specific aim 4: Develop a WSD decision-support platform for use by all WSD stakeholders to use in piecemeal implementation of WSD

Methodology and Approach

The study was interdisciplinary in nature. A grounded theory approach was used to frame the study methods of ethnography, computer modelling and research by design.

Geographical Scope

The focus of the study was using WSD approaches to develop spatial urban design proposals for Hangberg neighbourhood. Hangberg is in Hout Bay, a suburb to the southwest of Cape Town city centre. For context, the study also made an urban proposal for Hout Bay to ensure integration of ecological and urban system interactions between the smaller- and large-scales.

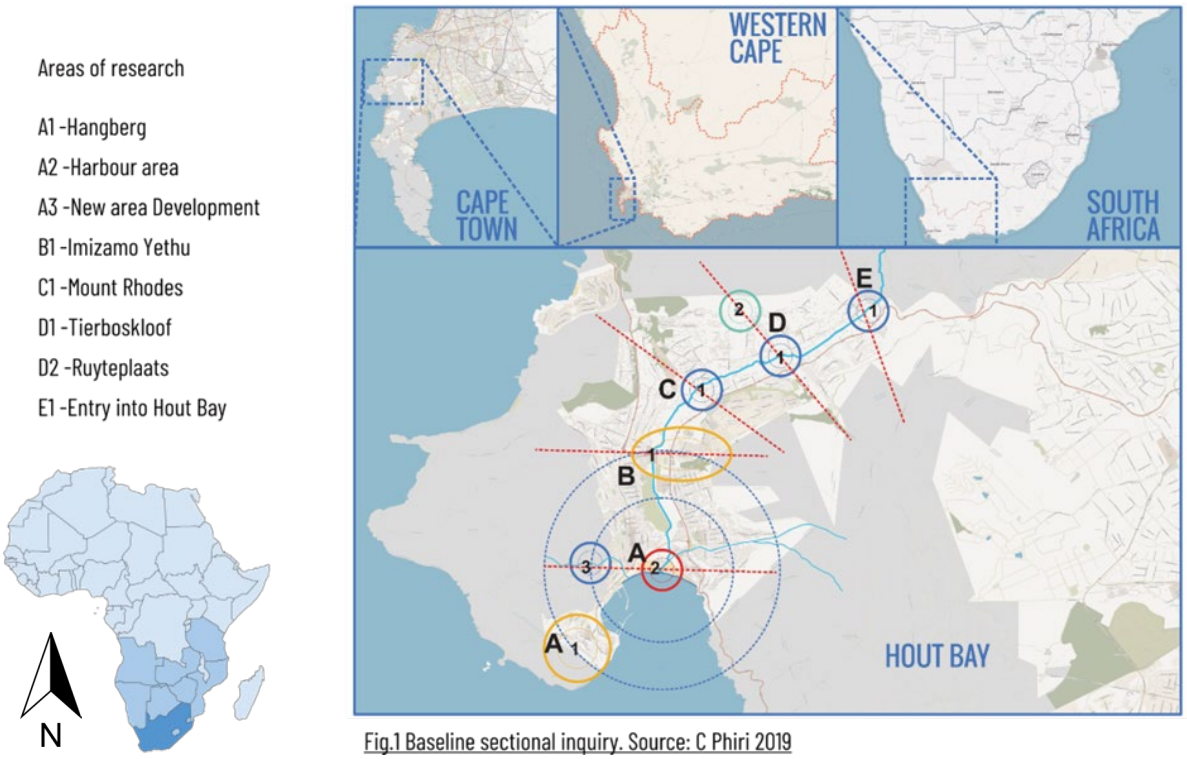


Fig.1 Baseline sectional inquiry. Source: C Phiri 2019

Figure 1: Geographical Context and Scope. (C Phiri, 2021) Main focus is Hangberg Neighbourhood (A1 on the map. See also Chapter 7).

Figure 2: Site Section through Hangberg harbour area LN Deliverable 3, 2019

A continuation of the study was looking at architectural scale – at a scale level below the neighbourhood. Concurrent with the spatial studies, an ICT decision support platform was developed. Thus, spatially scoped and focused, the study brought together streams of knowledge from hydrological engineering, sociology (environmental humanities), urban planning, urban design, architecture and information systems.

Report Outline

Chapter 2 provides a literature review and background on WSD. Chapter 3 frames the research by establishing methodology for the overall study and its respective components. Chapter 4 presents the hydrological study outcomes. Chapter 5 focuses on water sensitive spatial planning for Hout Bay. Chapter 6 presents sociological insights and urban design proposals for Hangberg. In Chapter 7 a decision support platform for WSD is presented. Finally, Chapter 8 gives the study's main conclusions and recommendations for further research.

Sustainability

Water Sensitive Design (WSD) is encompassed broadly under sustainability. Sustainability has a long history dating back to pre-historic societies and their holistic attitudes to life, such as the magical worldview. Science and its reductivist worldview took hold in the 16th and 17th Century concurrently with the development of capitalism (Pepper, 2019; Bernstein and Gardner, 2004). The agricultural and industrial revolutions multiplied forces of production, disrupted rural areas and spurred urbanization (Frampton, 2020). In search of raw-materials and new markets, Europe moved to colonise vast territories in all continents. The agricultural and industrial revolutions resulted in rapid population growth and increased standards of living (particularly in the Global North). The Great Acceleration started in the 1950s. The Great Acceleration was spurred by vast increases in population, real GDP per capita, industrial production and consumption (McNeill and Engelke, 2016). The second agricultural revolution of the 1960s saw further increase in agricultural production fed by selective breeding, fertilisers, irrigation and pesticides. The effects of unbridled industrialization and rational large-scale agriculture came with environmental and social costs. The Great Acceleration characterized by exponential growth in consumption of non-renewable raw-materials (like fossil fuels) and pollution of land water and air. Because of these massive changes, the 1950s are proposed as one of the possible starting periods of the Anthropocene – an age in which human activity is the main driver of change in the structure and functioning of the earth's systems. This period also comes with socio-economic contradiction between the affluent Global North and the poverty-stricken Global South. They are further reflected in inequality within countries as well as the informal/formal divide in cities. Up to 40% of people in Global South cities live in informal settlements. These issues are particularly acute in South Africa, which, according to the World Bank (2022), is the most unequal country in the world with a consumption per capita Gini coefficient of 67% in 2018.

In the 1960s, a number of publications and grassroots movements confluenced in opposition to the widespread environmental and socially environmentally destructive and socially unjust production practices. Tansley (1935) had proposed the term ecosystem to describe the complexities of nature. He defined an ecosystem as an interactive system of living things and their nonliving habitat. Developing the ecosystem concept, Eugene and Howard Odum laid the foundation for ecology as modern science in the 1950s and 1960s (see Mang and Reed, 2020). Rachel Carson's *Silent Spring* (1962) warned that agricultural pesticides (DDT) were building up in natural systems and the food chain. Meadows et al. (1972) argued, with mathematical models, that there are limits to industrial, agricultural and population growth. In

juxtaposition to scientific reductivism, Lovelock and Margulis (1974) proposed that earth is a single holistic organism, a Gaia.

The Brundtland Commission (1982) defined sustainable development as development that fulfills the needs of current generations without compromising the ability of future generations to fulfill their own needs. This definition has been criticized as anthropocentric "shallow ecology" in contradistinction to ecocentric "deep ecology" (see Sanya, 2007).

Nevertheless, the UN has speared-headed global institutionalised efforts for sustainability. In 1992, at the Earth Summit in Rio de Janeiro more than 178 countries adopted Agenda 21 to build a global partnership for sustainable development. In 2000, at a summit in New York the UN adopted the Millennium Declaration and elaborates eight Millennium Development Goals (MDGs) to reduce extreme poverty by 2015. In 2002 the Johannesburg Declaration on Sustainable Development and Plan of Implementation was adopted. In the 2002 United Nations Summit, Johannesburg distinction was made between Green and Brown Agenda. Green Agenda was described as preoccupied with environmental issues particularly in the Global North. The Brown Agenda deals with poverty and inequality as experienced in the Global South.

The Rio+20 Conference in Rio de Janeiro initiated a process to develop a set of Sustainable Development Goals (SDGs). The 2030 Agenda for Sustainable Development, with 17 SDGs, was adopted at the UN Sustainable Development Summit in New York in 2015. The multiple benefits of WSD contribute to the objectives of resilience, sustenance and environmental protection that underpin the 17 goals. The Sendai Framework for Disaster Risk Reduction and the Paris Agreement on Climate Change were adopted in 2015.

Designing with Nature

In Garden Cities of Tomorrow, Howard (1902) demonstrated an urbanisation model that balances nature and the built environment to create interconnected compact centres surrounded by nature and agricultural land. Geddes (1915) argued nature and decent housing must are indispensable to good city design to enhance workers' wellbeing, improve productivity and hence guarantee the city's economic vitality (see Sanya, 2022). McHarg (1969) laid the base for an ecological approach to urban landscape design. McHarg's basic concepts were eventually developed into today's geographic information systems (GIS) (see Mang and Reed, 2020).

In 1978, Bill Mollison, an Australian ecologist, and one of his students David Holmgren coined the word *permaculture* from a contraction of permanent agriculture or permanent culture. Drawing from indigenous knowledge systems and the study of nature, they developed design

techniques and practices for increasing self-sufficiency in communities and securing food yields while reducing dependence on environmentally destructive industrial practices

Mollison (1988) proposed that lifestyle should be based on profound understanding of nature. He also gave practical tools for tapping into natural forces to maximise yields and minimize wasteful energy flows. He proposed limiting human impact by using productive boundaries zones to progressively transition from domestic buildings, through tamed ecosystems to wilderness. He introduced the terms regenerative, generative, and degenerative as a framework for assessing the value of human practice. Local water flows, topography, flora and fauna are the generating elements of permaculture. John Tillman Lyle (1984) published Design of Human Ecosystems. He argued that "designers must understand ecological order operating at a variety of scales and link this understanding to human values if we are to create durable, responsible, beneficial designs." (quoted in Mang and Reed, 2020). Permaculture and regenerative thinking overlap therefore with water sensitive design at its different scales.

In 1994, John Tillman Lyle established the *Center for Regenerative Design* in California and published a book on *Regenerative Design for Sustainable Development*. In regenerative design, the aim goes beyond mere minimisation of environment resource consumption to actively working to enhance the functions and vitality of natural systems (Mang and Reed, 2020).

Mostafavi (2010) proposed ecology urbanism as a design approach that harmonises human and ecosystem needs. Bhika (2017) combined ecological urbanism with an ecosystem services framework to define imperatives for WSD.

Water Sensitive Design (WSD)

Fletcher et al. (2019) describe evolution of WSD simultaneously in Australia, UK and USA starting in the 1960s. In the USA, the term used was Low Impact Development (LID) or Low Impact Design Development (LIDD) while in the Australia and UK the term was Water Sensitive Urban Design (WSUD). Armitage et al. (2014) arguing that WSUD excludes rural areas, proposed for adopting the term Water Sensitive Design (WSD) for the South African context. Hence, this study uses the term WSD throughout.

Water Sensitive Design (WSD), or Water Sensitive Urban Design (WSUD), is an interdisciplinary approach to urban water management that offers practical strategies to improve the health of freshwater ecosystems while simultaneously enhancing water security within cities or neighbourhoods (Armitage et al., 2014; 2018; Fletcher et al., 2015). It focuses on improving the relationship between the built and natural environment (Cuevas et al., 2015; Rohr et al., 2014; Wong et al., 2000; Furlong et al., 2019). WSD aims to secure and enhance city freshwater

supplies, and aquatic ecosystem services. WSD operates at a full range of scales in the city from the building to metropolitan scale and to the hinterland catchments beyond. WSD synergies with other holistic approaches to urban water management. These are Integrated Urban Water Management (IUWM), Integrated Catchment Management (ICM). These approaches are founded on values and principles that acknowledge the interconnectedness of water, land, humans, and other living systems.

Integrated Urban Water Management (IUWM) is nested within the broader umbrella of Integrated Water Resource Management (IWRM) (Bahri, 2011). These approaches move away from the traditional centralised, linear, and technocratic water management approach, towards an integrated and systems-based approach that has multiple objectives (Armitage et al., 2014; Putri, 2019). To achieve this, IWRM/IUWMs is built on three principles, namely, social equity, economic efficiency, and environmental sustainability (Ashton, 2000; Bahri, 2011; Hassing, 2009).

Integrated Catchment Management (ICM) is a concept that deals directly with water management within the unit of a catchment area (Ashton, 2000; Fenemor et al., 2011; GWP, 2011). Lundberg et al. (2005:6) describe this concept as a "a specialized discipline of planning that deals with planning for and managing natural and [human-made systems that are typically contained within watersheds (river catchment area) and which include hydrologic, biological, economic, and political systems" (Lundberg et al., 2005:6).

Water Sensitive City

A Water Sensitive City (WSC) is an aspiration and end-state of Water Sensitive Design (Wong et al., 2013). Water sensitive cities are sustainable, resilient, productive and Liveable through a combination of physical and natural infrastructure, governance arrangements and social engagement.

Brown et al. (2016), propose a water-sensitive city framework with six overlapping states: water supply city, sewered city, drained city, waterways city, water cycle city, and water-sensitive city. Each city state is associated with a set of sociopolitical drivers (demands and expectations) and a set of service delivery functions. Within each phase, change must occur within five domains: actors (individual networks of people); bridges (formalized or semi-formalised organisations, structures, and processes that facilitate collaborations); knowledge (scientific understanding and contextualised local knowledge); projects (experiments and demonstrations); and tools (such as legislative and regulatory instruments, market mechanisms, to help embed the new practice).

However, Armitage et al. (2014) point out that this process will not look the same in a city in a Global South country such as South Africa. Cities in such countries have starkly different settlement typologies that have huge discrepancies in service delivery and infrastructure The needs of informal settlements differ markedly from the needs of formal settlements in their transition towards water sensitive settlements. They therefore proposed a bifurcated framework which acknowledges the uniqueness of informal and formal areas but with the ultimate objective of convergence into a Water Sensitive City. Transition towards WSC's in South Africa is hampered by the institutionally fragmented and siloed municipal authorities and the historical way of thinking that views stormwater as a burden on urban settlements (Armitage et al., 2018). This indicates the need for a paradigm shift in how practitioners of the built environment view and perceive stormwater and other natural water resources in cities (Armitage et al., 2014). A paradigm shift can start at the level of planning by reflecting the value of all water resources in SDFs (Rohr et al., 2014; Fourie et al., 2020)

The natural water cycle is an inter-dependent, interconnected, and continuous process of evaporation, condensation, precipitation, and groundwater recharge (Abbott et al., 2019). It is the process of water moving from rivers to oceans, into the atmosphere, and back onto land. The natural water cycle is altered by human activities, land-use change, impervious surfaces, and civil infrastructure (Abbott et al., 2019; Wong et al., 2000). For example, when the predominant land cover of urban areas is complex and impermeable, water runs rapidly along these impervious surfaces picking up pollutants that collect on these surfaces and transported via the stormwater infrastructure into rivers, wetlands, and the sea. This means more surface runoff, less evaporation, and less surface water replenishes groundwater (Ashton, 2000; Barron, 2013). This results in an imbalance in the water cycle and the degradation or complete loss of freshwater ecosystems (Barron et al., 2013; Chithra et al., 2015; Grafton et al., 2011).

The urban water cycle is a synthetic process created to provide drinking water to homes and businesses, remove wastewater and sewage, and transport stormwater from cities and into waterways (Ashton, 2000; Parkinson et al., 2005; Wong et al., 2000). Traditional approaches to managing urban water systems have taken a linear design approach, i.e. source freshwater, treat it, transport it from treatment to cities, then distribute it to households and businesses, collect and treat wastewater, and dispose. This is a centralised, technology-driven, and resource intensive process (Ashton, 2000; Parkinson et al., 2005; Wong et al., 2000). There is a need for alternative approaches to urban water management.

Techniques and methods in WSD include: water user efficiency, diversification of sources, recycling, alternative sanitation approaches with resource recovery. A key component of WSD

is sustainable urban drainage systems (SuDS). SuDS came under other names like green infrastructure (GI), Nature-Based solutions (NBS) and blue-green infrastructure (BGI).

Table 3: Types of SuDS

Source control	**Swales and Conveyance channels**	**Filtration**	**Infiltration**	**Retention & detention**	**Wetlands**
- Green roofs - Rainwater harvesting - Pervious surfaces - Other permeable surfaces	- Vegetated Swales	- Bioretention areas - Filter trenches - Filter strips;	- Rain gardens - Infiltration basins - Infiltration trenches - Soakaways	- Detention basins - Retention ponds - Geocellular storage systems	- Natural wetlands - Constructed wetlands

based on **www.susdrain.org/suds-components**)

To enhance ecosystem function and structure, SuDS should be designed connectively with ecological buffers and corridors.

WSD delivers multiple benefits to the city. Morgan (2013) identifies, with reference to available research, 13 such benefits:

- Diversifies available water sources
- Improves water quality
- Reduces pressure on wastewater treatment infrastructure
- Protects habitats and nature
- Attenuates flood risk
- Increases aquifer recharge
- Facilitates urban agriculture, edible landscapes and fishing
- Enhances human health and wellbeing by
    - improving air quality
    - offering recreational opportunities
    - facilitating active living
- Mitigates the urban heat
- Reduces atmospheric carbon dioxide
- Offers education opportunities
- Improves aesthetics
- Increases land value

Scaling WSD and Space

Spatial design operates at a range of scales. Spatial scales correspond to legislative instruments and administrative units that guide the spatial growth of a city. Voordt (2002) defines a range of spatial scales (see Figure 3 below). In this study, the Sub-National level corresponds to the Western Province; Regional and Sub-regional levels to the Cape Town Metropolitan Area; the District to the Cape Town Southern District; Area/Village to Hout Bay Sub-district; and Neighbourhood, corresponds to Hangberg. Below the neighbourhood level are building complexes, individual buildings what is contained inside the buildings.

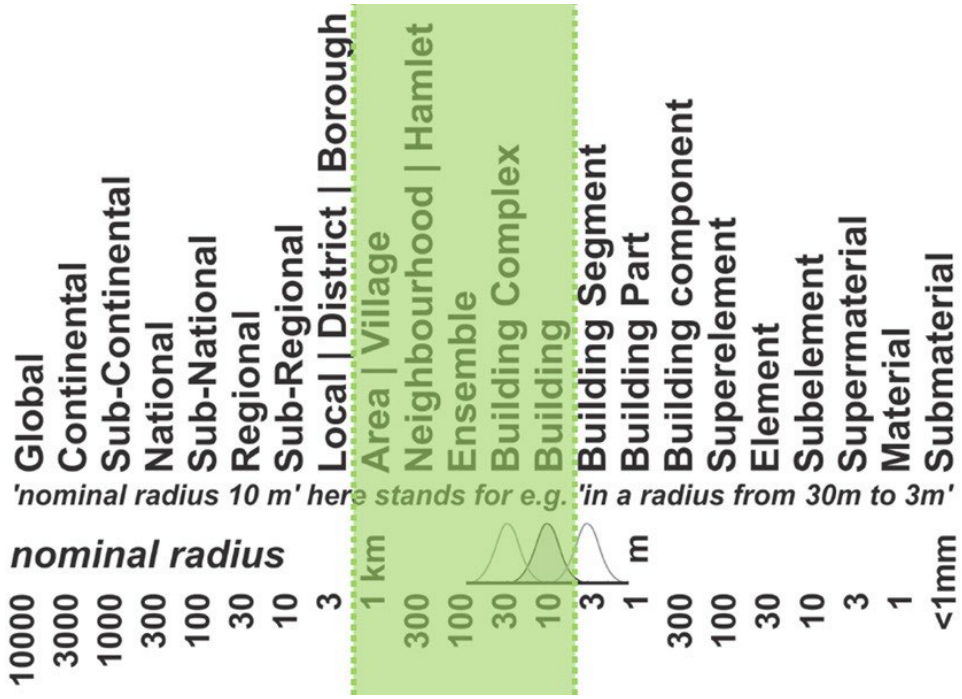


Figure 3: Orders of spatial scale (After Voordt, 2002)

Table 4: Scale as relates to Hout Bay and Hangberg. Hout Bay and Hangberg are the empirical sites for the study.

IWRM		IUWRM		WSD (Scale Focus in this Study)			
National	**Sub-National**	**Regional and Sub-regional**	**District**	**Area/Village**	**Neighbourhood**	**Precinct**	**Building**
South Africa	Western Cape	Cape Town Metropolitan Area	Southern District	Hout Bay Subdistrict	Hangberg	Within Hangberg	Within Hangberg

WSD also deals with a range of spatial scales (Bacchin et al., 2013). Bacchin et al. describe WSD scales as follows:

- the macro, which deals with the urban catchment area at the city or regional scale;

- the precinct (meso-scale), which is comprised of green ecological corridors that connect core areas;
- and the neighbourhood (micro-scale), at which urban design occurs.

We extended Voordt's conceptualisation with Bacchin et al. to define WSD natural systems and technologies as they would occur insitu seen in Figure 4 below.

Territorial unit	Area/point	Linear
Macro	Water: lake; aquifer; bay/delta	Water: River
	Green: forest; nature conservation area; park; agricultural land; botanical gardens	Green: Riparian green
Precinct (Meso-scale)	Water body: natural pond; Detention basin; retention pond; Natural Wetland; Small pool; wet pond (retention basin);	Ecological blue corridors: Stream; natural streams;
	Urban green space: District parks; green conservation areas; public parks; sports fields	Urban ecological green corridors:
Neighbourhood (Micro-scale)	Ecological infrastructure: Infiltration basins	Ecological blue corridors: rivulets; street edge streams;
	Urban green space: Local parks and open spaces (green squares); sports fields;	Ecological green corridors: road greenways; Ecological infrastructure: vegetated swale
Building-complex/individual building	Water: swimming pool; fountain; ornamental pool; bird bath	Ecological infrastructure: infiltration trench; rain gutter
	Urban green space: private open space (attached green spaces, residential gardens); Ecological infrastructure: green roof; rain gardens; permeable pavement; constructed wetlands; lagoons; Soakaway pits; filter drain	
	Efficient water use: xeriscapes and water-wise gardening	Efficient water use technologies: Drip irrigation
	Alternative water sources: rainwater capture systems; aquifer (well-point and borehole); stormwater capture; greywater recycling	
	Alternative Sewage treatment technologies: constructed wetlands; lagoons; septic tank system; biogas system; intermittent sand filters; leach field	
Building component/ element	**Alternative water treatment technology** small-scale proprietary systems; greywater recycling systems Efficient water technologies: low-flow taps; efficient dish washers; efficient washing machines; elimination or efficient use of space comfort process water (cooling and heating)	Dual reticulation
	Alternative Sewage treatment technologies: composting toilets; form flush; micro-flush; waterless urinals; system; urine separating toilets; lagoons; recirculating biofilters; sequencing batch reactors; membrane bioreactors; recirculating bioreactors;	Dual reticulation

Figure 4: Point and Linear Water Sensitive Design Options Across Scales, Source LNRP adapted from Voordt, 2002. See Chapter 6: Urban Scheme For scale break down.

The Neighbourhood Concept

Empirically focused on Hangberg, the Liveable Neighbourhood study was instigated at a *neighbourhood* scale. A significant component of the study engaged with the area precinct scales (Hout Bay sub-district) to delineate a broader contextual framework for neighbourhood spatial design. Another component focused lower down to investigate the implications of WSD at neighbourhood level on buildings and their water and sanitation systems.

The "neighbourhood unit" was first described by Clarence Perry in 1923. He characterised the neighbourhood as (see Perry, 1929)

- a distinct geographical area with clear boundaries (natural feature or roads, etc.)

- having certain homogeneity of buildings, e.g. by size, style, tenure, state-of-repair, etc.
- having a certain degree of social uniformity, e.g. household size, class
- sharing several services such as community hall, schools, recreation spaces

The neighbourhood concept has been criticised for promoting homogeneity, rigid social stratification and look-alike suburbia. Roads separating neighbourhoods can result in atomised cities. Though unwieldy tunnels and bridges are employed for pedestrians to use to overcome separation, the system is ultimately divisive. The idea of the "average family" as the basic constituent of the neighbourhood is also contested. Contemporary cases prove a wide variety in types of family and live-together arrangements.

However, the concept still has strong influence in urban planning and design. In Cape Town, the neighbourhood is identified as one of the spatial units to distribute civic facilities (see Southern District SDF, 2021). The research, therefore, uses the concept of a neighbourhood but with due attention to its criticisms, particularly as they relate to the unique challenges of segregated South African cities.

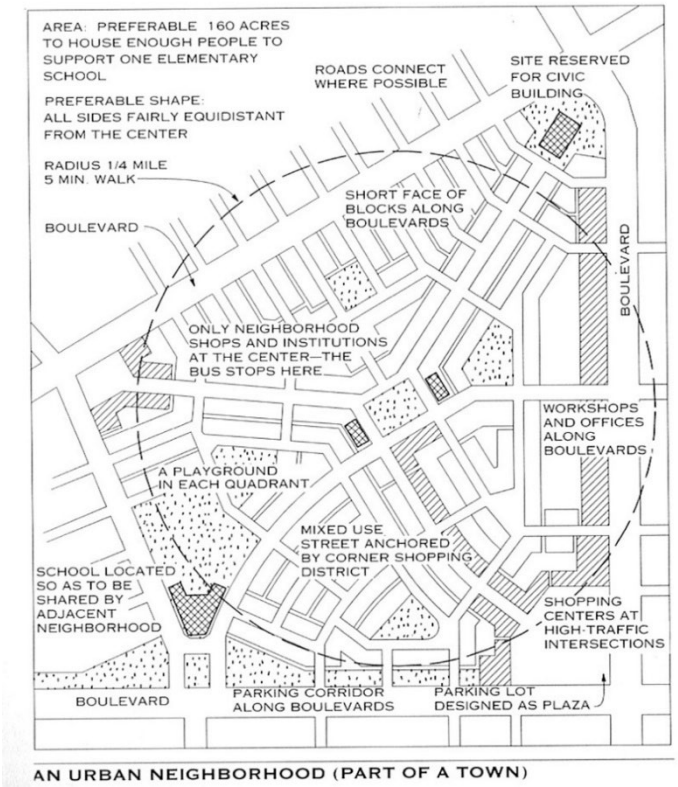


Figure 5: Urban Neighbourhood after Clarence Perry – Centralised, bound roads, uniformity

Liveability

As described above, the Great Acceleration spurred rapid urbanization. In the 1950s and the 1960s, roads and utility infrastructure were the defining elements for urban space. Planning was driven by quantitative considerations such as capacity of transportation, number of houses, acreage and density, functional zoning, plot ratios, etc. This resulted in poor quality urban spaces in many parts of the world. A consequence was urban neighbourhoods "with increased problems of congestion, monotonous new development, threats to natural systems, and a general decline in the quality of public space". In the 1960s, the field of urban design emerged to drive quality urban spaces (Southworth, 2003 and Southworth, 2016).

Beyond functional and utilitarian considerations, quality of urban spaces should focus on residents' wellbeing, comfort, safety and general satisfaction with their living conditions. Quality urban spaces contribute to making a city or neighbourhood liveable. According to Southworth (2016), liveability is a rather vague notion that is endorsed by nearly everyone, but rarely defined in operational terms". He therefore articulated 9 main attributes of a liveable neighbourhood or city as below

- Wellbeing
    - Healthfulness of natural environment
    - Urban environmental health
    - Social health (opportunity to meet and socialize)
    - Quality of public spaces
    - Convenient access to parks and recreation
- Safety
    - Protection from natural disasters
        - Fires
            - Wild
            - Human made
        - Floods
        - Landslides
        - Safe streets and spaces
    - Absence and safety from crime
- Opportunities for employment
- Housing
    - Varied
    - Affordable
    - Decent
- Social mix
    - Vulnerable first
        - Elderly
        - Children
        - Handicapped
        - Poor
- Public facilities
    - Schools
    - Libraries

    - Local shops
    - Other services
- Transport
    - Non-motorised possible (walk, bicycle)
    - Variety of means
    - Public transport
    - Street grid
    - Block size
- Respect for heritage and history and making it visible
- Respect for nature

It is significant that Southworth mentions respect for nature last without articulating what this would involve. Similarly, the otherwise excellent performance-based Melbourne Liveable Neighbourhood 20 objectives make no mention of nature.

The Western Australian Planning Commission (2015) identified the following principal performance-based objectives for liveable neighbourhoods:

- To achieve a sustainable urban structure that balances the provision of urban development through site-responsive design.

-To develop a coherent urban system of compact walkable neighbourhoods which cluster around activity centres capable of facilitating a broad range of land uses, employment and social opportunities.

- Provide a network of interconnected streets based on function within attractive, safe and pedestrian friendly streetscapes, which facilitates accessibility for all users to, within and between neighbourhoods and activity centres.

- Promote mixed use development and activity centres that optimise commercial opportunities, access to public transport and efficient street network connections.

- Plan for public open space that meets the recreational, social and health needs of existing and future communities.

- Ensure that water is protected and managed to maximise efficiency by incorporation of urban water management techniques into the urban design.

- Facilitate housing diversity, responsive built form, local employment and amenity within a coherent and efficient urban structure of compact walkable neighbourhoods.

- Provide education sites and other community infrastructure to meet the needs of existing and future communities.

- Provide utility services in a land efficient, environmentally responsible and sustainable manner

Create a permeable street network that prioritises pedestrians, cyclists and public transport and is integrated with surrounding land use.

- Create a safe street environment for all users by applying appropriate street geometry design and traffic management.

- Ensure all streets provide space for utility services, stormwater drainage, street trees and lighting.

- Ensure urban form and lot design facilitate safe and convenient access to services, facilities and employment in mixed land use, 'main-street format' activity centres.

- Create a site responsive street and lot layout that provides local amenity, safe and efficient access and promotes a sense of place.

- Provide housing density and diversity to meet the changing community needs.

- Provide sustainable utility services to each new lot in a timely, cost-effective, coordinated and visually acceptable manner.

- Coordinate the design and delivery of an integrated network of public open space that provides communities with access to nature, sport and recreation.

- Optimise the siting and design of public open space to promote accessible and efficient use of land.

- Ensure that education sites are developable, serviceable and accessible; promoting safe, adaptable and efficient use of land and other community infrastructure including public open space.

- Ensure a servicing movement network that facilitates safe and efficient access to education sites by all users.

The above approaches to liveability, though comprehensive and offering many desirable urban qualities, do not give adequate attention to environmental protection. The Economist Intelligence Unit (EIU) annually ranks more than 173 cities on a Liveability Index using five criteria which stretch anthropocentric, even elitist, valuing of cities to the limit.

Referencing Morrison (1978), this study proposes that water sensitive design be a wellspring for liveable cities and neighbourhoods in which arrangements of natural, spatial, fabricated, temporal and ethical components work to offer a range of ecosystem benefits to nature and all residents. A liveable city or neighbourhood enhances life in all its forms and provides a sustainable and secure place for living things on this earth. In this conception, sustenance of all people (rich, poor, handicapped and vulnerable alike) is included. This definition goes beyond the anthropocentric to embrace all other living things in their interdependent overlapping ecosystems.

Literature and Theory Summary

Water Sensitive Design is encompassed under the broader notion of sustainability. Sustainability is counter to perceived ills of reductivist science, and the socially and environmentally destructive production patterns of global industry and capitalism. The Great Acceleration that started in the 1950s resulted in geometric acceleration in consumption, production and measurable indicators of environmental stress. The modern sustainability movement took root around the 1960s. In the 1980s, the Brundtland Commission defined imperatives of sustainable development as focusing on the needs of the world's poor and environmental conservation.

But ideas of designing with nature date back to 1902 with Ebenezer Howard's Garden Cities and 1915 with Patrick Geddes Urban Planning. These ideas influenced a nascent movement for ecological design in the late 1960s and into the late 1970s. This included including the landscape designer McHarg. Bill Morrison founded permaculture. In permaculture, local hydrology, topography, flora and fauna are the generating elements for design and living. Scaffolding these pioneers' efforts, John Tillman Lyle established regenerative design as a process and as a practice aimed at not merely conserving but regenerating the vitality of ecosystems.

Mostafavi subsequently proposed ecological urbanism to harmonise cities with ecosystems. In South Africa, ecological urbanism was part of a conceptual framework in which Bhika developed imperatives for water sensitive design using an ecosystems service framework.

Water Sensitive Design (WSD) is quintessentially interdisciplinary. Inter alia, WSD techniques include water user efficiency, diversification of sources, recycling, alternative sanitation approaches with resource recovery and SuDS. The outcome of WSD is Water Sensitive Cities (WSC). The aspiration is to return urban areas to a state that approximates natural water cycles in terms of evapo-transpiration, evaporation, infiltration and runoff. WSC offer multiple benefits such as improved liveability, cleaner air, reduction of heat island, building cooling, options for local subsistence. WSD links to broader umbrellas of Integrated Urban Water Management (IUWM) and Integrated Water Resource Management (IWRM). WSD, IUWM and IWRM cover social, economic and environmental aspects. WSD can applied to scales of the urban districts, neighbourhoods, precincts and buildings.

The focus of this WSD study was at neighbourhood scale (Hangberg). For contextualization, a broader study was executed at the scale of the subdistrict (Hout Bay Subdistrict). A neighbourhood is a well-bounded urban area with common characteristics and shared community facilities. In Cape Town, the neighbourhood is identified as one of the units for distributing civic facilities. Due to functionalist planning, many neighbourhoods in the 1950s and 1960s had poor quality public spaces, were congested and threatened natural systems. Urban design emerged as a field to counter to this negative trend. Urban design aspires to make cities more liveable. Inter alia, liveability includes health and wellbeing of residents, mix of uses, quality of public spaces, access to recreation, safety, varied housing options, balanced social mix, availability of public facilities, promotion of non-motorized transport, respect for heritage and respect for nature.

WSD can be a wellspring for the above qualities of a liveable neigbourhood and enhance a range of ecosystem benefits to nature and people.

Chapter 3: Research Approach (Methods and Conceptual Framework)

Introduction

This chapter first frames a worldview for the study. Next a conceptual framework is presented to illustrate how the different knowledge tributaries confluence in this interdisciplinary study process. Finally, details on different methods used are presented.

Worldview

This study was framed under a naturalist worldview. Contrary to the positivist worldview, the naturalist worldview acknowledges and engages with the role of values and ethics in knowledge production and practice. It further embraces diverse ways of knowing and accepts co-constituted between subject and object. Therefore, the naturalist paradigm extends scientific and technocentric approaches with diverse knowledge types – including scholarly knowledge and the knowledge that communities possess of context and lived experiences of problems. Knowledge is relational, contextual, contingent and evolves from multiple perspectives. There is, therefore, a great value in co-production and reflexive iteration. It is imperative to reflect on work ethics, particularly how these relate to communities and the environment. The environment is conceptualized as a common good and a complex web of phenomena with intrinsic worth. The naturalist worldview is extended by the emancipatory worldview – with a critical framing of disadvantage; through racial, gender, disability and bio-rights, for instance. In naturalist and emancipatory worldviews, knowledge is created insitu, in-context, and is co-produced. It is therefore in naturalist and emancipatory worldviews that the systemic issues of sustainability and the water cycle can be adequately framed and engaged fundamentally (Sanya, 2020). Basing on the above, the study was anchored in the ecocentric philosophy of Deep Ecology which challenges man to continually expand his appreciation of nature, recognise the co-constitution between unit and whole (Naess, 1990). Deep Ecology recognizes the worth of all people, their independence with nature and the intrinsic worth of nature. Deep ecology espouses phenomenology – a holistic ontology in which the unit of survival is "the organism and its environment" (Naess, 1990). Phenomenology intersects with spatial design (Noberg-Schulz) in its conception of the boundary, not a divider, but a connector. The boundary is not a mere separating line but is a corridor rich in life, continuous mix renewal and generative potential. Deep ecology and phenomenology, offered a lens to use WSD for places with co-benefits for people and nature.

Overarching Conceptual Framework

Cities and neighbourhoods contain ecosystems. In turn, cities and neighbourhoods are contained within ecosystems. In cities, a complex web of people, built environments and natural environments interact. Crucially, water and the hydrological cycle weave all these

elements intricately at the multiple scales of the city. WSD aims to protect, reveal and connect water and nature at the multiple city scales. WSD proposals in this study were undertaken at the urban planning scale (Hout Bay Subdistrict); the urban design scale (Hangberg neighbourhood) and the architectural scale. A prerequisite for design interventions was baseline investigation of the hydrology, the social context, urban context and nature. Because WSD is a process, the study also defined a decision support platform to connect various WSD role players.

Therefore, the study used an overall interdisciplinary research strategy aimed at mutually supportive packages of knowledge about water, people, nature and city spaces. Research objectives and timelines and research objectives were carefully aligned and sequenced to make a high-level conceptual framework for the study as shown in Figure 6 below.

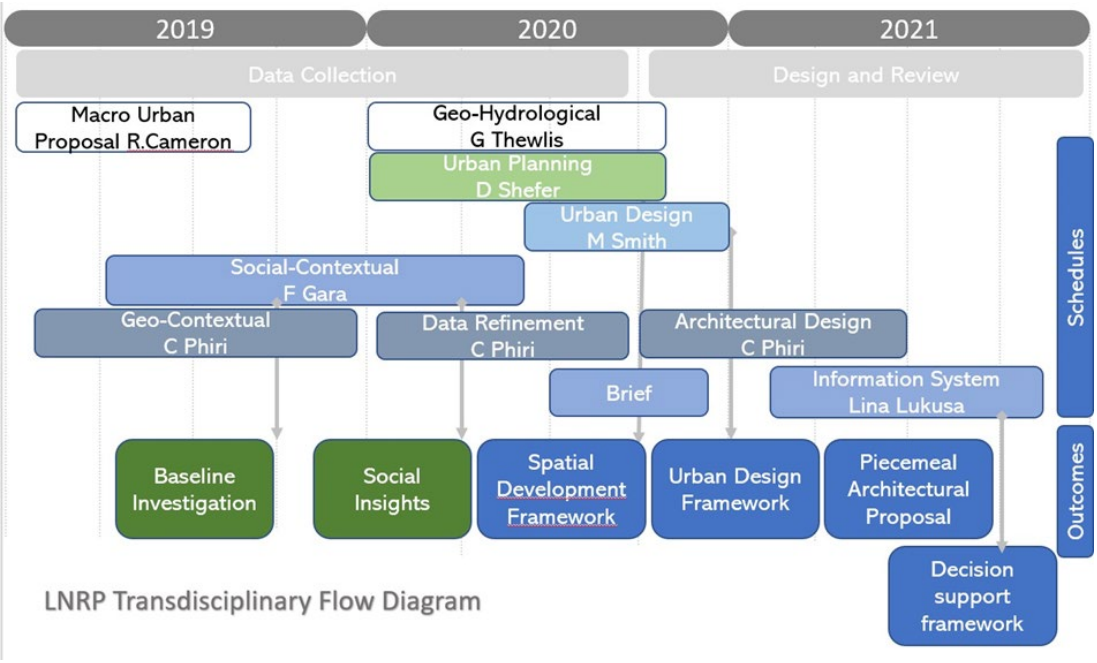


Figure 6: Conceptual Framework for the Study (Phiri, 2019)

Grounded Theory as Overarching Method

The study adopted grounded theory as an overarching research method. According to Charmaz & Mitchell (2001), Ground Theory is a qualitative methodological approach that begins with asking a question, in this case what for a liveable neighbourhood? This required a subset of questions to understand the ways in which current residents lived with water and what kind of homes and neighbourhoods they aspired to. Using the grounded theory approach allowed the study to build thematic areas of focus to emphasize how "action and meaning are constructed" (Charmaz & Mitchell, 2001: p160). Grounded theory included:

- simultaneous data-collection and analysis in an ongoing process of drawing on and building new questions from emergent themes.
- pursuit of emergent themes through early, ongoing data analysis.
- discovery of basic social processes within the data.
- inductive construction of abstract thematic categories that explain and synthesize these processes.
- integration of categories into a theoretical framework that specifies causes, conditions and consequences of the process(es) that are specific to each scalar unit approached. (ibid)

Grounded theory provided a process of data collection in an iterative framework. In this way, the questions were developed and revisited, and the work was continually analysed so that new emergent themes could be incorporated into the growing list of questions. This also allowed for mixed methods at data gathering level.

Under the overarching grounded theory methodology, the study was executed using the following sequential but overlapping steps: baseline investigation and research through design.

Baseline Investigation

The baseline investigation constituted contextual analyses of physical, social and history aspects of the study. It included a hydrological study, an ethnographic study, urban analysis.

Hydrological Study Method

A hydrological model for the Hout Bay Catchment was developed on the Personal Computer Storm Water Management Model (PCSWMM). PCSWMM is an advanced modelling software for stormwater, wastewater, watershed and water distribution systems. The model was developed to investigate the ability of sustainable drainage systems (SuDS) to mitigate flooding, in the catchment area, due to storm events. A model to represent the current situation in the catchment was developed first. This provided a base on which intervention models could be developed and compared. The intervention models included various SuDS interventions.

GIS datasets used in the model development included: land use surface types (LUST), soil type, digital elevation model and roadways. The Hout Bay stormwater network was modeled including the river and its tributaries, conduits, junctions, storage units and outfalls, river networks, stormwater bodes, open space, 5 m contour lines, stormwater conduits, manholes, catch pits, rainfall intensities. The study undertook the 5-year, 2-year, 1-year and 6-month return

period design storms investigations. To this end, GIS shapefiles containing a point rainfall distribution grid used with rain gauges inserted into simulated subcatchments.

The river sections were developed by utilising PCSWMM's transect creator tool to create cross-sections along the river lengths. The transect creator tool used the digital elevation model (DEM) from the City of Cape Town (CCT) Data Portal to develop cross sections at specified intervals.

Sub-catchments were developed by utilising the PCSWMM's built in 'Watershed Delineation' tool and the DEM from the City of Cape Town. The tool delineated the catchment to create sub-catchments. Each sub-catchment was allocated a rain gauge. PCSWMM's 'Area Weighting' tool was used to calculate each sub-catchment's runoff and infiltration volumes and rates from the land use and soil type background layers.

Ethnographic Research

The study used ethnographic research techniques such as participant observation, face-to-face interviews with residents and relevant stakeholders, discussions with residents, and a focus group discussion to gain insights into the processes and diverse experiences that Hout Bay residents live with concerning water. These research techniques were essential to outline the different experiences people have with water in a field mostly dominated by the engineering, technical and economic aspects associated with water.

A member of the study team lived in the area and engaged with various people to learn their different experiences of living in that space and experience the conditions firsthand. This included staying in Hangberg for three nights and four days in the last week of June 2019. The study team member talked to the local community members, observed how they live and relate with water. Walks with Hangberg residents through the neighbourhood revealed stories of different experiences of residents, available infrastructure, and the state of the built environment. The researcher also stayed in Imizamo Yethu for two nights and three days in July 2019. Living in these two areas was done to understand how people live with water and to be part of their daily experiences connected to space, including their needs and strategies employed to access water where there are limits.

The study member also spent one day talking to a resident in an affluent neighbourhood (Bokkemanskloof estate), observing how the household lives with water. The aim was to understand how people who have full access to water supply make use of water and may choose to engage with water.

These research techniques were essential to outline people's different experiences with water in a field mostly dominated by water's engineering, technical, and economic aspects. Most

of the data is from stories of additional observations experiences, including the researcher's own sensory experiences during fieldwork and various stakeholder engagements. Tsing (2014, p.30) notes that anthropologists learn about the social by being present; they learn about societies by experiencing them and paying attention to lifeways. Accordingly, the fieldwork was grounded on presence in the field to know and pay attention to how residents live with water in the area. The methodology employed in this study was inspired by Ways of Knowing (Fournillier, 2009; Brugnach and Ingram, 2017). For example, in trying to develop the story of the place, the research depended on residents' memories of the area compared to present. While our memories are not always a reliable source of information, as they are constructed every time we recall them depending on the specific circumstances during the narrative (Locke, 1971; Buzekova, 2006). The researcher was interested in how memories may shape meaning and relationships to one's environment.

Urban Analysis

The historical evolution of Hout Bay was and Hangberg was studied through a literature review. Various urban plans for the Hout Bay Subdistrict were also reviewed. In addition, literature review was used to gain insights into strategic urban planning tools that can enhance water sensitive practices. Also, a literature review of CoCT policy, plans and spatial frameworks was undertaken to gain insights into their implications for WSD.

Furthermore, using GIS and data from CoCT's databases, Hout Bay Subdistrict and Hangberg neighbourhood were analysed in maps and drawings based on CoCT's land use zoning surface types:

- conservation & nature (including water bodies),
- agriculture,
- homesteads,
- residential (low, medium and high density)
- institutional,
- townships
- commercial
- schools & sports grounds,
- public open spaces,
- industrial,
- roadways

Conservation and nature was further analysed using the seven biodiversity categories of the City of Cape:

- Protected areas
- Critical Biodiversity Area 1 (CBA 1)
- Critical Biodiversity Area 2 (CBA 2)
- Ecological Support Area 1 (ESA 1)
- Ecological Support Area 2 (ESA 2)
- Other Natural Area (ONA)
- No Nature Remaining (NNR)

In the analyses, the state of the natural environment was assessed and possibilities for enhancing biodiversity via using water sensitive design identified.

Research Through Design

The study focused on spatial aspects of water sensitive design at different scales of the city. Research through design was used for urban planning, urban design and architectural design. Results from the baseline investigation (context) were brought into the research through a design process. The study used four iterative steps in the design process: baseline analysis; concept; programme; design. (see Figure 7 below). The four steps are described below.

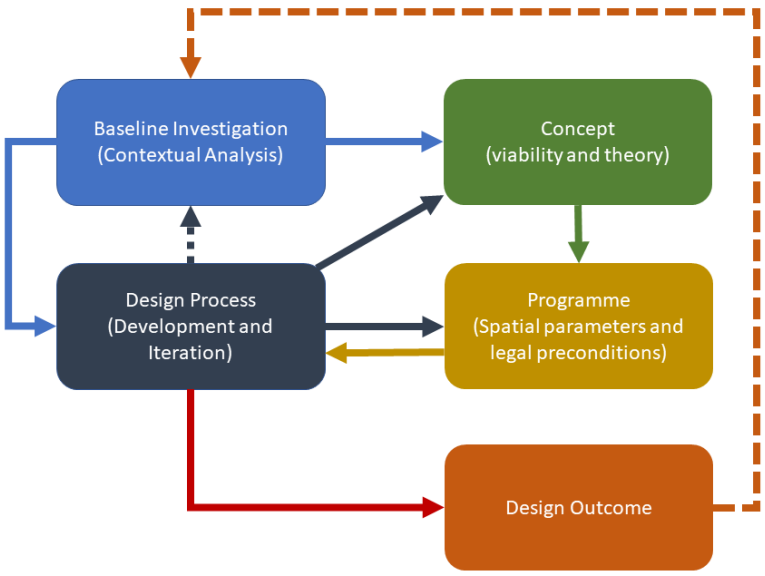


Figure 7: The iterative process adopted in tackling research through design.

Concept

The concept gives purpose and direction to the planning and design process.

The concept is concerned with understanding the nature of the problem instead of the symptoms of the problem and identifying the role and the best use of the site. The product of this process is a statement of 'what should be'. The concept in this study was aspirational and was also stated as vision, illustrated as a conceptual diagram. In the study the design concepts and visions emerged from the study intention to relook at the relationship between water and urban space to provide solutions that integrates the urban water cycle with good qualities of planning and design to enhance liveability at urban planning, urban design and architectural levels.

Programme

The programme formulated the quantities and qualities of uses on the site at a given scale. It describes the target user-group or population, the different functions to be accommodated It also describes the desired quantitative outcomes. The programme in this study included urban planning objectives, urban design performance targets, a building design brief and goals for a decision support platform.

A non-programmatic

A non-programmatic approach (see Dewar, 2011) was used in urban planning and urban design scales. At these scales, the study made no attempt to determine the spatial distribution of human activities through top-down decision-making on land use zoning. Rather, the study proposed a framework to which human activities can respond to create broadly predictable outcomes. The concentrated on creating choice instead of attempting to define liveability for all people. In this way the plan is enabling rather than prescribing a way of life. Three aspects are important in the non-programmatic approach:

Structure is used in designing settlement to order the landscape. The elements of public structure such as green spaces, movement lines, social facilities and public open space are manipulated and co-ordinated to create a logic to which all activities (whether large or small, private or public, formal or informal) can respond. The structure also establishes a logic of publicness and privacy. Through this process, choices are offered without imposing a certain form of lifestyle for everyone (Dewar, 2011). Rivers, wetlands, and ecological corridors and buffers were also part of the structuring elements in this study.

Space: In the non-programmatic approach all public spaces can are conceived as social space. Public spaces are designed to be multi-functional and significantly enhance the urban environment. The hierarchy of public spaces creates a logic for where public facilities should

be located. Facilities that are used by all urban inhabitants are located in the most prominent locations (Dewar, 2011; Dewar & Louw, n.d.). Non-programmatic approaches therefore integrate the hierarchy of access and the hierarchy of spaces into a framework that creates a logical structure of publicness and privacy where all activities can be located in terms of their own requirements. The quality of the defining framework contributes directly to the quality of the urban environment and liveability (Dewar, 2011).

Minimalism:: A trademark of positive urban environments is that they are complex. This complexity, however, cannot be designed and results from process. When the design process is dominated by the ingenuity and creativity of only a few people, sterility and monotony are inevitable consequences. At each scale, spatial plans should only depict the minimum-actions that are necessary to give direction in order to allow for the ingenuity and creativity of all designs and decision-makers to enrich the urban environment. The approach is therefore concerned with process and allows a range of actors to be incorporated into the process (Dewar, 2011).

Design

The design process brings from the context, concept and programme. It teases out the connections between the known, the loosely defined, the unknown and the emergent into cohesive design solutions. Decisions iteratively evolved from analyses, postulates, freehand sketches, and scaled drawings.

Methodology Summary

Water Sensitive Design in South Africa to date has generally not been critically located in philosophy and worldviews. The study adopted a naturalist worldview which promotes engagement with values and ethics in scholarship and practice, and embraces diverse ways of knowing. Knowledge possessed by lay people is just as important as formal knowledge of experts. Co-production and reflexive iteration are important. Consequentially, the study located in a Deep Ecology philosophy and its holistic ontology of phenomenology – whereby the unit and whole are co-constitutive and mutually dependent. By thus adopting a worldview and philosophy, the study yielded a reference framework for the research process and for the and for critique of its results.

This interdisciplinary study aimed to generate mutually supportive packages of knowledge from the study fields of anthropology, hydrological engineering, urban planning, urban design, architecture and information systems. The study therefore proposed a conceptual framework to articulate the parts, and their sequencing as well as their interdependencies. Underpinned by the conceptual framework, the study opted for grounded theory as an overarching research methodology. Grounded theory is a qualitative research approach which looks for

meaning and insights from context by iteratively theming empirical data. Within an overarching grounded theory methodology, the study was executed in two stages: baseline investigation and research through design.

The baseline investigation focused on analysing the physical, social, and historical aspects of the context. The study simulated the hydrology of the Hout Bay Catchment hydrological using the Personal Computer Storm Water Management Model (PCSWMM) software. The study also used ethnographic research techniques such as participant observation, face-to-face interviews with residents and relevant stakeholders, discussions with residents, and a focus group discussion to gain insights into the processes and diverse experiences that Hout Bay residents, especially in Hangberg live with concerning water. Urban context analysis was undertaken on the history of Hout Bay and Hangberg, and relevant CoCT policy for WSD. The study also used GIS to analyse the physical characteristics of Hout Bay and Hangberg, such as, built up areas, natural features, and nature conservation areas.

The study used research through design method for urban planning, urban design, architectural design and to develop an ICT collaboration platform. Choice of this method was important especially because the focus of the research is spatial. The study articulated research-through-design into four generic iterative steps: Contextual analysis, concept, programme, and design.

The next three chapters, present the study results. First, an overarching baseline investigation for the study is presented. This includes a hydrological study (as is and under different storm scenarios) and an introduction to the context's natural, morphological and urban characteristics. Second, urban planning results are presented. Third, results from the sociological study are presented alongside the urban design outcomes. Fourth and finally, the results for the ICTS decision support platform are presented.

Chapter 4: Hydrological Study

Introduction

The primary objective of the model development was to investigate the feasibility of utilizing SuDS to mitigate flooding in the Hout Bay Catchment. The made two scenarios: (i) as is [baseline scenario] and (ii) with SuDS [SuDS scenario]. The second model was aimed at investigating the viability of SUDS in attenuating flooding.

The land use surface covers. Impact on the pervious or impervious and these were modelled in the PCSWMM model to study the stormwater system of Hout Bay Catchment and to propose improved SuDS scenario.

The modelled baseline scenario yielded 2915 sub-catchments in the Hout Bay catchment. In the SUDS scenario, another 19 sub-catchments were added to the model. Rain gauges were then distributed in the sub-catchments.

Model Inputs

Rainfall

For rainfall, rain gauge depths were modelled for 6-month, 1-year, 2-year and 5-year return periods using sixteen different rain gauges. The results are in Table 3 below.

Table 5: PCSWMM Rain Gauge Depths

Rain Gauge	Return Period Depths (mm)			
	6 Months	1 Year	2 Years	5 Years
1	52,6	69,4	83,3	109,5
2	58,4	77.0	92,5	121,6
3	47,5	62,6	75,2	98,9
4	56,1	74.0	88,9	116,9
5	46,8	61,7	74,1	97,4
6	40,2	53.0	63,7	83,7
7	24,9	47,1	72,3	99,1
8	37,5	49,4	59,3	78.0
9	20,9	34,3	49,1	65,8
10	23,5	38,5	55,2	74.0
11	47,1	62,2	74,6	98,1
12	36,6	48,2	57,9	76,2
13	35,4	46,7	56.0	73,7
14	47,9	63,2	75,9	99,9
15	37,8	49,9	59,9	78,8
16	54,4	71,7	86	113,1

Land Characteristics

Soil type and land use affect permeability. The soil types in the Hout Bay catchment, along with hydraulic features such as suction head, hydraulic conductivity and initial moisture deficit were modelled. There are sixteen land use types in the Hout Bay catchment. Each land use is associated with an impervious factor (%):

- Agriculture (10%);
- Commercial (80%);
- Conservation & Nature (5%);
- Homestead (25%);
- Industrial (90%);
- Institutional (50%);
- Public Open Space (5%);
- Residential – high density (90%);
- Resident – low density (50%);
- Residential – medium density (75%);
- Roadways (90%);
- Schools and Sports Grounds (40%);
- Township (80%)

The land uses and their respective impervious factors were also imputed into model.

Stormwater System in Hout Bay

The stormwater system in Hout Bay consists of the following parts: subcatchments, conduits, junctions, storage units and outfalls. These were all identified and modeled for the "as is" and "with SuDS" model (see Table 4 below).

[also see Figure 8 for "as is").

Conduits

There are an estimated 4263 conduits in the Hout Bay catchment. The conduits are of two types: the stormwater network and river sections. The stormwater network is a system of concrete, circular pipes. The internal diameters of the pipes range from 0.3 to 1.2 m. The conduits were modelled for the baseline case. In the SuDS scenario, an additional 19 conduits (vegetated swales) were modelled.

Junctions

Junctions indicate conduit connections. An estimated to be 4258, indicate conduit connections, manholes, catch pits and cross-section changes. These were modelled in the as is (baseline) scenario. In the SUDS scenario, eight additional junctions were included.

Storage Units

Storage units are nodes within the drainage system that provide storage for stormwater runoff. They include physical features such as ponds, dams, wetlands and lakes. Five existing storage units were identified and modelled: three wetlands, an estuary and a pond. In the SUDS model scenario, an extra five storage units (detention ponds) were added.

Table 6: Visual object quantities

Visual Object	As is	Intervention Model Additions
Sub-catchments	2915	+19
Junctions	4258	+8
Storages	5	+5
Outfalls	10	
Conduits	4263	+19

*Junctions are used to indicate conduit connections, manholes, catch pits and cross-section changes.
*Outfalls represent the terminal node of a drainage system and are the final downstream elements

Outfalls

Outfalls are the terminal nodes of a drainage system and are the final downstream elements. The Hout Bay stormwater system consists of multiple drainage networks. An outfall is required for each network. Ten outfalls were included in the catchment as is (baseline) model. On the following page the modelled elements are represented visually on maps (figures 9 & 10 below).

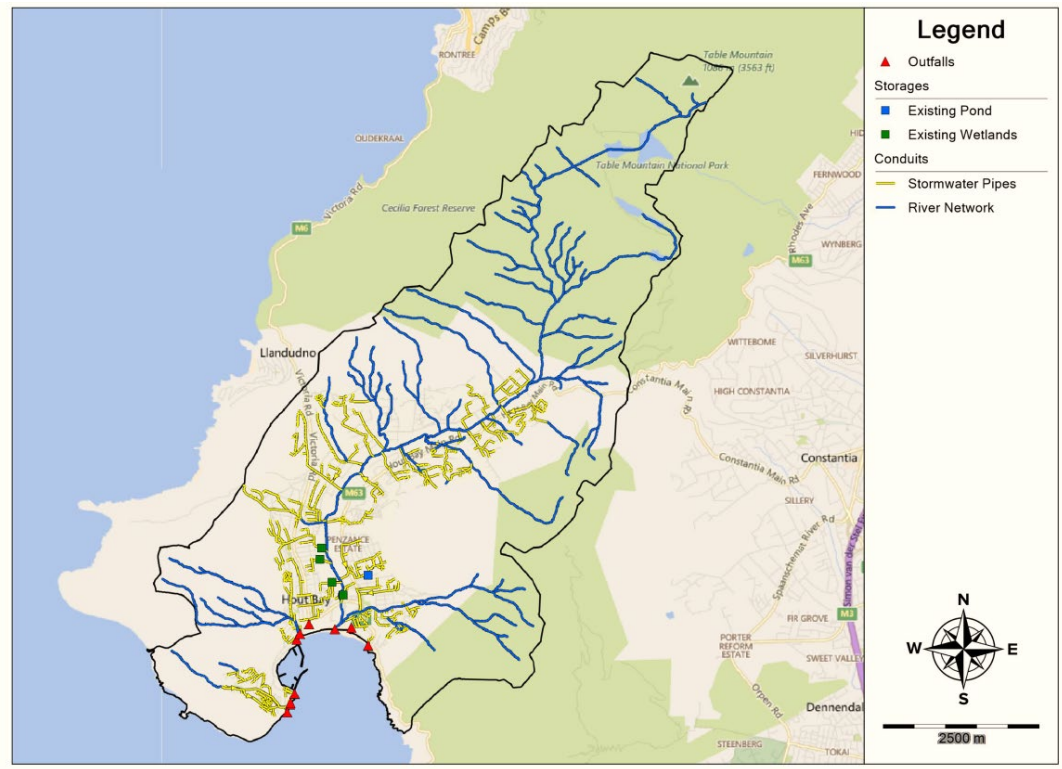


Figure 8: The Hout Bay catchment area, the conduits, storage units and outfalls incorporated into the 'As Is' model.

Flood Risk in Baseline Scenario

An important objective of the model development was the identification of locations with a flood risk. These were determined by running the "As Is" scenario under each of the design storms. 5-year, 2-year; 1-year and 6-month return period design storms were investigated. Nodes flooding for longer than 30 minutes were identified as at-risk points. As an example, Figure 9 (see below) identifies these nodes in the entire catchment for a 5-year storm event (see Gewhlis, 2020 for the other storm events).

The results indicate many nodes in Hout Bay are face a high 5-year flooding risk (see Figure 9 below). Many of the nodes at the risk of flooding are distributed along a section of Main Road for 2.5 km from the coast and the estuary. It is significant that this section of Main Road runs along the 50-year floodline (see also Chapter 4 pages 73 and 74) .

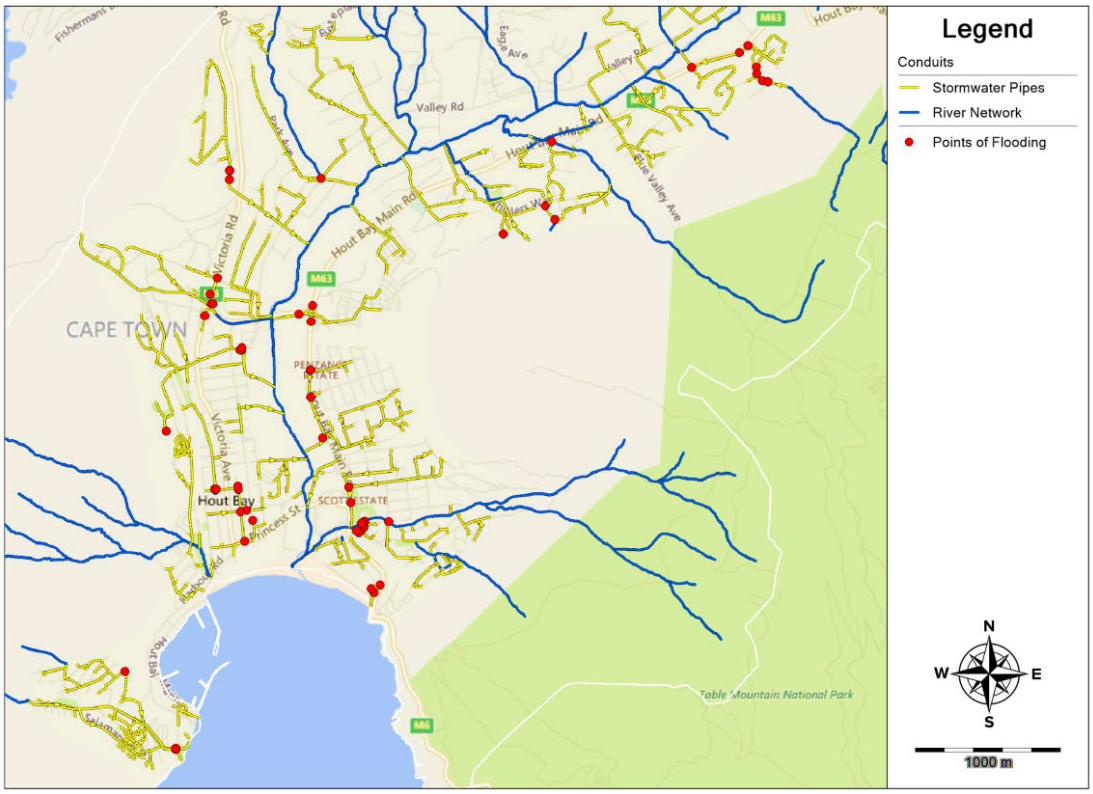


Figure 9: Crucial points in 5-year design storm flooding

SUDS Interventions Scenario

Adding vegetative swales and detention ponds to the baseline, a SuDS Intervention Model was created.

Vegetative Swales

The swales utilised in this project were designed with a trapezoidal cross-section and grass lining along all but one. In total 19 swales were implemented in 10 different zones. Multiple swales were used in several zones as the ground conditions, such as slope, varied and the swales varied with it. A standard berm height of 400 mm was utilised and side slope of 4 (run/rise). The longest swale was 296 m and the shortest 106 m. The narrowest swale was 2 m and the widest 12 m.

Swales were implemented in 10 zones (see Figure 10 below). In the model, the swales are named consecutively by zone number. For example, swale 1.5 is the fifth swale in Zone 1. Figure 11 shows some of the swales implemented.

Summary of Modelled Elements in Intervention model.

Figure 10: Summary of modelled elements in the SuDS intervention. The figure shows zones and vegetative. Each swale is named by Zone number and Swale Number.

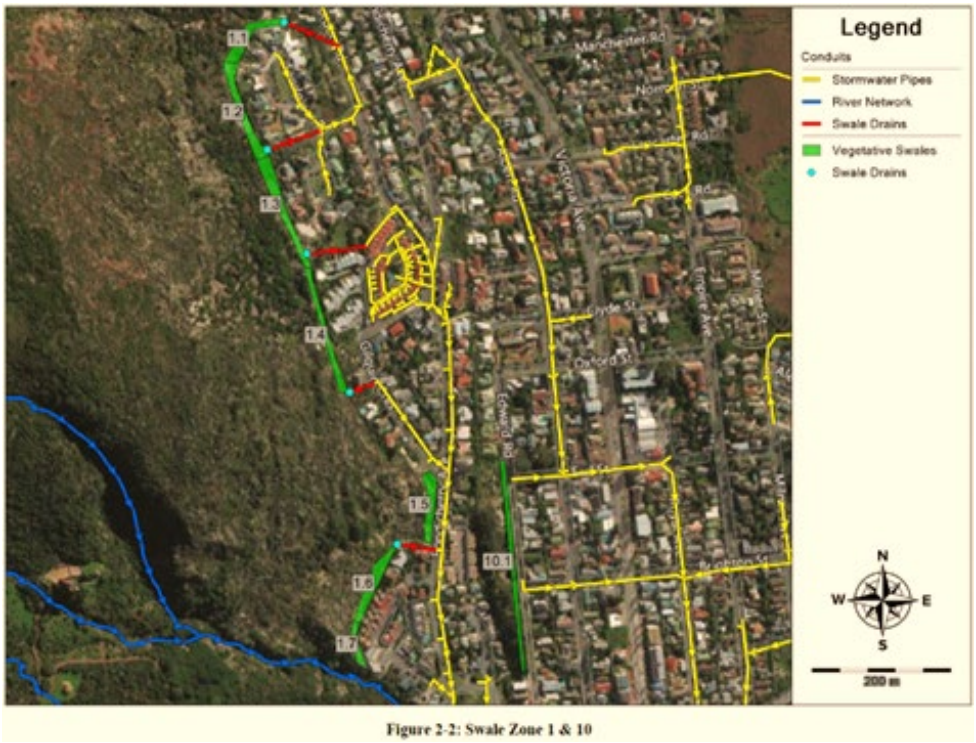


Figure 11: Depiction of Swale Zones 1 and 10 showing examples of implemented swales.

Detention Ponds

Detention ponds, also referred to as detention basins, are landscaped depressions used for the temporary storage of stormwater runoff during and for a short period after storm events. The basins are normally kept dry but are deigned to store runoff from storm events. If well-designed, the ponds can serve a recreation function when dry. The basins may allow runoff to infiltrate into the surrounding soil but also allow runoff to be drained into the downstream network. The basins can either be lined with vegetation, such as grass, or a hard surface, such as concrete.

Five additional detention ponds were added to the model as flood mitigation measures. These were implemented as storage units with conduits leading to and from them to connect to the main network. Four of the five detention ponds were designed with a grass lining to infiltration. The fifth swale utilised an existing football field with a false turf covered football pitch with a concrete foundation that did not allow any infiltration but still contributed to flood attenuation. Each detention pond was designed with a temporary storage depth of 0.5 m. Table 5 gives more details about the detention ponds.

Table 7: Proposed Detention Pond design details

Implemented Detention Ponds	Storage Type	Surface Area (m^2)	Temporary Storage Depth (m)	Side Slope (run/rise)	Contributing Area (ha)	Contributing Impervious Area (ha)
Scott Estate Field	Detention pond	2208	0,5	3	477,338	80,35
The Riding Centre Field	Detention pond	2116	0,5	3	28,05	9,69
Carmel Community Park	Detention pond	1625	0,5	3	2,85	1,93
Royland Crescent Park	Detention pond	1963	0,5	3	26,73	11,86
Harbour Heights Football Pitch	Detention pond	4900	0,5	0	50,34	12,25

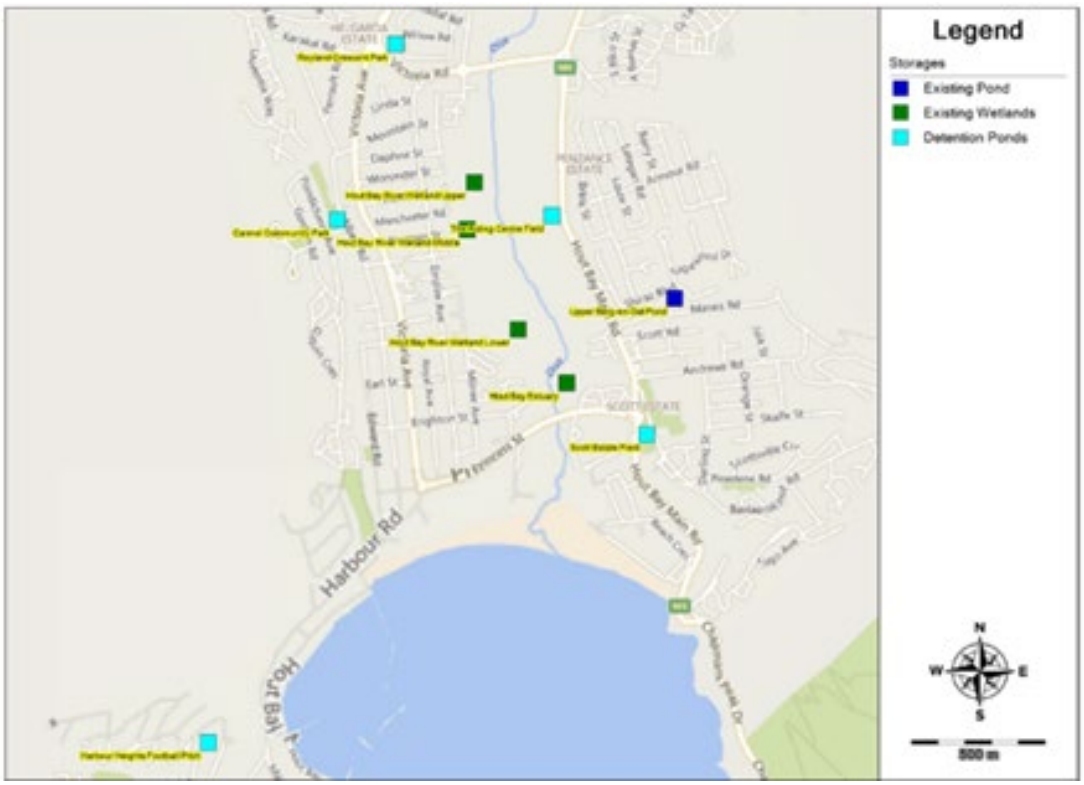


Figure 12: Location of Detention Ponds (existing and proposed)

Figure 12 above shows the location and placement of the detention ponds. The largest proposed pond is at the Harbour Heights Football pitch. It has an area of 4900 m^2 but serves an area of only 50 ha of which 12 ha are impervious. The proposed Scott Estate Field detention pond at a surface area of 2208 serves an area of 477 of which 80 ha are impervious. Figure 13 below shows zoomed detail of the proposed Scott Estate Field Pond.

Figure 13: Proposed Scott Estate Field Detention Pond.

Flood Improvements in SuDS Scenario

The addition of the vegetative swale and detention pond systems had a great impact on the flooding in the Hout Bay Catchment. Key indicators were identified to quantify this improvement. These key indicators included the number of nodes flooded, the longest flood period experienced and the average flood lengths. Additionally, the ten longest flood periods for each design storm were identified and compared to the results experienced after SuDS intervention. Table 6 presents the key indicators and their values.

Table 8: Indicators for Flood Quantity Improvements

Key Marker	5 Year		2 Year		1 Year		6 Month	
	As Is	SuDS	As Is	SuDS	As Is	SuDS	As Is	SuDS
Flooded Nodes	620	575	486	456	397	352	270	258
Longest Flood Period (hr)	20,82	0,94	19,98	0,7	19,32	0,59	18,18	0,44
Average Flood Period(min)	12,82	9,6	11,17	7,65	10,44	7,01	10,48	5,97
Decrease in Flood Period (%)	25,5		31,5		32,8		43,0	

From Table 6, it is clear that mitigation is enhanced In the SuDS intervention model across all key indicators. The higher the probable frequency of the flood event (1-year and 6-month rain event), the better the flood mitigation potential of the SuDS.

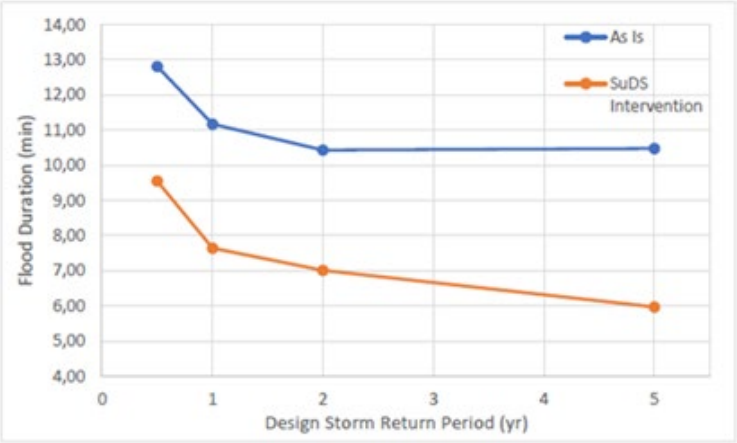


Figure 14: Average Flood Duration. In all rain flood return periods, the flood duration in minutes is reduced significantly in the SuDS intervention model.

The graphs in Figure 14 and Figure 15 display the extent to which the flood levels were decreased due to the SuDS implemented.

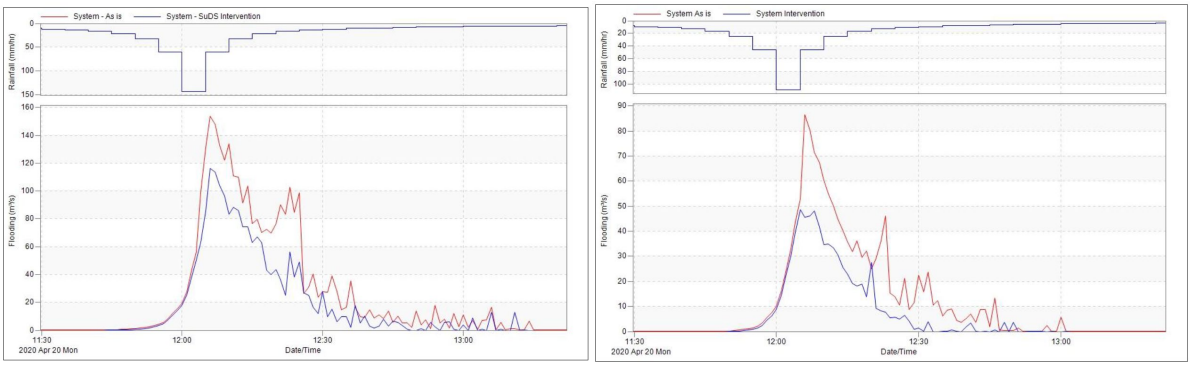


Figure 15: 5-Year design storm rainfall and system flooding (left) and 2-year design storm rainfall and system flooding (right). The SuDS model results in much flood mitigation in both cases.

Runoff and Infiltration

SuDS work to mimic natural hydrological processes and water cycles within a catchment. This is done by increasing permeable land coverage and slowing stormwater runoff. Infiltration and ground water recharge are very important parts of a natural hydrological cycle.

Table 7 presents the infiltration experienced by both the 'As Is' scenario as well as the 'SuDS Intervention' scenario during all four design storms. Figure 16 illustrates the decrease in runoff volumes due to the SuDS intervention.

Table 9: Runoff and infiltration volumes

Table 3-2: Runoff and Infiltration Volumes

Volume (10^3 m^3)	5 Year		2 Year		1 Year		6 Month	
	As is	SuDS System	As is	SuDS System	As is	SuDS System	As is	SuDS System
Total Precipitation	3733,02		2824,24		2276,47		1684,25	
Infiltration Loss	3191,31	3247,06	2452,33	2489,59	1994	2019,31	1491,09	1483,87
Surface Runoff	533,52	478,61	361,34	323,7	271,1	244,75	180,39	169,02
Runoff Volume Decrease (%)	-	10,29	-	10,42	-	9,72	-	6,30
Continuity Error (%)	-0,18	-0,202	-0,145	-0,131	-0,138	-0,092	-0,091	-0,047

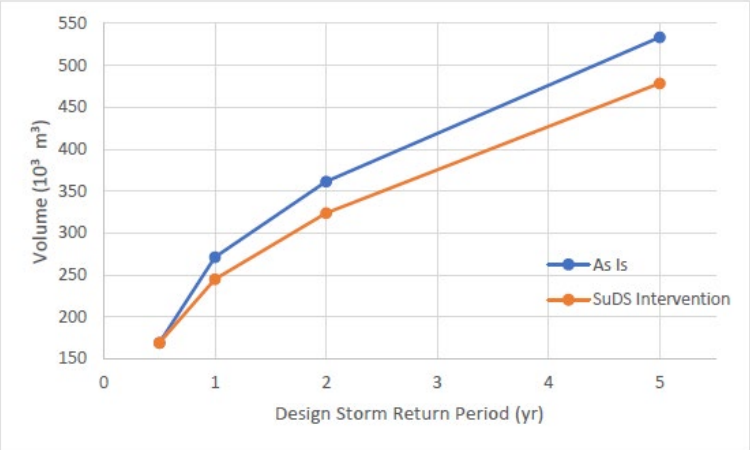


Figure 16: runoff and infiltration volumes

Hydrological Study Summary

A PCSWMM model was used to study baseline conditions in Hout Bay and to propose an improved SuDS scenario. The objective was to investigate the feasibility of utilizing SuDS to mitigate flooding in the Hout Bay Catchment. The study made two scenarios: (i) as is (baseline) and (ii) with SuDS. Rainfall and land characteristics were mode inputs. The conduits, junctions, storage units and outfalls of the Hout Bay stormwater network also imputed in the model. Design storms for 5-year, 2-year; 1-year and 6-month return period design storms were simulated. Nodes flooding for longer than 30 minutes were identified as at-risk points.

Results indicated a significant flood risk in the lower reaches of the Hout Bay River Catchment, with many junctions facing having a high flooding probability especially for 5-year and 2-year design storm events.

In the SuDS Intervention Scenario, 19 swales and 5 detention ponds were introduced in different areas of the catchment. The SuDS greatly reduced period of flooding (in minutes) by

between 25% (for a 5-year design storm) and 43% for a 6-month design storm. Moreover, the SuDS improved infiltration as indicated by the reduction in runoff.

An extra advantage of the detention ponds introduced is that, if appropriately designed, they can used for recreational purposes.

In 1800 William Duckit described the (Hout Bay) river "There is a great quantity of water issuing from the cliff, which spreads itself along the flat of the bay (see Grindley, 1988)

Introduction

Cape Town has seven districts: Blaauwberg, Cape Flats, Helderberg, Khayelitsha/Mitchells Plain, Northern, Southern, Table Bay and Tygerberg. Each district is divided into sub-districts. This study located in Hout Bay. Legislatively, Hout Bay is a sub-district located in the Southern District of the Cape Town. This further examines the baseline conditions in Hout Bay and makes WSD proposals for the subdistrict.

Natural Systems in the Hout Bay Catchment Area

The Hout Bay Catchment Area

Figure 17: The suburb of Hout Bay surrounded by mountain ranges (adapted from google earth [accessed 01.12.2020])

The Hout Bay Catchment area is 33.8 km^2 in size and consists of tributaries that flow into the meandering Hout Bay River (Hutchings et al., 2016). The headwater of the Hout Bay River is controlled by five dams on Table Mountain with a total capacity of just over 2 million litres of water: Hutchinson Reservoir, Woodhead Reservoir, Victoria Reservoir, Alexandra Reservoir, and

the De Villiers Dam (Grindley, 1988) (see Figure 17 above). From the mountain, the river flows down in two tributaries: The perennial Disa Stream flows from Hely-Hutchinson and Woodhead reservoirs while the seasonal Original Disa Stream flows from Alexandra, Victoria and De Villiers reservoirs. In Orange Kloof, the two tributes confluence into the Hout Bay River. The river flows through the valley down to the bay. The Disa Stream is longer. It is 12 km from source of Disa Stream to mouth of Hout Bay River at the bay. Woodhead and Hely-Hutchisom reservoirs supply water to a filtration plant above Camps Bay via the Woodhead Tunnel. Water from Victoria and Alexandra reservoirs flows into De Villiers Reservoir and then to water treatment plant at Orange Kloof (Grindley, 1988).

Table 10: The Streams and Dams of the Hout Bay River

	Storage Dam	Depth (m)	Capacity (Ml)	Date of Construction
Disa Stream (perennial)	Hely-Hutchinson	15.24	924.646	1904
	Woodhead	37.19	954.000	1897
Original Disa Stream (seasonal)	Victoria	6.4	128.425	1903
	Alexandra	12.12	125.724	1903
	De Villiers	27.84	242.443	1907

The river catchment is divided into five zones. The zones, which closely correlate to the topography and underlying geology, are: the upper reaches, the middle reaches (erosion zone), the lower reaches (deposition zone), and the coastal zone (estuary and seasonal lagoon) (see Figure 18).

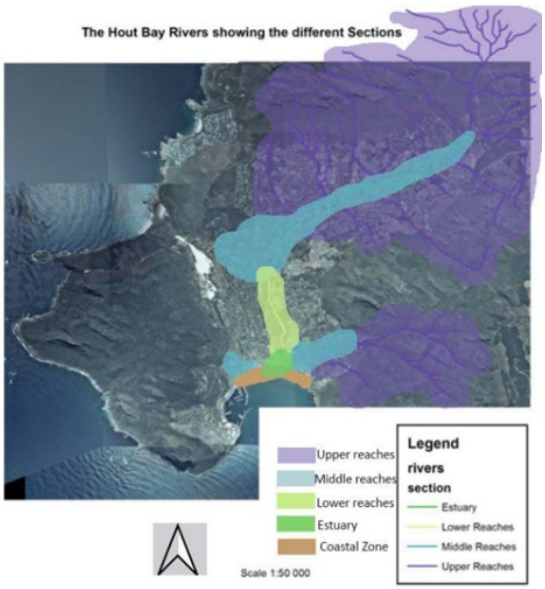


Figure 18: The Hout Bay River Zones (Map Adapted from FORHB, accessed at bit.ly/3ook53c [18 August 2020])

Photograph 2: The Hout Bay estuary flowing into the Atlantic Ocean during the winter months (Authors own, July 2020)

Figure 19: The Hout Bay estuary flowing into the Atlantic Ocean during the winter months (D Shefer, July 2020)

Water Systems

The Hout Bay river runs through the Hout Bay valley, through the farms, equestrian centres, and the residential and commercial areas of the suburb of Hout Bay (Grindley, 1988; HBR-Main Report, 1996). A 26 km network of mostly intermittent tributaries drains the slopes of the surrounding mountains to feed the Hout Bay River (HBR-Main Report, 2020; Grindley, 1988).

During the summer months, when rainfall is low, the estuary is enclosed by a sandbar and forms a lagoon (FORHB, 2020). During winter, the sand bar disappears, and the estuary flows into the Atlantic Ocean, as shown in Figure 19 above (FORHB, 2020). During this time, freshwater from the rivers of Hout Bay mix with seawater in the bay. This results in a nutritious environment that is dynamic and productive (HBR-Main Report, 1996).

There is a productive aquifer in the Hout Bay valley (CoCT, 2018) which can potentially offer alternative water sources for local catchment areas. But urban development has occurred over an aquifer and in manner that compromises the groundwater system (Clark, 1986). Figure 20 below shows the above and below-ground water systems in the Hout Bay Catchment.

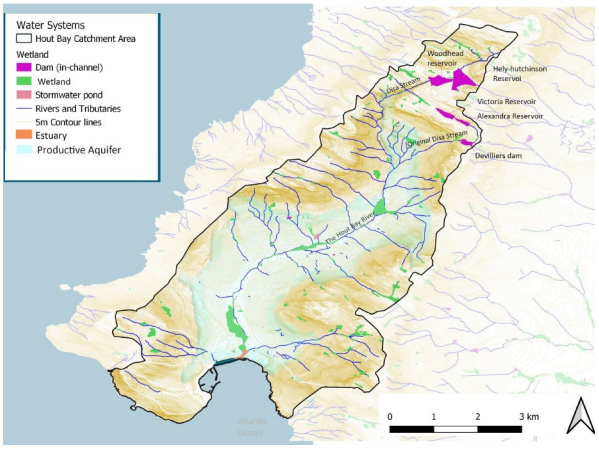


Figure 20: The above-and-below-ground water systems that function in the Hout Bay catchment area

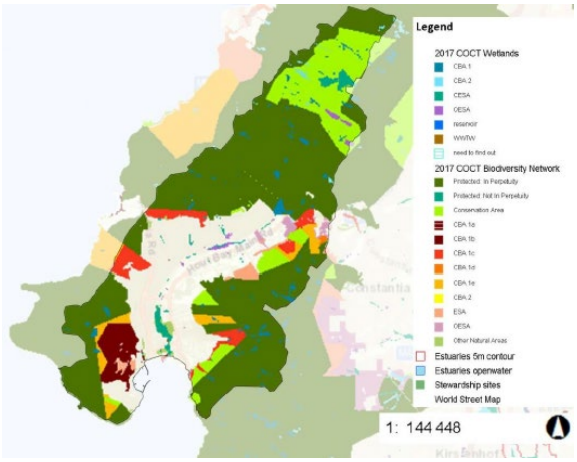


Figure 21: The Biodiversity Network and Classification of the freshwater and terrestrial ecosystems that function in the Hout Bay Catchment Area (Adapted from BGIS, Cape Town Biodiversity Network, 2017)

Biodiversity Network

CoCT has identified a network of biodiversity areas (CoCT, 2019). This network is spatially expressed in a Biodiversity Plan for The City with seven categories (CoCT, 2016) (see Table 8 below and Figure 21 above).

Some wetlands in the middle reaches of the catchment have been classified as CBAs and others as Critical Ecological Support Areas (CESA). Intact Critical Biodiversity Areas (CBAs) are mostly on the slopes of the mountains in Hout Bay but even these are threatened by urban development pressures. The map represented in Fig 21 is important for water sensitive spatial planners to apply in guiding strategic land-use decisions (CoCT, 2018) to protect nature in the city.

Table 11: CoCT network of biodiversity areas (CoCT, 2019)

Category	Code	Description	Land Management Objective
Protected Area 1	PA1	Protected areas include: National Parks, Provincial Nature Reserves, Local Authority Nature Reserves and private contractual stewardship sites with perpetuity title deed restrictions;	To be maintained as Protected Areas.
Protected Area 2	PA2	Conservation and stewardship sites pending proclamation and those without perpetuity title deed restrictions and private nature reserves.	To be proclaimed and maintained as Protected Areas.
Critical Biodiversity Area 1	CBA1	Non-protected terrestrial and aquatic features that are critical for conserving biodiversity and maintaining ecosystem function.	To be managed for biodiversity conservation purposes, restored where required and incorporated into the Protected Area network
Critical Biodiversity Area 2	CBA2	Remaining Critically Endangered remnants (i.e. 100% irreplaceable in terms of biodiversity targets) in poor (restorable) condition. T	To be restored and managed for biodiversity conservation purposes and incorporated into the Protected Area network
Critical Ecological Support Area	CESA	Natural areas, including wetlands, essential for ecological function, connectivity and viability of CBA biodiversity elements.	To be managed for biodiversity conservation purposes, restored where required.
Other Ecological Support Area	OESA	Transformed (e.g. extensive agriculture) sites with conservation importance for ecological function, faunal movement and viability of CBA biodiversity elements. Includes canalized rivers and wetlands in poor condition	Current land use should be maintained, or else restored to a more natural state.
Other Natural Vegetation	ONV	Natural vegetation areas not required to meet biodiversity targets	As per the City district EMF
Transformed	TRAN	Areas transformed by human activities, including urban and rural development, cultivated land and mines.	As per the City district EMF

Analysis of the Urban Systems that Function in the Hout Bay Catchment Area

Water Shapes Land use, and Settlement patterns in Hout Bay

There is evidence of Late Stone Age occupation of a cave near the Hout Bay estuary. Before the arrival of the Dutch colonists, the Khoisan fished at the bay, hunted wild buck in the forest, and herded their cattle and sheep in the valley (INDISA, 2007).

Starting in 1615 the forests of Hout Bay were exploited by travellers who named the bay Chapmans Chuance. Dutch settlers came to the Cape in 1652. One of Jan Van Riebeek's

scouts reported seeing a "fine large forest of very tall straight growing trees …" in the river catchment (quoted in Grindley, 1988). After driving out the Khoisan, the white settlers took over the agriculture and fishing activities, intensified logging indigenous trees in the valley (HBR-Main Report, 1996; Grindley, 1988).

A track opened along the valley to give access for farming. In 1677 Simon van der Stel was the first to rent land for agriculture. By 1681, Kronendal and Ruiteplaats were granted as freehold farms. Farming flourished in the valley over the decades and by 1850s, wine, vegetables, meat and milk were sold locally and to passing ships. The valley also had plenty of merino sheep and horses. The sheltered position of Hout Bay suited it to a lucrative business in growing early spring vegetables for Cape Town. Farming continued for decades in the valley. Water from the river was taken, via furrows to irrigate the farms. By 1944, up to 104 hectares was cultivated. Between 1944 and 1958, an additional 249 hectares were farmed. All the banks of the river downstream of Orange Kloof were farmed. As late as 1986, water was still being diverted from the river for crop irrigation and livestock. Agriculture and logging caused loss of indigenous palmiet and trees (Grindley, 1988).

In the 1960s, Hout Bay lost its competitiveness to other irrigation schemes. Farming started to decline, and this was hastened by farm parcelling as farmers in successive generations divided land among their sons. The small farms were not viable for agriculture and it became more profitable to sell the land to property developers (Grindley, 1988). Alien species such as acacia and pine were planted and crowded out indigenous vegetation.

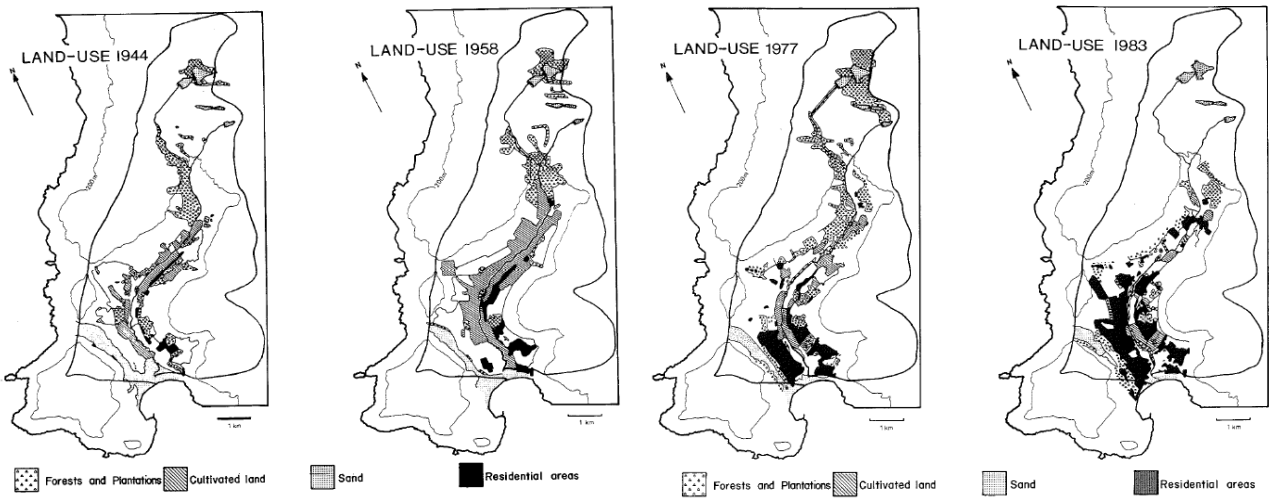


Figure 22: Land use patterns in the Hout Bay River Catchment 1944 and 1958 (S. Grindley, 1984) 17 also shows the evolution of the settlement pattern and associated land use in Hout Bay from 1944 until 1992 (after Grindley, 1988)

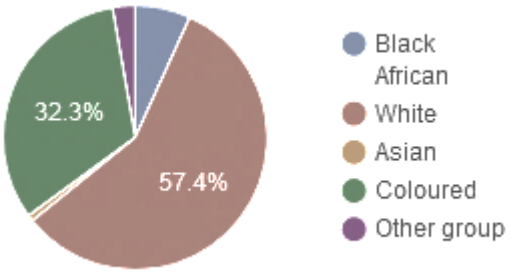
Plans to connect it Hout Bay by road and rail, and later by commuter ferry caused a land boom. But the advent of the private motorcar was the largest factor in urbanisation of Hout Bay. With the establishment of the first car assembly plant in 1932 in South Africa (Port Elizabeth) and others subsequently, the number of people owning cars increased (see this link) and Hout Bay become an attractive commuter suburb. In the 1930s, Scott and Penzance estates on the slopes of Constantiaberg and Beach Estate near the harbour were marketed. The scenic catchment attracted affluent residents to build their homes in Hout Bay. They demanded for better roads, water-supply and health facilities. In 1937, Hout Bay was proclaimed a Local Area. The precinct's scenic quality maintains the area's value and allure (Grindley, 1988).

Fishing has always been important in the Bay. Commercial fishing started in 1889 with snoek being smoked for export to Mauritius. In 1903 The Hout Bay Canning Company started exporting crayfish. In 1937 a breakwater was built to which a South breakwater was added in 1938 and a north breakwater in 1968 to make a harbour basin of about 16.4 hectares. In 1946, several fishing companies combined to form the South African Sea Products Limited. The demand for labour in the fishing industry further increased population in the 1950s and 1960s. The industry gave added impetus for roads and infrastructure provision. In 1986 (Grindley, 1988), five factories operated from Hout Bay: SA Sea Products, Chapmans Peak Fisheries, KDB Holdings, Live Rock Lobster and Irvin and Johnson. This is in addition to scores of small-scale fishers.

First residential development occurred in the valley along the river, and later expanded up the slopes of the mountains (Clark, 1986; Grindley, 1988; HBR-MainReport, 1996). A large proportion of the fishermen who lived in the valley were of mixed-race descent (SAHO, 2015). During the 1950s these residents (who were classified as "Coloured"6 under apartheid) were forcibly removed (under the Group Areas Act No. 41 of 1950) to an area above the harbour on the slopes of the Sentinel. This led to the establishment of the Hangberg neighbourhood (SAHO, 2015). The location of Hangberg within the catchment is shown in Figure 17. This is how Grindley (1988) described Hangberg: "The harbour area is characterized by high density, low-income public housing, where the overcrowded living conditions, the high incidence of disease and poverty result in a low quality of life for Coloured residents. The absence of urban landscaping has also made this area a prominent visual eyesore in an area of the highest recreational and tourist value". A more detailed study of Hangberg is in Chapter 6.

The nineties saw Hout Bay transform from a rural and fishing centre to a semi-urban settlement with farms being converted for residential developments (HBR-Main Report, 1996; Grindley, 1988). Gated estates became a popular development typology in Hout Bay catering to high-

income groups (IES international, 2017). Hout Bay population was 10 000 in 1986. By 2011 the population had increased to 17 900 and distributed as per Figure 23 below.



Population Group (C 2011)	
Black African	1,216
White	10,274
Asian	135
Coloured	5,779
Other group	495

Figure 23: Population group of Hangberg Harbour area 2011 (Statistics SA)

Today Hout Bay is also characterised as a valuable tourist destination (CoCT, 2012; 2018). Popular attractions and recreational activities are surfing, sailing, boat trips, the harbour market, and nature hikes to waterfalls in the valley and mountains (CoCT, 2012; 2018).

Shortage of affordable housing in Hout Bay led to expansion of Hangberg and establishment of Imizamu Yethu (SAHO, 2019). Today IY and Hangberg, continue to expand and are characterised as high-density, overcrowded, low-income, and poor communities with major service and infrastructure backlogs (SAHO, 2015; 2019). The low-income areas are a reservoir of cheap labour for manual jobs, domestic helpers and factory workers in Hout Bay.

Figure 24: The photograph shows the Hout Bay harbour with the neighbourhood of Hangberg in the background (D Shefer, Aug 2020)

Figure 25: The photograph shows a nature trails along the tributaries of the Hout bay river (D Shefer, Aug 2020)

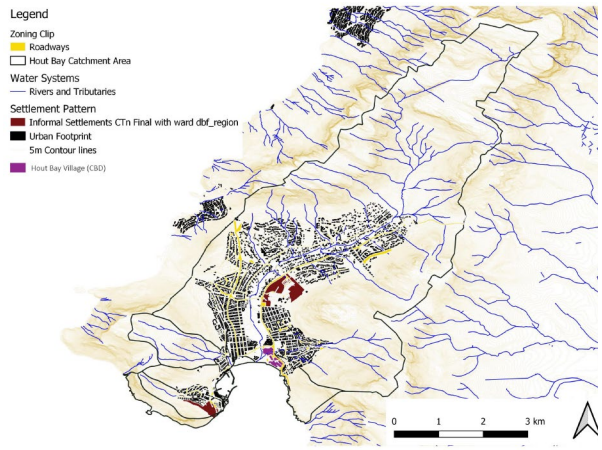


Figure 26: The map presents building footprint, main roads, CBD and informal settlements in the Hout Bay Catchment area ((D Shefer, July 2020))

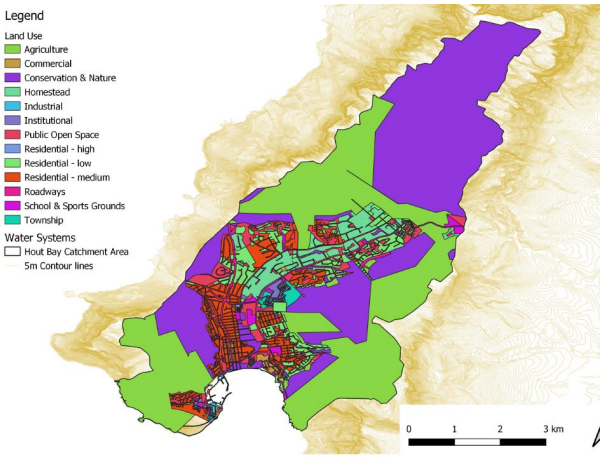


Figure 27: The map presents Land use (zoning schemes) in the Hout Bay Catchment Area (data: CoCT, 2017, map: (D Shefer, July 2020))

Legislative Context

Water Sensitive Spatial Planning (WSSP)

The 2020 Cape Town Water Strategy (CTWS, 2020) articulates an aspiration to transition to a Water Sensitive City by the year 2040. Internationally, there is a growing field within urban planning that is concerned with freshwater ecosystems which is referred to as Water Sensitive Spatial Planning (WSSP), or Water Sensitive Planning (WSP) WSP enables transition to Water Sensitive Cities (WSCs) (Armitage et al., 2014; Carmon et al., 2020; Fourie et al., 2020; Rohr et al., 2014). A number of tools are available for WSSP The include land use schemes, Ecological Land-use Complementation, Integrated Catchment Management and Urban Living Labs.

A land use scheme is a management tool used in urban planning, and natural resource and landscape management, to designate where certain human activities will take place and how the land will be converted for human use (Colding, 2007). To attain ecological and social wellbeing, it is imperative that urban planners first consider and understand the freshwater and terrestrial ecosystems that function in a city such groundwater sensitive areas, ecologically sensitive areas, and biodiversity hotspots like wetlands and estuaries (Fourie et al., 2020; Rohr et al., 2014, Bouma, 2014; Colding, 2007; Rohr et al., 2014).

A similar tool that is concerned with more consciously planning urban development according to the natural systems is Ecological Land-use complementation (ELC) (Colding, 2007) (See fig 27). This is a method of land use planning that begins with understanding the natural processes

and systems in a landscape, to protect and enhance their value within the built environment (Colding, 2007).

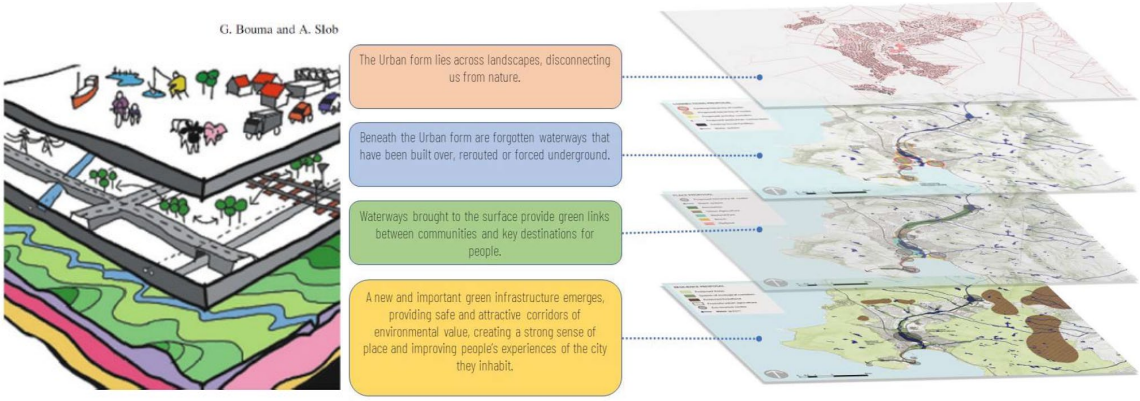


Figure 28: Left**:** Ecological Land-use Complementation (ELC) Approach (source: Bouma et al., 2014:334) and Right: the breakdown of LNRP adaptation of the ELC approach. The layout, by Phiri (2021) consists of three layers (from bottom to top): natural system layer (soil and water), network layer (physical infrastructure networks) and occupation layer (urbanisation and spatial functions) (

Spatial Development Frameworks and Water Sensitivity

A Spatial Development Framework (SDF) is a strategic planning instrument that guides and informs urban development and investment decisions within an urban area (Rohr et al., 2014). The Cape Town Spatial Development Framework (CTSDF) articulates the spatial implications of Cape Town's Integrated Development Plan (IDP). The five-year IDP, which is the main planning instrument at metropolitan level, sets a vision and aligns the plans and budgets in all urban institutions in its jurisdiction. The SDF has a timeframe of 20 years and articulates the spatial implications of the IDP (Sanya, 2014). At the time of the study, the prevailing IDP was 2017-2022 IDP. And the prevailing SDF was the 2018–2038. At a lower level of the CT Metropole, each district makes a District Spatial Development Framework (DSDF). And within the district, each subdistrict makes a Subdistrict Spatial Development Framework (SDSDF).

An SDF sets out a vision and delineates a set of development goals, objectives, strategies and recommendations to steer development in the desired trajectory. These are accompanied by a set of plans or maps that illustrate the desired spatial outcomes. SDFs can thus offer opportunity to mainstream WSD in the city ((Du Plessis, 2014 and Rohr et al., 2014).

Public participation by all – including the voices of the disadvantaged in society – must be integral to all stages of the SDF process, from visioning to implementation.

Urban Living Labs

An urban living lab (ULL) provides a platform for collaboration between stakeholders to creatively tinker around the integration of planning and water management (McCormick et

al., 2016; Puerari et al., 2018). ULL's also provide spaces to ground international best practices in different contexts. (McCormick et al., 2016). The concept is based on five characteristics defined by McCormick et al. (2020). It A physical space to collaborate, engage, and test out or experiment with new concepts. This physical space can range from a street to a district, or a catchment area. ULLs allows for new, creative, ambitious ideas to be implemented and tested in a real-life context. Public participation: ULLs bring citizens, academics, and other stakeholders in cities in a common space. The leadership of such projects aims to be a hybrid of multiple stakeholders including universities, municipalities, or businesses or a hybrid of institutions and community leaders. Evaluation is vital and leads to a better understanding of how a project can function within a specific context (McCormick et al., 2016).

The Cape Town Floodplain and River Corridor Management Policy is framed as part of a package of policies at national, provincial and city level (Table 10 below). The policies overlap with WSSP.

Table 12: The Cape Town Floodplain and River Corridor Management policy at national, provincial and city level

National	Provincial	City of Cape Town
National Building Regulations & Building Standards Act, 1997 (Act 103 of 1977)	Western Cape Planning & Development Act (Act 7 of 1999)	Cape Town Water Strategy (CTWS, 2020)
Conservation of Agricultural Resources Act (Act 43 of 1983)	Land Use Planning Ordinance, 1985 (Ordinance 15 of 1985)	Integrated Development Plan (2007/8 to 2011/12)
National Water Act (Act 36 of 1998)		By-law relating to Stormwater Management (Promulgated September 2005 – PG 6300)
National Environmental Management Act (Act 107 of 1998)		Greening the City: Open Space and Recreation Plan for Cape Town (1982)
Disaster Management Act (Act 57 of 2002)		Roads and Stormwater Department: Catchment, Stormwater and River Management Strategy (2002)
National Environmental Management: Biodiversity Act (Act 10 of 2004)		Biodiversity Strategy (2003) and Biodiversity Report (2008)
National Environmental Management: Protected Areas Act (Act 57 of 2004)		Coastal Zone Strategy (2003) and Coastal Zone Management Review and State of the Coast Report Year 3 (2006)
		Cape Town Metropolitan Open Space Strategy (MOSS, 2005)

National	Provincial	City of Cape Town
		Planning for Future Cape Town (2006)
		Integrated Catchment Management (ICM)

CoCT Adopts an ICM approach in Urban Catchment Areas

Spatial planning connects to Integrated Catchment Management (ICM) because spatial planners are concerned with balancing the pressures that are placed on terrestrial ecosystems while catchment managers are concerned with the pressures on aquatic ecosystems. Also, urban development affects water systems. There is therefore an important intersection between spatial planning and ICM (Bouma et al., 2014; Wong et al., 2002). Hence natural boundaries of a river catchments and municipal boundaries must be aligned to coordinate spatial and nature conservation priorities within and beyond catchment areas (Norton, 2018).

The CoCT has adopted an ICM approach to managing its freshwater ecosystems and stormwater infrastructure (Obree, 2004). The Hout Bay catchment area falls within the Central Catchment Management Area, as seen in Figure 29. This area spans over two districts namely: the Southern District and the Table Bay District. The catchment is therefore split between two planning jurisdictions. This strains the integration of the urban planning domain.

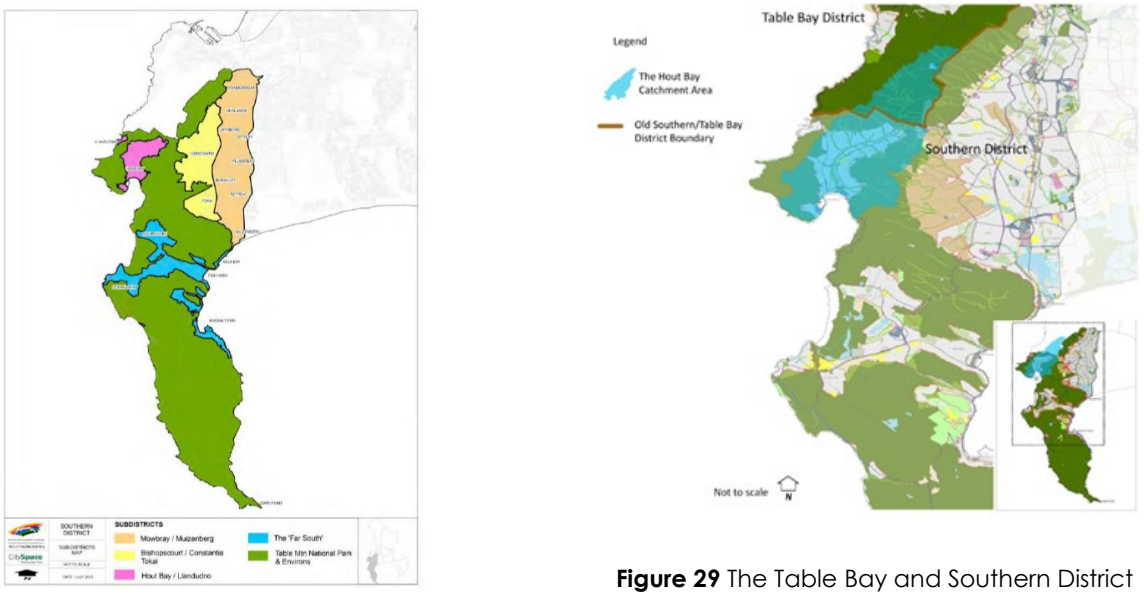


Figure 29 The Table Bay and Southern District municipal boundary cuts through the Hout Bay Catchment Area (Author adapted from CoCT, 2014; 2015)

The Floodplain and River Management Policy (2009)

The Floodplain and River management policy (2009) aims to protect floodplains from inappropriate urban development to reduce the effects of urban flooding, improve the economic efficiency of stormwater infrastructure, and to provide social amenities (CoCT, 2009). The aim is to (i) To protect human life, property, and infrastructure from flooding (ii) preserve ecosystems (iii) ensure economic efficiency (iv) ensure efficiency of drainage infrastructure (v) provide public open space, recreational areas and enhance tourism (v) education. The policy requires that SDFs express ecological buffers for rivers, floodplains, and wetlands (CoCT, 2009). For watercourses, buffers are measured from the top of the bank and can vary in width from 10 m to 40 m. For wetlands, the requirement can be up to 75 m from the edge of the wetlands.

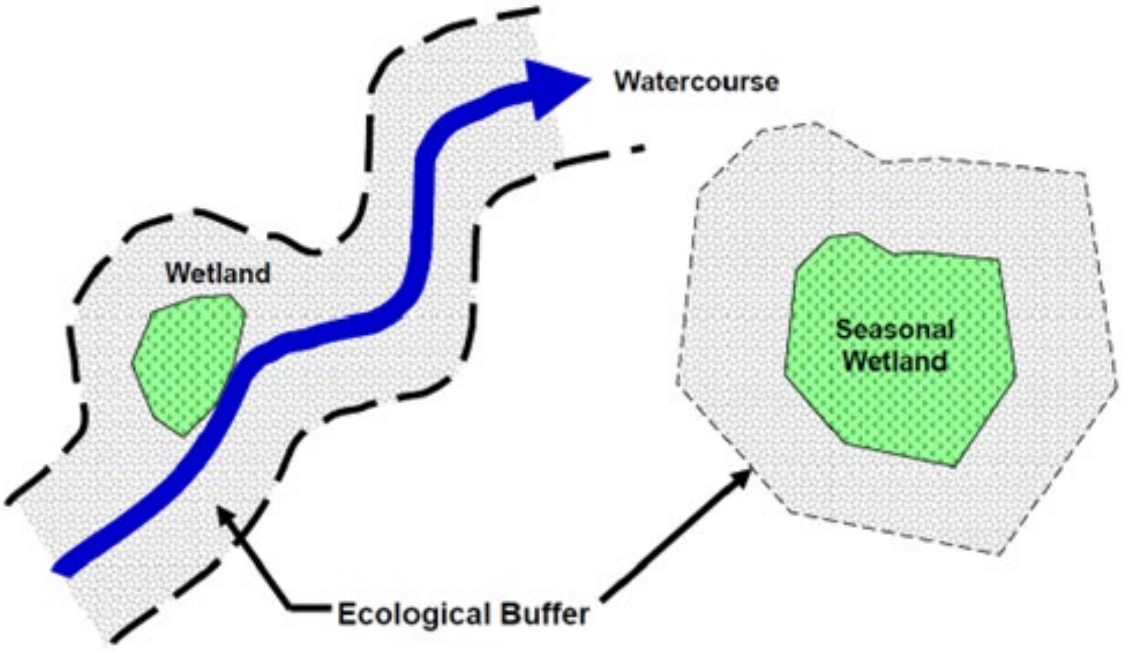


Figure 30: Schematic Representation of Ecological Buffers (CoCT, 2009:8)

The policy further requires that SDFs identify 2-year, 5-year, 20-year, 50-year and 100-year flood-lines on their directive maps. Each flood-line is associated with permissible, conditional, and prohibited land uses. Above the 100-year flood-line, all land use types are permissible. Residential, hotel and resort land uses are conditionally permissible between the 50-year and 100-year flood lines provided that (i) floors are above the 100-year flood level and (ii) basements (non-habitable purposes) are flood-proofed to 50-year flood level. Only nature reserves, conservancies, and public and private open space are permitted below the 2-year flood-line.

In the Hout Bay estuary area, several large residential and commercial properties are located below the 50-year floodplain. All the rest of the Hout Bay valley, urban development has is generally above the 50-year floodline. But because the 100-year floodline for the Hout Bay is not defined, it is probable that many properties fall between the 50-year and 100-year floodline without being compliant with applicable Floodplain Policy requirements. Building below the 100-year floodline without restrictions compromises the river's ecosystems. Globally, there is an increase in flash floods due climate and such properties increase flooding risk to people and property. Therefore research is required to (i) identify the 100 floodline in Hout Bay (ii) assess compliance of properties within 50-year and 100-year floodlines with Flood Policy (ii) Where necessary, identify and implement for retrofit to adhere to Floodplain policy.

The 2012 SDSDP for Sub-district 1 (Hout Bay) was produced after the Floodplain Policy. The 2012 HBSP represents the 50-year flood-line, as seen in Figure 31. The flood-line encompasses much of the wetlands and sections of the estuary. But the area designated for intensive-development is adjacent to the estuary and falls within the flood line. This can cause potential ecological and human risks (CoCT, 2009).

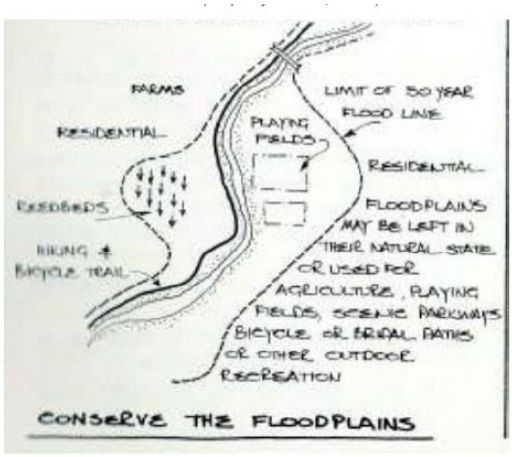


Figure 31: Strategy to Conserve the Flood-lines (Source: The Clark, 1986:21).

Water and Spatial Planning in Cape Town

The CTMSDF of 2018

Cape Town Municipal Spatial Development Frameworks (CMSDFs) use ecosystems as key planning informants (see CoCT, 2012; 2018; 2020). The CTMSDF (2018) provides several directive maps that locate freshwater ecosystems such as rivers, wetlands, groundwater, and estuaries in the City. These features are associated with protective statuses or development principles. However, the most significant finding is that the freshwater ecosystems are represented on four separate directive maps, namely: Significant Precautionary Areas, Agricultural Areas of Significance, The Biodiversity Network, and The Heritage Resources. Hence, there is no single map depicting the interconnectivity of all water systems (human-made and natural).

The Biodiversity Network, shown in Figures 21 and 27 above, identifies the wetlands as important areas to protect from harmful development. Some rivers in The CoCT are designated as CBAs but the Hout Bay River is not. Thus, the Hout Bay river is rendered vulnerable to harmful development.

The Significant Precautionary Areas, (see CTMSDF, 2018), are the natural and man-made constraints to development (CoCT, 2018). The Hout Bay River is identified in this map. The associated development principles address reducing harmful development and protecting the integrity of freshwater ecosystems. The Hout Bay River is represented as a proposed heritage area on the heritage map (CoCT, 2018: p). This provides a further degree of protection as the policy guideline for heritage sites addresses conserving the authentic state of the resource (CoCT, 2018). The Agricultural Areas of Significance, identifies the aquifers in CoCT including the one in the Hout Bay Valley. The development principles require protecting this valuable resource through appropriate approaches (CoCT, 2018).

The 2012 Southern District Spatial Development Plan (2012 SDSDP)

Hout Bay is located in the Southern District of Cape Town. The Southern District contains of five sub-districts (CoCT, 2012). The urban extent of Hout Bay covers Sub-district 1 (Figure 32 below). The 2012 Southern District Spatial Development Plan (2012 SDSDP) guides development in these sub-districts (CoCT, 2012). The SDSDP 2012 contains a more detailed plan for Subdistrict 1 (Hout Bay). Th detailed plan is the 2012 Hout Bay Spatial Plan (HBSP, 2012) shown in Map X below.

In the HBSP 2012, the Hout Bay River was categorised as Core 2. Core 2 areas are regarded as ecological corridors, river corridors, or Critical Ecological Support Areas (CESA) (see Biodiversity above …). The Hout Bay River demands a unique management approach and must be protected (CoCT, 2012). However, the 2012 HBSP plan does not include protective directives for the wetlands and the estuary. Instead, the plan proposes mixed-use intensification at the river mouth (see Figure 32). This development directive encroaches on the estuary and opens room for destructive development (Murphy, personal communication, 2020). The HBSP (2012) came after the Floodplain policy. But still does not identify the 100-year flood. Already, wetlands and sections of the estuary have been infilled for the development of residential estates and shopping centres (name..)(Coetzee, personal communication, 2020).

The 1986 Hout Bay Spatial Plan (HBSP, 1986) presented the river as a significant natural structuring element that guides human development and activities in the Catchment area. It emphasizes that maintaining human access to the river is vital for human wellbeing as the river offers spiritual and recreational value to the residents of Hout Bay (Clark, 1986). Figure 33 below shows the development strategy for the valley. The strategy emphasised maintaining a

continuous route of public access to open space and long the river open space along the valley and extending this route into the mountains (Clark, 1986). This has both the aim to protect the floodplains and connect people with nature and water in Hout Bay.

The network of public open space has been termed the "fingers of green open space". (Clark, 1986). The Development strategy (1986:18) spatially defines areas for "land sensitive uses". In HBSP (1986), the river and tributaries are buffered and protected with green fingers which are also visually represented on this map. Hence the 1986 offers some lessons for enhancing water sensitivity in Hout Bay today. The HBSP (1986) was produced before the Floodplain and River Management Policy. It does include development policy for protecting the Hout Bay River and the 50-year floodplain (Clark, 1986:21). But it did not set development restrictions between the 50-year and 100-year floodplain. The 1986 HBSP came at a time when Hout Bay was about to undergo massive urban growth. By not considering the 100-year floodline, these the scene for current state of Hout Bay where developments start just above the 50-year floodline but many fall within the 100-year endangering people, property and ecosystems.

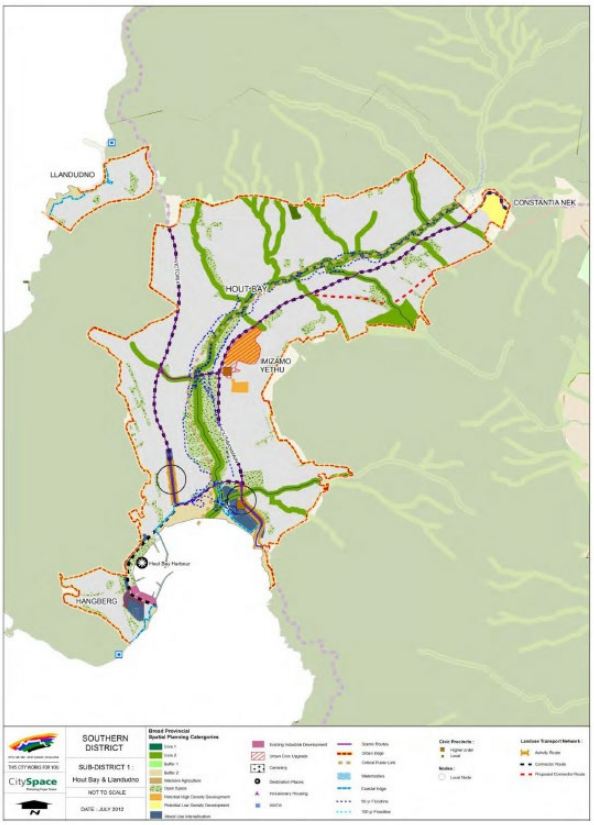


Figure 32: The plan for the urban extent of Hout Bay (source: SDSDP, 2012:119)

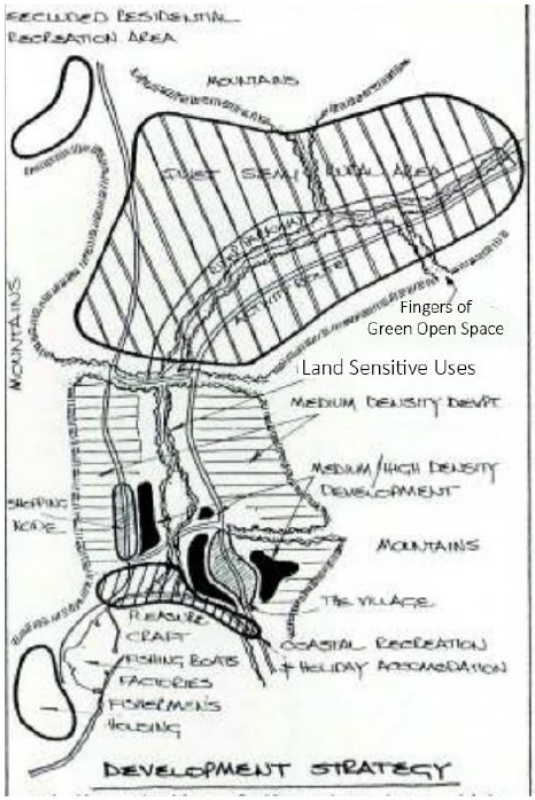


Figure 33: Hout Bay Development Strategy (Source: HBSP, 1986:18, Author has adapted the text to make it more visible)

WSD Policies and Guidelines

The Cape Town Municipal Spatial Development Framework (CTMSDF) (2018) promotes uptake of WSD under policy 24, To protect freshwater ecosystems from development, ecological buffers, setback lines and development edges must be delineated CoCT, 2018) (see Figure 30 above for how buffers and corridors should be represented on maps). This policy and its guidelines should reflect at all scales of SDFs.

The CTMSDF vision, objectives, plan and guidelines for Sub-district 1 aim to protect the Hout Bay River valley corridor and open space with a focus on promoting recreational use and tourism (CoCT, 2018). However, there is no mention of the goals and principles of WSD and the this renders the plan ineffective. Ironically, the guidelines propose "high-intensity development" which should be accompanied by WSD principles but without any clarity on how this is to be done.

Therefore, the existing development guidelines are vague and offer little practical tools for planners to ensure that development is sensitive to the freshwater ecosystems in Hout Bay. The plan for Sub-district 1 needs to be accompanied by more strategic water-sensitive development objectives and guidelines for WSD implementation.

Key Stakeholders in Water Management

Roads and natural stormwater conduits (i.e. rivers) are managed by the Department of Transport. The Hout Bay River Catchment falls in the Central Catchment of Cape Town. Stormwater (CoCT, 2015).

Several community-based organisations (CBO) in Hout Bay seek to identify and address the key negative land use impacts on freshwater ecosystems. These include, Friends of the Rivers of Hout Bay (FORHB), the Hout Bay River Catchment Forum (HBRCF) and Thrive.

Friends of the Rivers of Hout Bay (FORHB) is dedicated to the rehabilitation and conservation of the river system in Hout Bay (FORHB, 2020). The CBO is run by volunteering members of the public who consult with environmental agencies, experts, and government and municipal authorities (FORHB, 2020; Murphy, personal communication, 2020). They address such threats as invasive plant species, canalisation, pollution, and water abstraction (FORHB, 2020).

Thrive is a group that works to connect diverse communities in Hout Bay through environmental education and awareness projects (Mdalase, personal communication). The stakeholders involved in these projects assess opportunities and key areas of concern with regards to water security in Hout Bay. *It is important that these stakeholders publicly participate in the inception of SDFs, so that community water needs, and challenges are sufficiently addressed.*

The Hout Bay River Catchment Forum (HBRCF) is a voluntary body of residents that facilitates discussion between the wider community of Hout Bay and the authorities involved in the management of the Hout Bay catchment area. The HBRCF is partnered with The CoCT's Transport Department who funds the "pilot projects" that are proposed by the HBRCF. One such pilot project is the establishment of the Hout Bay Rivers Conservancy and Nature Park which aims to reduce the threat of urban development encroaching on the wetlands and estuary (Murphy, personal communication, 2020).

Figure 34: The properties on the right are set back from the river, allowing for informal public walkways to develop and allows for public interaction with the river (Donna Shefer, July 2020)

Figure 35: Private fencing along the river includes large portions of the riverbank into private property restricts public access to the river along the riverbanks (Donna Shefer, July 2020)

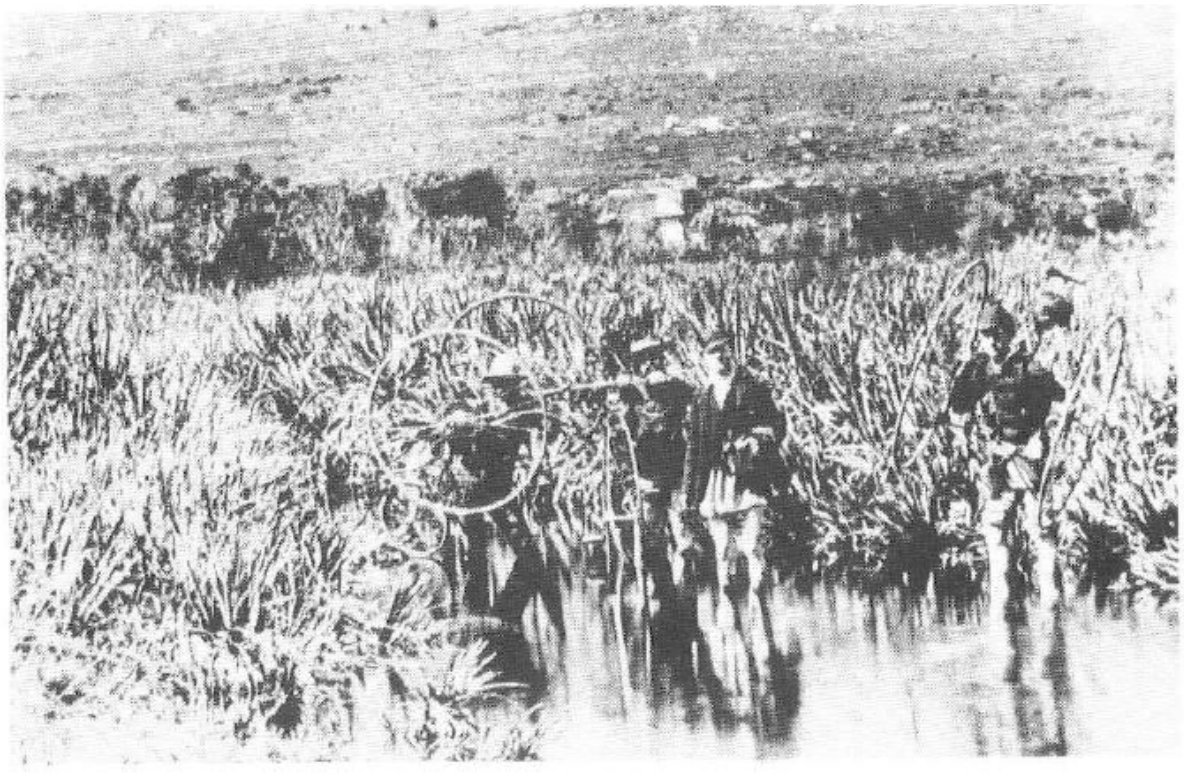


Figure 36: The once dense palmiet in lower reaches of the Hout Bay river (source: Hout Bay museum 1887, extracted from Grindley,1988).

Figure 37: The Hout Bay river flowing beneath the Victoria bridge in Hout Bay. Two stormwater pipes feed into the river, one is directly adjacent to the bridge and the other, larger one, is further downstream. The riverbanks have been invaded with alien grass species (Donna Shefer, July 2020, site visit).

Figure 38: The vegetated wetlands of the middle reaches of the Catchment, with Kikuyu grass growing in the background (Donna Shefer, July 2020, site visit)

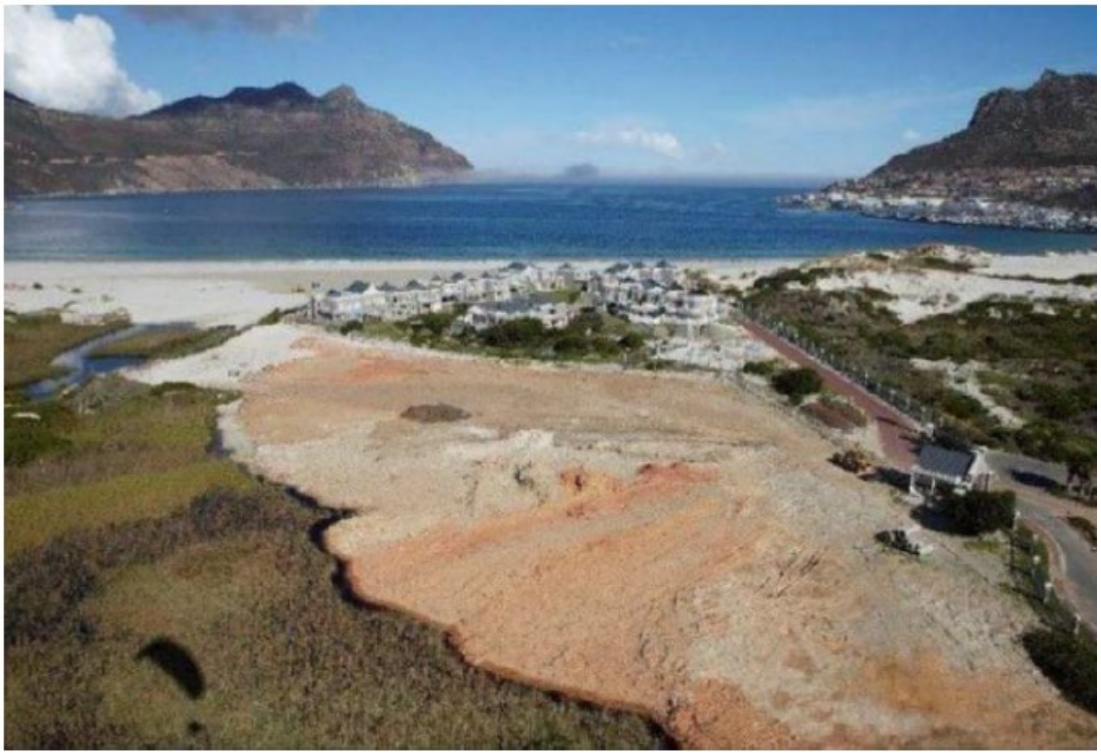


Figure 39: An aerial view showing the infilling of the Disa [Hout Bay] River floodplain as part of the Beach Club housing development. (Photo by Anthony Allen, CA, 2011)

Figure 40: A signpost in the lower reaches of the river, expressing a city health warning to the general public. The sign 64warns the public of the health risk that the river poses due to the polluted and unhealthy state of the Hout Bay river. (Donna Shefer, July 2020, site visit)

Current Land-Use versus Water-Sensitive Land-Use Considerations

The Hout Bay River, wetlands, and estuary are not represented in the 2018 land use scheme (see Figure 27). Hence, this study compared Figure 20 (which shows the water systems in Hout Bay) against Figure 27 (which shows the current land use scheme) to analyse the impact of development on the catchment ecosystems.

The middle and upper reaches above Victoria Road are mostly zoned for homesteads (see Figure 27). Homesteads are associated with farming activities (DEADP, 2018) including equestrian centres, nurseries, an animal rescue centre, and large residential gardens (site visit, 2020). This land use allows for the riverbanks to remain vegetated and relatively undeveloped making the area relatively low impact.

The lower reaches of the catchment area, the estuary, and around the coast are zoned for schools, sports fields, low and medium residential, and commercial land uses. The lower reaches of the catchment area are more developed and less permeable open land is

available. The areas below Victoria Road and within the 50-year floodplain areas are zoned for public parks and schools. But the bordering properties make much of the green inaccessible to the public.

Public open space is sparse and scattered throughout the urban extent of the Hout Bay (See Figure 27 above). Public accessibility to open space along the river is limited and inconsistent. Some properties are set back from the river to maintain public access to the riverbanks, but many have fenced the floodplains into their private gardens (See photos in Figures 34 and 35 above). This is obviously against the floodplain policy.

The Impacts of Land Use Change and Urban Developments on Freshwater Ecosystems

The indigenous riparian vegetations including trees, palmiet and dense reedbeds had been cleared from the floodplains (HBR-MainReport, 1996; Grindley,1988). This contributed to the erosion of the riverbanks and the depletion of the groundwater supply (HBR-MainReport, 1996). With urbanisation, there has been an increase of area of impermeable surfaces and alien species. Kikuyu grass from residences in the affluent neighbourhoods has evaded the riverbanks (Figure 38) and pine, which replaced the indigenous yellowwood, covers the slopes (Site visit, 2020; Snaddon, personal communication, 2020).

Figure 40 above shows a signpost situated along the banks of the Hout Bay River. It warns the public of the unhealthy and polluted state of the river. Thus, the public cannot enjoy the river for recreational purposes such as swimming and fishing, nor is the water quality fit for consumption (Anciano et al., 2018; CoCT, 2012 (Site visit, 2020; Coetzee, personal communications, 2020).

Water sensitive spatial planning and land use schemes can play a role in ensuring that these ecologically fragile and important areas are safeguarded from insensitive development. spatial planners, therefore, play a key role in learning the distribution of ecologically fragile areas that cohabitate with urban settlements.

Socio-Economic and Ecological Systems in Hout Bay Catchment Area

A Segregated Community

The suburb of Hout Bay has diverse racial and socio-economic populations (StatsSA, 2011). However, there is little integration across racial groups, social class, and household income levels (Frith, 2011; StatsSA, 2011). Coloured residents were relocated to Hangberg which, while white residents stay throughout Hout Bay. Black African residents established a settlement at Imizamo Yethu.

Water Sensitive Planning Interventions

This section proposes water spatial sensitive planning (WSSP interventions for the Hout Bay Subdistrict. Three interventions for WSSP are proposed, respectively: (i) Principles that Inspire Hope and Vision (ii) Mapping The Catchment Area, and (iii) Water Sensitive Development Objectives and Guidelines. In each, the role of language in shaping people's attitudes towards nature is highlighted. The animacy of nature in celebrating spatial local character and stimulating communities is also acknowledged.

The first intervention provides a set of guiding principles that encompass the Vision for Hout Bay and underpin the recommendations in the next two interventions. The second intervention proposes five maps to illustrate requirement for improving the water-sensibility of land-use management schemes and SDFs. In the final intervention, development objectives and guidelines for the above maps are given.

Intervention 1: Vision

An aspirational water-sensitive vision for the Hout Bay catchment area is set based on deep reverence for water bodies and connection to the wellbeing of all life. The vision draws from but extends the metropolitan CTWS (2020). To challenge dominant anthropo-technocentric attitudes to development, figurative language is deliberately used in the vision:

The Hout Bay river is teaming with life. She lives harmoniously with microbial organisms in the soils, with the fish and birds that live and feed in her wake, and with the humans that walk, play, swim, and drink consciously from her body. The Hout Bay river flows and expands naturally through the seasons. There is room for her to grow during winter and vegetation to hold her banks in place during the dry summers. She flows from Table Mountain and feeds the estuary and wetlands in the valley. She meets the sea at the estuary. Clean and fresh is her water and her organisms are healthy. Then she mixes her freshwater with the salt to form a rich and nutrient abundant nursery for many ecological systems to flourish. With help from her vegetated plains, she protects all from flooding in heavy rains and offers refuge to cool off in summer. All human livelihoods, health and wellbeing are improved because she is healthy and provides many benefits.

Residents and visitors of Hout Bay have a deep appreciation and reverence for water in the catchment area. Water is used with restraint, and all community members are active and engaging in water sensitive practices and management. Urban development is water sensitive and allows rainwater to seep back into the ground. Local water harvesting mechanisms are incentivized and encouraged by local authorities and the private sector. Anyone can access the river's banks and water, because properties are permeable and embrace her beauty. Thus, all the residents of Hout Bay have access to safe water and adequate sanitation services.

By 2031 the Hout Bay catchment area will be a healthier and living river that flows from source to sea. Many benefits are provided to the Hout Bay communities through the existence of healthy connected ecosystems. All residents will have access to safe services and infrastructure and reside within a liveable and joyful water sensitive neighbourhood.

This vision for the Hout Bay catchment area underpins the guiding principles of reverence, balance, interconnectedness, restraint, responsibility, and connection. The principles inform the rest of interventions, interventions and recommendations.

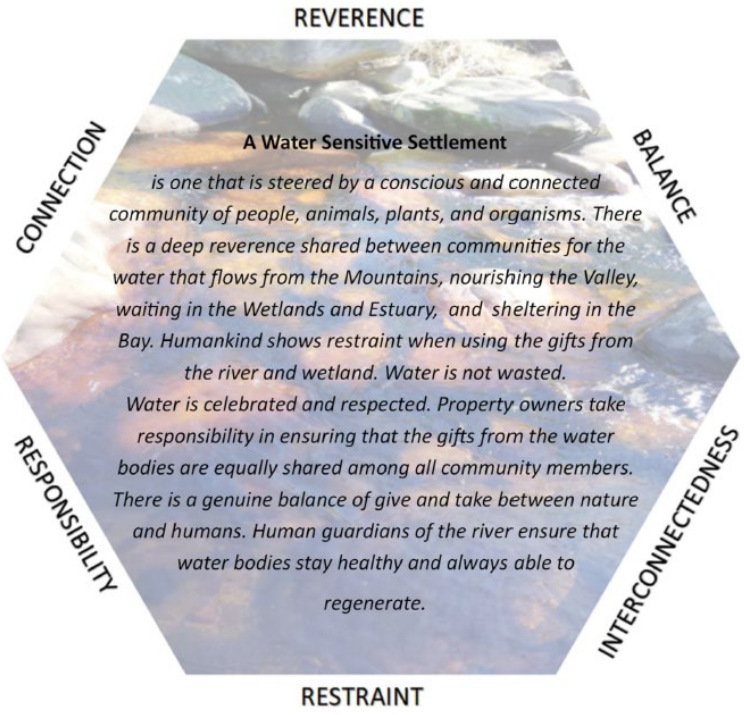


Figure 41: The principles that steer Hout Bay's aspiration to transition towards a water sensitive settlement. In the centre of the hexagon is the definition of what a water sensitive settlement can look like in Hout Bay. This is achieved through upholding the six principles on the edge of the hexagon (Shefer, 2020)

Intervention 2: Mapping The Catchment Area

The purpose of this intervention is to visually express how land use management schemes and SDFs can be enhanced for WSSP in the Hout Bay Catchment area. The maps are presented under the five proposals to translate concepts from the realm of water management (i.e. IWRM, ICM and WSD) into useful tools for urban spatial planning and practice.

Proposal 2a: Aligning District Boundaries with the Catchment Boundaries

Currently, the municipal boundaries of the Southern District and the Table Bay district cut through the upper reaches of the Hout Bay Catchment area. This study proposes realignment of the Southern District boundary to include the entire Hout Bay catchment area (See figure 42 below). This is significant as it ensures that administration jurisdictions align with natural boundaries for better coordinated decision-making and implementation.

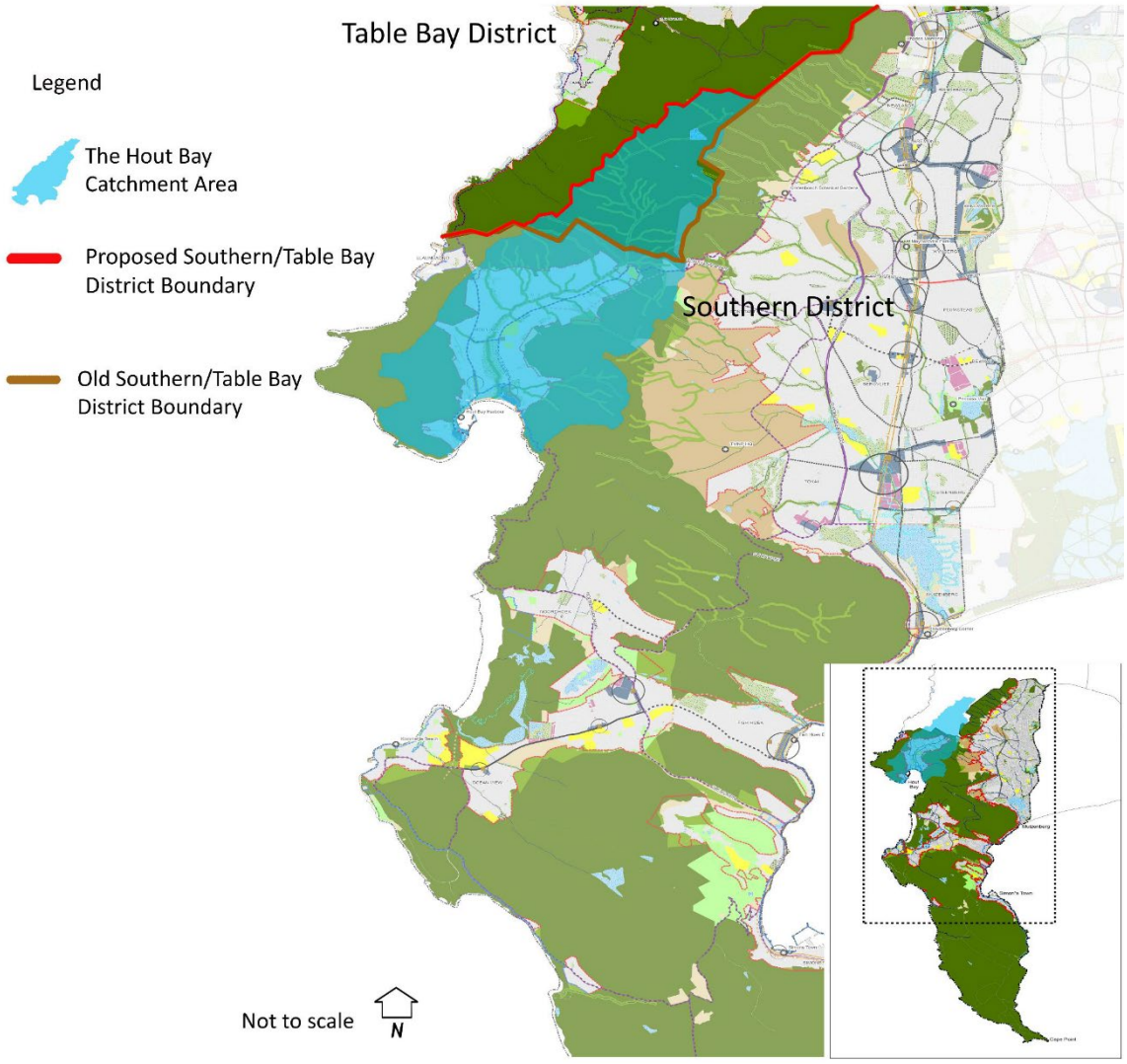


Figure 42 The proposed Southern/Table Bay district boundary includes the entire Hout Bay catchment area (D Shefer; Data: CoCT, 2012)

Proposal 2b: Water sensitive Land Use Management

The second proposal under this intervention is that two amendments be made to land use schemes to enhance their water sensitivity in Hout Bay. First, The original land use map does not represent freshwater systems such as the Hout Bay River and its tributaries. Therefore, the first amendment is to include the river in land-use schemes (see figure 43). This allow for more conscious placement of land uses according to the requirements of water sensitive spatial planning. By understanding where the river flows, planners can zone the land sensitively, for instance by delineating floodplains and floods, critical ecological support areas, freshwater ecosystems and soft public open space to maintain the natural character and functioning of these spaces.

Second, current zoning along the river depicts disconnected public open spaces. The second proposed amendment is therefore rezoning within the catchment area to create continuous public open spaces. Within these spaces, natural systems will be protected, and multiple ecosystem services offered (e.g. bird watching, nature walks, and educational activities) in line with the Floodplain and River Corridor Management Policy (see figure 43 below).

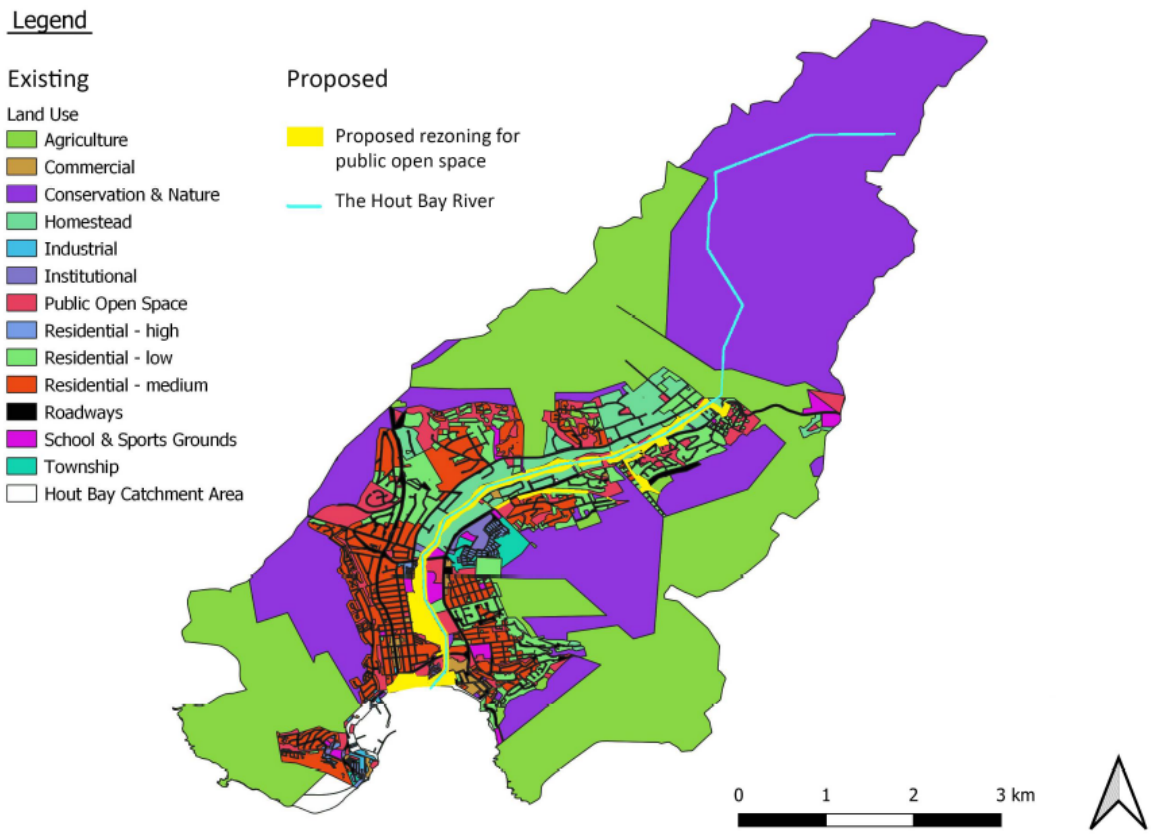


Figure 43: Rezoning areas for public open space with conservation, education and nature walks as primary activities D Shefer, 2020)

Proposal 2c: Making Room for Critical Ecological Support Areas and Floodplain

Currently, wetlands and the estuary are informally protected by the HBRCF and other CBOs who voluntarily guard these areas against proposals that might cause harmful development. And yet, as discussed above, the existing SDSDP (2012) recommends that the area adjacent to the estuary (on the eastern edge) be zoned for intensive mixed-use development. Thus, despite the efforts of these local activists and environmentalists, development proposals that impede the wetlands and estuary continue to be submitted.

Proposal 2C therefore aims to protect the estuary and wetlands of the Hout Bay River. It is a protective recommendation that delineates where urban development must not occur within the catchment (Figure 44 below).

The proposal has three components (i) establishment of the River Corridor Ecological Breathing (ii) Protective overlay for swamps (iii) Protective overlay for the Estuary (iv mapping the aquifer.

In combination, the components are aimed at reducing exposure to flood risk to protect life, property and community infrastructure while protecting the natural flood carrying capacity of watercourses and wetlands. They are further aimed to enhance ecosystems and multiple services they offer to people. This proposal is in line with the Floodplain and River Management Policy to protect and connect watercourses and wetlands with their adjacent riparian areas and associated fauna and flora.

The most significant component is the establishment of the River Corridor Ecological Breathing Room along the river and its tributaries. This is an initiative to conserve the river's floodplains and all it encompasses. The ecological breathing room component proposes an ecological buffer encompassing the river, the wetlands and the estuary. (figure 44)

There is a productive aquifer under the surface of the urbanised valley (CoCT, 2012; 2018). In terms of the SDSDP (2012) a productive aquifer is regarded as an "environmental management priority" (CoCT, 2012:88). The aquifer is therefore mapped (Figure 44) to ensure that developments safeguard groundwater infiltration.

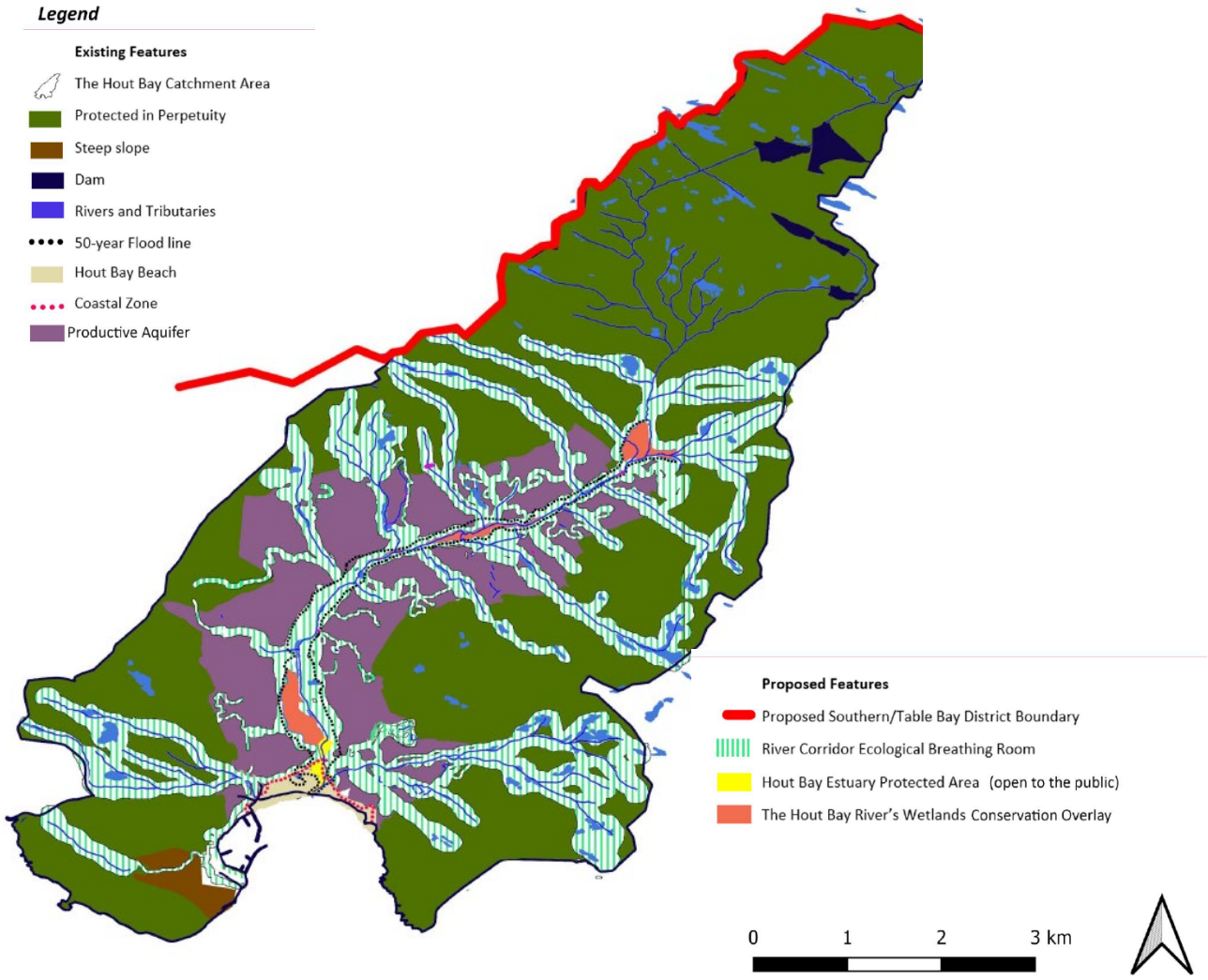


Figure 44: Protective Directives for Conserving the Freshwater Ecosystems in Hout Bay D Shefer, 2020)

Proposal 2d: Blue-Green Connective Tissue as a Continuous Public Open Space

Referring to the HBSP (1986), the study proposed green fingers that functions as a continuous network of public open space along the river's floodplains within the urban extent of Hout Bay. The study renames this network as blue-green connective tissue and extends the corridor through the urban extent to connect it to the mountain paths of Hout Bay (see Figure 45 below). This enables easy access to nature paths in the mountains and facilitates a deeper connection of the urban area to the surrounding natural environment.

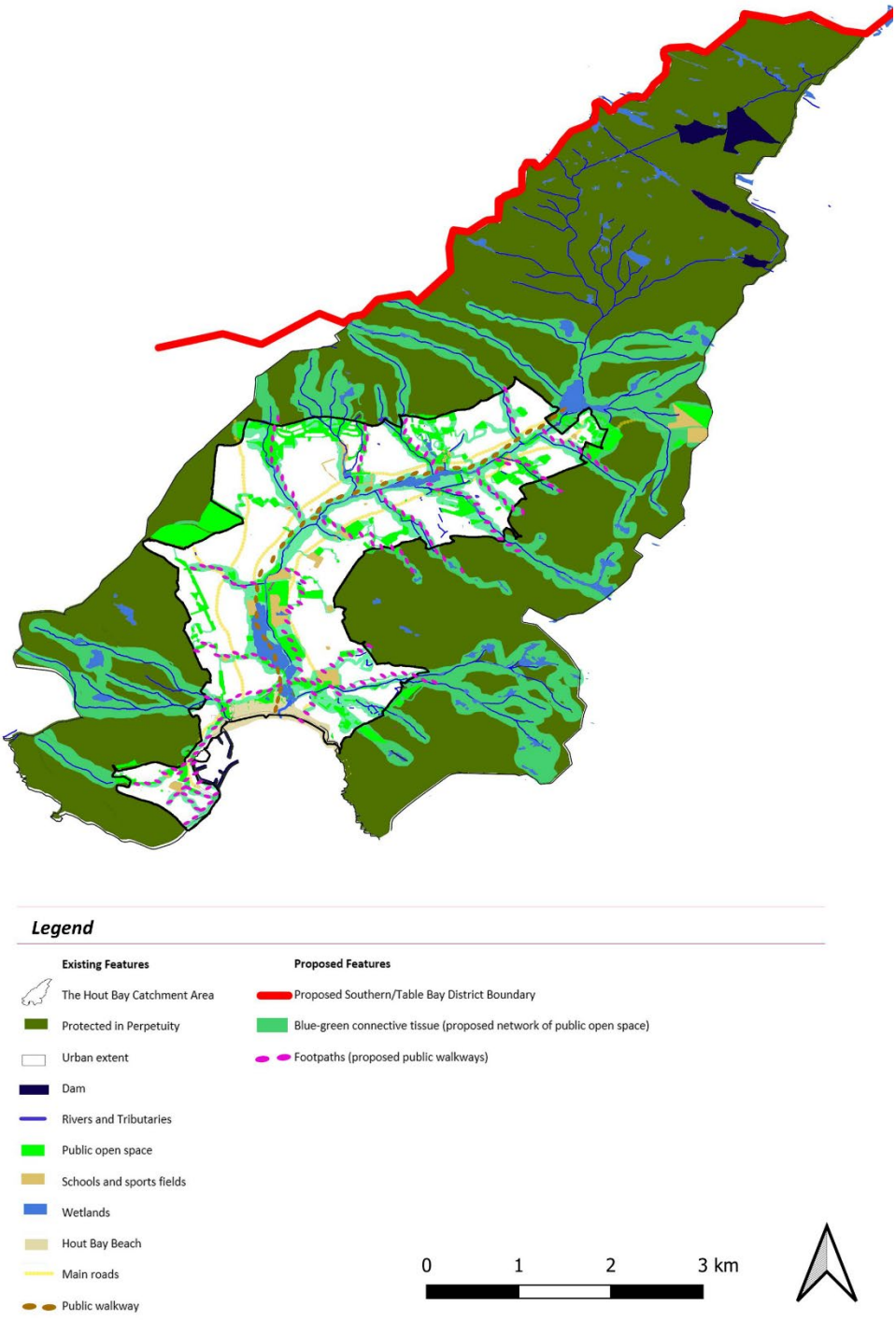


Figure 45: Multi-functional Blue-Green Connective Tissue & Pedestrian Pathways (Source: D, Shefer, 2020)

On the map in Figure 45, the blue-green connective tissue is a continuous network of public open space. It lies within the spatial extent of the river ecological breathing room and is envisioned as a multifunctional space that provides public open space and ecological infrastructure. The network connects the existing public open space, sports fields, schools, and the river with the neighbourhoods in Hout Bay. By connecting schools to the blue-green network immersive learning and a deeper link between young people and nature is nurtured. Allowing nature to flow more easily into urban spaces thereby, softening the urban fabric and easing the perceived urban-nature boundaries. The continuous connective tissue also offers multiple benefits to people and nature in the city.

Furthermore the new proposed footpath (public walkway) connects all communities of Hout Bay including the Hangberg and YI communities (and the greater Hout Bay neighbourhoods) to the river, beach, and Hout Bay CBD and public facilities. The connective tissue aims to facilitate integration between the diverse communities and neighbourhoods in Hout Bay.

Proposal 2e: Development Directives for Water Sensitive Development and Activities

In Figure 46 below, four development directives are proposed: WSD within existing footprint; groundwater sensitive development; river interactive properties and low impact development

WSD within the Existing Footprint

The objective of this proposal is to delineate the areas in the catchment areas that are most suited for development. Under this proposal, the study recommends that all development remains within the existing urban edge (as identified in the existing plan for Subdistrict 1 – and all future development is done in an ecologically and water sensitive manner. This means incentivising WSD approaches for retrofit and new developments.

The existing urban developments within the estuary and the wetlands must offset their adverse ecological effects (due to wetland and estuary infilling) through retrofit to integrate water sensitive measures such as permeable pavements, green roofs, rainwater harvesting, raingarden and indigenous flood-resistant vegetation and ensure wastewater effluent is clean and non-polluting.

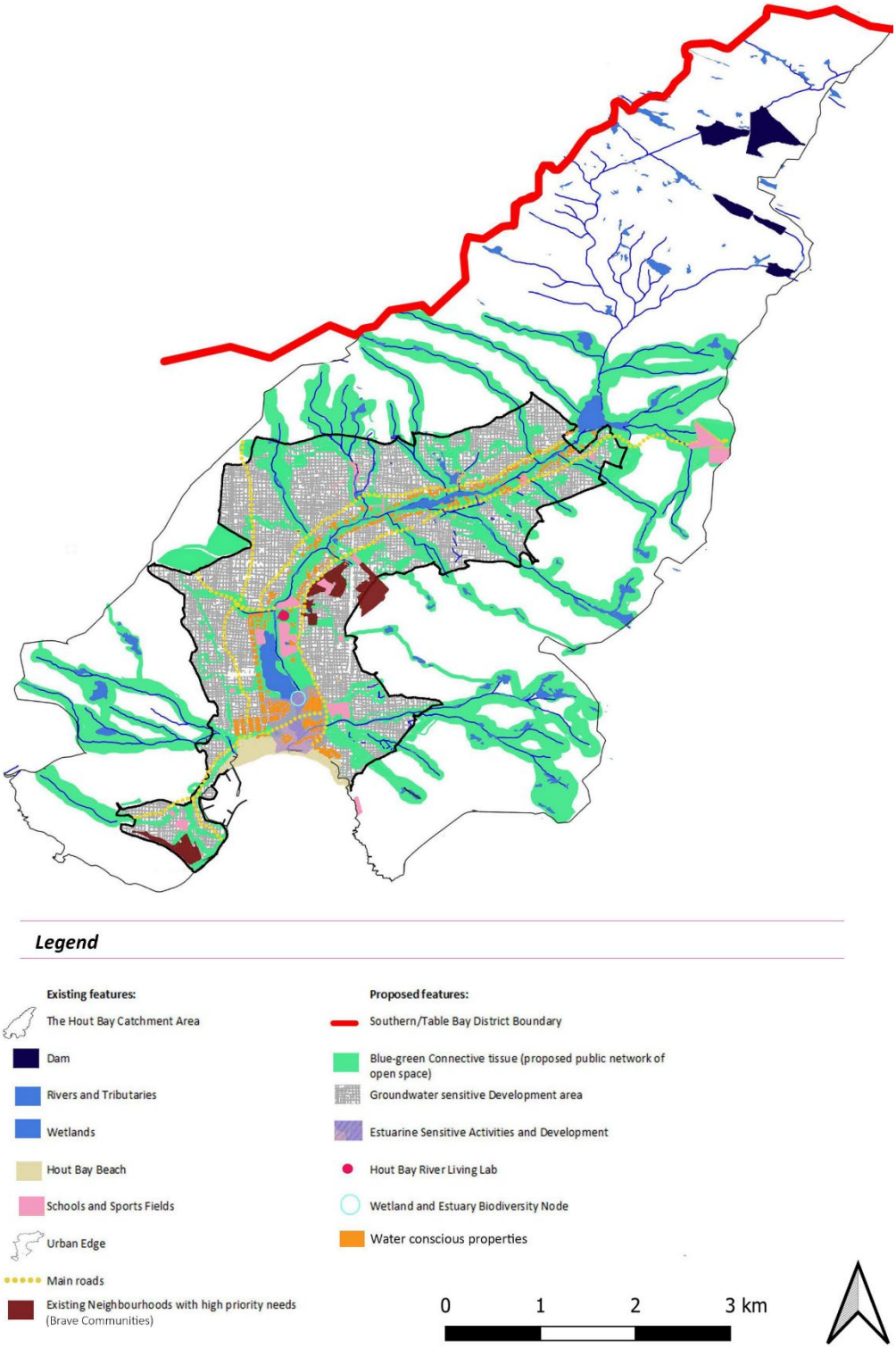


Figure 46: Development directives (Source: D. Shefer, 2020)

Groundwater Sensitive Development Zone

Furthermore, to protect the productive aquifer, this study proposed that the area above the aquifer be designated as a "Groundwater Sensitive Development Zone", as represented on figure 46. Specific measures are required for any developments in the area to ensure that: planned and existing properties are sensitive to groundwater needs.

River Interactive Properties

The study also proposed that all properties adjacent to the river, wetlands, and estuary become water conscious properties (figure 46). This means that these properties need to actively participate in regenerating the health of the river and associated freshwater ecosystems. They must embrace the river corridor rather than turn their backs on these natural features while ensuring that there is public access available to these natural systems. Furthermore, since the properties adjacent to the river are within the 100-year plain they must, if necessary, be floodproofed according to Floodplain and River Corridor Management Policy.

Low Impact Development in Wetland and Estuary Biodiversity Node

This is to counter the SDSDP (2012) recommendation to rezone the area east of the estuary as *mixed-use intensive*. This study therefore proposed an "estuary protected area" (Figure 46). For further protection, the study redesignates the area's development specification to *Low impact water-sensitive development area*. The study thus proposes an estuarine sensitive development overlay over the existing developments in the estuary. The implication of this proposal is that if further development is proposed, a NEMA requirement for environmental impact assessments will be triggered. The rehabilitation of the estuarine and wetland ecosystems will help strengthen the proposed "Wetland and Estuary biodiversity node" indicated on figure 46.

Proposal 1f: Introduction a Living Lab

The study also proposals introduction of a Hout Bay Living Lab (See map on Figure 47).

The proposed Hout Bay living lab is situated upstream of the estuary, below Victoria bridge, see (Figure 26). This is strategically located at a pressure point where polluted stormwater is entering the river. It is also close to major transport interchanges, three schools, and a recreational centre. Imizamo Yethu is 200 m from the site and the site is open to the public. The living lab is located within the proposed network of public open space (the ecological

Precedent:

The Water Hub, in Franschoek South Africa

This proposal has been adapted from the urban living lab called the Water Hub which is situated in Franschhoek in the Western Cape of South Africa The water hub tackles similar issues to those expressed in Hout Bay catchment where contaminated runoff is entering a river and has resulted in the unhealthy and degraded river system. They draw on NBS such as biofiltration beds to filter the contaminated water.Once cleaned they feed the water back into the river and extract sustainable amounts to feed the community food garden. See Chapter 2 Section 2.7.2 for more details.

breathing room). The living lab will be a space a deep experimentation, connection, community, celebration, and understanding of the natural world that lives in Hout Bay.

Figure 47: Location of the living lab and its connection to the greater Hout Bay community and schools

Water-Oriented Living Labs (WoLLs) are defined as: "real-life, water oriented and demo-type and platform-type environments with a cross-sector nexus approach, which have the involvement and commitment of multi-stakeholders (including water authorities) and a certain continuity, and provide a "field lab" to develop, test, and validate a combination of solutions …, which include technologies, their integration as well as combination with new business models and innovative policies based on the value of water." water-oriented-living-labs

Intervention 3: WSD Objectives, Guidelines and Implementation Plan

This section aimed to add detail and specificity to the above WSD interventions and proposals. It drew from but extended existing spatial frameworks and plans, specifically:

- the 2012 Southern District Spatial Development Plan (SDSDP, 2012: 10 and 120);
- the 2018 Cape town Metropolitan Spatial Development Framework (CTMSDF, 2018)
- the 1986 Hout Bay Spatial Plan (HBSP, 1986).

The development objectives and guidelines were presented in a detailed table. The development objectives were framed by the guiding principles for the vision for Hout Bay (first column of the table). Compared to existing plans, three new spatial development objectives were introduced (second column of the table) and development guidelines were articulated to provide more insight into how the objectives can be achieved (third column of the table).

The spatial extent (in the fourth column) identifies where each objective and guideline is applicable by referring to Fig 42-46 (the detailed table is not presented in this report but available on request).

This study's guidelines and objectives are an improvement on those proposed in SDSDP (2012: 10) in the following ways.

- they are directly linked to an underpinning values and guiding principles
- they introduce three new objectives specifically focussed on WSSP
- each objective is linked to its own set of guidelines
- the guidelines are precisely linked to spatial areas to facilitate ease of implementation

The implementation plan links to each of the above interventions and to a set of action recommendations in a ten-year implementation plan. The implementation plan provides a timeframe for each recommendation in the short-, medium- or long-terms. The implementation plan also connects interventions and recommendations to the relevant role-players, the city-line functions and highlights new taskforces required. Finally, the implementation plan connects the recommendations to the relevant existing policies, and, where necessary, proposes new transformative and visionary policy (the detailed implementation plan is not presented in this report but is available on request).

Finally, the above guidelines and implementation plan were developed into "Guidelines for Water Sensitive Spatial Planning". The guidelines are in eight iterative steps (see Figure 48 below). They are graphically illustrated and linked to relevant policy documents, possible finance sources, key role players, etc. Each is illustrated with examples from Hout Bay WSSP proposals as executed in this study.

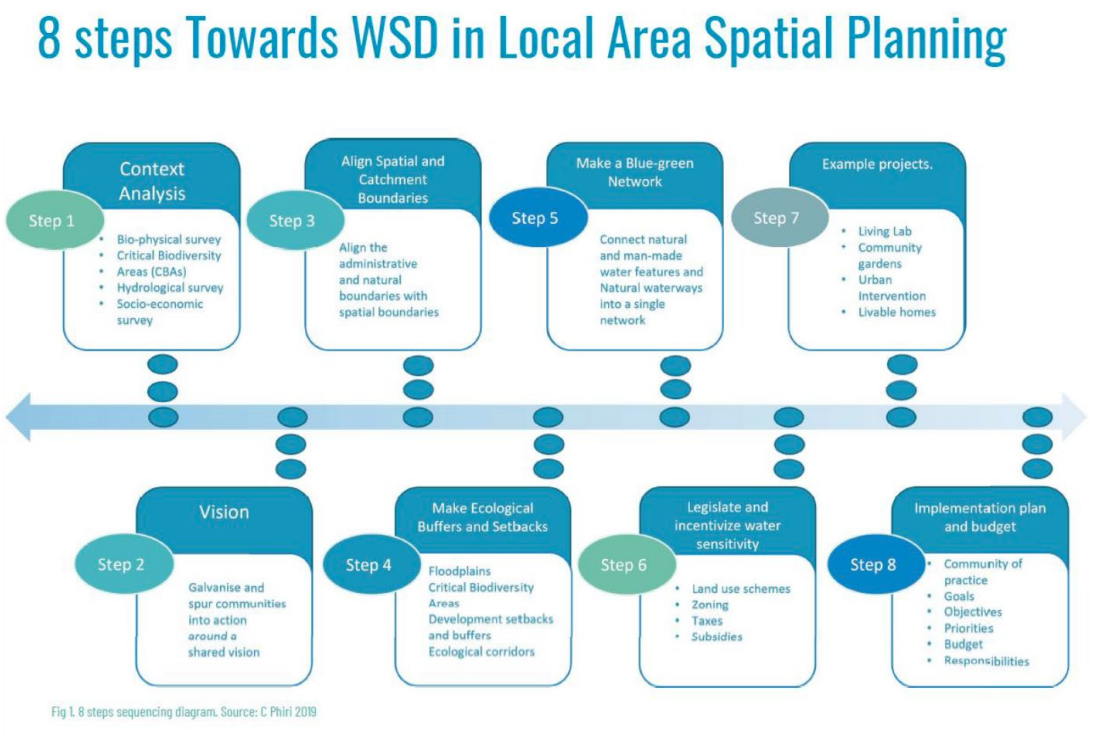


Figure 48: Steps towards WSD in Local Area Spatial planning (Source C Phiri, 2021 adapted after D Shefer, 2020)

Water Sensitive Spatial Planning Summary

Khoisan had a nomadic fishing and hunting existence in the area before the arrival of Whiteman. White travellers started exploiting the timber as early in the catchment as early 1615. With the establishment of Jan Van Riebeek's Cape colony in 1652, there was intensification of fishing, logging and establishment of farms. This caused massive change to the river valley including loss of indigenous vegetation and deforestation.

Starting in the late 1930s, the private motorcar made scenic Hout Bay an attractive area for residences. In the 1950s, Coloured families were forcefully displaced to Hangberg and the Hout Bay was marketed to high income white residents. Staring in the 1990s, the valley was rapidly converted to a residential neighbourhood. Hout Bay is today mainly residential, but the fishing industry remains important. The area is also a valued recreational and tourism destination. Hangberg and Imizamo Yethu are two low-income enclaves in this otherwise high-income residential suburb.

Water Sensitive Spatial Planning (WSSP) is an approach aimed at transforming an urban area into a Water Sensitive City (WSC). Strategic tools for spatial planning include land use planning and Spatial Development Frameworks (SDFs). By underpinning these tools with responsiveness to aquatic and terrestrial ecosystems, WSSP enables transitioning to WSCs.

The 2020 Cape Town Water Strategy (CTWS 2020) places transitioning to a Water Sensitive City as a key pillar. Although Cape Town has not formally adopted WSSP, there many elements in the city's existing planning instruments that share overlaps with the approach. SDFs at the scales of the metropole, the district and subdistrict are required to be responsive to natural assets of the city, such as, biodiversity, aquifers, and agricultural areas. The Biodiversity Network. The Floodplain and River Corridor Management Policy requires that SDFs identify 2-year, 5-year, 10-year, 20-year, 50-year and 100-year floodlines and delineate respective land uses according to strict criteria. The criteria are aimed at enhancement of ecosystems for the benefit of all urban residents and nature, and protection of life and property from flooding. The policy requires inclusion of interconnected ecological buffers and corridors in SDFs.

Cape Town Municipal Spatial Development Frameworks (CTMSDFs) have maps that identify significant biodiversity areas and locate freshwater ecosystems such as rivers, wetlands, groundwater and estuaries as well as other significant biodiversity areas. However, these are presented on different maps, and this renders cohesive planning to balance ecosystems with urban development difficult. For instance, land use maps in Hout Bay do not represent the river and its tributaries. Moreover, the Hout Bay Catchment falls within two different spatial planning jurisdictions.

Within the Southern District of Cape Town, the Hout Bay Subdistrict encompasses the Hout Bay River catchment. The 1986 Hout Bay Spatial Plan (HBSP, 1986) did not restrict development between 50-year and 100-year. This was before the Floodplain Policy. Contrary to the Floodplain Policy, the 2012 Southern District Spatial Development Framework (SDSDF 2012) also did not identify the 100-year floodline. Developments in Hout Bay occur just after the 50-year floodline. Therefore, many developments are between 50-year and 100-year floodlines. Furthermore, the 2012 plan encourages intensification of development below the 50-year floodline in the estuary area. This places those ecosystems at risk and compromises aquatic ecosystem services. Placement within the 50-year plain places lives and properties at immense risk of flooding. This especially concerning in as flash floods increase globally due to climate change.

There is a productive aquifer in Hout Bay catchment which is endangered by insensitive urban development and surface hardening.

The catchment is rich in biodiversity. Biodiversity in the mountains is better preserved but along the valley, the swamps and estuary the biodiversity is under pressure.

The current health of the Hout Bay River, and other freshwater ecosystems, has been compromised by past and present unsustainable human activities. These freshwater

ecosystems continue to be threatened by encroaching developments and failing or inadequate infrastructure. Thus, the preservation of the estuary, wetlands, and floodplains is of particular concern.

Land use schemes for Hout Bay omit prominent freshwater ecosystems such as the river, the estuary and the swamps. This presents a barrier to assigning complementary land use according to the water systems in the landscape. Representing river corridors on land use schemes can reflect the importance of these vital ecosystems and help planners assign water sensitive land use and activities accordingly on the same map. Furthermore, current plans provide little guidance on how development can be made more water sensitive. Besides, the development principles associated with these maps are ambiguous and do not directly mention concepts such as WSD or NBS.

Water sensitive planners must also pay attention to the presence of groundwater. This includes providing development guidelines including those of WSD specifically for areas that are suitable for infiltration.

The public open space in Hout Bay is fragmented and discontinuous. Many of properties have fenced off portions of the floodplains into their private gardens. By reclaiming these into the public realm, there is an opportunity to connect public open space with ecological buffers and corridors to form a continuous network that includes freshwater ecosystems, to bring together the different communities and settlements.

Active community-based waterwise communities exist in Hout Bay. These must be leveraged in water sensitive planning and transitioning implementation.

Basing on the above analyses of the catchment, the study proposed four WSSP interventions for Hout Bay Subdistrict.

The first intervention was a vision. Animated language was used to articulate a compelling vision for water sensitive Hout Bay that enhances the wellbeing of people and nature. The vision was steered by the principles of reverence, balance, interconnectedness, restraint, responsibility, and connection.

The second intervention was mapping the catchment. This was articulated in five maps. The first map proposed realignment of spatial jurisdiction boundaries to ensure that the entire Hout Bay River catchment is bounded in the Southern District to ensure coordinated planning. The second map proposed including the river and its tributaries on the land use map and rezoning to create link up the currently disjointed public open areas in the catchment. The third map created ecological buffer corridors for the river system, established a protective overlay for

swamps and the estuary, and identified the area above the aquifer as a sensitive zone. The fourth map proposed blue-green fingers to extend along the ecological corridors of the river and its tributaries into the mountain.

The fifth map proposed the blue-green fingers as multifunctional infrastructure with ecological function, heritage value, public open space, sports fields, recreational areas, tourist attractions and educational opportunities. The map proposed that all developments remain within the existing urban edge, and that existing developments are incentives towards WSD retrofit and all new develops are water sensitive. The map introduced a Groundwater Sensitive Development Zone and recommended that all properties near the river and estuary interact with the water spatially, aesthetically and in ecological function. To counter intensification of development in the estuary, the map introduced an Estuary Protected Area which means a further proposed development in the area will trigger an environmental impact assessment requirement. The map identified the existing biodiversity node and proposed that it be consolidated. A living lab was proposed for the within the node to bring together communities and facilitate demonstration, experimentation and innovation of WSD solutions.

Finally, the study proposed WSSP development objectives and guidelines. The objectives and guidelines translate the vision into actionable recommendations. The objectives and guidelines are specific and spatially anchored in the maps discussed above.

Together therefore, the vision and principles, the five maps, and the guidelines and principles articulate WSSP proposal which can significantly improve the water sensitivity of the Hout Bay catchment.

Chapter 6: Water Sensitive Urban Design

"Urban spaces and residents have become detached from water as infrastructure tends to be hidden underground and water is seen as a nuisance rather than an asset. Even though we depend on water resources, it is often not a priority in the design and development of our urban spaces. We need to relook at the relationship between water and urban space to provide a solution that integrates the urban water cycle with good qualities of urban design to create a liveable neighbourhood" (Mari Smith).

Introduction

At the Hout Bay Harbour, yachts for the wealthy sail and tourist stroll. On the slopes of the Sentinel above the harbour is Hangberg neighbourhood with its low-cost council flats, hostels, row houses and informal shacks. This section is deeper dive into Hangberg, both in baseline and urban design proposals.

Sociological Insights

Hangberg is a place in the margins in terms of its geographical location. The area is located on the border of the South African National Parks (SANParks) land on the slopes of the Sentinel Mountain. Residents often complained that they are a forgotten and excluded community, and that the area has had very little assistance and development in terms of housing, water, and infrastructure to improve living conditions for the growing population.

The study executed an ethnographic investigation in Hangberg to get a deeper understanding of the residents' lived realities.

Fishing

For years, the nomadic Khoi San fished in the area. Fish factories have also existed in the bay since the 1860s. During Apartheid, there was a plan to displace Coloureds from Hout Bay. Subsistence fishing has always supported the livelihoods of many Coloureds1 in the area. Fish factories have also existed in the bay since the 1860s Fish factories have also existed in the bay since the 1860s. During Apartheid, there was a plan to displace Coloureds from Hout Bay. But to ensure a ready supply of cheap labour for the fish factories, some Coloured families were moved to council-built housing at a new settlement in Hangberg in the 1950s. Today, many residents in Hangberg are employed in the fishing factories. Fishing continues to be an important part of the local economy with formal and informal practices. There are competing interests on the fish. Large commercial fishers export canned lobster while local people fish for subsistence and retail income. Government provides licences with quotas to prevent overfishing. But poaching continues at great risk to those involved. Through discussions with residents, the researcher discovered how the fishing industry's closure and the regulation of fishing permits have significantly altered residents' livelihood opportunities.

"The ocean was full of food, now fishing quotas restrict fishing activities, and our sons lose their lives while trying to make a living from poaching in the harsh conditions at sea", lamented

JoAnne (Hangberg, July 2019), a woman in her 80s who lost two grandsons from drowning while fishing illegally.

Larger companies also break the quotas. For example, Blumenfeld (2002) reported that the Hout Bay Fishing Company was found guilty of overfishing the west coast rock lobster and hake for export to the United States. They were also found guilty of bribing fisheries inspectors.

The Evolution of Hangberg

As a result of population growth and lifestyle change in Hangberg, young couples sought to establish their own households within proximity of the extended families. Households split and new dwellings (many of them shacks) were constructed. Hence, the settlement grew organically with shacks to accommodate new or expanding families. In Hangberg, this construction of shacks is known as shack farming. Shacks are also farmed for rental income.

Figure 49: Evaluation of Hangberg overtime

Dina is a 71-year-old woman who was interviewed at the local recreational club where pensioner's, mostly women, meet every Wednesday morning to have tea and socialise. Dina has lived all her life in the area. Her family moved to a company flat owned by Oceana (where her father worked). When she was 19 years, her mother passed away and left her to take care of her sickly father and eight siblings aged between two and seventeen years.

After her father passed on, the family was evicted from the flat and moved in with a relative. *"We were a huge family in a tiny space with one bedroom: a living room and kitchen. We shared the toilet, which was outside, with other people. All my life, I have struggled to have a place I call home. About twenty years ago, I was allocated a council flat, which I shared with my sister and her grandkids" (Dina, Hangberg – June 2019).*

From the above, it can be surmised that the area was not planned to provide sufficient housing for residents but to house workers close to the fishing industries. As seen in Dina's statement, her

family had to find alternative accommodation after her father passed away. Large families were already sharing tiny living spaces decades ago. It is inevitable that due to population growth in the area, the informal site has dramatically expanded (see above) to meet the demand for housing.

"We used to live up on the edges of the mountain, all four families here were neighbours. Our structures were comfortable, big enough for most of our needs. We incrementally expanded as we needed and did what we could afford.

Since the area of Hangberg was not designed for growing families but workers, present generations continue to bear the burden of the past deficient designs. Against a history of displacement and unequal society, one can sympathise with this struggle for housing and services as an inevitable development. But still there are limits to organic growth, which if ignored can pose disutility to individual households and the public good.

"I was born here in Hangberg. When I got married, my husband and I started our family in a zinc structure – we used the shared toilets. After three years, we built a wooden bungalow. It is always flooding every year, so we saved up until we slowly built this brick, three-roomed house. We own this house; we built it ourselves, 16, 17 years ago. Only one room (the bedroom), a kitchen and this room (Living area and a toilet). This house we built with bricks by ourselves. Now we always struggle with water pressure – so I still have to store water in containers to use. Sometimes I do laundry in the odd hours of the nights because the tap is usually only dripping during the day." (Clara, Hangberg – June 2019).

CoCT provides shared water and sanitation facilities for shack dwellers. But Hangberg residents prefer to use individual household water and sanitation services. Hence, resulted in (sometimes illegal) improvisations, to access services by connecting to the city water and sewage infrastructure.

Figure 50: Examples of connections Hangberg residents have made to water and sanitation services (source Faith Gara).

However, the infrastructure has expanded to accommodate the new connections and the growing population. The infrastructure is very stressed. Water pressure is reduced and supply to households is unreliable. Sewer pipes burst frequently due to increased load.

Figure 51: Flooding and infrastructure decay in Hangberg

Unplanned growth also results in passing of public cost to private individuals. In Imizamo Yethu (an informal settlement on the other side of the valley), Malibongwe and his wife live right next to the community's toilets and two water taps. The couple, in their 60s, raised six children in their shack after failing to get a formal house. As the area's population increases, the couple is burdened with cleaning the toilets to avoid the smell as the toilets are less than 10 metres

from their door. Malibongwe's story demonstrates the burden of carrying social costs by individuals due to unplanned growth and inadequate infrastructure.

"I clean these toilets every day. I wake up at 4 am to clean; they are right on my door; the smell is unbearable. I have approached the council to give me a contract and some cleaning material to make things better, but they don't help. The paid cleaners come only once a week, can you believe it so many people using these few toilets and they come only once! I also buy toilet paper with my money because people use the wrong paper, which causes blockages and gives me more problems. I do all this mostly from my pocket; some neighbours also leave some coins in that container there to buy cleaning chemicals. I even put lights and change globes so people can see at night and not mess. My life is tough here, but I have no choice". (Malibongwe, Imizamo Yethu – July 2019)

The Displacement of Nature by Urbanisation

Urbanisation is accompanied by gradual, imperceptible, but steady disappearance of biodiversity in the city. That things change is often noticed by nostalgic realisation that what once was naturally abundant is gone. As urbanisation insidiously consumes nature and biodiversity, memories of nature remain as fragments of a paradise lost.

"You see that park there; I played there as a child. We would spend the day eating berries from those bushes and chasing butterflies while our parents were working. We would just leave home having had porridge before school and go back in the evening. Now there are no more berries, and my grandkids do not even know a butterfly, imagine. There are no fruit trees here. You have to get every fruit and vegetable from the supermarket. There is just no land or space for a garden" (Rachel – Hangberg, June 2019).

The absence of biodiversity in the city speaks volumes about unsustainable transmutation from pristine nature to city. The transformation started in the Hout Bay catchment when the lush natural habitats that were once fishing, hunting and gathering grounds for Khoi San, were transformed by white colonists through lumbering and farming. Looking at the Hout Bay River valleys and the adjacent mountain slopes today, it is difficult to imagine that 200 ago years the entire habitat was mostly natural and that as recently as 1990s the valley was predominantly an agricultural area.

But there is nature still in the Hangberg, attributable to the protected status of SANParks. The changing of seasons brings forth many challenges of interspecies relationships. Residents spoke of snakes coming down from the mountain and a researcher observed many snakes in Hangberg during a focus group discussion. But given current urbanisation pressures, it is conceivable that nature will gradually become but a remnant.

The Firebreak

Figure 52: Different structures in Hangberg to deal with flooding and unstable slopes (source: Faith Gara)

The firebreak (die sloot) is meant to separate Hangberg settlement from protected ecological areas above the mountain. All land above the firebreak is owned by SANParks. The firebreak also helps control spread of fires and is an important a stormwater drainage channel. But residents, ostensibly in desperate search for housing land and against the city's advice, have gone ahead to build above the firebreak line and encroached on protected land on the steep unstable slopes. Moreover, the firebreak itself is full of rubbish, overgrown by vegetation and pressured by shack construction. Predictably, flooding and landslides are a constant occurrence in winter. In summer, the settlement is prone to fires and exposed to dusty winds.

"It was really hard living up there. In winter there was a risk of flooding and mudslides, which forced us to build with brick when possible. windy days were the worst, it was like living outside, so much sand and dust in the houses. I used to cough a lot up there. The hall doesn't have privacy but at least its dry and clean". (Viola, Hangberg – February 2020). Who relocated to the communal hall.

Water and Nature as Nuisance

Water is an excellent household resource for washing, cooking, and general hygiene. But water also can also be a nuisance. In Hangberg, there is house where water comes out of the ground, breaking through the cement floor every rainy season.

"It has been like this since I came to this area in 2004. I have never seen this place dry. It gets worse when it rains, sometimes it looks like a little stream". (Tony, Hangberg resident – June 2019).

Figure 53: Water coming out of the ground in shacks in Hangberg (source: Faith Gara)

This implied that, owing to lack of knowledge or siting alternatives, local hydrology is not fully considered in locating such houses. The consequence is buildings where water become a constant nuisance and health danger. In this case, water, which could have been a resource, instead creates unhygienic undignified living conditions. Given enough resources, a solid and dry house could be constructed in the same location using technical solutions such as subsoil drainage, raised floors and waterproofing. This would render water invisible in the city. A WSD approach on the other hand, carefully responds to local hydrology to site buildings better, avoid the above problems and yield multiple ecosystem services.

Mutual Support

In conditions of poverty, precarious day-to-day existence and inadequate institutional support, people in Hangberg and Imizamo Yethu informal settlements have developed social networks for mutual care based on kinship, friendship and neighbourliness. These social networks help inhabitants to navigate their common problems and to secure their livelihoods in the city. This includes shared childcare and sharing of food and space in multi-generational dwellings.

"One cannot survive here without the support of neighbours and friends, we watch each other's children and property, there are some people who take chances and try to benefit when there is chaos, but if we catch you, we teach you a lesson" (Mama Noma – Imizamo Yethu, July 2019).

Such networks also provide opportunities for social bonding – for example, there is an elderly group of ladies in Hangberg who meet for tea every Wednesday. It is important that urban

design proposals take care not to disrupt these crucial relationships. Design must also provide spaces where social bonding and network building can occur.

Bottom up WSD initiatives

Craig, who lives in the affluent Hout Bay neighbourhood of Bokkemanskloof, uses an eco-pool which is chemical-free. The pool can be filled up by rainwater and employs different water filtration plants run on energy-efficient pump. The 2017/2018 drought added a greater sense of urgency to Craig's WSD initiatives. In most households in the less affluent Hangberg, storing rainwater and greywater is an everyday reality that arises from insufficient water pressure, limited water supply, and high water bills.

There is therefore evidence of waterwise living in Hout Bay amongst the rich and poor alike. Whereas the affluent resident implements waterwise measures because he can afford them to cushion against possible city-wide shortages, the indigent in Hangberg are driven by lack of resources (deficiency) to adopt them as an everyday practice.

Figure 54: The haves and have not: Sanitation facilities in Imizamo Yethu (left) vs a shower in Bokkemanskloof Estate (source Faith Gara)

Constraints, Mistrust and Sabotage

Shack farmers have a vested interest in rental informal structures. There is perception that they sabotage the city's upgrading efforts. Shack farming is one of the issues causing delays in the Hangberg in situ Development Association (HiDA) project of CoCT. Moreover, project timelines take time from the drawing and approval of plans, budgets and awarding of construction tenders. By the time the project is ready to commence, the vacant land planned for installing infrastructure would have been occupied with shacks. In some cases, the vacant land allocated for settling residents during construction also gets occupied. This challenge leads to no progress, as planners have to go back to the drawing board and devise new plans. It also costs a lot of money to keep repeating processes. According to City officials, residents do not

agree to stop further shack construction. City officials suggest the problem is complicated because, many people who were allocated new housing to vacate the informal areas, refused to demolish their existing structures as per the agreement. Some sold their dwellings in the informal settlement, while others gave them to their family members.

According to City officials interviewed, there is no suitable city-owned land for another building project in Hangberg. The previously allocated free land was deemed unfit for human settlement because of smell due to proximity to factories. This put more pressure on the SANParks land. Residents have built above the firebreak line on SANParks land, over which the CoCT has no authority. SANParks ownership of land is a big challenge for upgrading the area, especially for the residents who have built over the fire break. The City is in ongoing discussions with SANParks for a power of attorney to access the land to enable construction of an access road. CoCT and SANParks have not reaching an agreement to transfer land rights and this has slowed upgrades.

In focus group discussions, participants highlighted limited communication between City Officials and residents. They alleged there was preferential treatment of residents, for instance in allocating Expanded Public Works Program (EPWP) jobs. From interviews and the focus group, most participants showed a strong sense of mistrust between residents and authorities, including those supposed to represent residents, such as the Peace and Mediation Forum (PMF). Residents interviewed stated that most protests arise due to misunderstanding emanating from limited communication between City authorities and residents. Not all community members agree with the conditions in the Peace Accord. Therefore, many do not trust information from the PMF. Even though the City meets regularly with the PMF members, residents suggested that not all parties or interests in Hangberg are being considered. Residents explained that there would be more progress if the CoCT did not take the whole Hangberg area as singular, as residents have different experiences. Therefore, a possible more inclusive strategy is consulting blocks or small areas.

Key Summary of Sociological Insights

This section surfaces voices from the poor neighbourhood of Hangberg by using an ethnographic approach. The study uncovered interesting, even surprising findings about Hangberg and the lived experiences of its residents. The study found that social networks are very important for people in Hangberg. WSD intervention must therefore preserve these networks and also provide spaces where social bonding and network building can occur.

There is overuse of a, potentially renewable common resource, by large commercial concerns and subsistence fishers. Overfishing can result in depletion and exhaustion of stocks. This emphasises the need for institutional protection of the common good. WSD and the natural

infrastructure and the ecosystem benefits it provides are also common good that must be protected and be made equally accessible.

Insufficient housing, the unplanned growth of Hangberg and illegal connections to infrastructure individual initiatives create broader disutility. The study observed clean water (from leakages) and raw sewage flowing through the settlement. Infrastructural ruin poses further dangers such as environmental contamination and health risks. There are also stories of residents without toilets breaking into other people's toilets.

These stories from Hangberg and Hout Bay are akin to what Galtung (1969) and Nixon (2011) term slow violence. There was incremental but steady debilitating erasure of nature to leave barren cities with isolated remnants of struggling scruffy flora and fauna. Moreover, oppression and displacement bred separated communities leaving an enduring trail of mutual suspicion. The stories are enacted in the coming together of Khoi Sans, Xhosa, European itinerant travelers and settlers, slaves and the intermarriages between these groups. These stories speak of intermingling. But prominently, they speak of extraction, segregation and displacement of people and nature. The urban pattern that emerges is founded on injustice and environmentally unsustainable practices. In Hangberg, the vulnerable poor bear the consequences. WSD should engage with these issues by offering spatial solutions that connect and benefit diverse the people and nature in Hangberg and Hout Bay.

Fish is renewable but endangered resource in the area. Subsistence and commercial fishers illegally fish beyond allocated quotas. Like the forests and agricultural land before, this important resource can disappear unless used more sustainably.

The firebreak is an important piece of public infrastructure that serves simultaneous roles of fire and flood protection, demarcation the start of biodiversity preservation and slope stabilisation area. But the firebreak is overgrown with vegetation and strewn with rubbish. Moreover, shacks have also been constructed above the firebreak contour line in steep, unstable protected natural areas. Because of these factors, Hangberg residents face winter flooding and landslides, and summer fires are frequent in Hangberg. Furthermore, urban development in the protected area is threatening biodiversity. WSD must reestablish the firebreak as a multifunctional public good in Hangberg.

As the city intervenes, it also needs to assess where the city's resources provide best value at dwelling and urban design levels. For instance, since the 1960s, it is known that no government can possibly anticipate and adequately build housing to meet all diverse and changing (Turner). Yet the main housing solution in Hangberg comprised of, first, council flats and then rentals that many residents complain are unsuited to their needs. Therefore, as WSD is

developed and implemented, government (CoCT) should focus its resources at the larger scale (protecting natural areas, providing bulk infrastructure, public transport, schools, etc.) to provide a non-prescriptive urban framework. Residents should then take over at smaller scaler where they understand their needs best and where more flexibility is required (Turner 19…) . Government can support private individuals to build their dwellings by offering support such as access to land, training, credit, materials and innovation. Approaches in this direction include the open building by approach Habraken (1961) cf. Cuperus (2001). Osman and Musonda (2017, p.224). Innovative building approaches are also required. An example is the self-build system developed by Walter Segal. Innovative building methods have also been tested and proven by Kevin Kimwelle in South African informal settlements.

Lack of anticipatory planning in response to demographic and social dynamics is a great contributor to making the Hangberg unliveable. The desperate solutions that people have provided for themselves endangers them, the public good and the environment. A larger planning perspective is needed to resolve the situation in Hangberg. This includes denser housing on available land and incentivization to relocate to well-located lands close jobs and amenities. This must be done sensitively so as not to disrupt social networks built up over decades. In this regard, the city, NGOs, and local community champions should work together following the government framework for informal settlement upgrading as presented by Islandla for instance (see Sanya, 2022) and tapping into available resources.

Bearing the above in mind, WSD should be used as an opportunity to bring back nature into the city and improve liveability of urban spaces. In this case, planning is underpinned, not with hard infrastructure rigidities. Rather, planning starts with the objective to protect and regenerate biodiversity by connecting ecologically functional blue-green networks as a scaffold for hard infrastructure and buildings. WSD solution should be used to increase use of ungridded infrastructure such rainwater harvesting and composting toilets (such as bassoon toilets). This would reduce pressure on city infrastructure, enable resource recovery and protect receiving water bodies.

But there must be care not to allow WSD planning and development (quality environments from WSD) to become appropriated by the neoliberal exclusionary processes of gentrification at the expense of the poor (Scott et al., 2016). WSD must therefore aim for what White (2019) calls "just design transitions". As such, the integration of Nature-Based Solutions in urban planning should be an opportunity to create equal places through working with residents [An example is the Green Belt Movement mobilised by Wangari Maathai to plant trees in rural Kenya, which brought many positive ecological and social impacts (see Michaelson, 1994)].

Urban Design

Subsistence fishermen from Hangberg go to sea to catch crayfish for food and retail. Lack of trees and seating in the neighbourhood renders it uncomfortable for pedestrians. The streets are peaceful now, but the neighbourhood is prone to riots over housing, land and fishing rights. Informal Hangberg faces winter flooding, summer fires and struggles with access to proper water and sanitation services.

Figure 55: View of Hangberg from the Harbour (M. Smith, 2020)

In this study, we used WSD approaches to make proposals to transform the low-income Hangberg into a liveable neighbourhood. Existing WSD studies) are mostly from the Global North and do not engage with how WSD and urban design can transform informal settlements into liveable water sensitive places. There is a need for a contextually informed exploration that integrates WSD insights with detailed urban design principles of placemaking to engage with the challenges of informality as experienced in the Global South. Basing in Hangberg, this urban design component of the study explores how we can relook at the relationship between water and urban space to provide a spatial design solution that integrates the urban water cycle with good qualities of urban design to create a liveable neighbourhood.

As presented in Chapter 3, a non-programmatic (non-prescriptive) research by design approach is used in three iterative parts: baseline investigation (context analysis),

programming, design. To focus the approach on urban space making, each part is executed through the spatial lens of *space structure*.

Space Structure

Space structuring elements include *nodes* and *corridors*. Nodes condense and attract activity. They therefore generate movement along corridors. Corridors are of two types: *urban* and *ecological*. Urban corridors are made up of a hierarchy of larger and smaller corridors. The smaller corridors align with less significant continuous routes that intersect with the main spine and respond to Non-Motorised Transport (NMT) flows (Dewar, 2011). Intensive activities tend to cluster at points of high accessibility along (intersections) along the corridor in a 'beads on a string' pattern (Dewar, 2011).

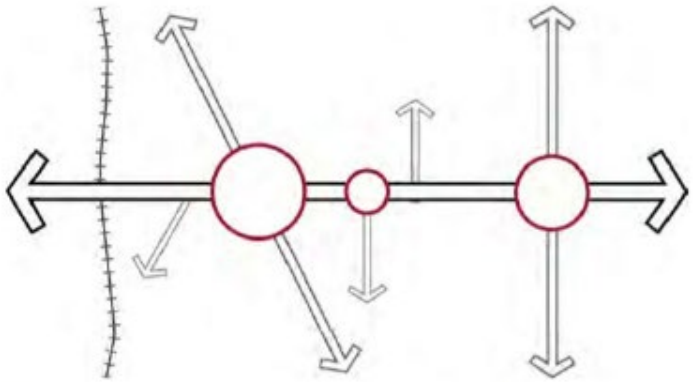


Figure 3.5: Hierarchy of access and nodes (Source: Author)

Figure 56: Hierarchy of access corridors and nodes (M. Smith, 2020)

According to Dewar (2011), successful urban nodes and corridors promote land use intensity to

- generate non-motorized traffic
- make public transportation viable
- stimulate a mix of activity and promote small business,
- promote urban integration
- improve equity and convenience of access.

Ecological corridors are strips of land used to link natural areas to ensure ecological connectivity for species and ecological processes. These corridors have buffer zones that protect them from disruptive urban development while. The corridors also deliver a range of

ecosystem benefits to people in the city. They cover natural landscapes such as rivers, floodplains, demarcated biodiversity areas, mountains, high agricultural value land as well as "corridors" of unsealed land. Ecological corridors should be created to enmesh all natural systems into a biodiversity network to ensure ecological function (Nilsson et al., 2013). Small fragmented ecological patches protected in a common buffer can serve as stepping stops that eventually merge to strengthen ecological connectivity and vitality (see Figure 57 below).

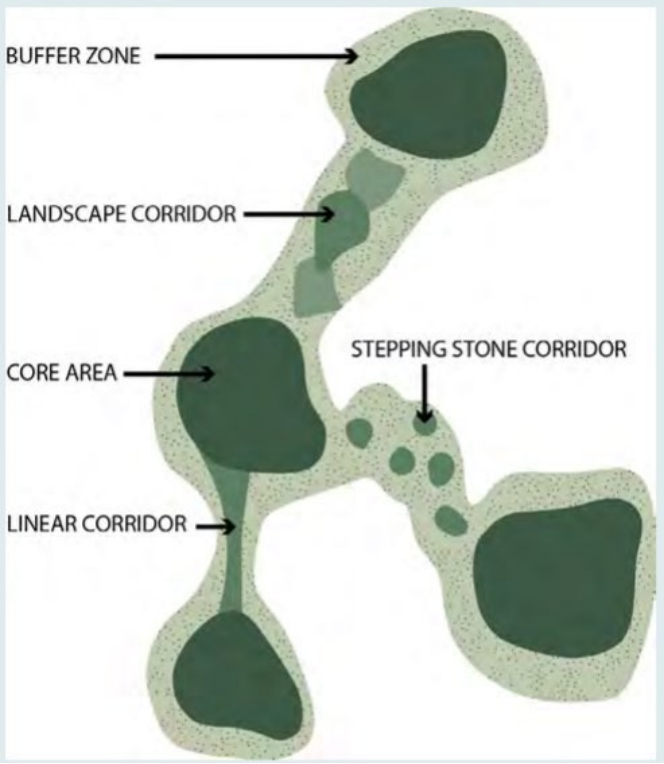


Figure 57: Diagram of an ecological corridor (Source: M. Smith, 2020)

Using the above space structuring elements, a detailed analysis of the context was undertaken to yield a detailed understanding of the various factors that impact the site, then a concept was developed by combining a response to context with aspirational design intentions (programme) for the area, and finally a design for Hangberg was proposed.

Geographical Context

Hout Bay Context

Hout Bay was analysed to gain an understanding of the green systems, public facilities and connections of the area surrounding Hangberg (see Chapter 5). In Chapter 5 broad scale urban analyses and Water Sensitive Spatial Planning (WSSP) proposals were made for Hout Bay Subdistrict (HBSD). This section augmented the above WSSP proposals with bottom-up analyses using the urban design space structuring concepts of urban and ecological nodes and

corridors. The bottom-up analyses informed spatial design proposals for Hout Bay, which in turn contextualised the urban design framework for Hangberg neighbourhood.

Hout Bay Ecological Systems

Hout Bay has a unique and valuable natural environment that includes the mountains, the river and its tributaries, and the coastline. The catchment also has areas of high agricultural productivity that supported farming. This green system provides an attractive and healthy setting for residential development with plenty of recreational opportunities. Therefore, the valuable green system and biodiversity must be conserved as part of the urban fabric and should be integrated into design proposals.

Hout Bay Urban Nodes and Corridors

The movement network in Hout Bay consists of two main elements: the roads and the public transport network (taxis and buses). Although there are vehicular corridors, there are no distinctive pedestrian corridors running through the area. This poses a problem as many residents living in the lower income areas (such as Hangberg) must access opportunities and facilities by foot.

There are three types of nodes identifiable in Hout Bay namely:

- CBD nodes where many businesses are located;
- A tourism node located at the harbour;
- Public facilities nodes, particularly in Imizamo Yethu and Hangberg

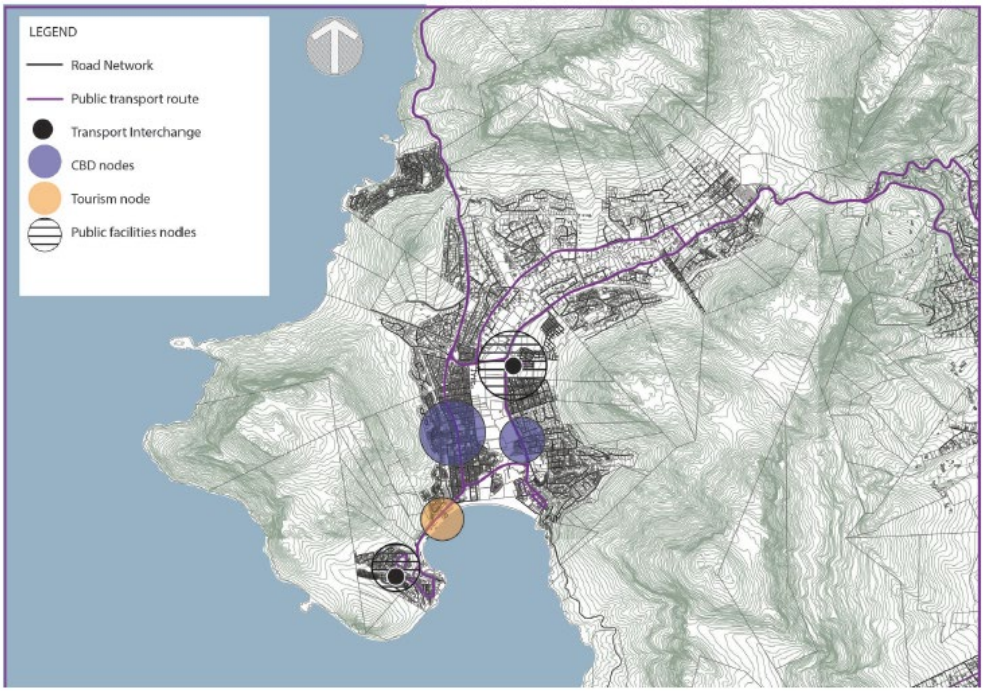


Figure 4.6: Hout Bay Connections analysis (Source: author)

Figure 58: Hout Bay Connections analysis (Source: M. Smith, 2020)

Hangberg Context

This section provides a contextual analysis of Hangberg neighbourhood. The analysis informed design proposals for Hangberg. The analysis is visually presented with the aid of maps and pictures.

Ecological Systems in Hangberg

The primary stormwater pipe channels the stormwater from the mountain. It runs under Oude Skip Road to channel water into the ocean.

The formal areas in the neighbourhood are serviced by conventional water and sewage systems. But informal structures have illegally connected to the water and sewage systems. This has resulted in reducing water pressure and frequent interruptions to water supply. It has further placed additional pressure on the on existing ageing infrastructure, causing frequent burst pipes and compromising public health.

Many residents have implemented their own interventions to combat frequent flooding and stagnant water by building on stilts, using tyres to build retaining walls and building small bridges or placing boards on walkways to be able to walk between buildings.

Figure 59: Drainage systems in Hangberg
(Smith, 2020)

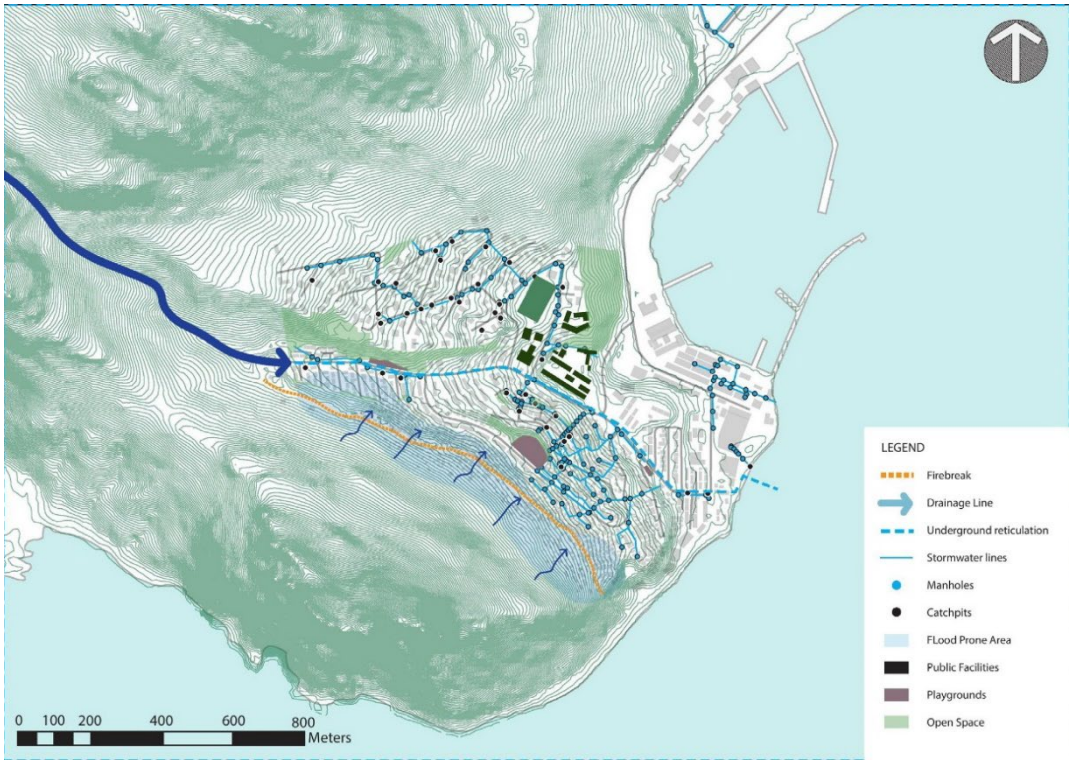


Figure 60: Hangberg water system analysis + Water systems in Hangberg (Source: M. Smith, 2020)

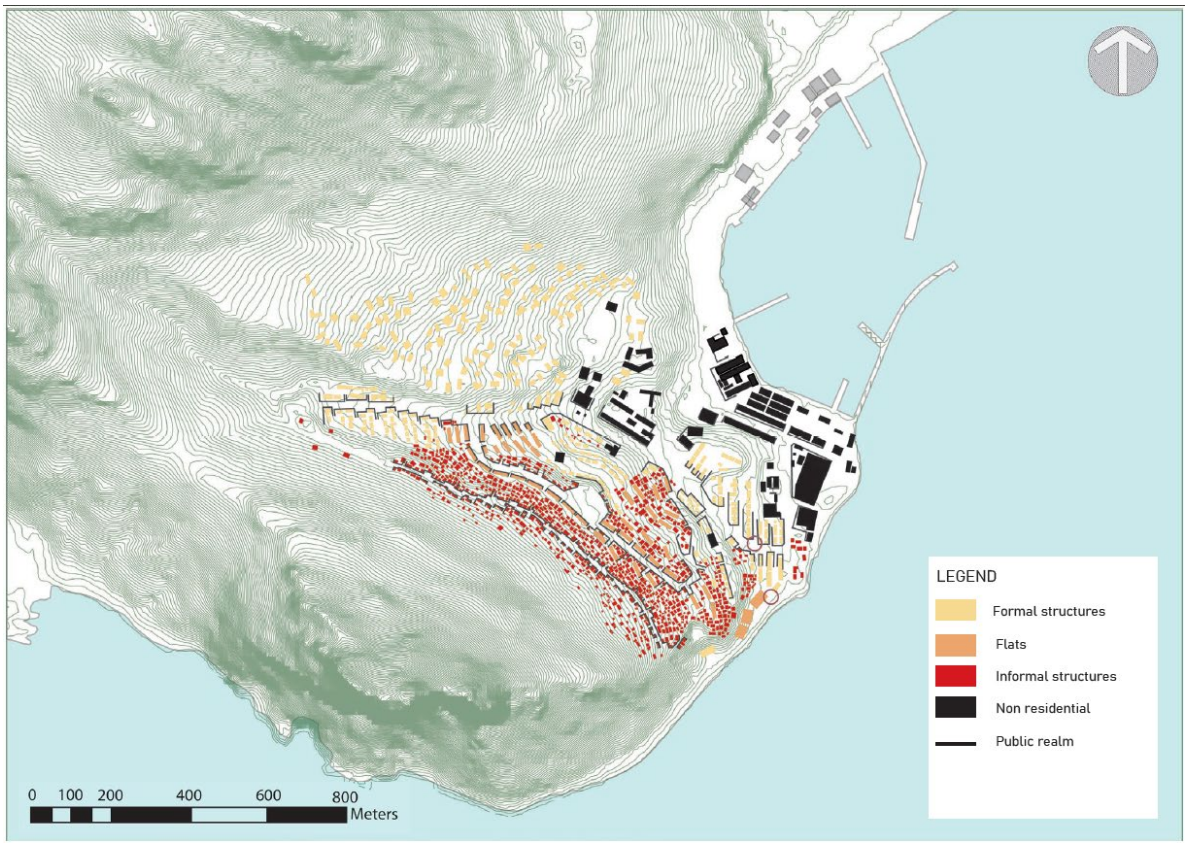


Figure 61: Hangberg Urban morphology analysis (Source: M. Smith, 2020)

Figure 62: Urban Morphology in Hangberg (Source: M. Smith, 2020)

Hangberg Morphology

Hangberg is characterised by row houses, council flats, backyard shacks and small informal settlements a cluster of freestanding areas. As the municipality has not provided affordable housing options, residents have taken it upon themselves to build informal structures. This has led to people building in areas that are dangerous. Such residents that are living over the firebreak (die sloot)

Hangberg Urban Nodes and Corridors

Hangberg has a strong central node where many social facilities are located such as the schools and sports fields. Taxis and the MyCiti Bus stop at the harbour the social facilities node. The upper part of the settlement on is not serviced by public transport.

Hence the majority of residents living in Hangberg must travel by foot – a task made difficult by lack of formal walkways, steps/ramps and streetlights in the steep terrain.

Lack of local markets has resulted in informal traders setting up adjacent to the two main roads in the area. The harbour is another node that attracts tourists and fisherman.

Figure 63: Hangberg pathways and facilities (Smith, 2020)

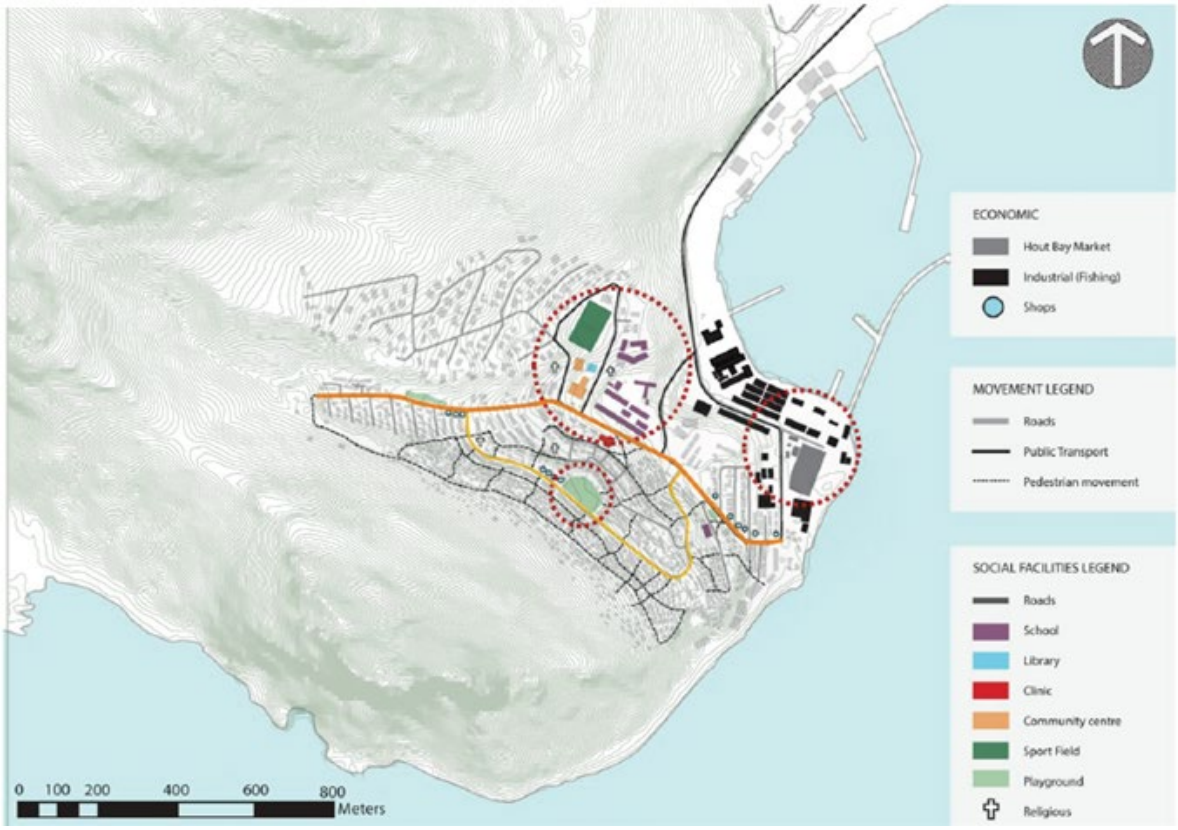


Figure 64: Hangberg connections analysis (Source: M. Smith, 2020)

Biophysical and Environmental Analysis

This section gives a biophysical analysis of Hangberg across five categories: landform, soil, hydrology, biodiversity and agriculture. The categories have different indicators, each of which is associated with development restrictions as follows:

No-Go: Sensitive environmental areas and areas of high significance for social and economic systems. The loss or degradation of these resources should be avoided (Critical Biodiversity Areas). This also includes areas that are dangerous or expensive to for infrastructure and building construction.

Tread Lightly: Sensitive environment areas where low-impact development could be considered (Precautionary Areas).

Table 12 gives criteria for how the restrictions are applied to the five biophysical elements.

CATEGORY	INDICATOR	RESTRICTIONS
Landform	• Steep slopes • Ridge lines	• Tread lightly • No-Go
Soil	• Stability	
Hydrology	• Minor river • Aquifer • Ground water	• No-Go • No-Go • Tread lightly
Biodiversity	• Protected area • Threatened ecosystems	• No-Go • No-Go
Agriculture	• Medium Productive potential • High Productive potential	• Tread lightly • No-Go

Figure 65: Development Restrictions Criteria table (Source: M. Smith, 2020)

Figure 66: Landform in Hangberg (M. Smith, 2020)

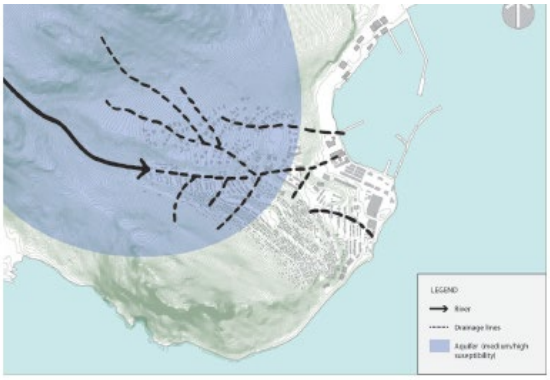


Figure 68: Hydrology in Hangberg (M. Smith, 2020)

Landform

The steep mountain which is adjacent to Hangberg has a sheer cliff dropping towards the sea. This is a significant barrier to development in the neighbourhood.

A firebreak runs above the 90 m contour line in Hangberg. The slope above the firebreak is 33% This is excessive and increases steeply uphill. This is greater than the gradient of 18% beyond which construction of buildings and infrastructure is much more difficult and expensive. Hence this study designates all land above the firebreak line as *no-go*.

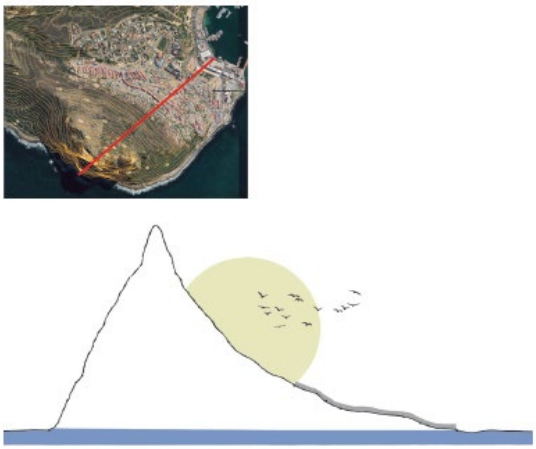


Figure 67: Section through Hangberg showing the shear cliff and height of the mountain (M. Smith, 2020)

Hydrology

There is one river running down the mountain which joins the main stormwater drainage below the Oude Skip Road. Several other storm drains join the main drain. However, the topography of the site and drainage lines cause problems with flooding. The urban design proposal will use sustainable urban drainage systems (SuDS) to floodproof the terrain and make Hangberg more resilient to flooding.

Soil

The soil condition in Hangberg is rocky with limited or no soil. It does not present any specific barriers to development.

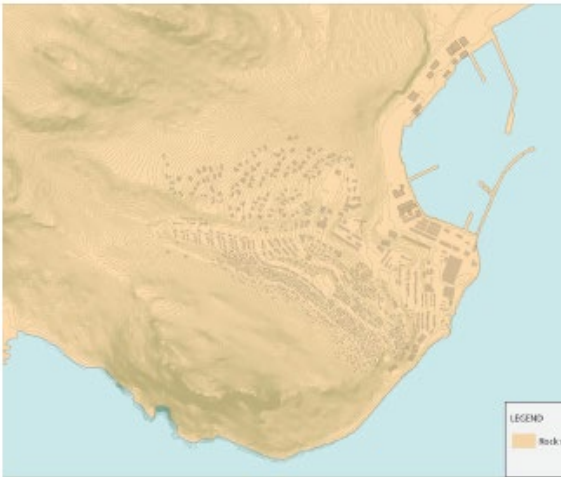


Figure 69: Soil in Hangberg (M. Smith, 2020)

Figure 70: Biodiversity in Hangberg (M. Smith, 2020)

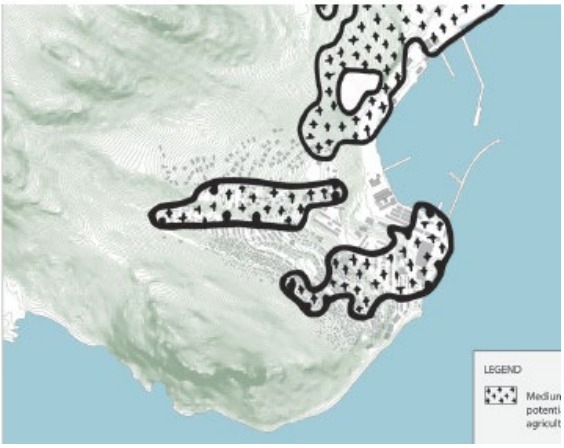


Figure 71: Agriculture in Hangberg (M. Smith, 2020)

Biodiversity

The significant conservation and Critical Biodiversity Areas (CBAs) and conservation areas just above the firebreak contour and on slopes above Hangberg are protected or ought to be protected in terms of the Cape Town Biodiversity framework. Therefore, this study designated the biodiversity areas identified in the above map as *no-go* areas.

Agriculture

Although there no high agricultural potential areas in Hangberg, there are places with medium agricultural potential in which urban agriculture can be introduced. This study designates these areas as tread-lightly zones

Figure 4.19: Composite biophysical informants (Source: author)

Figure 72: Composite biophysical informants (M. Smith, 2020)

Composite Bio-physical Analysis

Figure 72 shows the composite biophysical informants map which illustrates where development should and should not go in Hangberg. The biophysical analyses indicate that the slopes above the existing settlement are *no-go* areas. The analyses also indicate that most of the land that remains for development requires a tread-lightly approach in planning.

Performance Qualities

This study aimed at balancing the needs for good space-making with requirements for preserving nature. Urban corridors are usually focused around transit-orientated development (TOD) and high density residential development with commercial nodes in an effort to make settlements more compact and mixed-use. On the other hand, open spaces are usually fragmented and not well-integrated with the urban spaces and ecological areas. Moreover, many open spaces are anthropocentric and hence neglect ecological function. There is a danger that WSD leads to low urban densities and lack of urban space integration and monofunctional zoning. This study aimed to demonstrate WSD by integrating urban corridors with ecological corridors to define structure urban space and stimulate multiple ecosystem benefits to people and nature. The question that guided the urban design was: how to create more compact, equitable, resilient, and integrated neighbourhood using WSD? Where apartheid planning used green corridors to separate and segregate, this study used corridors as urban space integrators as recommended by Dewar (2011). Thus, urban and ecological corridors and nodes are used to make Hangberg into a liveable neighbourhood.

The population of Hangberg is an estimated 6500 people translating into about 1515 households. In the non-programmatic approach used in this study, focus is not on providing each of them with a house but rather on proposing an urban design framework that balances environmental protection and quality urban spaces while catalysing and empowering residents to co-create the built environment. This is also in line with the South African Upgrading Policy (see Sanya, 2022).

To this end, the study interpreted the CoCT Urban Design Policy (2012), Dewar et al., 2012; Dewar and Uytenbogaardt, 1995 and Dewar and Louw (n.d.) to propose six performance qualities to make Hangberg a liveable neighbourhood (see Table 11 below).

Table 13: Performance qualities (M. Smith, 2020)

	EQUITY An equitable urban environment enhances and promotes urban activities through its structure and form, thereby allowing residents to have easy access to these opportunities (Dewar & Uytenbogaardt, 1991). Equity primarily relates to the equity of access to opportunities within cities and implies that all people should be able to conduct their daily activities easily and inexpensively (Dewar et al, 2012).
	BALANCE There are two types of balance. Firstly, there is balance between nature and settlement. Everyone should have access to nature and actions on the ground need to be compatible with the natural conditions that are associated with the site. Secondly, is balance between urban and opportunities where all people have easy access to a range of activities and opportunities that make up urban life (Dewar & Uytenbogaardt, 1995).
	INTEGRATION The concept of continuity is central to integration: three types are important. The first is the continuity of movement. Continuous movement lines should tie different local areas together to break down fragmentation. Secondly, is continuity of green spaces as they are important for biodiversity and natural regeneration. It is also important that people have access to nature. Thirdly, is the continuity of the urban fabric which refers to the need to move away from urban forms that are a collection of fragmented parts towards an urban form that is a coherent system (Dewar & Louw, n.d).
	SENSE OF PLACE There are several factors that contribute towards the creation of a sense of place. Firstly, is the appropriateness of city form to the characteristic of the landscape. Secondly, is the quality and consistency of public spaces. Thirdly, is the legibility of the urban environment and the clear definition between public and private spaces. Finally, is the creation of 'special places' where people can escape the struggle of daily life and be treated with respect and dignity (Dewar et al, 2012).
	SAFETY + SECURITY Safety and security include security of tenure, food security, safety from hazards and natural disasters, safety from attack and security in terms of crime prevention. Emphasis should be placed on surveillance , exposure and permeability to promote safety. Designs should consider access to emergency services, and people should be able to access emergency services by foot (Dewar et al, 2012).
	EFFICIENCY Firstly, a compromise must be achieved between the conflicting requirements of mobility (road movement) and accessibility (dominance of NMT and public transport). Secondly, is the promotion of the compaction of urban forms to reduce sprawl and aggregate movement, to reduce the investment in infrastructure and to increase densities. Thirdly, is the promotion of mixed-use development and encouraging walking which will increase convenience (Dewar et al, 2012).

Main Informants

Opportunities and Constraints

Comparing the desired performance qualities described in Table 13 and the context analysis enabled identification of set of design constraints and opportunities Hangberg. The identified constraints and opportunities are presented in Table 14 below and are illustrated spatially to Figure 73 below.

Table 14: Hangberg Opportunities and constraints

PRINCIPLES	CONSTRAINTS	OPPORTUNITIES
EQUITY	**Spatial segregation:** Hangberg is spatially segregated from the larger Hout Bay area. This means that it is difficult for residents to access opportunities and facilities in the Hout Bay CBD as there is inadequate NMT and public transport facilities. Many residents are also employed as domestic workers or gardeners for residents in Hout Bay which makes access to jobs difficult.	**NMT routes:** There is an opportunity to provide adequate NMT facilities which can provide better access within Hangberg and to connect the neighbourhood with Hout Bay. **Clustering of Facilities:** Facilities can be clustered around nodes and corridors that have good access to public transport, this will help to reduce travelling distances.
BALANCE	**Pressure on Environmental Sensitive Areas -** The sprawling informal settlement is encroaching into the conservation areas and on critical biodiversity areas. There is also a lack of developable land in the neighbourhood. **Inadequate water management:** The neighbourhood has inadequate water infrastructure but the river that is flowing down the mountain is being channeled into the ocean which presents a lost opportunity.	**Fire Break:** The firebreak can be better defined to create a buffer between the urban and natural landscape which could prevent the encroachment of the settlements into the conservation area. **Blue/green infrastructure:** There is opportunities for blue/green infrastructure to capture and re-use water resources, control flooring and to mitigate the effects of climate change and improve biodiversity
INTEGRATION	**Urban fragmentation:** There is poor integration between the residential areas and the harbour area as well as the ocean. **Fragmented green spaces:** Urbanisation has resulted in the fragmentation of the green system which negatively effects the biodiversity of the area.	**Green Corridors:** The creation of continous green corridors throughout the neighbourhood can colsolifatie and define ecological areas and open spaces to enhance biodiversity and access to these spaces.
SENSE OF PLACE	**Inadequate public spaces:** There is a lack of adequare public spaces in the neighbourhood, the existing public spaces are neglected and some have become lost spaces. **Poor definition of the public realm:** Public spaces are poorly defined with dwellings either turning their backs on these spaces or there being a lack buildings that front onto these spaces. **Lack of special places:** There are very few special places such as landmarks, viewpoints or high quality public spaces that the community can enjoy.	**Network of public spaces:** The creation of a network of public spaces can integrate these spaces and provide adequate and equitable provision of public spaces within the neighbourgood. **Define the public realm:** Elements such as continous building frontages can create defensible spaces and clear spatial definition of public spaces. **High quality spaces:** The design of high quality spaces can encourage people to engage positively with the spaces and encourage collective ownership which will decrease vandalism.
SAFETY + SECURITY	**Disasters:** There are no emergency services in Hangberg, it is a safety risk for residents as flooding and shack fires commonly occur in the area, **Security of Tenure:** As there is a court interdict agains the erection of structures on SANPARKS land, residents are at risk of being evicted. **Safety:** Safety is a concern in the area, particularly in open spaces where there is a lack of activities and passive surveilanc	**Co-locate public facilities and open spaces:** The integration of different types of public facilities with open spaces such as sport fields, parks and the river can improve the safety in these areas. **Food security:** the introduction of urban agriculture on the productive agricultural sites can promote lcoal production and distribution of health food in the neighbouthoodl.
EFFICIENCY	**Monofunctional:** the neighbourhood is largely residential with a lack of mixed-use development **Lack of NMT facilities:** There are very few formalised NMT routes in the neighbourhood, this is a challenge as most residents rely on walking to access opportunities and facilities. **Sprawl:** the settlement is sprawling up the mountain, this makes providing adequate housing and infrastructure a challenge.	**Mixed-use development:** the encouragement of mixed use activities and development in the neighbourhood can improve urban compaction and provide additional facilities and opportunities in the neighbouthoof for the community to access **Higher density development:** The encouragement of higher density residential developments and different tenure options can provide additional housing opportunities in the area. Informal settlement upgrading: Different types of informal settlement upgrading such as re-blocking can improve housing conditions in the neighbourhood.

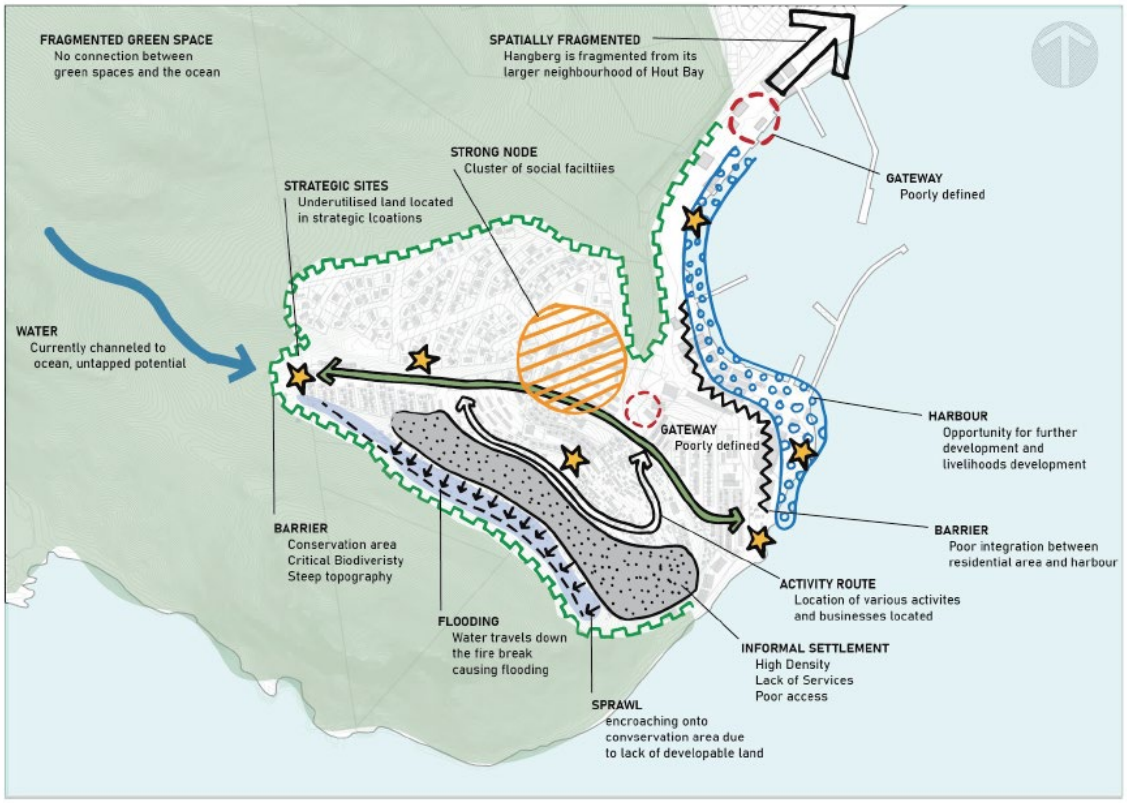


Figure 73: Urban Design Informants in Hangberg (M. Smith, 2020)

The above map of constraints and opportunities was a starting point for the development of the urban design framework for Hangberg below.

Design Framework

This section sets up the framework and space-making strategies to meet the six performance qualities of *equity, balance, integration, sense of place, safety and security and efficiency*. The performance qualities are interpreted into three key urban design space-making strategies namely: *connections, place and resilience*. Below the strategies are 12 sub-strategies. Each performance quality is supported by more than one sub-strategy. Also, each sub-strategy supports more than just one performance quality (see Figure 74). These overlaps yield synergies for urban space making in the design proposals for Hangberg. The sub-strategies provided a basis for decision making and identifying priority interventions for Hangberg.

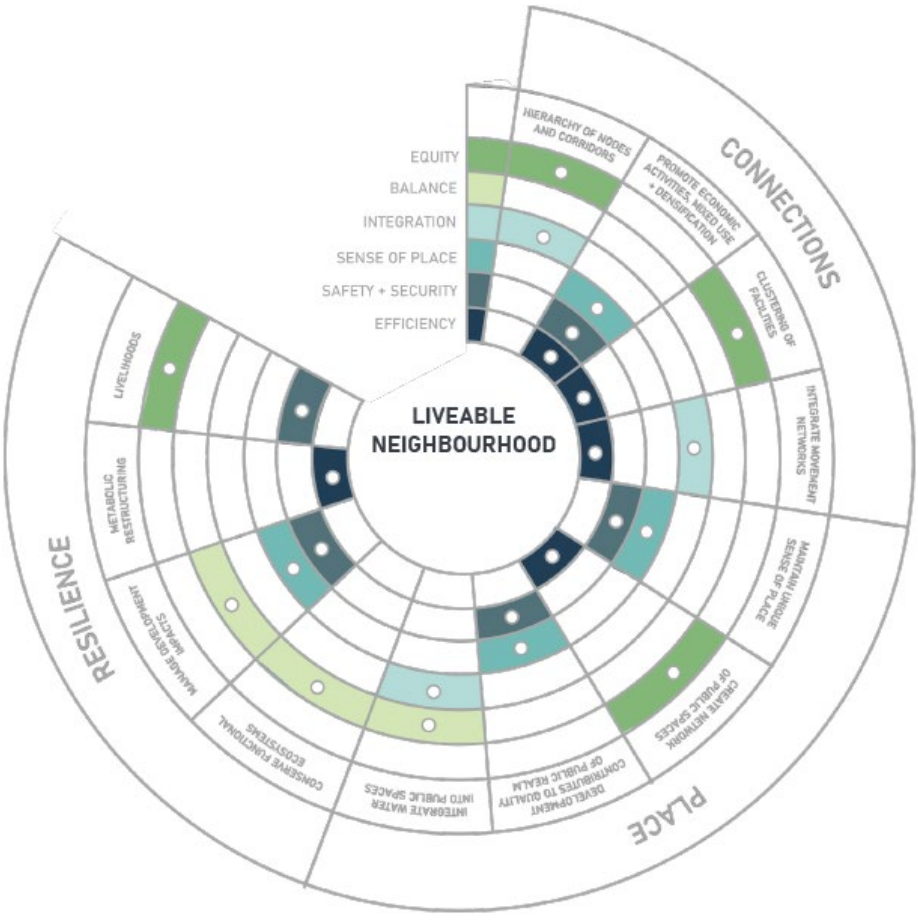


Figure 74: Diagram of the Design Framework (Source: Mari Smith)

The above depicts the three strategies on connections, place and resilience, their 12 sub-strategies and how they align with the 6 performance qualities.

Scales

The strategies of connections, place and resilience (and their sub-strategies) were applied to a design framework from Hout Bay and, subsequently, in making an urban design framework for Hangberg. At a lower scale, the three strategies were applied to develop an urban design framework for a precinct within Hangberg neighbourhood. This brought consistency in using water sensitive design to integrate urban requirements and ecological functions for a liveable neighbourhood. This is demonstrated in the Figure 75 below.

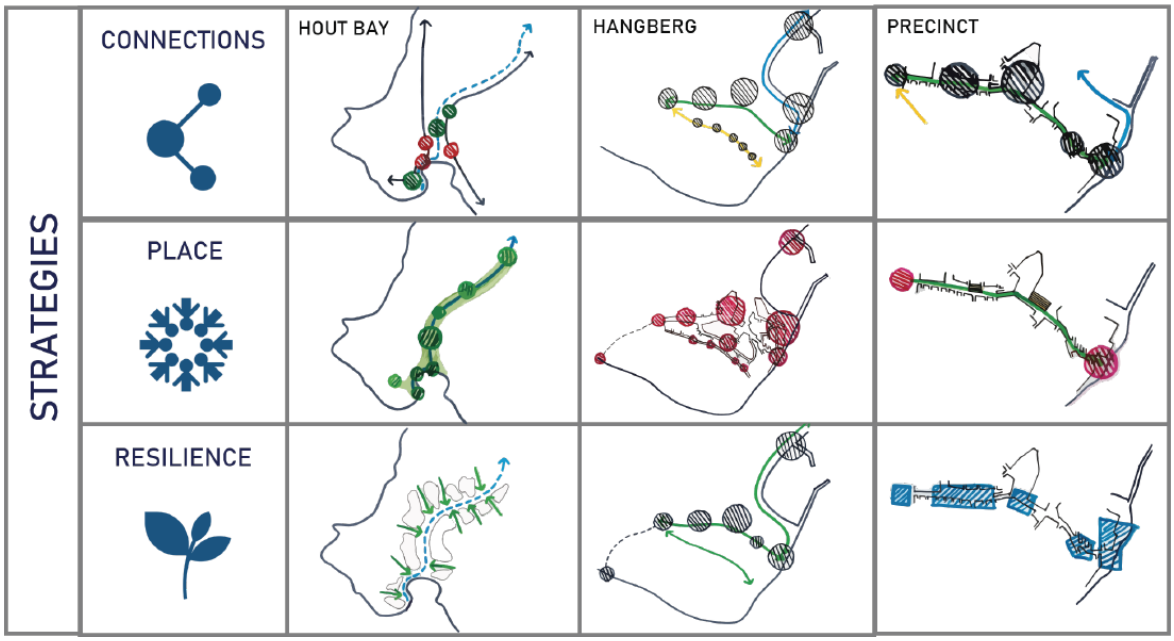


Figure 75: Scales used in the Design Framework (M. Smith, 2020)

Hout Bay Spatial Framework

The Spatial Framework for Hout Bay aimed to set up various spatial structures. This was guided by three strategies of connections, place and resilience (and the 12 sub-strategies).

Connections

Key elements in the connections strategy for Hout Bay include integrating the movement system and linking these with key destinations. This is in a system of proposed activity corridors and nodes. Another proposal was to introduce a continuous route along the river and harbour and to activate the public spaces. This is important to connect the isolated neighbourhood of Hangberg to the broader Hout Bay and economic opportunities (see Figure 76 below)

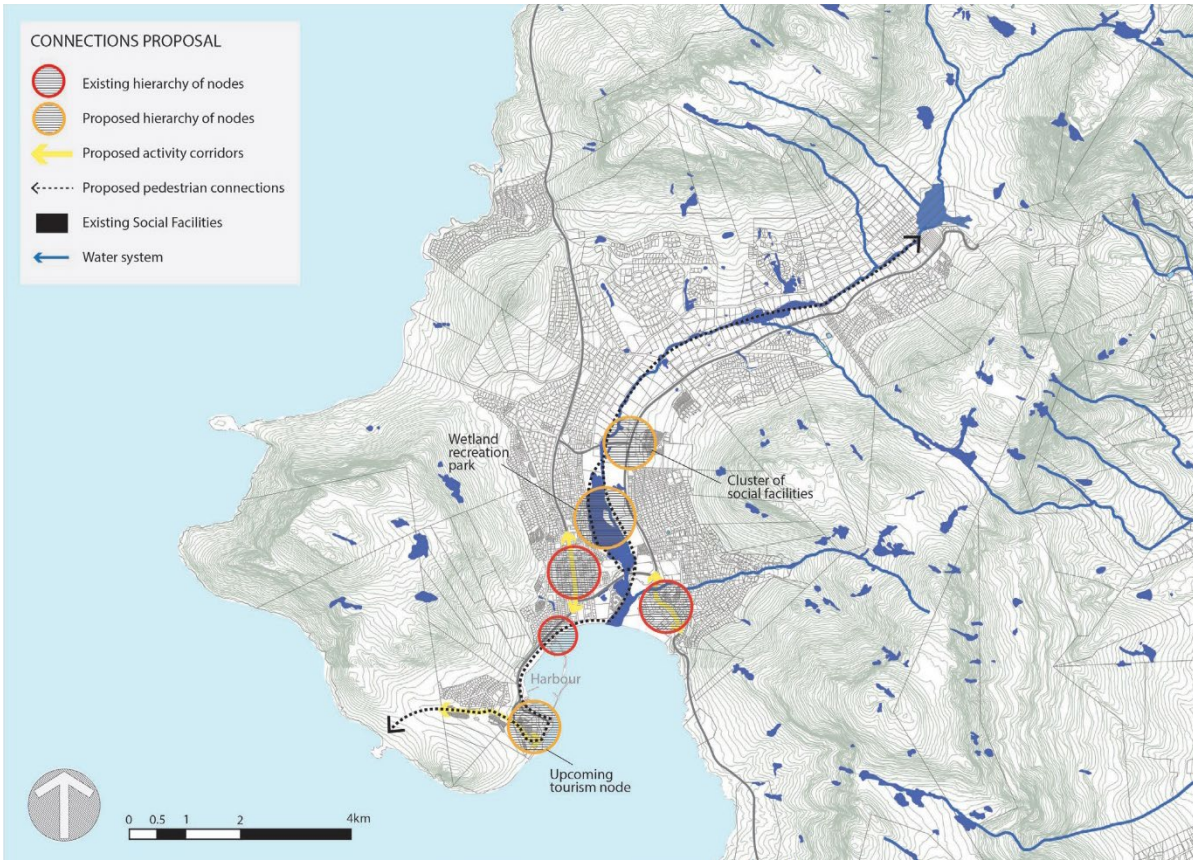


Figure 76: Hout Bay Connections (M. Smith, 2020)

Place

Key elements in the place design strategy for Hout Bay included creating places that are linked with the river, ocean and harbour. It also included maintaining the unique sense of place that Hout Bay has to offer. In addition to the existing nodes, a new hierarchy of nodes was proposed along the water system where various activities are promoted (see Figure 77 above)

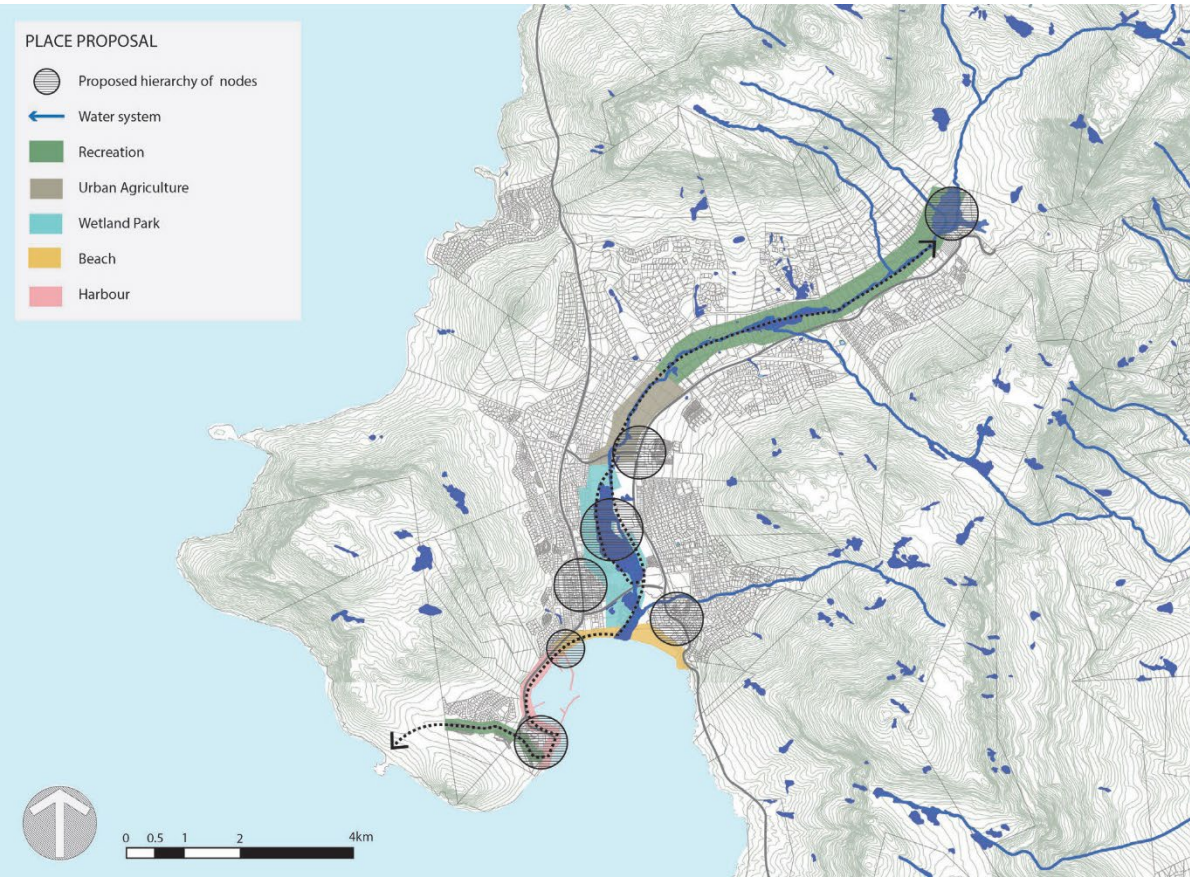


Figure 77: Hout Bay Place (M. Smith, 2020)

Resilience

Key elements in the resilience strategy for Hout Bay included preventing sprawl, integrating the natural and built environment and conserving valuable ecosystems. A system of green corridors was proposed to link up with the river and harbour, and to improve the connectivity between ecosystems.

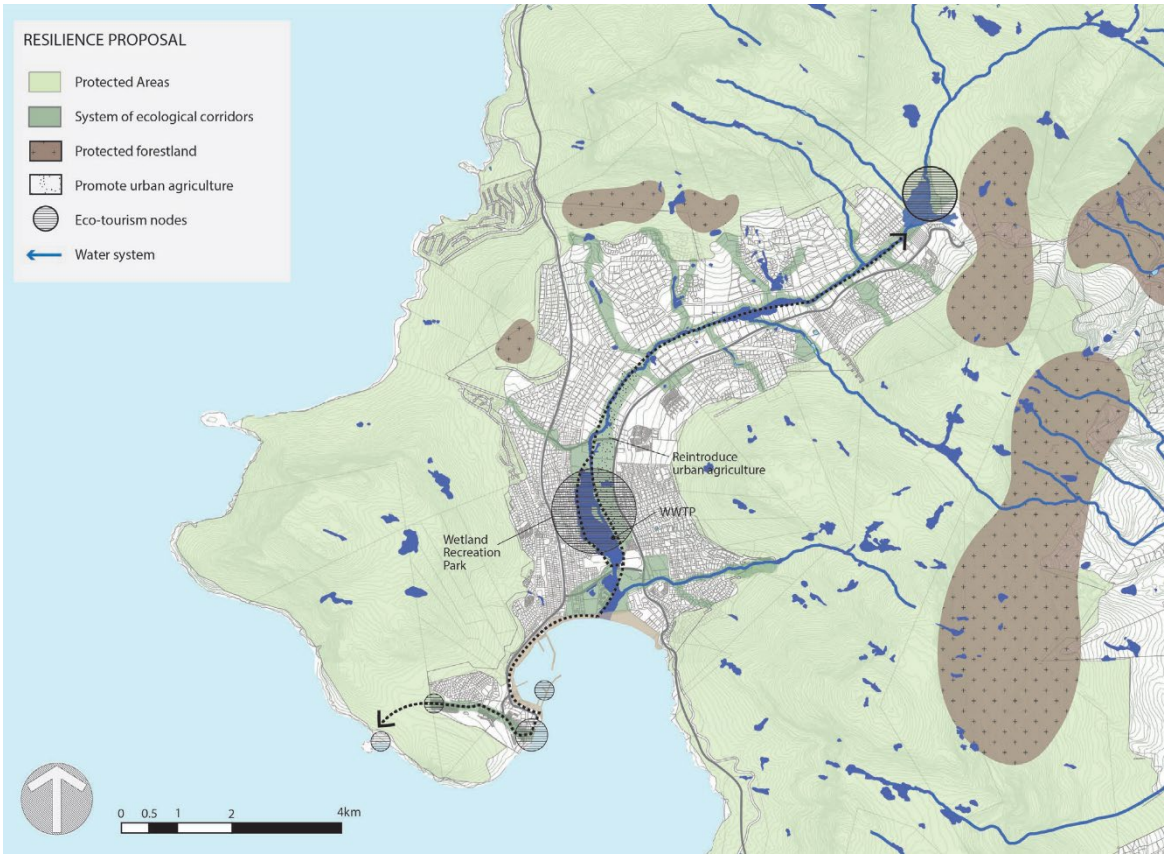


Figure 78: Hout Bay Resilience (M. Smith, 2020)

Hangberg Urban design Framework

In this section, the three strategies of connections, place and resilience (and their sub-strategies) were used to generate spatial design proposals for the Hangberg neighbourhood. Combining, water sensitive measures with recommended approaches to urban place-making, the proposals are, in combination, aimed making Hangberg into a liveable neighbourhood.

Connections

In the connection strategy, focus is on connecting Hangberg with the broader Hout Bay. The continuous Non-Motorised Transport (NMT) route leading from the proposed route along the Hout Bay River comes to the harbour in Hangberg (see Figure 79 below).

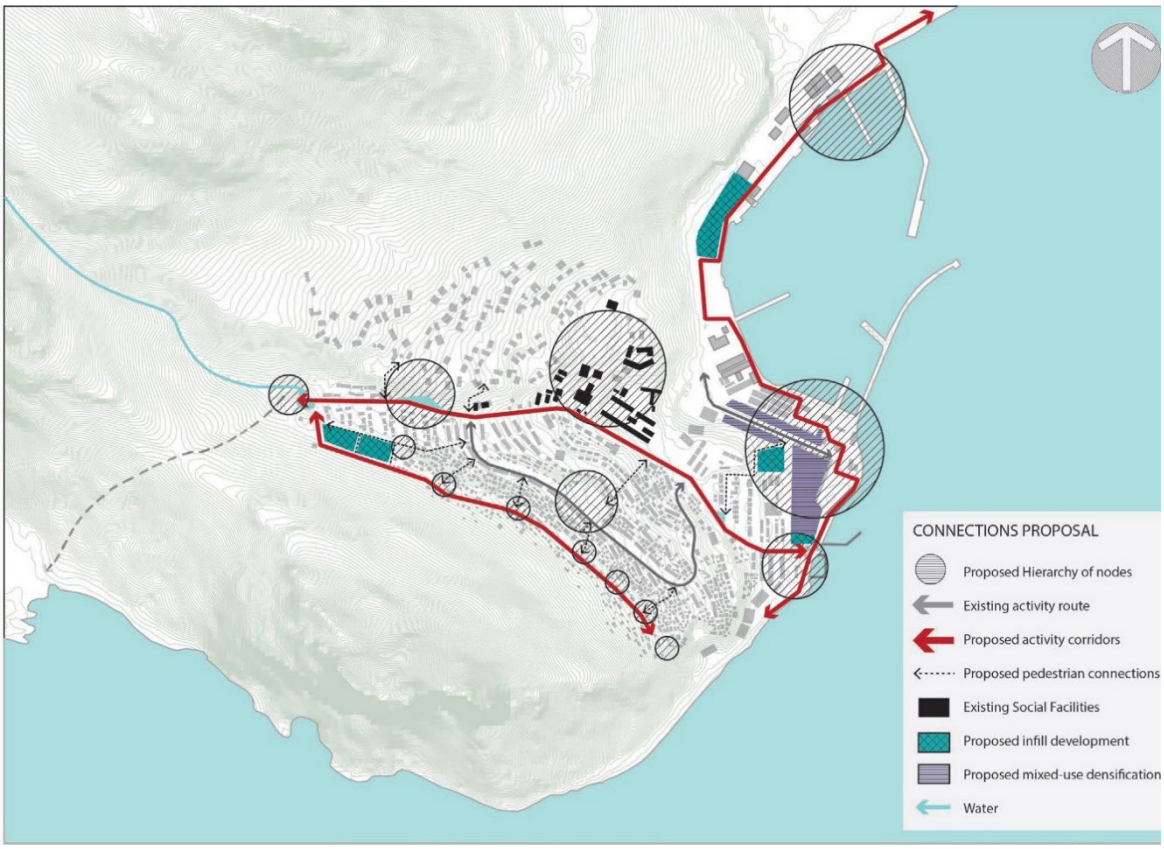


Figure 79: Hangberg Connections (M. Smith, 2020)

Along all the routes is a system of proposed nodes to provide equal access to opportunities for residents. Areas are also identified where infill development and densification can occur along these activity corridors.

Place

A key element of the place strategy was to create a network of public spaces throughout the neighbourhood to improve access to public spaces for all residents. These spaces should be integrated with the water system (Figure 80 below)

A system of safety points was proposed in areas that are currently vacant or underutilized and are prone to crime. A system of sanitation points was also proposed along the fire break where there is a lack of services. These safety and sanitation points will be integrated with the public space network. Elements such as landmarks, viewpoints and gateways are proposed to add to the spatial legibility of these spaces.

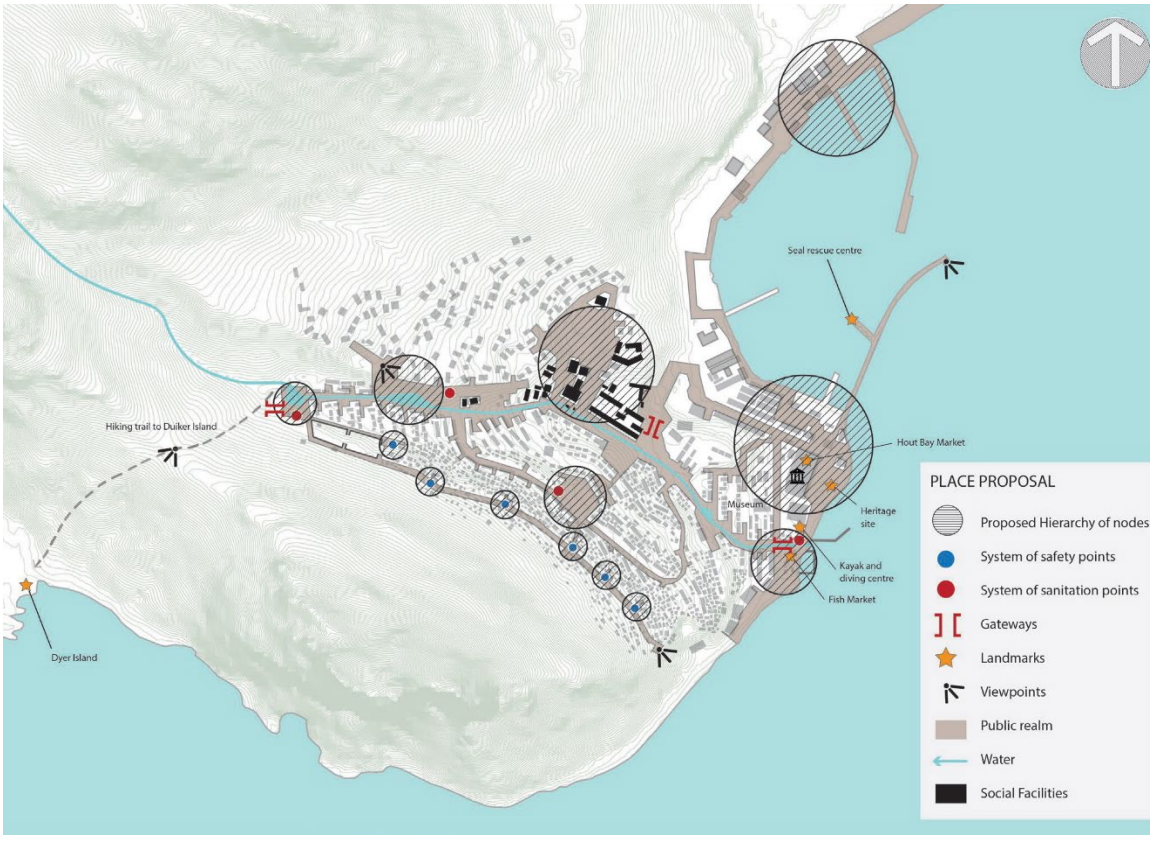


Figure 80: Hangberg Place (M. Smith, 2020)

Resilience

A key element of resilience strategy is to protect the natural systems in and around Hangberg.

This is done by creating ecological corridors that are linked with the Critical Biodiversity Areas (CBAs) above the settlement and the water system. Protecting and enhancing livelihoods is another essential element of resilience, this is done by providing opportunities for economic growth such as the introduction of urban agriculture and the building of a central marketplace for fisherman and farmers.

Eco-tourism is also introduced into the neighbourhood such as a hiking trail to Dyker island and a kayak and diving centre (Figure 81 below).

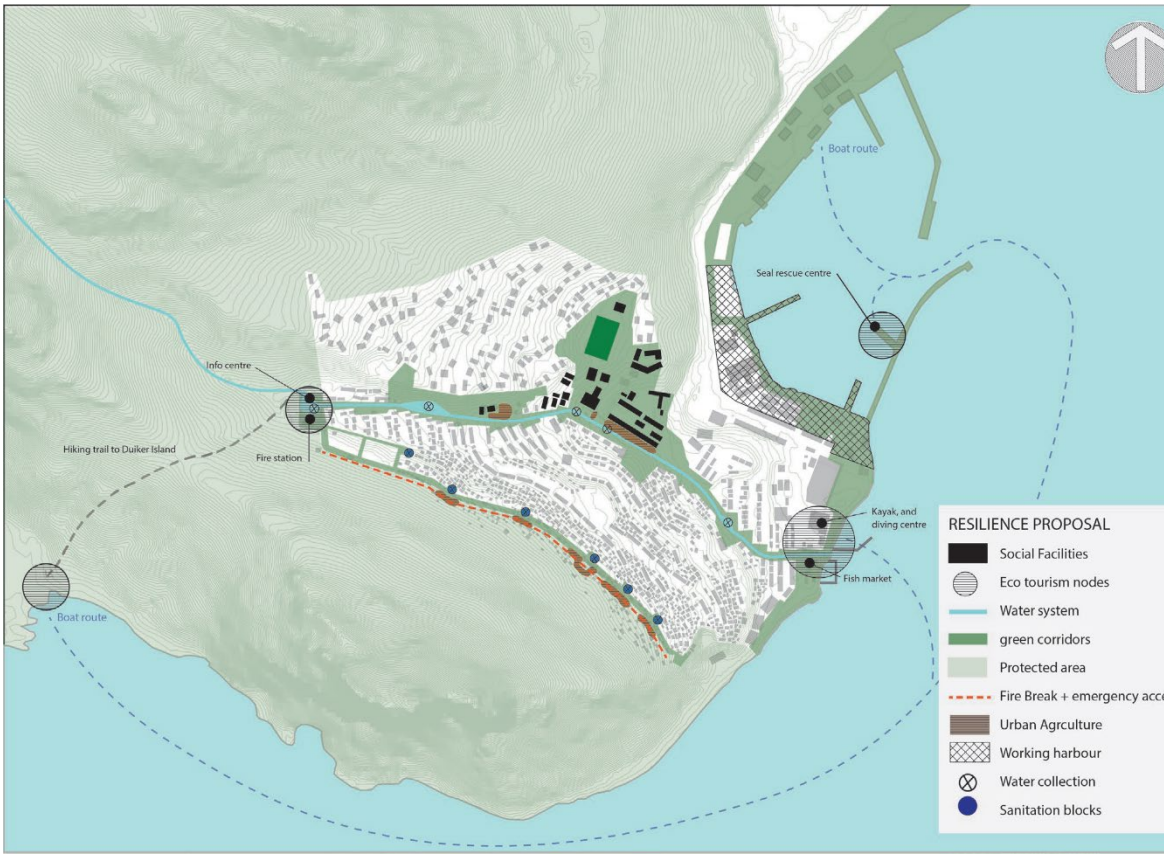


Figure 81: Hangberg Resilience (M. Smith, 2020)

Hangberg Integrated Urban Design Framework

The above maps that were individually produced from urban design proposals using strategies of connections, place and resilience (and their sub-strategies) were then layered to make the Integrated Hangberg Urban Design Framework (IHUDF) (Figure 82 below).

The Integrated Urban Design framework for Hangberg lays down general urban design principles to make Hangberg into a liveable neighbourhood in which the six performance qualities of equity, balance, integration, sense of place, safety and security and efficiency can be achieved.

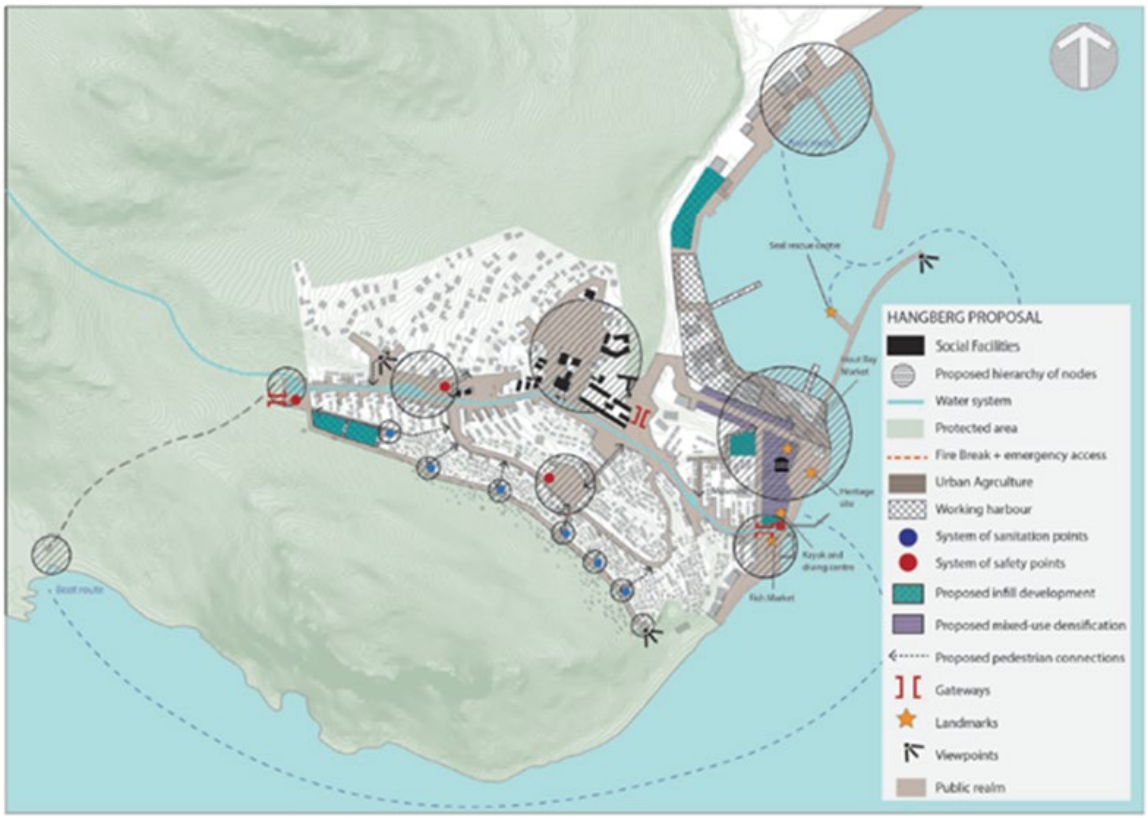


Figure 82: Integrated Urban Design Framework (M. Smith, 2020)

Key Structuring Elements; Three Corridors

The IHUDF is spatially structured with three multi-functional corridors with urban and ecological functions. The corridors have different hierarchies and functions. The three corridors are the (1) Harbour Corridor – along the Harbour and connecting to broader Hout Bay along the Hout Bay River (2) Green Corridor – following Oude Skip Road and the subterranean stormwater

drainage system in Hangberg, and (3) Fire Break Corridor – along the existing firebreak (die sloot) in Hangberg. The corridors constitute three key space structuring elements for Hangberg (see Figure 83).

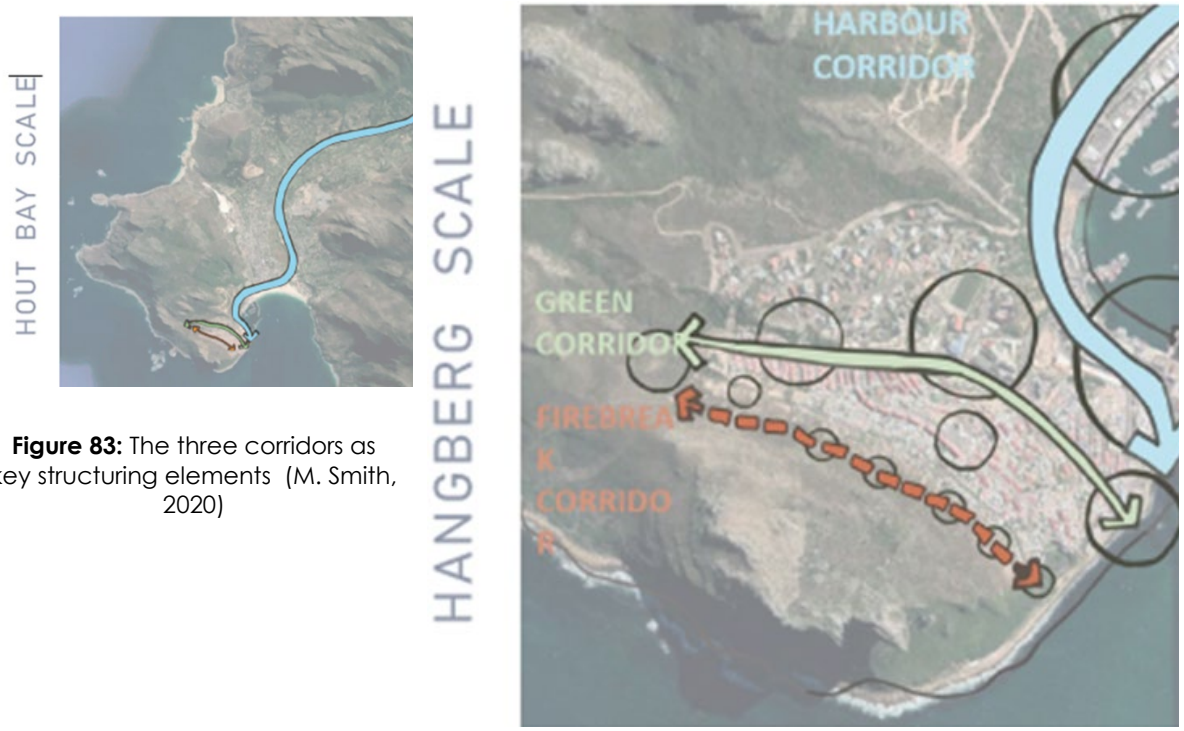


Figure 83: The three corridors as key structuring elements (M. Smith, 2020)

The visions and concepts for these three corridors are presented in this section. Carefully placed nodes attract and condense activity while generating traffic along each corridor. The three corridors are presented on a map to show scale, intent and spatial definition (see Figure 84 below). Each corridor is then presented using a collage – a loose, non-prescriptive illustration that suggests possibilities for appropriation into multifunctional liveable water sensitive spaces defined by nature and urban built fabric.

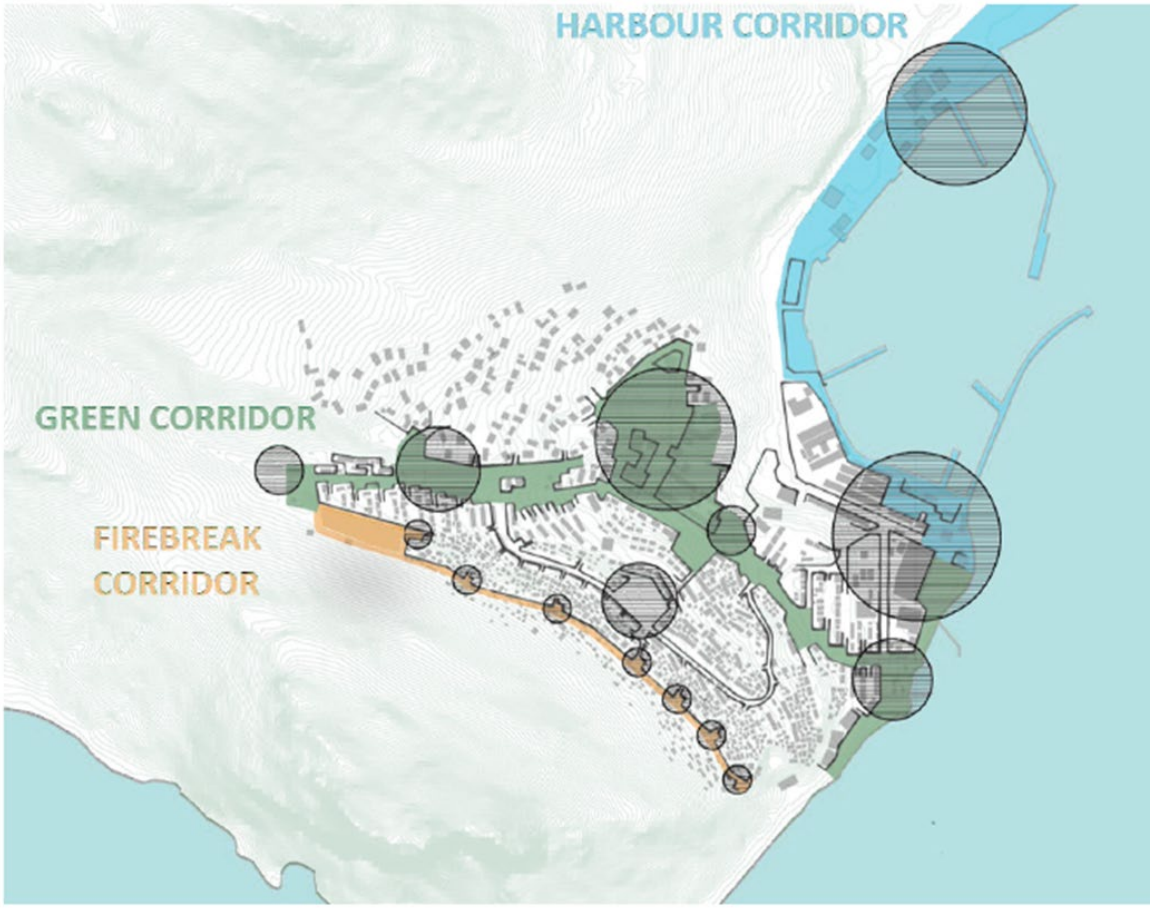


Figure 84: Key Structuring Elements (M. Smith, 2020)

The three corridors showing positive definition of urban spaces. Each corridor is punctuated by nodes. The corridors and nodes link and serve urban and ecological functions

Harbour Corridor

The Harbour Corridor is higher-order corridor that serves the larger neighbourhood of Hout Bay (Figure 85 below). The corridor aims to connect Hang Berg with Hout Bay by creating a continuous route along the harbour and river while also promoting tourism around the harbour.

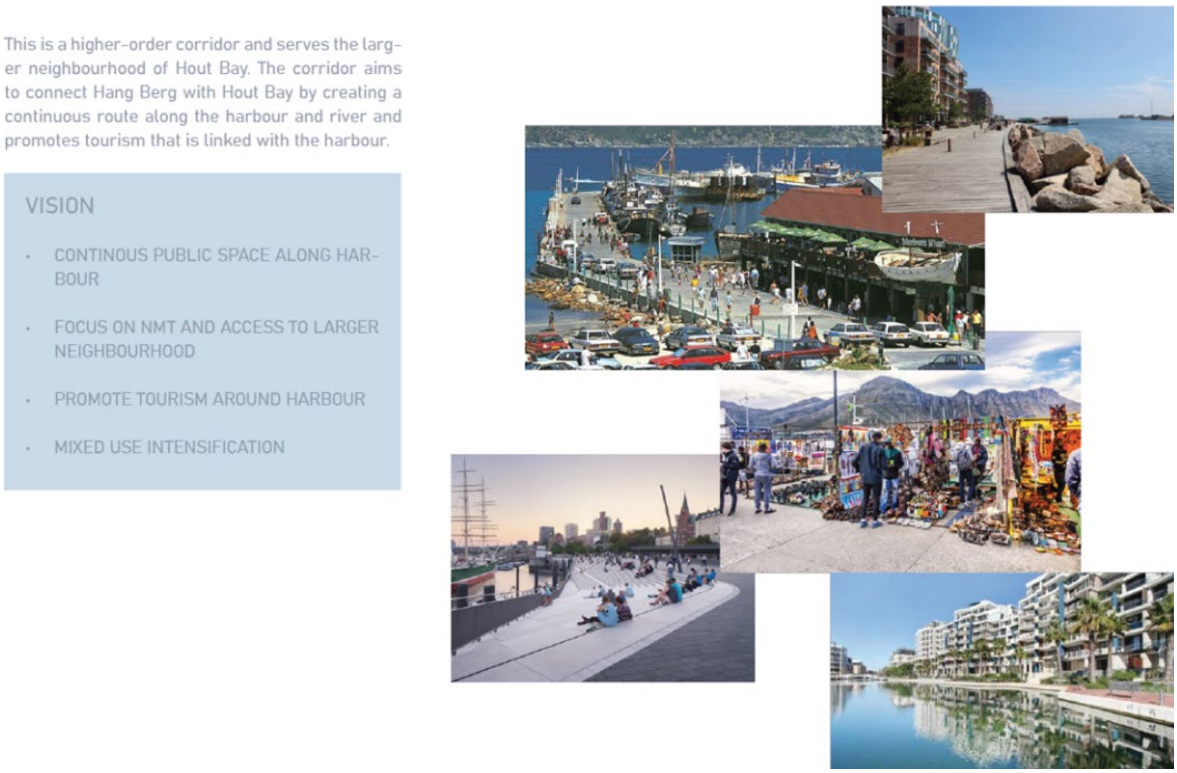


Figure 85: A Collage for the Harbour Corridor: Inspirational aspects of a water sensitive harbour area (M. Smith, 2020)

Green Corridor

The Green Corridor is a medium order corridor that serves the neighbourhood of Hangberg Figure 86 below). The corridor follows the water running down the mountain and underneath the main road. The design proposes that the water running underneath the corridor is resurfaced to connect ecosystems from the mountain to the ocean. The blue-green infrastructure on this corridor offers multiple benefits to people and nature in Hangberg.

Figure 86: A Collage for the Proposed Green Corridor (M. Smith, 2020)

Firebreak Corridor

The firebreak corridor is a lower order corridor that serves the local community residing along the firebreak (Figure 87 below). The corridor runs along the firebreak which also acts as a stormwater channel. Development is encroaching onto the nature reserve above the firebreak contour. The proposed firebreak corridor is aimed at controlling urban sprawl and consolidating the firebreak while also managing stormwater to prevent flooding and improve livelihoods. The corridor is also cleared to allow for access of emergency services (such as firefighting trucks) into the area.

Figure 87: A Collage for the Proposed Fire Break Corridor (M. Smith, 2020)

Precinct Plan

The Green Corridor was chosen to be the focus of the precinct to demonstrate the capacity of using WSD to combine ecological objectives and urban spacing principles. The Green Corridor provides an opportunity to resurface the water and link public urban spaces to the water system and nature. It is important to note how the precinct plan has been broken up with four key nodes labelled Focus Areas 1-4 (see Figure 88 below). Each node is attributed a quality of water sensitive activity. The three strategies of connection, place and resilience are applied to the precinct area at a finer level of detail.

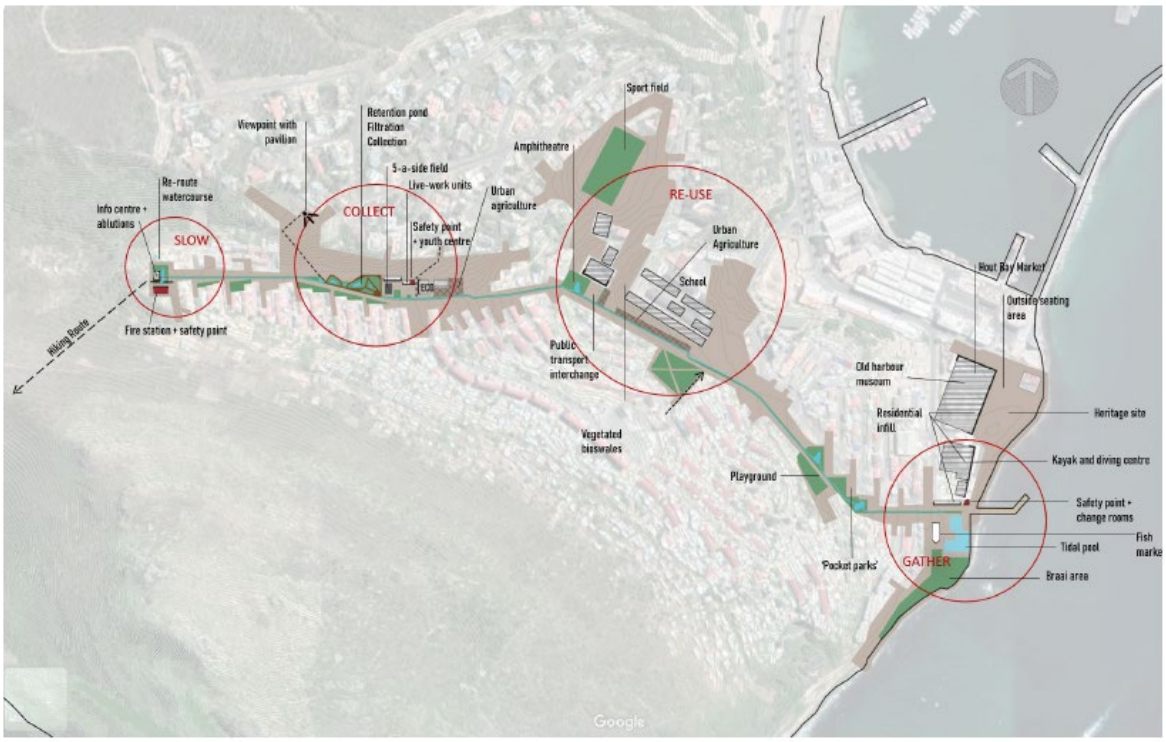


Figure 88: Urban design Precinct plan (M. Smith, 2020)

Precinct Connections

The Green Corridor was proposed as the primary activity route through Hangberg neighbourhood. Important pedestrian links come off this corridor. Four multifunctional nodes were proposed along the route. Development intensity, diversity and adaptability is encouraged along the corridors and its system of nodes (Figure 89 below).

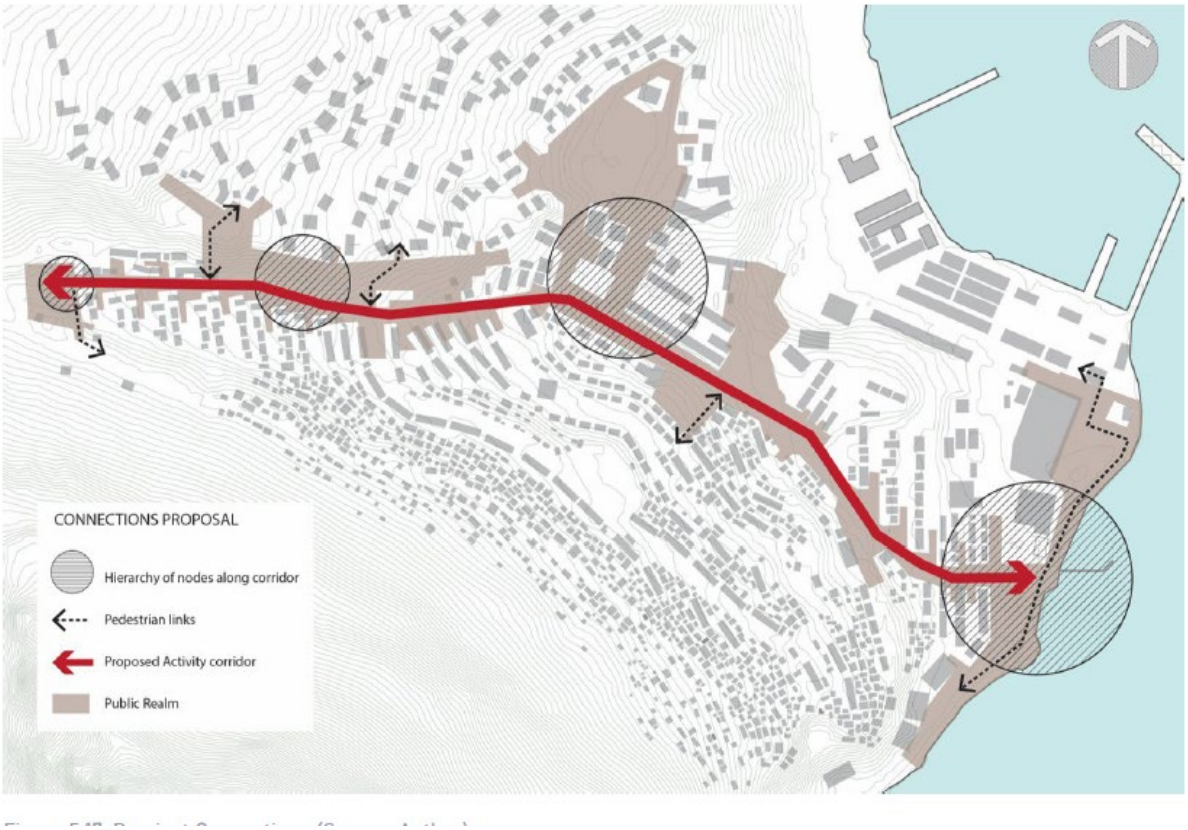


Figure 89: Precinct Connections (M. Smith, 2020)

Precinct Place

The four proposed public spaces (nodes) on the Green Corridor provide adequate and equitable access to public spaces while enhancing ecological function. The spaces are multifunctional and designed with the water system. The gateways into and out of the corridor become special places of celebration where the Green Corridor connects with the harbour to the east and the mountain to the west. Landmarks and viewpoints contribute to sense of place and improve the legibility of these public spaces (see Figure 90 below).

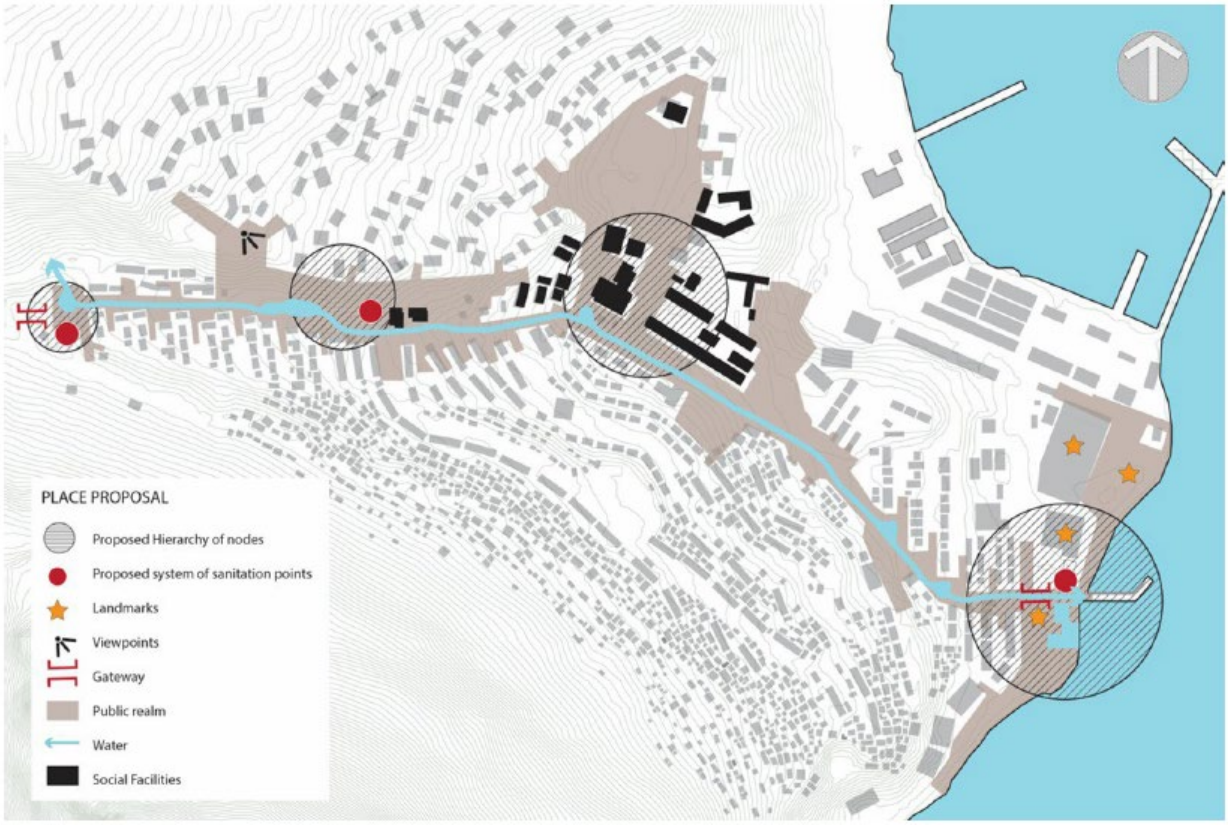


Figure 90: Precinct Place (M. Smith, 2020)

Precinct Resilience

The Green Corridor connected various ecosystems and water systems. The proposal was to resurface the stormwater running under Oude Skip Road to make a continuous bioswale running from mountain to sea. The bioswale is planted with trees and vegetation to allow water and nature to flow from mountain, along the corridor and down into the ocean. The proposal aims to ensure that most of the water is collected and reused before it reaches the ocean. Urban agriculture is introduced at education facilities such as the existing Early Childhood Development Centre (ECD) and the primary school. Training facilities, a jetty to access the ocean and a marketspace are also introduce to help support the livelihoods of the residents. Four nodes were proposed along the Green Corridor. The nodes have urban and ecological function (see Figure 91 below).

Figure 91: Precinct Resilience (M. Smith, 2020)

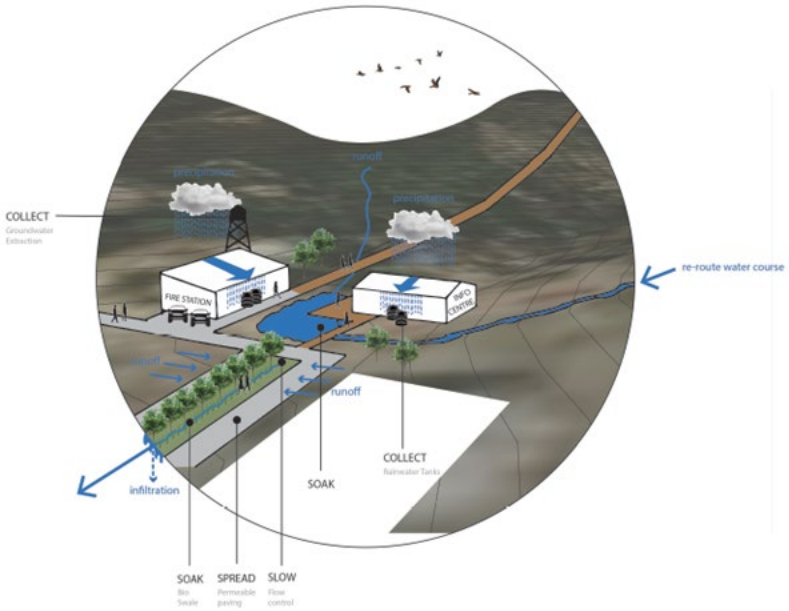
Precinct Nodes

The nodes have an urban and ecological function. To foreground water sensitive design and natural systems, each of the nodes in the precinct is named according to ecological function (Figure 92 below):

- The slow node is where different water sources coming from the mountain meet, are slowed down.
- The collect node is to treat and collect the water entering the node to be re-used and utilised elsewhere.
- The reuse node makes use of various collected water sources for uses such as the irrigation of the proposed urban agriculture and existing sports field.
- The gather node focus on connection between the neighbourhood and the ocean and to provide space for recreation and enhancing livelihoods.

Figure 92: Four Proposed Nodes on the Green Corridor (M. Smith, 2020)

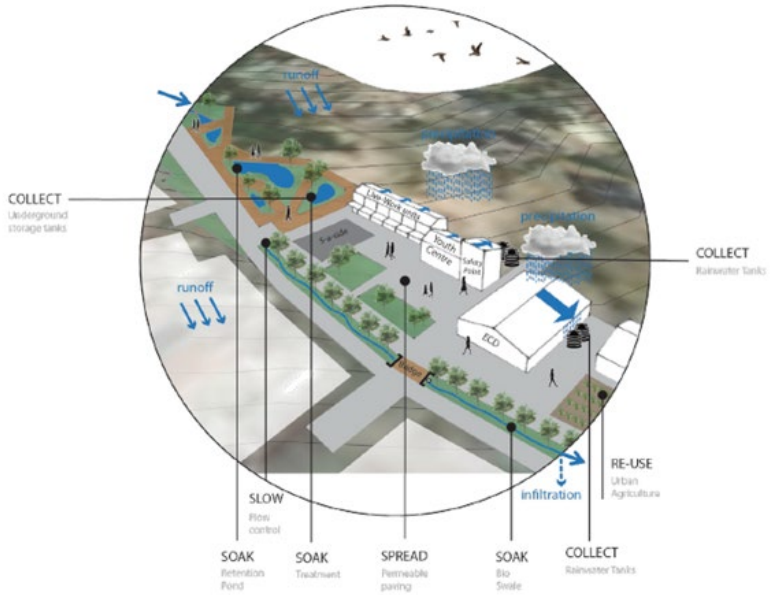
This section further explores the ideas and concepts for these four focus areas. Each node is presented in a concept diagram that captures the key spatial and built environment intent. Informed by the three strategies of place, connection and resilience, each node is explored in creative collage. Each collage presents non-prescriptive imaginaries for a liveable water sensitive urban node.



Slow Node

Figure 93: Slow node water concept diagram and visualisation (M. Smith, 2020)

The Watercourse running down the mountain is resurfaced so that it be visible along the green corridor. The topography provides an opportunity to collect the different sources of water from the mountain by gravity and to re-lease the water slowly the so that it can travel down the corridor through a system of bioswales. A water tower at a proposed satellite fire station stores water for firefighting.

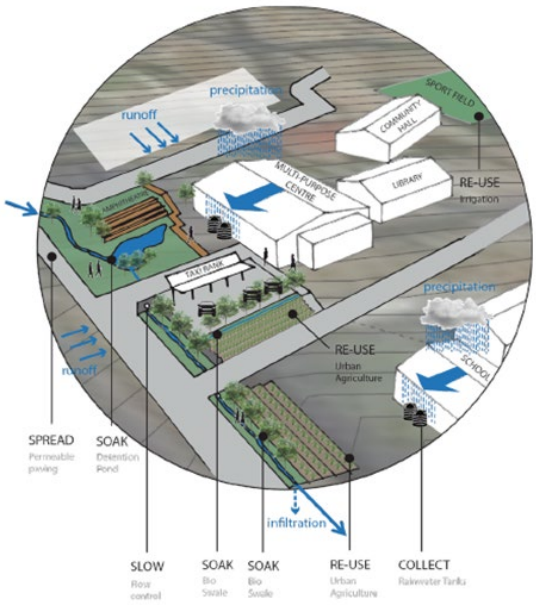


Collect Node

Water comes down from the mountain, through the bioswale into the Collect Node. This water is then collected and treated through a series of retention ponds which also acts as a recreation space. The water is collected in underground tanks and also in water tanks at buildings.

A water tower stores water for reuse in the proposed urban agriculture at the ECD and further down at the reuse node. Water continues to move down the corridor along bioswales. A spray park provides space for play and urban cooling. The space is provided with a five-a-side soccer pitch. A proposed new building with live-work units and a youth centre adds definition to the node. Public safety, social function and ecological function overlap in this area.

Figure 94: Collect node water concept diagram and visualisation (M. Smith, 2020)



Reuse Node

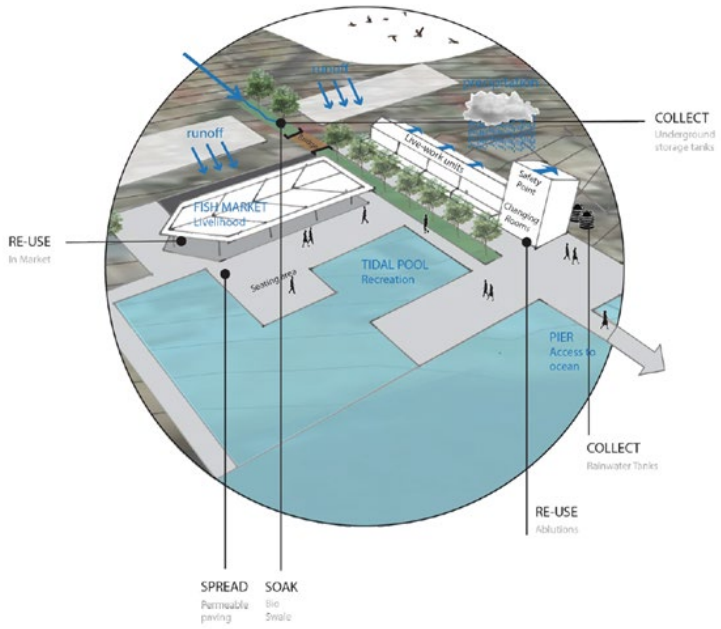
Water comes into this node along the bioswale. It is slowed down in a detention pond to become a feature element in a proposed amphitheatre.

Water that has been collected along the corridor is reused in this node for purposes like urban agriculture at the school and irrigating the existing sports field. Water then continues to move down the corridor along the continuous bioswale.

Figure 95: Re-Use node water concept diagram and visualisation (M. Smith, 2020)

Gather Node

Water from the reuse node comes into the Gather Node along the bioswale. It is extended by a pier which provides access to the ocean for fisherman and tourists. Recreational activities linked with the water such as a tidal pool, braai facilities, a kayak and a diving centre are proposed. A jetty that local fisherman can use to access the ocean is also proposed in the node.



The fish market provides a space where the local fishermen can sell their products and where local farmers from urban agriculture can sell their fresh produce. It is proposed that the existing Hout Bay market should be extended out into the heritage site and linked up with an old harbour museum at the top of the building to tell the story of Hangberg. Another safety point with changing facilities is proposed to be linked with live-work units that provide additional residential and economic opportunities.

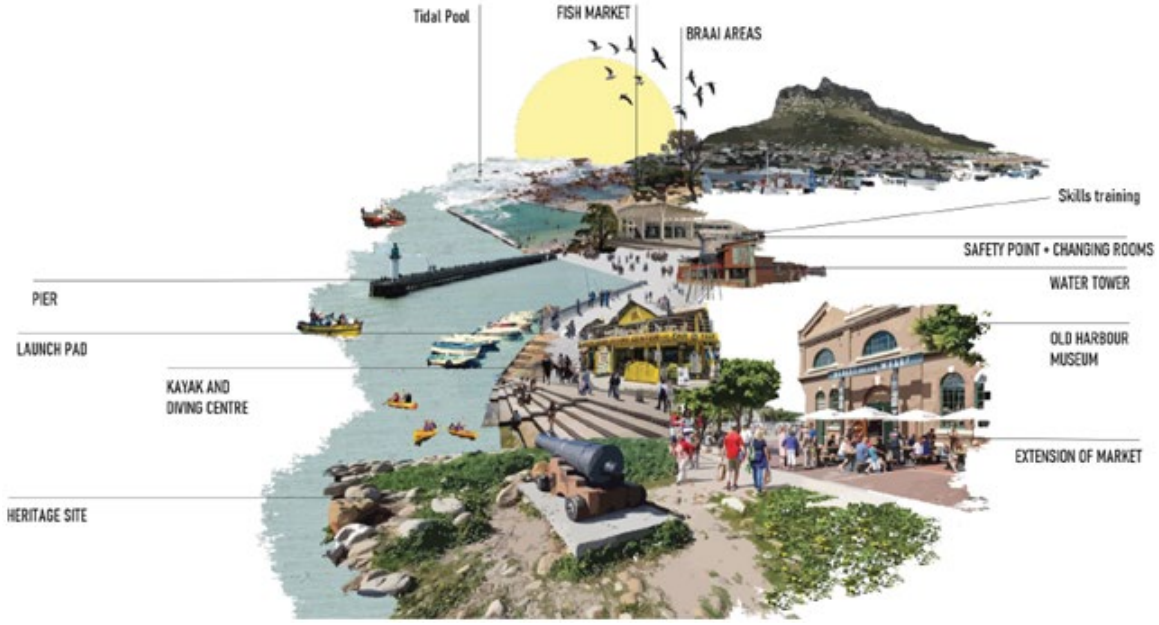


Figure 96: Gather node water concept diagram and collage (M. Smith, 2020)

Urban Design Guidelines

The urban design guidelines presented here accompany the above plans and collages. In accordance with the non-programmatic approach, the guidelines are non-prescriptive. They are an example to show the kind of elements that would be required to make a more comprehensive set of guidelines for Hangberg.

Table 15: Elements of Urban Design addressed in proposal

WATER ELEMENTS		
SANITATION BLOCKS	Provide water and wash points and sanitation facilities. Design to have male sanitation facilities on top floor. Female, children and disabled sanitation facilities on ground floor. Caretaker on site to ensure 24hr surveillance and maintenance. Make use of rainwater tanks	
WASTE COLLECTION POINTS	Designated waste disposal points for general waste and different forms of recycling. To be located in closse proximity to sanitation block	
WATER HARVEST	Make use of water harvesting to improve water security and resileince to climate change Rainwater harvesting Capture and store rainwater runoff from rooftops to be reused for domestic use and rrigation. Stormwater harvesting Capture, store and treat water runoff from urban areas such as streets to be used as recycled water for irrugation. Make use of retention and detention ponds. Greywater harvesting Capture, store and treat water from sinks, dishwashers, showers etc. to be used for flushing toilets and irrigation.	 

STORMWATER SYSTEM	Make use of blue/green infrastructure to create an integrated storm water system to enable the collection and filtration of water to reduce flooding, improve managed aquifer recharge (MAR) and reuse water. Bio swales: Make use of bioswales instead of pipes to convey and treat stormwater and to add to the aesthetic character of an area. Bio swales should be integrated with landscape features in parks and street. Ponds: Make use ponds for flood control, MAR and stormwater runoff treatment. Design these to be functional spaces so that when the ponds are empty they can become dynamic recreation spaces Use retention ponds to permanently hold water from percipitation and runoff from surrounding areas. Generally retention ponds require more area than detention ponds. Use detention ponds to hold stormwater for a short periof of time such as 24 hours. These ponds are generally only used for flood control measures and reduce runoff rates that are associated with storms and decrease flood damage.	  
URBAN AGRICULTURE	Urban agriculture should include the cu;tivating, processing and the distribution of food in and around the urban area. Where the topography is steep terraced urban agriculture can be created.	

BUILT FORM		
SAFETY POINTS	Strategically located system of safety points that act as safety beacons. The building should be 3 or 4 storey's high and have day and night occupancy for passive surveilance.	
BUILDING INTERFACE ON PUBLIC REALM	Promote mixed use buildings with economic activities on the ground floor and residential above. Buildings should have balconies on the upper floors to provide passive surveilance and should positively relate to the street with doors and windows facing onto the street. Low boundary walls allowed to facilitate street surveillance and interaction.	
INCREMENTAL HOUSING	Formalising housing in a phased approach where owners can improve their home as funding, time or materials become available.	

LANDSCAPE ELEMENTS		
SOFT LANDSCAPING	Use large shade trees that are suitable for the region with minimal maintenance and watering requirements. Tree cages can be used to support and protect trees against climatic conditions and vandalism. Trees to be planted as screens to protect from prevailing winds.	
HARD LANDSCAPING	Use permeable paving where possible to enable infiltration of storm water and rainwater runoff to the soil. This will increase groundwater recharge, improve stormwater quality and reduce high water flows entering the water system and urban areas. eg. Pervious concrete, porous asphalt, paving stones.	
PUBLIC SPACE COMPONENTS	Lighting: Provide Adequate Lighting along movement routes and in public squares and sanitation blocks that are resilient to vandalism. Bins: Bins located along prominent pedestrian routes and in public spaces to avoid littering and pollution Street furniture: Location of furnishing should correspond to framework and stimulate social encounters. Make use of materials that are resilient to vandalism	 
FIRE BREAK	Firebreaks should be positioned and prepared in such a way as to cause the least disturbance to soil and biodiversity. These spaces should also be multi-functional and include NMT and emergency access.	

The above technologies are brought together into a new set of user guidelines for water sensitive design in a four-step process (Figure 97 below). Each step is graphically illustrated with images the Hangberg neighbourhood, the precinct level proposals and architectural WSD proposals in this study. The guidelines are for use by policymakers, practitioners and the general public.

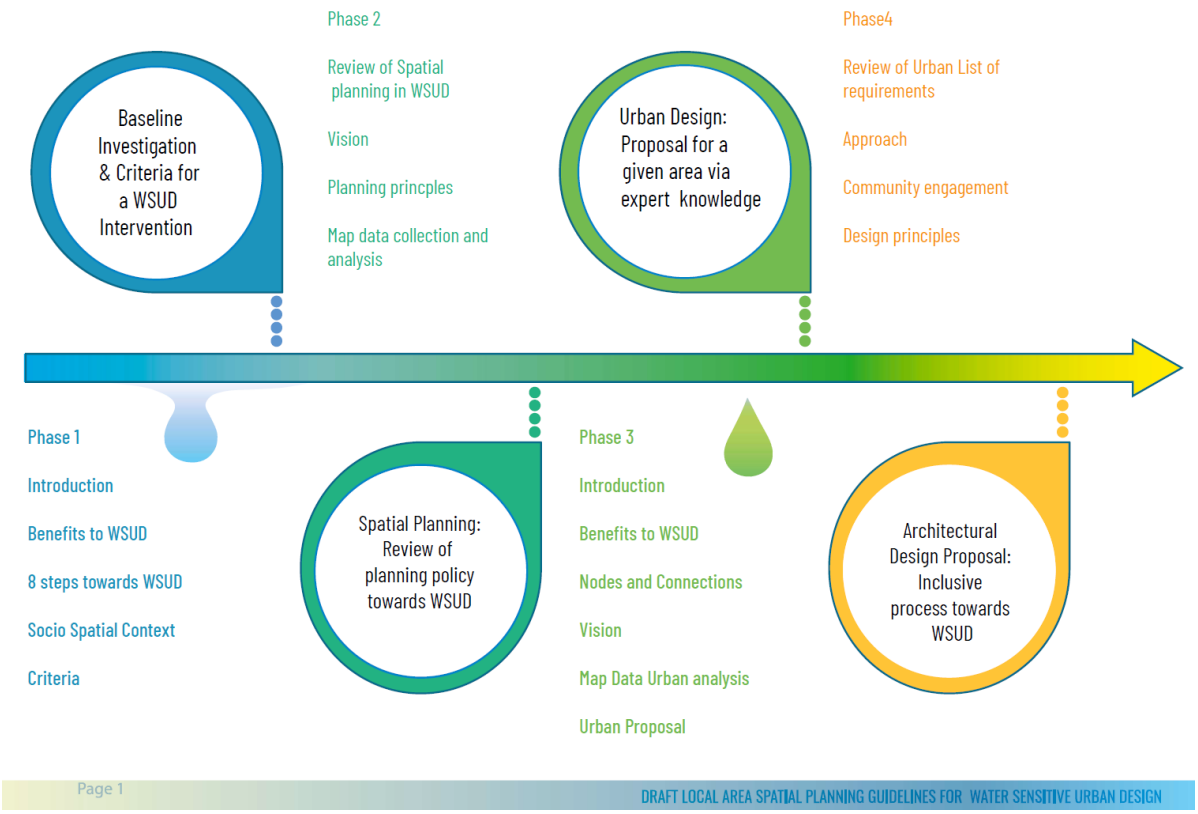


Figure 97: Overview of guidelines for a water sensitive urban design approach (C Phiri, 2021)

Figure 98: A visual representation of WSD in a livable Neighbourhood (M. Smith, 2020)

Hangberg Urban Design Summary

In this study, we used WSD approaches to make proposals to transform the low-income Hangberg neighbourhood into a liveable water sensitive neighbourhood. Hangberg is in Hout Bay. The study used space structuring elements of nodes and corridors in a series of maps and images. Ecological and urban nodes and corridors were used in context analysis, programme and concept formation and in developing design proposals.

In the context analysis, ecological systems were found to make Hout Bay into an attractive area for residence, recreation and tourism. These include the river, the natural areas in the mountain and the harbour. Many of the natural systems are threatened by urban development. A system of urban nodes and corridors exists in Hout Bay but Non-motorised Transport (NMT) facilities in the area in are inadequate.

Hangberg neighbourhood is hemmed-in by the harbour to the northeast and the edge of a Critical Biodiversity Area on the mountain to the southwest. The settlement contains low-income flats, hostels and informal shacks. Many of them are encroaching on the ecological areas. There are three urban nodes in Hangberg: at the school, the harbour and a playground. The settlement is not well-serviced by public transport and the pedestrian paths along the steep terrain are improvised and dangerous to navigate.

A firebreak (die sloot) is runs above the 90 m contour line in Hangberg. The gradient above the firebreak is too steep for technically and economically prudent urban development. But informal settlements in Hangberg have encroached onto environmentally sensitive areas above the firebreak (die sloot).

The firebreak (die sloot) serves several purposes

- Proprietary boundary: all land above the firebreak is owned by SANParks.
- Legislative boundaries: separates settlement and protected biodiversity area
- Functional
    - prevents spread of fire in either direction and allows a line of access for fire fighting vehicles
    - is an important line of drainage, positioned to channel stormwater from the mountain downhill
    - above the firebreak line, the slope is at least 33%. This is way beyond the recommended planning maximum of 18% slope. The slope above the firebreak is too steep for technically and economically prudent urban development
    - vegetation above the firebreak serves as a windbreak from cold winter winds and dusty summer winds.
    - Removal of vegetation from steep slopes without soil retention measures causes slope instability that results in erosion, landslides, and intense downslope flooding.

For the above reasons, this study prohibited development up above the firebreak.

Considering the above factors, the study recommended that development in Hangberg be limited to the existing urban footprint and using low-impact measures in the spaces adjacent to ecologically sensitive areas.

To balance needs for urban space making with requirements for environmental protection, the study proposed six performance qualities to transform Hangberg into a water sensitive liveable neighbourhood: equity (all residents can access facilities and opportunities), balance (nature/urban and good distribution of social services), integration (break down fragmentation between communities and between urban spaces and nature), sense of place (responding to unique qualities of the location and enhancing urban spaces), safety and security (security of tenure, food security, safety from hazards), and efficiency . Comparing the desired performance qualities to the analyses of context yield a set of constraints and opportunities, which were also visually presented on a map.

Subsequently, the six performance categories were interpreted into three urban design strategies: connection, place and resilience (and 12 sub-strategies).

The three strategies were used to develop a contextual design framework at the scale of Hout Bay. They were further applied to make an urban design framework for Hangberg and for a smaller precinct within the neighbourhood. By thus applying the strategies of connections, place and resilience to Hout Bay Subdistrict, Hangberg neighbourhood and one of its precincts, a consistency in using WSD to integrate urban design principles and ecological functions to create a liveable neighbourhood was attained.

The proposed spatial framework for Hout Bay subdistrict focused on linking Hangberg neighbourhood to the rest of Hout Bay with a NMT corridor running from the harbour and penetrating the rest of the suburb along the river. The route serves to improve ecological and urban connectivity and is punctuated by multifunctional nodes. To improve resilience, ecosystem services of Hout Bay are protected.

The strategies of connections, place and resilience were also used to generate urban design proposals for Hangberg neighbourhood. There a NMT connection from Hangberg, through the design to rest of Hout Bay (see above). This also links with two other main routes running along the contours in Hangberg. One of these is the firebreak which is consolidated to improve drainage and fire protection. Along the three routes, a system of nodes is introduced. To enhance sense of place, the nodes are designed as positive public spaces. Water is used as a generative element in the design. For increased resilience, the proposal promotes protection of nature and introduces a bioswale along one of the routes to connect the mountain to the harbour. For improved livelihoods facilities for urban agriculture, a fish mark and eco-tourism are proposed. Three separate proposals for Hangberg were made using the connections, place and resilience strategies (and their sub-strategies). These were then layered to make the Integrated *Hangberg Urban Design Framework (IHUDF)* on a map. The IHUDF has three key corridors, all related to water: Harbour Corridor, Green Corridor and Firebreak Corridor. Each

corridor was presented using collages to show possibility for appropriation into liveable water sensitive places.

The strategies of connections, place and place were applied in more detailed precinct proposal for the proposed Green Corridor and its four nodes. A bioswale along the corridor resurfaces stormwater which would otherwise run-in underground pipes. WSD technologies were used along the corridor to slow-down and collect water for firefighting, urban agriculture and household use. Ecological connectivity was enhanced by this blue-green corridor running from mountain to sea. And the corridor provides welcoming public spaces in the four nodes. In the slow node water is slowed and resurfaced and released slowly. A fire station protects the neighbourhood and the protected natural areas. In the collect water is collected and reused in an existing ECD and proposed live-work units for urban agricultural and domestic use. Work, play. In the gather node at harbour is a place where Hangberg residents intermingle with broader Hout Bay, the city and international tourists. Heritage is protected in the museum and economic opportunities provided to sell at the market. Each node was presented in collage to show possibility.

The above technologies were brought together in new user guidelines for water sensitive urban design in a step-by-step process. Each step was graphically illustrated from the Hangberg neighbourhood proposals and the precinct level proposals.

Aspects of WSSP and WSD are increasingly featuring in Cape Town's metropolitan and district level spatial developments. For example, the latest Southern District Spatial Framework and Hout Bay Subdistrict Spatial plan explicitly work to integrate spatial planning and ICM. However, there are no plans to date in Cape Town for neighbourhood and district WSD plans. The value of this study is in being the first to make such WSD proposals at neighbourhood and precinct scales.

Executing the Co-design

A participatory method was used, and twelve participants selected. The participants were all involved in water but in different capacities. Participants worked in three iterative steps in the co-design process: situation analysis, problem identification, collaborative design, prototype development, prototype evaluation. The iterative process allowed more flexibility for changes. Data from the co-design was analysed using NVivo qualitative analysis software to yield insights. These insights are presented here under each co-design step. They were collaborated by reference to literature as necessary.

Situation Analysis

In the situation analysis, opportunities, and challenges in WSD in were identified. Priorities for development of the ICT WSD platform were also discussed. It became clear that there are many stakeholder groups involved in WSD, such as: government entities, industries and businesses, consultants, academia, civic organisations and user communities.

The stakeholders currently engage using methods like workshops, seminars, conferences and accredited training programs, journal articles, brochures, and websites (Bradley, 2015; WRC, 2019). Posters and leaflets are used to inform stakeholders of upcoming events or meetings. Professionals and academics share knowledge in conferences and workshops. The South African WSD Community of Practice (CoP) is also important for engagement platform (Carden et al., 2016).

Problem Identification

A key problem is lack of a long-term vision around WSD. There is poor integration between departments and disciplinary perspectives. Stakeholders have different ways of referring to WSD. The name "Water Sensitive Design" therefore is not inclusive and is potentially confusing for an engagement platform.

The diversity of stakeholders creates language barriers. This leaves many people uninformed and unable to contribute their opinions. Misinterpretations and misrepresentation prevail. Ultimately, lack of consensus causes mistrust and resistance.

Although many excellent WSD datasets exist, it challenging to identify and understand the existing the data (Msimangira (2012). Furthermore, there are huge capacity gaps and skills shortages to successfully implement WSD.

Different constituencies have may have different, even conflicting interests in water management because of its wicked nature (Anna and Krozer, 2017; Sanya, 2020). For

example, people living in low-income areas struggle with basic needs such as sanitation, access to water, and while wealthier residents are more concerned with sustainability. Furthermore, the needs of smaller metros are different from the needs of larger metros.

Characteristics for a WSD Decision Support Platform

The goals here was to find the features and characteristics that would qualify a successful WSD decision support platform.

Accessible to all stakeholders

The platform must offer benefit to all WSD stakeholders, such as, government entities, industries and businesses, consultants, academia, civic organisations, and user communities

The platform must therefore consider all stakeholders' requirements, support a shared mission, and allow for a constructive dialogue. The platform should allow residents to raise their concerns, for example, to report faults or leakages or lack of water, and more. Furthermore, the platform should allow connection and exchange of ideas between stakeholders (Cosgrove and Loucks (2015). It should have a forum or message boards. The platform should play the role of an aggregator by linking to pre-existing platforms and social media platforms run by different stakeholder groups.

Easy to use platform

The platform must readily allow stakeholders from diverse disciplines and backgrounds to share insights and innovations between each other (Cosgrove & Loucks, 2015). The ICT platform should therefore have an interface that is understandable, stimulating and easy to use. It must be easy to navigate and work with and must include a *Frequently Asked Questions* (FAQ) section. The platform should also allow for image sharing, visual data sharing, and upload of sketches.

Inclusive Platform

The ICT platform should be accessible to anyone regardless of the background or experience. It must be adaptable and flexible so that it can respond to any stakeholders' requirements, considering those who have low technical skills (Cosgrove and Loucks (2015). The platform should be a democratic place and should be freely accessible to the users but with a moderator to ensure that users' content follow community rules.

Overcome Experts' language

To avoid potential misunderstandings between stakeholders, use of easily accessible language should be encouraged to balance expert language and industry-specific jargon. In this regard, visuals are a great way to share information to every type of stakeholder regardless

of their expertise. Furthermore, the platform must allow for summary of articles to translate research and break down complex topics.

Engaging Platform

The platform should have an appealing design. It should be eye-catching, and it must have a moderator who can respond to queries quickly. The platform should allow for mutual and interactive exchange of ideas and knowledge (WRC, 2019). Also, the platform should include links to WSD training material such as videos, and lectures hosted elsewhere.

The ICT platform should be a place to showcase success stories such as art competitions, photographic exhibitions, mural paintings on neighbourhood walls. It should also have a calendar showing upcoming events, conferences, and courses. Finally, contact information should be made available for stakeholders.

Create and integrate knowledge from different stakeholders

The ICT platform should integrate knowledge from other stakeholders – bringing together the private sector, civil society, academia, government, and communities to solve complex problems around water. The aim is to enhance service delivery, transparency in use of public resources and give updates on initiatives, ideas, and projects.

For example, academics must have the possibility to share research in an easily digestible format. Consultants should be able to upload best practices examples and contribute to the discussion or forum.

The public community should be able to share stories and pictures of the challenges that they are facing. While the municipalities can share official policies, documents, news, and more. The local government should highlight relevant policy and provide guidance on WSD implementation

Prototype Development

Using python programming language, a webpage responding to the above desired featured was coded.

The ICT platform was co-designed to enable stakeholder engagement in WSD was named *Water People and Place* (W2P). The platform has two main parts: the external pages and internal pages or dashboard. External pages do not require sign in. The internal pages (dashboard) require a username and password.

External Pages

The external pages offer a read-only access, meaning that users cannot modify the content. The ICT platform can be accessed by clicking on the following link: http://wpp.pythonanywhere.com/. The navigation menu is intuitive and descriptive (see Fig 98 below) and helps users to locate what they need quickly.

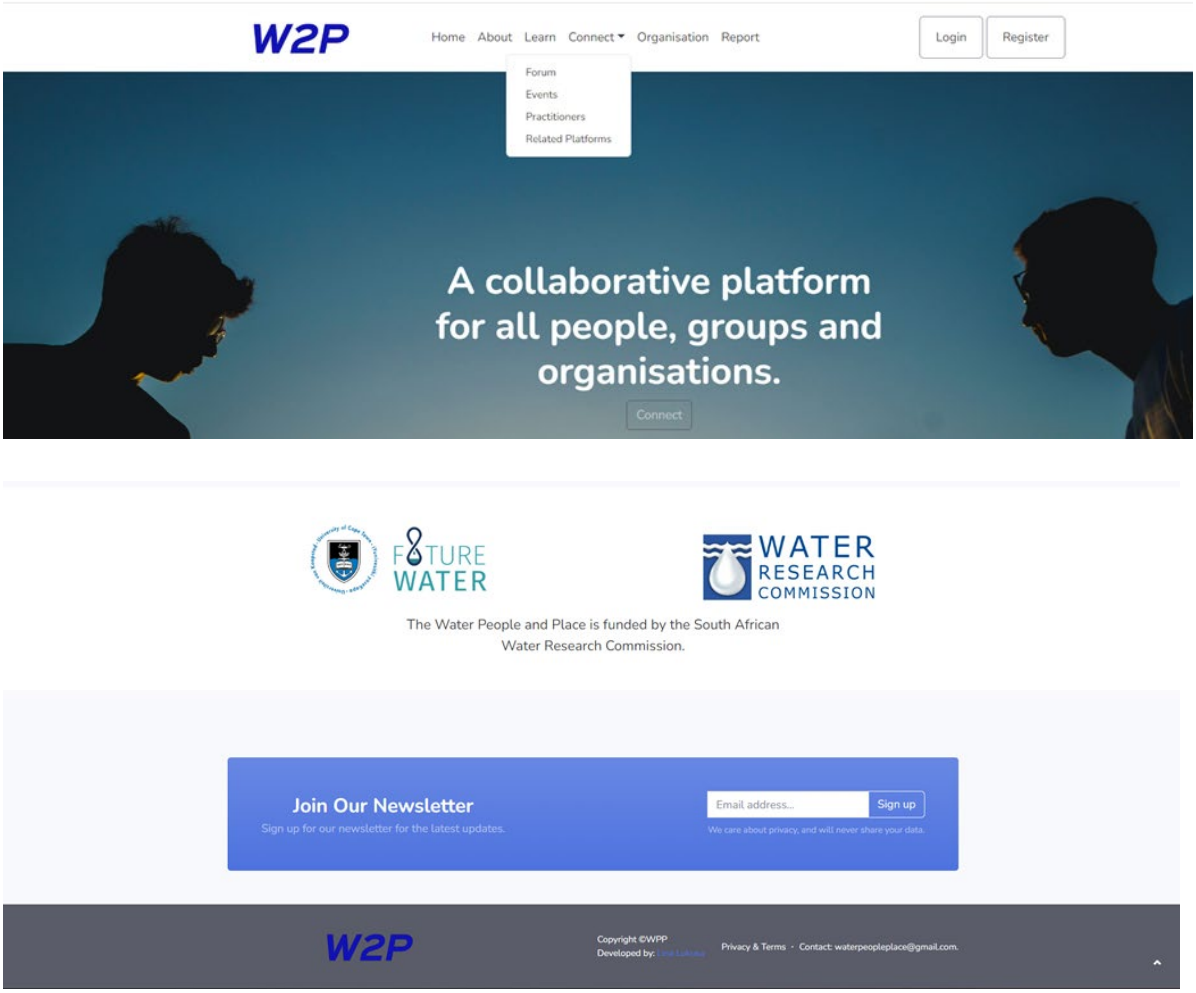


Figure 99: Intuitive navigation menu (L. Lukusa, 2021; accessed 08/2022)

The welcome page contains a catchphrase that aims to communicate to visitors what the platform is about in a matter of seconds. It is a concise and memorable text that targets stakeholders.

The welcome page offers the following menus:

- *About*: connecting to an *about page* that describes the mission and vision of the platform.
- *Learn*: leads to research papers and other informative publications

- *Connect*: this has three sub-menus
    - *Events*: connects to the events page
    - *Practitioners*: a list of WSD consultants, professionals, experts and companies along with their respective
    - *Related platforms*: other platforms with information on aspects of WSD
- *Organisation*: leads to a page with organisation and businesses that deal with WSD

Overall, the external pages are a simple and easy way to communicate the purpose and value of the platform.

W2P sponsors have been included at the bottom of the homepage. A newsletter has also been added to the platform. The purpose of the newsletter is to ensure constant engagement with stakeholders by sharing engaging content, relevant and valuable information, promote events and drive traffic to the ICT platform.

Internal Pages (Dashboard)

Users who have opened an account and confirmed their email address can engage and interact with other members on the internal pages. It was therefore necessary to include an authentication menu (Login/Register) that leads to the dashboard or internal pages where users can modify content.

The internal pages (dashboard) allow members to create content by sharing their publications, organisations and businesses, contact details, events. It also allows stakeholders to engage with each other through the forum section. The internal pages offer a read and write mode. Once moderated, the content shared on the internal pages appears on the external pages of the platform. Hence, the dashboard allows stakeholders to interact with each other by creating, sharing, and updating their content.

The dashboard has the following two parts: share and engage.

Share

The *share* section allows stakeholders section to create, share, and update content under three options: research, organisation and report a water issue

Research

Allows for upload of publications and informative graphic content and videos. The ICT platform asks stakeholders to share their papers by avoiding experts' language or translating research into accessible language. A banner encourages stakeholders to share their content

in non-expert language (see Figure 100 below), e.g. with summary and visuals. This allows all stakeholders to be included in the conversation, regardless of background and expertise.

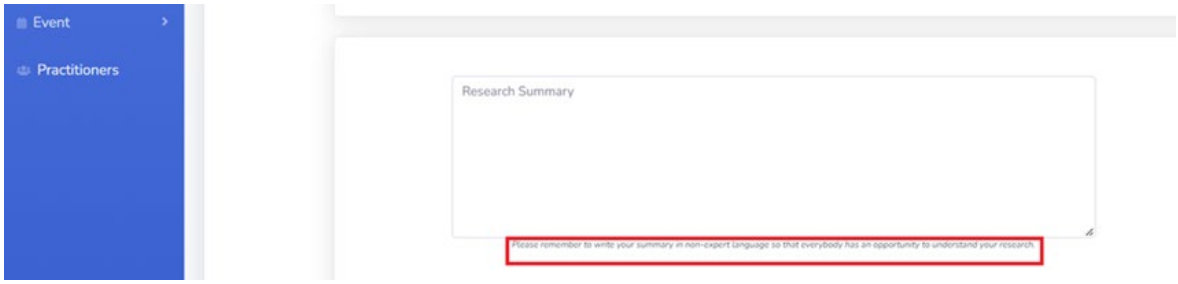


Figure 100: Use nonexpert language

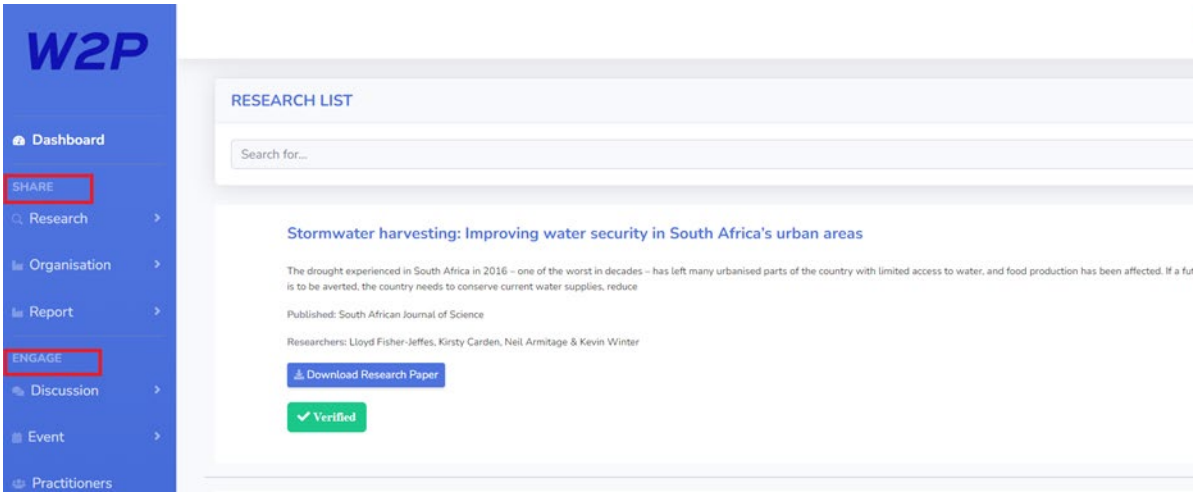


Figure 101: Research section of the online platform (L. Lukusa, 2021; accessed 08/2022)

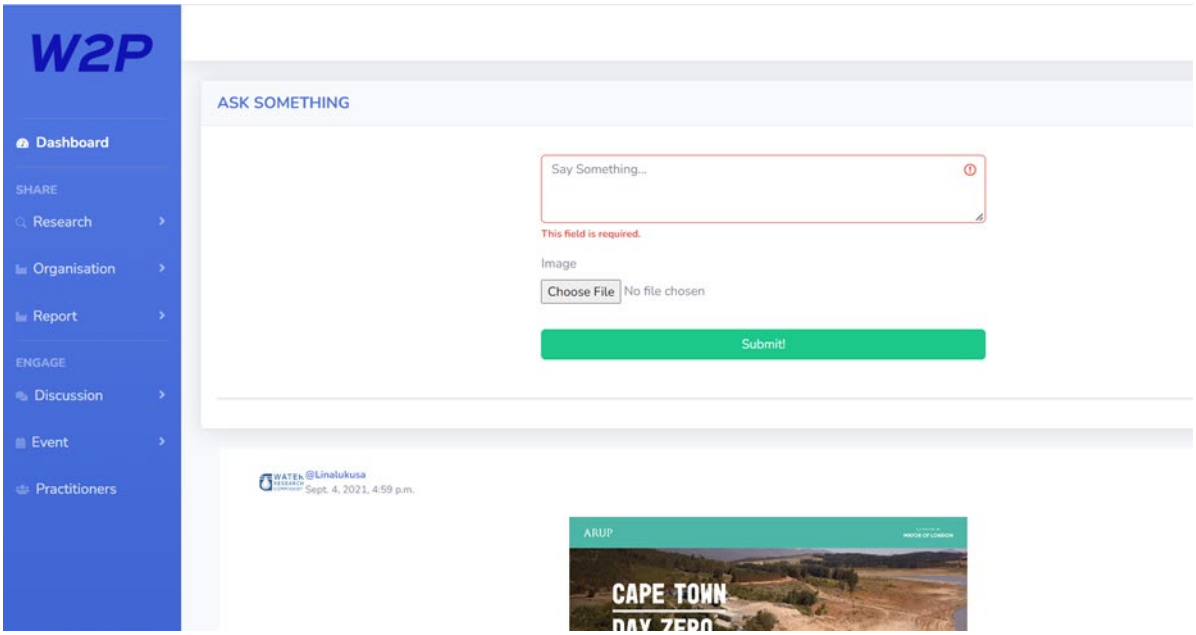


Figure 102: Contact question section of the online platform (L. Lukusa, 2021; accessed 08/2022)

Organizations

Users can give the contact details and describe their organisations and businesses. The organisation section of the platform helps identify organisations operating in the WSD space and how they can be connected to others in the green infrastructure environment.

Report a water issue

This links to various municipality interfaces for reporting water related issues. For example CoCT interface and eThekwini interface.

Engage

The *engage* section allows users to be involved in discussions via the *forum*, connecting with practitioners or discovering information about the latest happenings in the water space. The section includes a forum, an event subsection and a search function.

Forum

The forum allows two-way conversations. It brings stakeholders involved in water together. These stakeholders can post messages on the discussion threads, interact, and receive feedback from other users of the platform. Thus, the forum is an open mechanism for facilitating knowledge integration. The forum is a form of learning through networking ranging from sharing of opinions and experiences, brainstorming and reaction to postings with people

who share the same interest. It enables stakeholders to share their different views, at the same time, create a deeper understanding of the subject being discussed. Users can post text and images, like or dislike and comment on the forum.

Event

The event section comprises: the name of the event, a place to upload the flyer, the event location, a short description, starting time and end time. It also includes the website where users can find further information and contact details of the event organiser (as shown in figure 103 below).

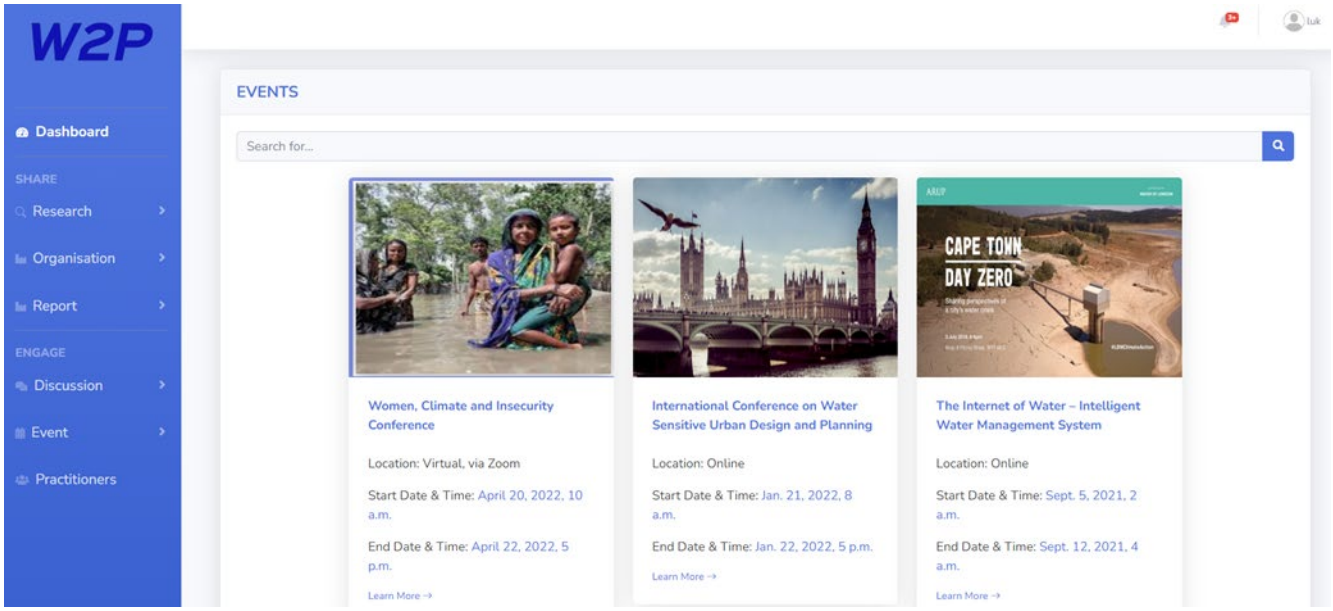


Figure 103: Events section of the online platform (L. Lukusa, 2021; accessed 08/2022)

Search Function

The platform could be a massive repository of water-related research information; thus, it has a search button feature to make finding of information efficient.

Decision Support Platform Summary

WSD brings together a diverse range of stakeholders. The stakeholders have varying of backgrounds, motives and priorities. Stakeholders include government entities, industries and businesses, consultants, academia, civic organisations and user communities. The stakeholders use various methods (workshops, report) to interact but engagement between them remains fragmented. Hence, it is difficult to attain consensus and communicate across the different groups. This hamper mainstreaming of WSD efforts thereby encumbering transition

towards water sensitive cities and liveable neighbourhoods. This study addressed this by designing an ICT WSD decision support platform using a co-design method. The platform aimed to bridge the gap between experts and communities as well as the diverse stakeholder groups in the WSD space. The platform is named *water people place* to make it inclusive of different stakeholder groups in the water space. The aim was to create an inclusive, easy-to-use and engaging platform that balances expert jargon with language that can easily be understood by lay people. The platform allows users to upload images and videos.

The ICT platform has an internal and external section. The external section is accessible to anybody without any need to register. And here they can access information like events, organisations, find WSD practitioners, and useful research. This is a read-only section.

The internal pages require registration and login. Here users, can actively create and share content. Once moderated, this content appears on the external pages. There also an option here to engage and request services from the city or report a problem. The internal pages also offer a forum where users can interactively discus in multi-directional conversations and upload images, videos.

The uniqueness about this WSD platform is that content will be user-generated and that it promotes multidirectional communication. Therefore, it will grow and be flavoured by different users and stakeholders. Hence the platform has the potential to connect stakeholders to evolve a common vision and support a community of discourse and practice for water sensitive living.

Chapter 8: Conclusion

Study Background

The focus of the study was using WSD approaches to develop spatial urban design proposals to transition Hangberg into a liveable neighbourhood. Hangberg is a low-income neighbourhood located in the otherwise affluent Hout Bay suburb to the southwest of Cape Town city centre. Originally, the Khoisan had a nomadic fishing and hunting existence in the yellow-wooded Hout Bay catchment. Establishment of the Cape Dutch colony in 1652, saw intensification of fishing, logging, and establishment of farms. This gradually changed the river catchment, through diversion of water for irrigation, loss of indigenous riparian vegetation and deforestation. Subdivision of farms amongst sons eventually made the land parcels too small for viable agriculture. This precipitated sale of farmlands in the scenic Hout Bay to residential developers. During apartheid, Coloured families were forcefully displaced from the catchment (some were resettled in Hangberg), and Hout Bay was marketed to high income white residents. From the 1990s, the valley rapidly converted to a desirable scenic residential suburb. The area is also valued for fishing, recreation, and tourism. Hangberg and Imizamo Yethu are two low-income enclaves in this otherwise affluent residential suburb.

Cape Town's contemporary problems are manifest in water stress, inequitable access to water and sanitation services, and degrading natural systems. The threat of Day-Zero during the 2016-2017 was a shock a reminder of the city's water supply. Segregated apartheid planning resulted in an atomized spatial geography. Historical apartheid spatial imbalances have resulted in scattered, segregated, low density urban geographies that are dependent on motorised road travel. The legacy of colonialism and apartheid in South Africa has left unenduring inequality. According to the World Bank (2022), with a consumption per capita Gini coefficient of 67% in 2018, South Africa is the most unequal country in the world. This inequality also reflects in Cape Town. Besides, there are projections that the city will warm significantly because of climate change. The expansion of the city results in loss of agricultural lands and biodiversity every year.

WSD delivers multiple benefits to the city: diversifies available water sources; improves water quality; reduces pressure on wastewater treatment infrastructure; protects habitats and nature; attenuates flood risk; increases aquifer recharge; facilitates urban agriculture, edible landscapes and fishing; enhances human health and wellbeing (by improving air quality, offering recreational opportunities and facilitating active living); mitigates the urban heat; reduces atmospheric carbon dioxide; offers education opportunities; Improves aesthetics; and Increases land value.

This study used WSD approaches to make urban proposals for spatial integration, densification, and mixed land-use to improve urban liveability.

Sustainability, Designing with Nature, WSD and Liveability

WSD is encompassed broadly under sustainability. Sustainability dates to ancient societies with their holistic animistic worldviews. Science, industrialisation, urbanisation, population growth, global colonial capitalism and consumerism have been the key drivers of environmental damage and social atomisation since the mid nineteenth century. Sustainability counters the socially and environmentally destructive production patterns of global industry and capitalism. Key publications, activists, and grassroots movements confluenced in the 1960s to ignite modern sustainability endeavours. By the early 1980s, the UN had taken the institutional baton with Brundtland's definition of sustainable development as aiming to balance human and environmental needs. Significantly, these efforts culminated in the current 17 SDGs. Water is focal to some SDGs and transversal to all.

Ideas of designing cities with nature date back to Ebenezer Howard's Garden Cities (1902) and Patrick Geddes (1915). From the 1960s until the 1990s, ecological landscape planning, permaculture, regenerative design, and ecological urbanism emerged as fields of practice and study.

WSD developed simultaneously in Australia, UK and USA starting in the 1960s. In SA and other developing countries, WSD transitioning must be inclusive of the poor and be a vehicle for informal settlement upgrading.

Water Sensitive Design (WSD) is quintessentially interdisciplinary. The outcome of WSD is a Water Sensitive City (WSC). The aspiration is to return urban areas to a state that approximates the natural water cycle. WSD is applicable to spatial scales of urban districts, neighbourhoods, precincts, buildings and lower.

This study was instigated at a neighbourhood scale. A neighbourhood is a well-bound urban area with common characteristics and shared community facilities. Functionalist planning in the 1950s and 1960s resulted in neighbourhoods with poor quality public spaces and declining natural systems. Urban design aspires to make cities and neighbourhoods more liveable.

Liveability was a push back against quantitative and rigid gridded infrastructure planning of the industrial city. Poor quality urban spaces, congestion, monotony, and lack of safe spaces precipitated the drive for liveable urban spaces. Liveable urban spaces should focus on residents' wellbeing, comfort, safety, and general satisfaction with their living conditions. Quality urban spaces contribute to making a city or neighbourhood liveable. Inter alia, liveability includes health and wellbeing of residents, mix of uses, quality of public spaces,

access to recreation, safety, varied housing options, balanced social mix, availability of public facilities, promotion of non-motorized transport, respect for heritage and respect for nature.

This study conceives WSD as a wellspring for liveable cities and neighbourhoods in which arrangements of natural, spatial, fabricated, temporal and ethical components work to offer a range of ecosystem benefits to nature and all residents.

Approach

Water Sensitive Design studies in South Africa to date, have generally not been critically located in philosophy and worldviews. This study adopted a naturalist worldview and anchored in the ecocentric philosophy of Deep Ecology and its holistic ontology of phenomenology. Because of these choices, engagement with values and ethics, and embracing diverse ways of knowing were required in the study.

This interdisciplinary study investigated interaction of water, people, nature, and urban spaces. The study generated mutually supportive packages of knowledge from the fields of anthropology, hydrological engineering, urban planning, urban design and information systems. Research objectives and timelines were carefully aligned and sequenced in a high-level conceptual framework to harmonise the diverse knowledge fields in the study. The study used grounded theory as an overarching research methodology. In this way, study questions were iteratively developed and revisited, and the work was continually analysed so that new emergent themes opened new avenues for ongoing investigations. Within this overarching grounded theory methodology, the study was executed in two stages: baseline investigation and research through design.

The baseline investigation analysed the physical, social and historical aspects of the context using water modelling software, GIS, field observations and ethnographic research techniques.

Finally, the study used *research through design* method for urban planning, urban design, architectural design and to develop an online WSD decision-support platform. Choice of this method was important because of the study's spatial focus.

Study findings

The Hout Bay Catchment Faces a Significant Flooding Risk

A PCSWMM model was used to study baseline conditions and to investigate the feasibility of utilizing SuDS to mitigate flooding in the Hout Bay Catchment. The study made two scenarios: (i) as is (baseline) and (ii) with SuDS.

A key finding was that there is a significant flood risk in the lower reaches of the Hout Bay River Catchment, with many junctions facing a high probability of flooding especially for 5-year and 2-year design storm events. But the introduction of SuDS in the simulation model greatly reduced period of flooding (in minutes) by between 25% (for a 5-year design storm) and 43% for a 6-month design storm. Moreover, the SuDS improved infiltration as indicated by the reduction in runoff.

Progressive Policy is not Fully Implemented in Management of the Hout Bay River Catchment

Water Sensitive Spatial Planning (WSSP) is an approach aimed at transforming an urban area into a water sensitive place. Strategic tools for spatial planning include land use planning and Spatial Development Frameworks (SDFs). WSSP can be integrated into these tools.

A positive finding of the study was that although Cape Town has not formally adopted WSSP, there are many elements in the city's existing planning instruments that overlap with WSSP. The city requires that SDFs at the scales of the metropole, the district and subdistrict consider the natural assets of the city. Indeed, Cape Town Municipal Spatial Development Frameworks (CTMSDFs) contain maps covering different high value ecological systems. On the less positive side, the study found that this information is scattered on different maps. There is also little guidance on how development can be made more water sensitive.

The 2009 Floodplain and River Corridor Management Policy requires that SDFs identify and specify appropriate land uses for 2-year, 5-year, 10-year, 20-year, 50-year and 100-year floodlines. SDFs must also delineate interconnected ecological buffers and corridors on maps. The 2009 Floodplain and River Corridor Management Policy restricts urban development within the 100-year and 50-year floodplains. A key finding of the study was that contrary to this policy, the 2012 Southern District Spatial Development Framework (SDSDF 2012) did not identify the 100-year floodline. Many existing developments in Hout Bay are between 50-year and 100-year floodlines. Furthermore, the 2012 plan encourages urban development intensification in the estuary area, which mostly appears to be within the 50-year flood plain. This compromises aquatic ecosystem services and exposes lives and properties to increased risk of flooding. Flood risk will be exacerbated by climate change.

A significant finding was that the Hout Bay Catchment falls within two different spatial planning jurisdictions. This hinders integrated management of the catchment. Furthermore, the study found that the productive aquifer in the Hout Bay Catchment is endangered by insensitive urban development.

The Hout Bay River Catchment is rich in biodiversity. Biodiversity in the mountains is relatively well-preserved. But within the valley, the swamps and in the estuary, biodiversity is threatened. Ecological areas and public open spaces in Hout Bay are fragmented and discontinuous.

The health of the Hout Bay River, and other freshwater ecosystems, is and will be compromised by past, present and proposed unsustainable human activities. These freshwater ecosystems continue to be threatened by encroaching developments and failing or inadequate infrastructure. On a positive side, the study found active community-driven initiatives working to protect ecosystems and the river: the Hout Bay River Catchment Forum (HBRCF); the Friend of the Hout Bay River (FOHR) and Thrive.

Spatial Injustice in Hangberg

Hangberg has a genesis in apartheid social injustice and dislocation. This left an enduring trail of mutual suspicion between neighbourhood residents and city authorities.

Fish is a historical renewable but endangered resource in the area. Subsistence and commercial fishers go beyond allocated quotas. Like the yellowwood and agricultural land before, this important resource could disappear.

Lack of anticipatory planning as Hangberg changed demographically contributes to compromising the liveability of the neighbourhood today. The desperate solutions that people provide for themselves endanger them, the public good and the environment. The study found that illegal connections to infrastructure in Hangberg cause broader disutility. The study observed clean water (from leakages) and raw sewage flowing through the settlement. This poses risks to the human health and the environment.

Hangberg has Limited Land for Expansion

In the context analysis, ecological systems were found to make Hout Bay into an attractive area for fishing, residence, recreation and tourism. These include the river, the natural areas in the mountain and the harbour. But many of the natural systems are threatened by urban development. A system of urban nodes and corridors exists in Hout Bay but Non-motorised Transport (NMT) facilities in the area are inadequate.

Hangberg neighbourhood is hemmed-in by the harbour and the Atlantic Ocean, and a nature conversation area on the steep slopes of the Sentinel Mountain. The settlement contains low-income flats, hostels, informal shacks and some bungalows. Many of the shacks are encroaching on the conservation areas. The settlement is not well-serviced by public transport and the pedestrian paths along the steep terrain are improvised and dangerous to navigate.

A firebreak (die sloot) is runs above the 90 m contour line in Hangberg. The gradient above the firebreak is too steep for technically and economically prudent urban development. But informal settlements in Hangberg have encroached onto environmentally sensitive areas above the firebreak (die sloot). By analysing and synthesizing information from fieldwork and literature, this study found that the firebreak is a key multi-functional infrastructural element that serves the following purposes.

- Proprietary boundary: all land above the firebreak is owned by SANParks.
- Legislative boundary: separates the settlement and protected biodiversity area
- Functional infrastructure
    - prevents spread of fire (from mountain to settlement and vice versa) and allows a line of access for fire fighting vehicles
    - is an important line of drainage, positioned to catch stormwater from the mountain and channel it downhill.
    - above the firebreak line, the slope is at least 33%. This is way beyond the recommended space planning maximum of 18% slope. The slope above the firebreak is too steep for technically and economically prudent urban development
    - vegetation above the firebreak serves as a windbreak from cold winter winds and dusty summer winds.
    - removal of vegetation from steep slopes without soil retention measures causes slope instability that results in erosion, landslides, and intense downslope flooding.

The study found that the firebreak is overgrown with vegetation and strewn with rubbish. Moreover, shacks have also been constructed above the firebreak on steep, unstable nature conservation land. As a result, Hangberg residents face winter flooding and landslides, and increased exposure to summer fires and dust. Additionally, urban development in the protected area is threatening biodiversity.

WSD Stakeholders Lack a Common Engagement Platform

WSD brings together diverse stakeholders with a range of backgrounds, motives and priorities. WSD stakeholders include government entities, industries and businesses, consultants, academia, civic organisations and user communities. The stakeholders use various methods to

interact (such as workshops, posters and reports) but engagement between them remains fragmented. Therefore, it is difficult to communicate and build consensus across the different groups. This hampers transition towards water sensitive cities and liveable neighbourhoods.

Study Outcomes

Hydrological Model for Hout Bay

The PCSWMM model developed for Hout Bay Catchment is an important outcome that can be used in future research to study other aspects of hydrology of the catchment.

Water Sensitive Vision, Spatial Plans and Guidelines for Hout Bay

A key outcome from the study is an ecocentric vision for transitioning the Hout Bay Subdistrict into a water sensitive place for the wellbeing of the river, the people and nature. The vision, which was articulated using animated language, is steered by the principles of reverence, balance, interconnectedness, restraint, responsibility and connection.

Founded in the above vision, the study made WSSP proposals for Hout Bay Subdistrict in a set of five maps.

The first map proposed realignment of spatial jurisdiction boundaries to bring the entire Hout Bay River catchment into the Southern District to ensure integrated catchment management. The second map proposed including the river and its tributaries on the land use map. It also proposed rezoning to integrate the currently disjointed public open areas in the catchment. The third map created ecological buffer corridors for the river system, established a protective overlay for swamps and the estuary, and identified the area above the aquifer as a sensitive development zone. The fourth map proposed blue-green fingers to extend along the ecological corridors of the river and its tributaries into the mountain.

The fifth map delineated the proposed blue-green fingers as multifunctional infrastructure with ecological function, heritage value, public open space, sports fields, recreational areas, tourist attractions and educational opportunities. The map further proposed that all developments remain within the existing urban edge. Additionally, the map directed that existing developments are incentivised towards WSD retrofit and all new developments are designed to be waterwise. The map introduced a Groundwater Sensitive Development Zone. It also proposed that all properties near the river and estuary interact with the water spatially, aesthetically and in ecological function. The map further introduced an Estuary Protected Area overly. Any proposed new developments in the estuary area will trigger an environmental impact assessment requirement. The map also proposed that the biodiversity node, currently under the care and custodianship of HBRCF, be spatially and legislatively consolidated. A

Living Lab was introduced into this node to bring together communities and facilitate demonstration, experimentation and innovation of WSD solutions.

As a corollary to the above principles and maps, the study articulated three new development objectives for water sensitive development of Hout Bay Subdistrict: (i) protect ecologically sensitive areas (ii) create inclusive urban spaces and natural areas (iii) drive water sensitive development. Each objective is accompanied by development guidelines. The objectives and guidelines translate the vision into actionable recommendations. The objectives and guidelines are specific and spatially anchored in the maps. A resulting implementation plan delineated timeframes (short-, medium- and long-terms), key role-layers, and enabling policies (existing and proposed) for transitioning Hout Bay into water sensitive place.

Finally, the study developed the above maps and recommendations into Guidelines for Water Sensitive Spatial Planning. The guidelines are an 8-step iterative process for planning and implementing solutions for water sensitive cities in the short, medium, and long terms. Each step is presented graphically with maps from this study. Each step further highlights responsible city departments, and fitting roles for community-based organisations and champions. Each step also cites relevant government legislation, helpful literature and, where applicable, possible funding sources. The guidelines are framed as an easy-to-use, graphically illustrated resource for municipal officials, planners, and as a public resource.

Water Sensitive Urban Design Proposals for Hangberg

This study used WSD approaches to make proposals to transform the low-income Hangberg neighbourhood into a liveable water sensitive neighbourhood. The study applied ecological and urban corridors in context analysis, programme generation, concept formation and in developing design proposals. Nodes punctuate the corridors to make an urban pattern of beads on a string.

To balance needs for urban space making with requirements for environmental protection, the study proposed six performance qualities for transforming Hangberg into a water sensitive liveable neighbourhood: equity (all residents can access facilities and opportunities), balance (nature/urban and good distribution of social services), integration (between communities and between urban spaces and nature), sense of place (responding to unique qualities of the location and enhancing urban spaces), safety and security (security of tenure, food security, safety from hazards), and efficiency. Comparing the desired performance qualities to the analysis of context yielded a set of natural, biophysical and urban constraints and opportunities. These were also visually presented on a map.

The above six performance categories were interpreted into three urban design strategies: connection, place and resilience. Using water and nature as design informants, the strategies were applied to generate the proposals for transitioning Hangberg into a water sensitive liveable neighbourhood.

Three corridors were proposed in Hangberg: Harbour Corridor, Green Corridor and Firebreak Corridor. A system of nodes punctuated the corridors. To enhance sense of place, the corridors and nodes were designed as positive public spaces.

The Harbour Corridor was proposed to integrate Hangberg neighbourhood with the rest of Hout Bay. It is a NMT corridor running from the harbour and continuing along the river.

The Firebreak Corridor was proposed to consolidate the existing firebreak as a multifunctional infrastructural element to improve drainage, fire protection, nature conservation, public safety and urban place making.

The Green Corridor was proposed along the current Oude Skip Road. This was conceived as the main corridor in Hangberg. The water running in the stormwater drain below the road was resurfaced to make a bioswale. The bioswale was extended to connect to the mountain and to the harbour. For improved livelihoods, facilities for urban agriculture, a fish market and eco-tourism were proposed in the corridor.

As another key outcome of this study, the above proposals were layered to make an Integrated Hangberg Urban Design Framework (IHUDF) on a map. The IHUDF has three key corridors, all related to water: Each corridor was presented using creative collages to show possibility for appropriation into liveable water sensitive places.

The strategies of connections, place and resilience were applied to make more detailed proposals for the Green Corridor and its four nodes. The bioswale along the corridor resurfaces stormwater which would otherwise flow in underground pipes. WSD technologies were used along the corridor to slow-down, collect and store water for firefighting, urban agriculture and household use. Ecological connectivity is enhanced by the bioswale corridor running from mountain to sea. And the corridor provides welcoming public spaces in the four nodes. Importantly, each node on the Green Corridor is presented in a concept diagram and collage to show possibility for appropriation by residents. In the slow node water is slowed and resurfaced and released slowly. A fire station protects the neighbourhood and the natural areas. In the collect node, water is collected for urban agriculture and domestic use in an existing ECD and proposed live-work-play units. At the gather node, the Green Corridor intersects with the Harbour Corridor to connect to the greater suburb. This node is place where Hangberg residents intermingle with broader Hout Bay, the city and international tourists.

Heritage is protected in the museum and economic opportunities provided to sell at the market.

The above technologies were brought together to make new step-by-step Guidelines for Water Sensitive Urban Design. Each step is illustrated with graphics from the above Hangberg neighbourhood proposals. The guidelines are a useful resource to animate discourse, inform policy and instigate action.

Aspects of WSSP and WSD are increasingly featuring in Cape Town's metropolitan and district level spatial developments. For example, the latest Southern District Spatial Framework and Hout Bay Subdistrict Spatial plan explicitly work to integrate spatial planning and ICM. However, there are no plans to date in Cape Town for neighbourhood and corridor-level WSD interventions. This study is the first to make such WSD proposals at neighbourhood and corridor scales in the Cape Town context.

Decision Platform for WSD Stakeholders

This study designed an online WSD decision support platform using a co-design method to foster collaboration. The platform aimed to bridge the gap between experts and communities as well as the diverse stakeholder groups in the WSD space. The platform is named *water people place* to make it inclusive of different stakeholder groups. The aim was to create an inclusive, easy-to-use, and engaging platform that balances expert jargon with language that can easily be understood by lay people. The platform will allow users to upload text, images, and videos.

On the platform, users can access information such as events, useful reports, and contact details of WSD organisations, and practitioners. Users can actively create and share content. They can also request service from city water authorities or report a problem. In the forum, users can engage in conversations and upload documents, images and videos.

The uniqueness of this WSD platform is that it is designed to promote multidirectional communication and host multi-media user-generated content. Therefore, it will grow and be flavoured by different users and stakeholders. The platform has the potential to connect stakeholders to evolve a common vision and support communities of discourse and practice for water sensitive living.

Study Recommendations

Catchment Hydrology Recommendations

Cities face increased flood risk due to climate change. Use hydrological models to simulate design and implement SuDS that optimally attenuate flooding and increase rainwater infiltration.

Water Sensitive Spatial Planning Recommendations

Scaffold Water Sensitive Spatial Planning (WSSP) approaches into conventional strategic tools for spatial planning such as land use planning and Spatial Development Frameworks (SDFs). This ensures that WSSP is not an isolated novelty but becomes an integral part of city planning.

Leverage existing community-driven initiatives and groups to create a community of practice for water sensitive spatial planning and implementation.

Identify the 2-year, 5-year, 10-year, 20-year, 50-year and 100-year floodlines on SDFs at all scales and issue development directives to ensure that future urban development is complaint with a prudently formulated floodplain and river corridor management policy.

Articulate a compelling and shared vision for a water sensitive place aimed at enhancing the wellbeing of water systems, the people and nature.

To facilitate integrated catchment management, undertake strategic remapping at city-level to align spatial jurisdiction (district, subdistrict and neighbourhood) boundaries with natural catchments and micro-catchments.

Place rivers, other aquatic ecosystems, sensitive ecological areas and farmlands on the same SDF map to surface interconnectivity between these systems. Include rivers, tributaries and other elements of natural hydrology on the land use map. This ensures the water systems are visible to all stakeholders as they debate and make spatial development decisions. On the land use map, rezone disjointed public open areas and ecological areas in the catchment to integrate them physically and in ecological function.

Create ecological buffer corridors for river systems on a map and establish protective overlays for swamps and estuaries. On the same map, delineate the area above any aquifers as a sensitive development zone. Link up all public open spaces and connect them with ecological buffers and corridors to form a continuous network that includes freshwater ecosystems.

Introduce blue-green fingers to extend along the ecological corridors of the river and its tributaries into the mountain. Use WSD as an opportunity to bring back nature into the city and

improve liveability of urban spaces. Underpin planning with the objective to protect and regenerate biodiversity by using ecologically functional blue-green networks as a scaffold for hard infrastructure and buildings. Ensure WSD solutions increase use of decentralised infrastructure such rainwater harvesting, composting toilets and SuDS. This reduces pressure on city resources, empowers residents and increases resilience.

Use another map to consolidate WSSP proposals and give protective overlays to sensitive ecological areas. Delineate all proposed blue-green fingers as multifunctional infrastructure with ecological function, heritage value, public open space, sports fields, recreational areas, tourist attractions and educational opportunities. Particularly, limit all urban development to the existing urban edge and rehabilitate natural areas. Incentivise existing developments towards WSD retrofit and legislate that all future developments be waterwise. Introduce a Groundwater Sensitive Development Zone and stipulate that all properties near rivers and other hydrological elements interact with the water spatially, aesthetically and in ecological function. Introduce protective overlays for sensitive areas such estuaries so that any proposed new developments trigger an environmental impact assessment requirement.

Legislatively and spatially consolidate an existing or new biodiversity node. Designate the biodiversity node as a Living Lab and design it as a meeting point for community-driven groups and others working to enhance ecosystems and promote water sensitivity. Use the Living Lab to facilitate demonstration, experimentation, and innovation of WSD solutions.

Complement all the above maps with WSSP development objectives and guidelines. The objectives and guidelines must translate the vision into actionable recommendations. Make the objectives and guideline specific and spatially anchor them in the maps. Subsequently, develop the objectives and guidelines into an implementation plan that delineates timeframes (short-, medium- and long-terms), key role-layers, and enabling policies (existing and proposed) for transitioning to a water sensitive place.

Recommendations for People Centred WSD

Use WSD as an opportunity to connect communities, co-create equitable spaces and bring nature back into the neighbourhood.

Use WSD interventions to preserve and enhance social networks. The urban poor depend on these networks for survivalist mutuality. Provide spaces where social bonding and network building can occur. Collaborate with NGOs, and local community champions to secure sustainable WSD outcomes in a participatory process.

Expend the city's resources to attain best value by focusing on the larger scale (protecting natural areas, providing bulk infrastructure, public transport, NMT, schools, etc.) to provide a

non-prescriptive urban framework. Encourage and empower residents to take implementation initiative at the smaller scaler (such as dwelling construction) where they understand their needs best and where more flexibility is required.

Successful implementation of WSD solutions will result in quality water sensitive cities and neighbourhoods. Put measures in place to ensure that these spaces are safeguarded from appropriation by neoliberal exclusionary processes of gentrification. Leverage WSD for just design transitions. Use integration of Nature-Based Solutions in urban planning as an opportunity to create equal places by working with residents based on trust and spatial justice in a participatory, even political, process.

Use a larger planning perspective to resolve the situation in crowded neighbourhoods with limited land for expansion. This must include denser housing in available land in the neighbourhood and incentivisation to move to well-located lands close to jobs and amenities.

WSD Recommendations for Liveable Neighbourhoods

To balance needs for urban space making with requirements for environmental protection in design, use the following performance qualities for transforming a neighbourhood into a water sensitive liveable neighbourhood: equity (all residents can access facilities and opportunities), balance (nature/urban and good distribution of social services); integration (between communities and between urban spaces and nature); sense of place (responding to unique qualities of the location and enhancing urban spaces); safety and security (security of tenure, food security, safety from hazards); and efficiency .

Use the performance qualities in context analysis to uncover the prevailing natural, biophysical and urban constraints and opportunities for WSD in the neighbourhood. Present the constraints and opportunities on a composite map to inform the urban design process.

Translate the above performance categories into a set of urban design strategies, for example: connection, place and resilience. Using water and nature as design informants, apply the strategies in the urban design process.

Introduce a hierarchy of corridors to serve simultaneous urban and ecological functions in neighbourhoods. Punctuate the corridors with a system of nodes. To enhance sense of place, design the corridors and nodes as positive urban public spaces defined by mixed-use buildings and community facilities.

Limit development to the existing urban footprint. Particularly, ensure that urban development does not occur on slopes with a gradient greater than 18%. For settlements bordering steep protected biodiversity areas, r/establish a firebreak corridor separate the neighbourhood from

steep slopes and nature. To protect the settlement, use WSD to consolidate the firebreak as a multifunctional public good. Use the firebreak to protect the settlement and biodiversity areas against fires. Also design the firebreak as a stormwater drain and plant vegetation on the steeper slopes to stabilise the soils and prevent landslides.

Integrate isolated (low-income) neighbourhoods with more affluent areas using a NMT route that runs along blue-green elements such as rivers and parks. This reduces daily commuting costs for the poor residents while giving them health-enhancing mobility options.

Create a main corridor in the neighbourhood as a visible integrator of WSD solutions, urban space making, ecological protection and social facilities. Make detailed proposals for the main corridor and its nodes. In steep mountain-side neighbourhoods, resurface any stormwater in pipes below to make a bioswale along the corridor and use this as an opportunity to enhance ecological connectivity from the upper slopes of the catchment to the bottom slopes. Introduce WSD technologies along the corridor to slow-down, collect and store water for purposes such as firefighting, urban agriculture and household use. For improved livelihoods, introduce urban agriculture, a neighbourhood market and eco-tourism on this corridor. Design the nodes on the main corridor as equitably accessible public spaces defined by live-work-play building units, affordable housing options and community facilities. Introduce a fire station in one of the nodes to protect fire-prone low-income neighbourhood and the natural areas. In another node, collect water for urban agriculture and for use in buildings.

Intersect the main corridor with a higher order NMT corridor to connect the neighbourhood to the urban subdistrict and district beyond. Introduce a node at the intersection of the main neighbourhood corridor intersects with the higher order NMT corridor. Design this node as place for neighbourhood residents to intermingle with residents of the broader district, the city and international tourists. Include income generating opportunities for the neighbourhood residents in the node. Display the neighbourhood's history and heritage in the node (in museum for example) and also create a gateway through this node to the rest of the neighbourhood for ecotourism.

Ongoing Architectural Study

The architectural component of the study is ongoing. As a condenser of context, architecture must, inherently, respond and contribute to the above urban design and urban planning study outcomes. In the phenomenological ontology of this study, architecture is distinct and bounded and yet in mutual interaction with the social, built and natural contexts. Built architecture is corporeal and spatial. It is subject to precision in scale, and to functional and constructional adjacencies in plan and section below, on and above the terrain. And

therefore, though the *research by design* strategy is also used in the architectural study, the level of detail requires commitment to a greater set of iterative decision-making informants.

The strategy adopted was to layer the urban design proposals with the urban planning proposals to uncover overlaps, synergies, and contradictions as a generative basis for the architectural propositions. Furthermore, due to Covid lockdown, urban design and urban planning did not include much community participation. Therefore, the ongoing research has a strong element of community input.

According to White (2003), Rapoport argues that we need to be fully conscious of the power of social interaction in driving change. If a greener, more sensitive future is required, a deeper, more inclusive social approach to design itself is a necessary precursor. Social Design or Social Impact Design refers to the practice of design for the public good, especially in disadvantaged communities. Social design targets equal access and inclusivity, aiming at fulfilling social needs across divisions of income, gender, age and origin and culture (Lasky, 2013). It further aims to generate and create alternative funding strategies. Social design ultimately aims to expand networks, emphasise stories, build a culture of evaluation, and form intelligent coalitions in communities of practice.

The integrated Hangberg Urban Development Framework (IHUDF), from Chapter 6 above, was taken back to Hangberg for participatory feedback from residents (see Figures 104 and 105 below) in a focus group discussion. The community inputs were perceptive and constructively critical. The residents engaged with the urban design framework and layered over complementary or alternative spatial solutions. They discussed various ways in which WSD solutions (such as rainwater harvesting, recycling, food gardening) can be integrated into the neighbourhood and how these can catalyse community connections in an inclusive manner. Much interest was given to the idea of improving water pressure, piping, and the quality of housing.

Figure 104: Participatory action research via *Participatory action mapping (C. Phiri 2021)*

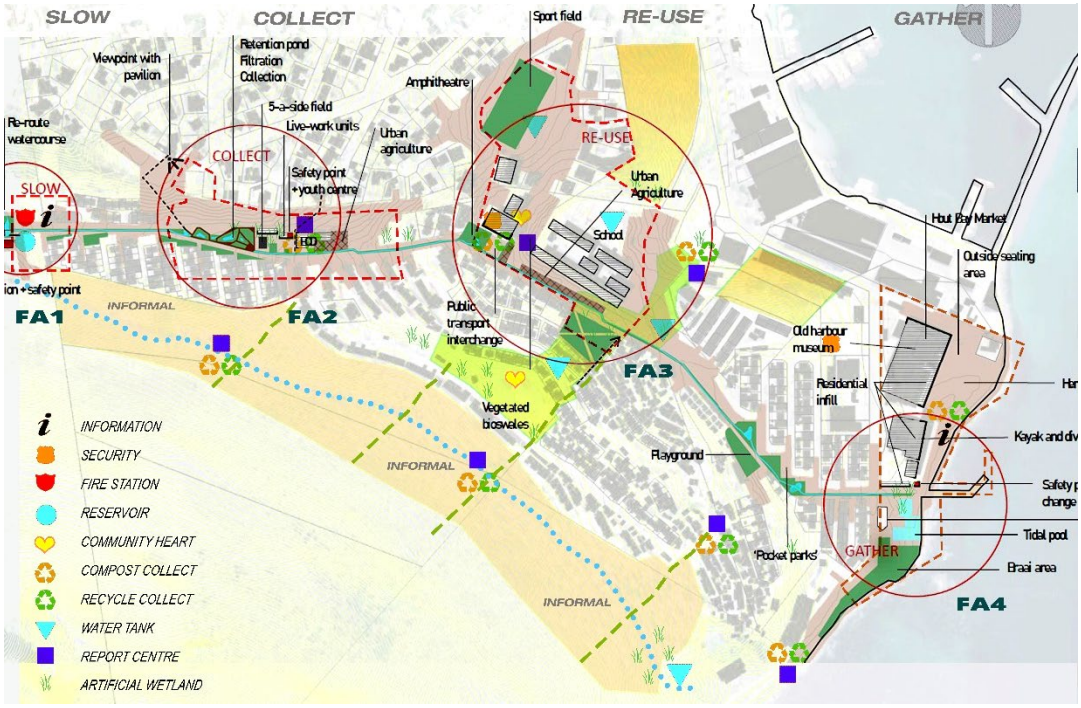


Figure 105: Overlay of Urban Design (Source M. Smith) and) PAR mapping (C. Phiri)

Furthermore, feedback on the proposals was sought from various key informants in Cape Town. These included: CoCT officials, architects specialising in sustainable design, landscape architects, and participatory designers.

Urban design and planning proposals, community feedback and key informant inputs were layered and evaluated against the functional, constructional and aesthetic requirements of architecture. In an iterative process the reuse node in the IHUDF was developed into a spatially, formally and functionally constrained conceptual architectural proposal (see Figure 106 below). Modularisation was used to allow for variety within standard pallet of elements. The

modules were designed to enable expansibility of buildings as resource become available. Modular construction elements are to be fabricated by small-scale enterprises. This proposal will undergo further rounds of community feedback, key informant input and design development until an architecturally realistic solution is generated for the Hangberg context. The idea is that communal facilities will be designed as demonstration units. So that the whole Hangberg becomes a site for harnessing the power of residents to in a process similar to Habraken's open building approach.

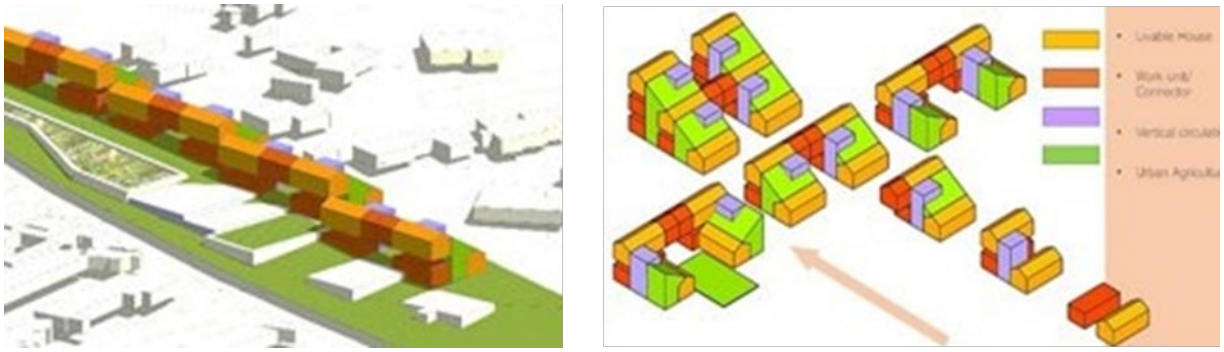


Figure 106: Densified arrangement of Livable house proposals on the green corridor and exploration of modular mass for a liveable house

Limitations and Future Research

Face-to-face meetings and team engagement would have been valuable in breaking down silos and unlocking the value of interdisciplinarity. There is an opportunity for the current PhD student and other researchers to unlock and activate this aspect in future studies. The study has generated evidence that spatial integration of WSD solutions in an informal neighbourhood in a Global South city is possible. But what is missing is demonstrable benefits of implementing WSD in such a setting. Future studies can generate this evidence through simulation studies, for example using *Rhinoceros3D-Grasshopper* software and its *Ladybug* suite of environmental design plugins. Further evidence can be generated in demonstration projects and Post Occupation Evaluation (POE).

The findings and recommendations from this study had empirical basis in a single catchment (Hout Bay River Catchment) and a single neighbourhood (Hangberg). Critically leveraging this study's findings and recommendations, future studies in other catchments and neighbourhoods can bring new insights and lessons to advance WSD as a field of study and practice.

In the Hout Bay estuary area, many large residential and commercial properties are located below the 50-year floodplain. In the rest of the Hout Bay valley, urban development is generally above the 50-year floodline. But because the 100-year floodline for the Hout Bay is not defined, it is probable that many properties fall between the 50-year and 100-year floodline without

being compliant with applicable Floodplain Policy requirements. Building below the 100-year floodline without restrictions compromises the river's ecosystems. Globally, there is an increase in flash floods due climate and such properties increase flooding risk to people and property. Therefore, research is required to (i) identify the 100 floodline in Hout Bay (ii) assess compliance of properties within 50-year and 100-year floodlines with Floodplain Policy (ii) Where necessary, identify and implement retrofit measures to adhere to Floodplain policy. Similar floodline studies are also required in other catchments in Cape Town and elsewhere.

This study developed a WSD decision support platform. The platform must be activated in an engaged scholarship model to animate a community for water sensitive places.

There is value in building a demonstration building, such as the proposed Living Lab in Hout Bay. Such a place can be conceived as a meeting point for water sensitive communities nationwide and internationally. It can be a source of real-life lessons and a site for future Post Occupancy Evaluation (POE).

Cape Town is a big metropole. There is an opportunity take lessons from this study to investigate appropriate WSD spatial solutions in smaller metropole in Western Cape or elsewhere in South Africa.

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