

rise

REVITALISING INFORMAL
SETTLEMENTS AND
THEIR ENVIRONMENTS



Water-sensitive informal settlement upgrading: Overall principles and approach



MONASH
University



Acknowledgements

This publication is a joint effort between many people and institutions cooperating through the Revitalising Informal Settlements and their Environments program (RISE). The report is part of the work of the **Asian Development Bank (ADB)** to make cities more prosperous, resilient and liveable across Asia and the Pacific. The authors wish to thank ADB colleagues Robert Guild, Manoj Sharma, Lara Arjan, Joy Amor Bailey, Joris van Etten and Vijay Padmanabhan for their inputs, support and guidance. Preparation of this publication was co-financed by the Asian Development Bank (ADB) and the Urban Climate Change Resilience Trust Fund (UCCRTF).

This report is based on the work of the **RISE intervention team**, including Kerrie Burge, Anna Leersnyder, Peter Breen, Amalie Wright, Tony Wong, Diego Ramirez-Lovering, Michaela Prescott, Dasha Spasojevic, Matthew French, Mohamed El-Sioufi, Brett Davis, Ihsan Latief, Liza Marzaman, Muhamad Faisol, Nur Intan Putri, Noor Ilhamsyah, Iliesa Wise and Mere Naulumatua.

The work has been supported by the broader **RISE team**, including Isoa Vakarewa, Fitriyanty Awaluddin, Ancha Ansariadi, Amelia Turagabeci, Jane Wardani, Rebekah Brown, Karin Leder, Candice Lever, Amanda Cameron, and the RISE consortium members (pg 45). Thanks to Ivy Hajduk and Daniela Tinios for graphic design and illustrations that bring the report to life.

Finally, the RISE team and report authors are grateful to the officials and communities in the cities of Makassar and Suva for their commitment and engagement with this work.

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This document was published under ADB TA 9593: Revitalisation of Informal Settlements and Their Environments Using a Water-Sensitive Approach. The TA is financed by ADB-managed trust funds: the Urban Climate Change Resilience Trust Fund (UCCRTF) with funding from The Rockefeller Foundation and the Governments of Switzerland and the United Kingdom; and the Urban Environmental Infrastructure Fund (UEIF) with funding from the Government of Sweden. The views expressed in this publication are those of the authors and do not necessarily reflect the views and policies of the funders or ADB.



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What is RISE?

The challenge — Informal settlements are home to more than a billion people who suffer from poor health and wellbeing as a result of inadequate water and sanitation services, and environmental exposure to pathogens, pollutants and disease vectors.

Our vision — Our vision is to improve human, environmental, and ecological health in informal urban settlements across the developing world through a new approach — a water-sensitive approach — to the delivery of urban water services, bridging the gap between WASH and big pipes infrastructure.

Our aim — RISE is a research program that aims to collect the first-ever rigorous scientific evidence if a localised, water-sensitive approach to upgrading informal settlements can deliver sustainable, cost-effective improvements to health and the environment.

Our method — We are conducting a randomised control trial involving 12 informal settlements in Suva, Fiji and 12 in Makassar, Indonesia. In the first phase of the trial, six settlements in each country will undergo a water and sanitation upgrade. The impacts of the upgrades on the health of the environment and the health of the communities will be monitored, and compared against the other six settlements in each country.

Our demonstration projects — In parallel to the randomised control trial, we have also upgraded a settlement in Makassar and Suva to demonstrate the approach and range of technologies. The content of this report draws from this experience.

Want to know more? — visit our website at: www.rise-program.org

RISE is aligned with the ADB Strategy 2030's Operational Priorities to achieve prosperous, inclusive, resilient and sustainable Asia and the Pacific <https://www.adb.org/documents/strategy-2030-prosperous-inclusive-resilient-sustainable-asia-pacific>. RISE is supported by the Urban Climate Change Resilience Trust Fund (UCCRTF) in Makassar, Indonesia and the Urban Environment Infrastructure Fund (UEIF) in Suva, Fiji.

ISBN: 978-1-921994-46-3

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To cite this Report: ADB and RISE (2021) *Water-sensitive informal settlement upgrading: Overall principles and approach*. Asian Development Bank and Monash University.



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Acronyms and key terms

ADB	Asian Development Bank
CRCWSC	Cooperative Research Centre for Water Sensitive Cities
MSDI	Monash Sustainable Development Institute
RISE	Revitalising Informal Settlements and their Environments program
SDG	Sustainable Development Goal
UCCRTF	Urban Climate Change Resilience Trust Fund
WASH	Water, Sanitation and Hygiene
WSC	Water-sensitive cities (approach)
WHO	World Health Organization
Bio-filtration	The process of using beneficial bacteria to clean water on a molecular level to remove contaminants. Biofilters contain grains (e.g., sand, granular activated carbon) that are covered with biofilms, which break down nutrients and organic carbon as well as capture other unwanted contaminants in the influent water.
Blackwater	Solid and liquid waste from toilets that contains faecal matter and urine.
Co-benefits	Achieving multiple positive outcomes from a single intervention/investment
Co-design	A participatory and inclusive process of involving all relevant stakeholders, especially community members, in the conceptualisation, planning, design and implementation, and monitoring and operation/maintenance of programs and projects that affect their lives.
Demand Management	Encouraging households to reduce (water) consumption and adopt energy efficiency measures.
Greywater	Wastewater that has been used for washing, laundering, bathing or showering.
Informal settlements	Defined as having at least one of five deficiencies according to UN-Habitat's (2003) criteria: poor quality of housing, unsafe water, unsafe sanitation, overcrowding, and/or lacking tenure security.
Intersectionality	A theoretical framework for understanding how aspects of a person's social and political identities (e.g., gender, sex, race) combine to create modes of discrimination and privilege.
Land tenure	The rights that determine who can use land, for how long and under what conditions based both on official laws and policies, and on informal customs.
Nature-based solutions	Actions that work with and enhance nature so as to help people adapt to change and disasters and protect, sustainably manage, and restore natural or modified ecosystems.

Pressure tank	A rotomolded plastic tank, one of the components in a pressure pod.
Pressure pod	The unit that collects, stores and discharges wastewater, as part of the treatment train. It houses a grinder pump and level sensor and float switch.
Resilience	Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.
Retention time	The length of time that a compound remains in a wastewater treatment tank or unit.
Reticulated water supply	The piped-water network (as opposed to well water).
Safeguards	A framework to help to ensure that, at the very least, a project doesn't inadvertently harm people or the environment.
Septic tank	A chamber through which domestic wastewater flows for basic treatment where settling and anaerobic processes reduce solids and organics.
Subsurface wetland	An engineered system that uses vegetation, soils and organisms to treat wastewater which is below the surface of the soil, with the interaction between the plant roots removing contaminants.
Surface (flow) wetland	Saturated engineered systems with wastewater above the soil exposed to the atmosphere for final treatment.
Social capital	A set of shared values that allows individuals to work together in a group to effectively achieve a common purpose.
Tenure security	A continuum of tenure with multiple forms, underpinned by the ability of residents to remain and utilise the land and dwelling they occupy.
Treatment train	An engineered sequence of multiple wastewater treatment technologies to treat and safely discharge wastewater.
Wastewater	Water that has been contaminated by human use, including blackwater and greywater.
Water-sensitive	Actions to complement conventional approaches to deliver services by working with nature to improve urban liveability, access to services, and restore the natural environment. The water-sensitive approach includes 'nature-based' technologies such as constructed wetlands, rainwater harvesting, and bio-filtration gardens.



"This project demonstrates how collaboration with big donors like ADB and leading research institutions like Monash University can make people's lives different".

Masatsugu Asakawa, ADB President. Makassar, March 2020.



Water-sensitive upgrading involves blending technical aspects with social aspects, to generate localised, socio-technical solutions that can deliver water services for urban informal settlement residents, ensuring no one is left behind.

Executive summary

Almost one billion people live in urban informal settlements characterised by inadequate water and sanitation services, poor housing and tenure security, and vulnerability to climate change impacts.

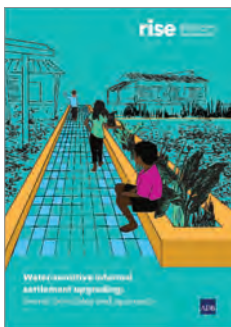
These conditions cause significant health and well-being problems, negatively impact on urban liveability, and exacerbate local, regional and global environmental crises. Conventional water and sanitation approaches to overcoming these challenges are not fit for purpose, and not implementable at the scale — nor in the time frame needed — to drastically improve urban livability and to meet the Sustainable Development Goals (SDGs) by 2030.

The water-sensitive cities (WSC) approach offers an opportunity to deliver services, improve city functioning and liveability, strengthen ecosystem servicing, and transform urban health and well-being. This report provides an overview of the WSC approach, the rationale for how it can complement conventional approaches. It outlines the five principles and 10 components of a WSC approach, with the ambition to deliver on the SDGs in an integrated and transformational way and ensure no one is left behind.

A three-part series

This report, *Water-sensitive informal settlement upgrading: Overall principles and approach* provides foundational knowledge of the technical requirements and considerations for implementing nature-based technologies in urban informal settlements, with particular emphasis on Indonesia. It provides an overview of criteria and design considerations for technical audiences, answering common technical questions regarding the functioning of nature-based technologies and interventions. The Series has three volumes.

The series is *not* intended to be a step-by-step guidebook. Rather, it aims to showcase the possibilities, principles, best practices and main considerations for policy makers and practitioners. It draws on experiences since 2017 with the Revitalising Informal Settlements and their Environments Program (RISE), a decade-long transdisciplinary impact research (TIR) endeavour that aims to improve human and environmental health in urban informal settlements by trialing the water-sensitive cities (WSC) to water and sanitation servicing (www.rise-program.org).



Part One

Water-sensitive informal settlement upgrading: Overall principles and approach provides the entry-point for understanding the rationale and concepts for a WSC approach, and a high-level summary of the main components and considerations for policy-makers and practitioners interested to utilise the approach in Asia and the Pacific.



Part Two

Co-design of water sensitive settlement upgrading, provides more detailed information and guidance on how to design and deliver a community-based, participatory process for project implementation. This Part equips the reader with an understanding of the tools and techniques that can foster meaningful participation of settlement residents, as well as government, industry and service provider stakeholders, into the design and delivery of WSC upgrading projects.



Part Three

Water-sensitive upgrading: Description of approach and technologies builds on the other two reports by providing foundational knowledge of the technical requirements and considerations for implementing nature-based technologies in urban informal settlements, with particular emphasis on Indonesia. It provides an overview of criteria and design considerations for technical audiences, answering common technical questions regarding the functioning of nature-based technologies and interventions.

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1. Introduction

With close to 1 billion people currently living in urban informal settlements the world desperately needs fit-for-purpose solutions to improve the liveability of cities and quality of life of all residents. For many cities in Asia and the Pacific, informal settlements house a significant proportion of the population, and the number of informal settlement dwellers is projected to rise in the coming two decades, reinforcing the need for new approaches to address this urban challenge.¹

Informal settlements are characterized by inadequate access to water and sanitation services, overcrowding, tenure insecurity, and poor housing quality.² These socio-spatial and physical characteristics result in significant health and wellbeing impacts, including high rates of infections and diarrhoeal disease, premature mortality, and compromised mental health and wellbeing. Women, children, and the most vulnerable are often the most severely impacted by unhealthy informal conditions and ecosystems and the eco-servicing of cities are compromised by their incremental, unplanned encroachment and exacerbated vulnerability to environmental stressors and shocks such as extreme weather events. Informal settlements are already feeling the effects of climate change and will continue to be on the forefront of this irreversible challenge in the coming decades.³

Informal settlements are often located in hazardous marginal areas (i.e. river banks, coastal area, hillsides) with high flooding and landslide exposure risk. In such contexts, delivering sanitation that can function under these challenging conditions requires customizing projects to the local conditions.

Conventional approaches to servicing informal settlements are not keeping pace with the scale and demand facing cities today. Centralised sanitation systems such as underground sewers and wastewater treatment plants are indeed effective technical solutions for improving human health but are often not feasible given their significant upfront capital investment requirements, and the challenges of reaching dense informal settlements often located on marginal land. Water, Sanitation and Hygiene (WASH) approaches have also been shown to be technically advantageous to improve health and dignity in rural areas and low density settings where the environment has the carrying capacity to absorb and deal with human waste. In dense urban informal settlements, however, WASH is not always fit for purpose and is not a long-term strategy for urban equity and liveability at the scale that urbanisation rates demand.⁴

The 'water-sensitive cities' (WSC) approach offers an opportunity to complement conventional approaches to deliver services in a holistic manner. WSC is an approach to addressing servicing needs and priorities by working with nature, at a range of scales, to improve urban livability, access to services, and restore the natural environment and improve biodiversity, to help cities be well placed for a climate-friendly future.⁵ The water-sensitive approach includes 'nature-based' technologies such as constructed wetlands, rainwater harvesting, and bio-filtration gardens. These have been proven to deliver sustainable, cost-effective health and environmental improvements in many developed countries, but have not been routinely used, monitored, or comprehensively implemented in developing countries to date.



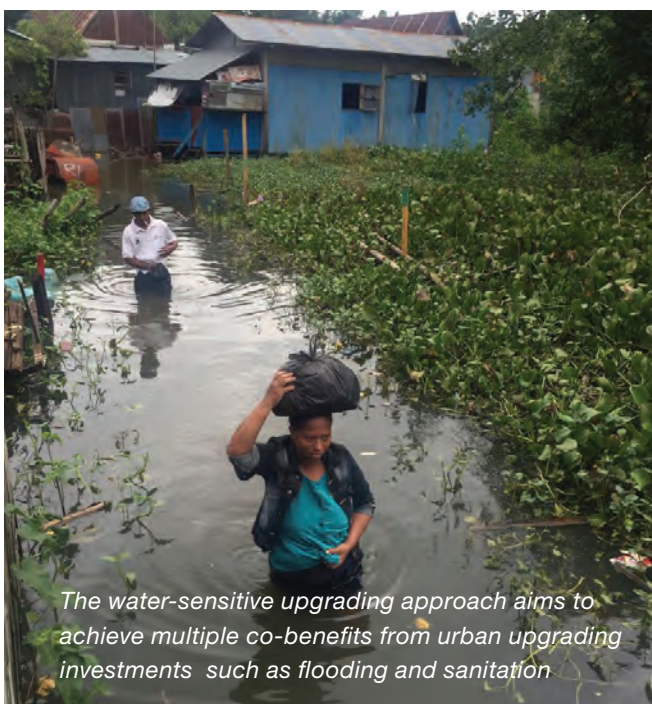
" We have to build resilient communities. I really commend RISE, because you are factoring that into the work that you are doing, and making sure that this project lasts and can be replicated elsewhere"

The Rt. Hon. Jacinda Ardern, Prime Minister of New Zealand. Suva, February 2020

The WSC approach is founded on a principle of dealing with full water cycle management in a holistic way that provides opportunities for multiple co-benefits from a single urban investment. The approach is not new. For over 30 years now, WSC has been developed, refined, and implemented in a wide variety of countries that have a range of climatic, political, social conditions. Recently the approach has been implemented in cities in the developing countries, and only very recently in the context of urban informal settlements.

The Revitalising Informal Settlements and their Environments program (RISE), led by Monash University in partnership with the Asian Development Bank (ADB), has a vision to transform investments in informal settlements in Asia and the Pacific using the water-sensitive cities approach.⁶ With support from the Wellcome Trust, RISE is implementing a randomised controlled trial researching the health and environmental impacts of a WSC upgrading approach. This report documents and codifies the experience since 2017 with implementing the demonstration projects in Indonesia and Fiji. This Report sets out the rationale and concepts for a WSC approach, and summarises the main components and considerations for policy-makers and practitioners interested to utilise the approach in Asia and the Pacific.

This document is structured around the five principles and 10 components of WSC upgrading. The five principles are overarching foundations for WSC upgrading in any context. They are non-negotiable and all five should underpin any WSC upgrading project. The 10 social and technical components of WSC may vary according to country, city, and settlement conditions. They can be considered a practical 'toolbox' of components (i.e. wetlands, biofilters, etc.) that can be deployed and arranged based on local conditions.



The water-sensitive upgrading approach aims to achieve multiple co-benefits from urban upgrading investments such as flooding and sanitation



Box 1: The water-sensitive approach is globally tried and tested

Over the past three decades the water-sensitive approach has been successfully implemented in a wide range of countries. It is known by a range of names, including water-sensitive urban design (WSUD), low-impact development (LID), nature-based solutions, and sustainable drainage system (SuDS). Core to all are a philosophy and practice of working with natural systems to provide

environmental, social and economic benefits. Projects aim to improve diversity and bring natural features and processes into urban areas through locally-tailored engineering and design interventions. While the concepts and approach are well accepted, they have, until now, seldom been applied in low-income and resource-constrained settings, such as informal settlements.



Singapore



Kunshan, People's Republic of China



Tel Aviv, Israel



Melbourne, Australia

Box 2: A step change is needed in the Pacific

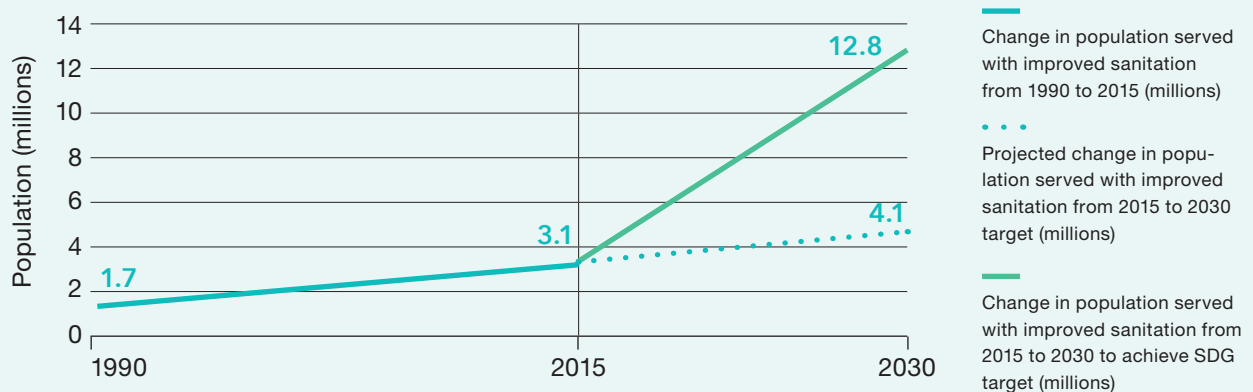
Conventional water and sanitation approaches are not meeting demand in Pacific island countries. The World Health Organization’s 2015 review of achievements with the Millennium Development Goals (MDGs) found that while good progress had been made with increasing access to safe water and sanitation, these rates are insufficient to meet the demand facing Pacific Island countries as a result of urban and population growth.

To meet universal safe water coverage as envisaged in the Sustainable Development Goals requires a five-fold increase in the population served compared with existing rates. For

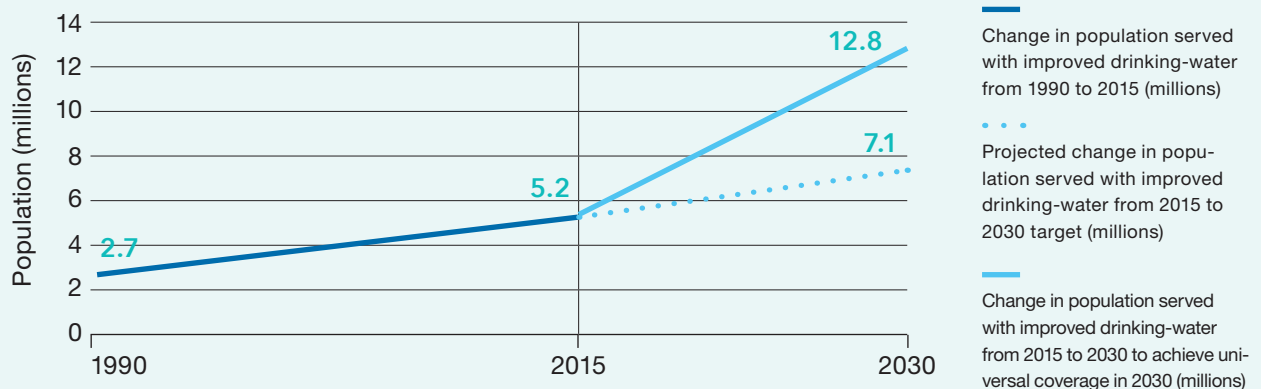
sanitation it is even more challenging with a twelve-fold increase required to meet universal sanitation access in the Pacific. The projected deficits are alarming: with millions of people remaining underserved by 2030 if current rates of improvements are not dramatically improved.

The challenge is similar in many developing countries with the data indicating that conventional approaches and delivery rates are not meeting the demand for safe water and sanitation access. Novel, cost-effective approaches that can be delivered in a timely manner are needed if countries are to meet the SDGs and ensure no one is left behind.

To meet the SDG water targets requires a 5x step up



To meet the SDG sanitation targets requires a 12x step up



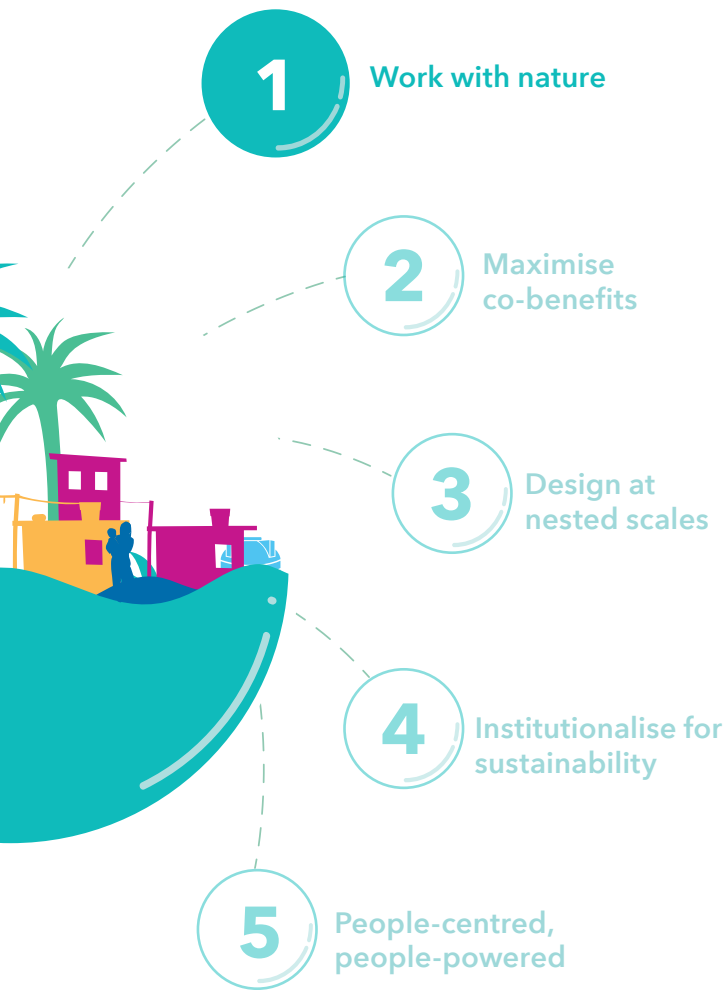
Reference: World Health Organization et al (2015) Sanitation, drinking water, and health in Pacific Island Countries, 2015 update and future outlook. World Health Organisation: Geneva.

2. Water-sensitive upgrading: 5 key principles

The water-sensitive cities (WSC) approach to upgrading informal settlements is underpinned by five foundational principles.

These five principles broadly align with contemporary best practices,^{7,8} and advance them in a manner that can foster the implementation of the water-sensitive cities approach. While the social and technical components of WSC may vary according to country, city, and settlement conditions (see below), these five principles remain valid across contexts in shaping WSC program and project design. Importantly, the principles build on each other and are an integrated set, for example designing at nested scales also requires institutionalising projects across various levels of government and associated jurisdictions.



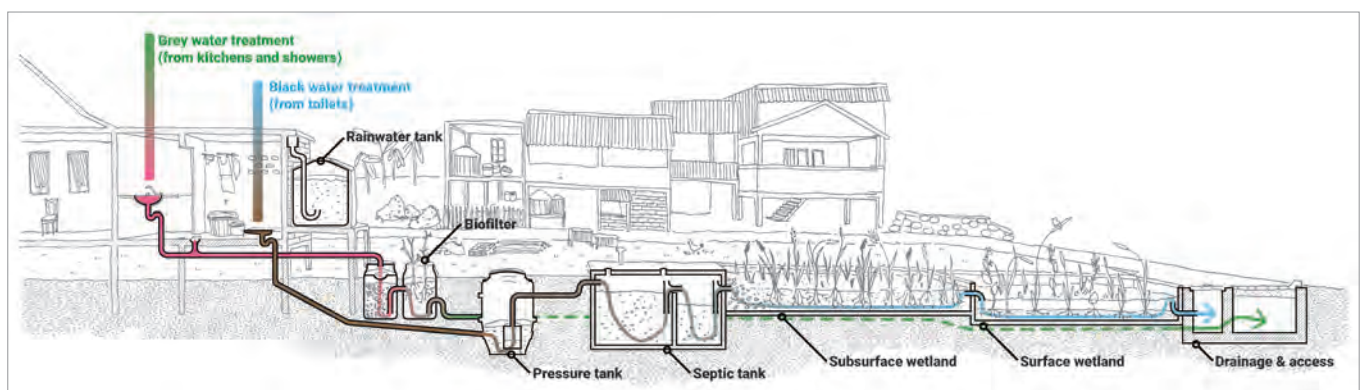


Central to the WSC upgrading approach is a sanitation ‘treatment train’ which safely collects, cleans, and discharges blackwater within informal settlements using natural systems and bio-filtration processes.

Principle 1: Work with nature (green engineering)

Conventional engineering approaches to providing water and sanitation services are rooted in 18th and 19th century technologies, i.e. centralised wastewater treatment plants, citywide sewerage systems and reticulated water supply. For many developing countries, these technologies are not always financially viable, can take generations to reach marginalised urban informal settlements, and, unfortunately, come at a significant environmental cost to build, operate and maintain. Complementary to these conventional approaches, the WSC approach offers opportunities to expand water and sanitation services using decentralised technologies to safely treat wastewater, improve water availability, and restore local ecosystems. A WSC approach combines green technologies (nature-based solutions and water-sensitive urban design) with traditional ‘gray’ technologies and smart systems to support a more sustainable, resilient and liveable city. *Principle 1: Work with Nature*, aims to:

- ✓ Use natural systems and processes to safely treat wastewater (e.g. biofilters, constructed wetlands);
- ✓ Improve water quality, availability and affordability (e.g. rainwater harvesting, fit-for-purpose water quality treatment and usage);
- ✓ Reduce the impact of seasonal and extreme flooding;
- ✓ Restore the environment, especially waterways and soils, to reduce contamination resulting from human activity;
- ✓ Use low-impact design and technologies that build local capacity and resilience to shocks;
- ✓ Improve biodiversity and urban ecosystems to rejuvenate the natural balance of flora and fauna in cities;
- ✓ Design for, and build, social and technical resilience to climate change (e.g. flooding, extreme weather events, urban heat island effects).



Principle 2: Maximise co-benefits

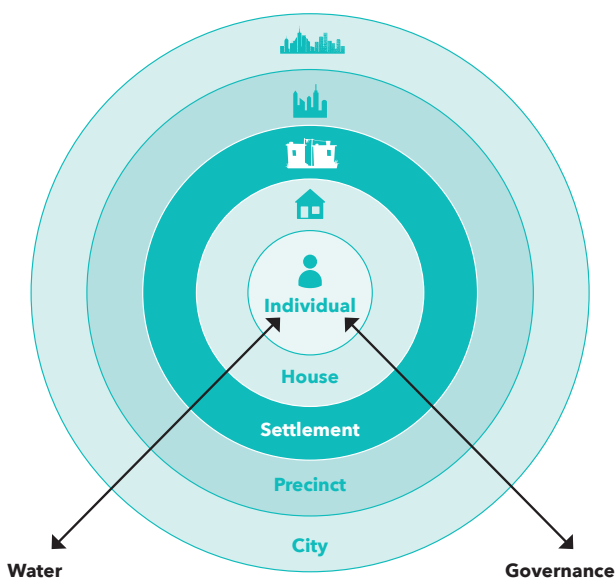
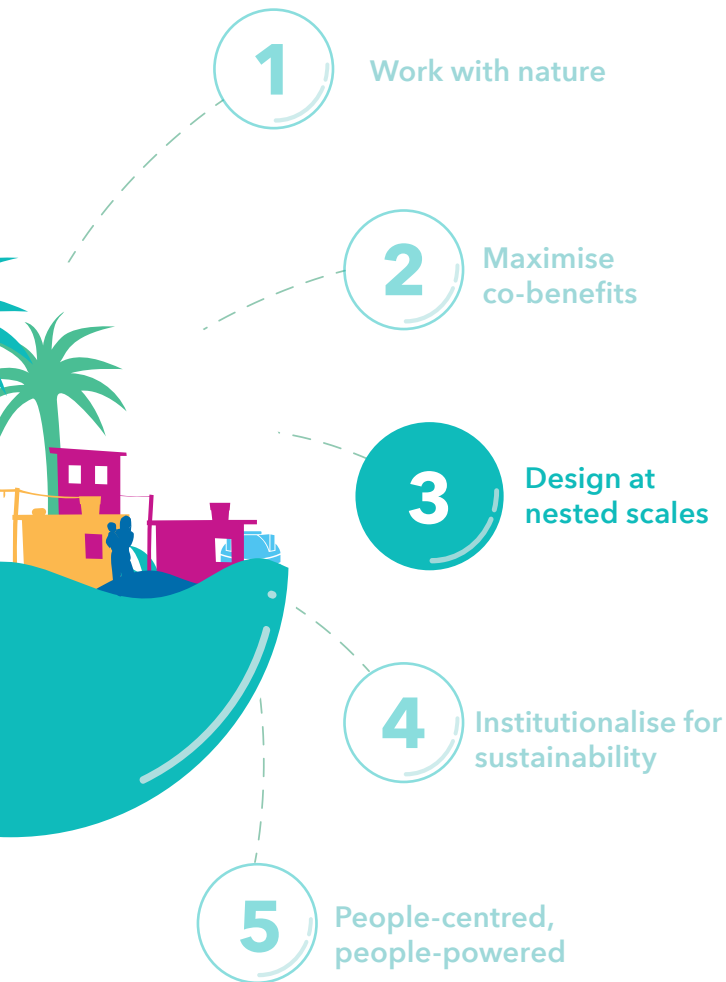
Conventional informal settlement upgrading projects are too-often piecemeal and target only one or two specific sector improvements, such as housing, water supply, access or drainage. Informal settlements, however, are dynamic social and physical environments. Their challenges are complex and their upgrading needs are often interrelated, meaning dealing with only one aspect, such as drainage and access, is unlikely to have transformative impacts.

The WSC upgrading approach aims to maximise water-related and built-environment co-benefits from a single upgrading project and investment. It approaches informal settlements in a holistic manner, understanding the true nature of their challenges - as well as their opportunities - to develop comprehensive neighbourhood upgrading plans that can transform the health and wellbeing of occupants and the environment. In doing so it drives for harnessing investments to maximise a wide range of benefits for cities and urban residents. *Principle 2: Maximise co-benefits*, aims to:

- ✓ Undertake comprehensive assessments to understand the upstream and downstream drivers and constraints on health and wellbeing;
- ✓ Develop comprehensive community plans (master-plans) that can guide settlement investments and development for the long-term;
- ✓ Design and implement fit-for-purpose engineering interventions that can meet immediate needs while also providing additional urban amenity;
- ✓ Leverage endogenous development opportunities for social and economic co-benefits from infrastructure investments;
- ✓ Design for the ongoing morphological growth of settlements to allow for system expansion and growth;
- ✓ Recognise that tailored, site specific projects are needed which incorporate a broad range of site specific variables into the design and implementation of programs and projects.



An example of a WSC upgrading project that achieved multiple co-benefits, including: (a) Waste-water treatment using constructed wetlands; (b) improved water security using rainwater tanks; (c) greywater treatment using household biofilters; and (d) access improvements.



Principle 3: Design at nested spatial scales

The health and environmental challenges facing informal settlement residents are often a result of broader urban challenges beyond their immediate settlement boundaries. Therefore, connection and linkage with city vision and city overall and thematic plans is important. Citywide settlement upgrading has become a leading approach to addressing informal settlements.⁹ It recognises the limitations of ad-hoc projects implemented at the settlement scale which are seldom transformative given their narrow spatial focus. Citywide upgrading views the city as an ecosystem and aims to undertake in-situ upgrading in a systematic, programmatic manner to improve all informal settlement within a city by looking at the challenges at a range of inter-related spatial scales.

Water stressors and the associated ill-health effects are often associated with variables and conditions at the broader catchment and precinct levels, with inwards contamination from areas outside the settlements. Likewise, solving a problem in one settlement can often exacerbate problems downstream. For example, implementing access road and drainage improvements, a common upgrading intervention, often makes flooding and contamination for downstream communities even more vulnerable and at risk (moving the floodwater to neighboring areas not covered by project). Therefore, there is a need to look at water catchments and flows at a range of nested scales, in order to develop interventions that can significantly improve the immediate conditions for informal settlement residents. *Principle 3: Design at nested spatial scales*, aims to:

- ✓ Broaden out the assessment of water stressors beyond the immediate spatial boundaries of a project settlement to reach a fuller understanding of the hydrological dynamics;
- ✓ Develop interventions at the precinct and catchment scale to reduce contamination and vulnerability of the urban poor to flooding and contamination;
- ✓ Integrate street/access improvements into the urban open space and mobility network;
- ✓ Design to also account for spatial and socio-physical variation within informal settlements;
- ✓ Align access and land tenure regularisation interventions with precinct and citywide strategies and plans;
- ✓ Integrate WSC upgrading projects into citywide urban planning and land management for the purposes of socio-spatial integration of informal settlements in their wider urban systems.

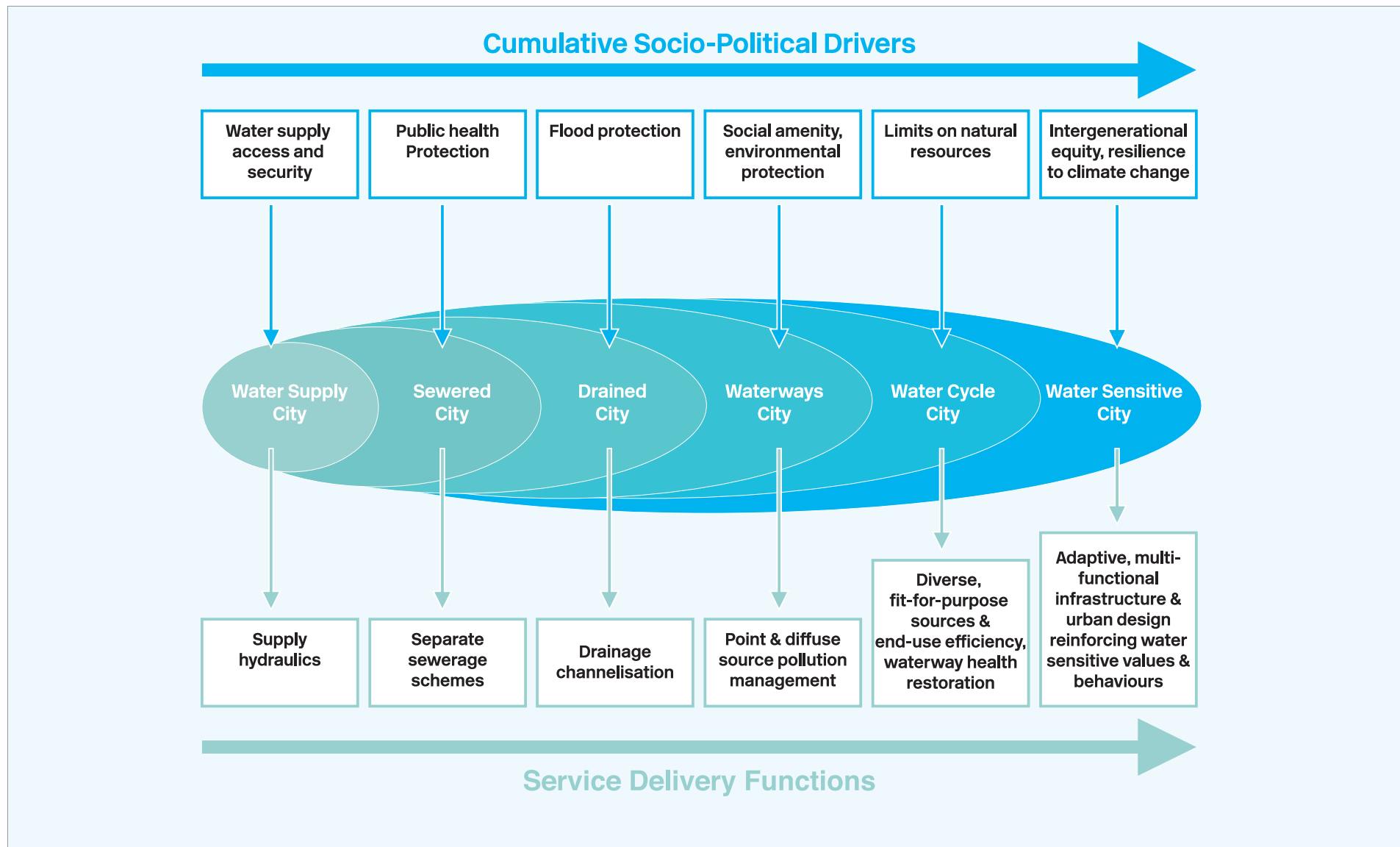
Principle 4: Institutionalise for sustainability

The WSC approach requires a unique institutional ecosystem that is different from conventional approaches to design and deliver projects and, importantly, to ensure their ongoing operations and maintenance. The full transformation of cities to more sustainable water-sensitive cities requires a major shift in the governance and institutional mechanisms for delivery and operations and maintenance.¹⁰ Contemporary institutional systems and approaches need to be adapted and reformed to promote system resilience. Furthermore, ecosystem services for the built and natural environment under a WSC approach cut across multiple governance regimes and jurisdictions and also require shifts towards water-sensitive understandings and behaviours.

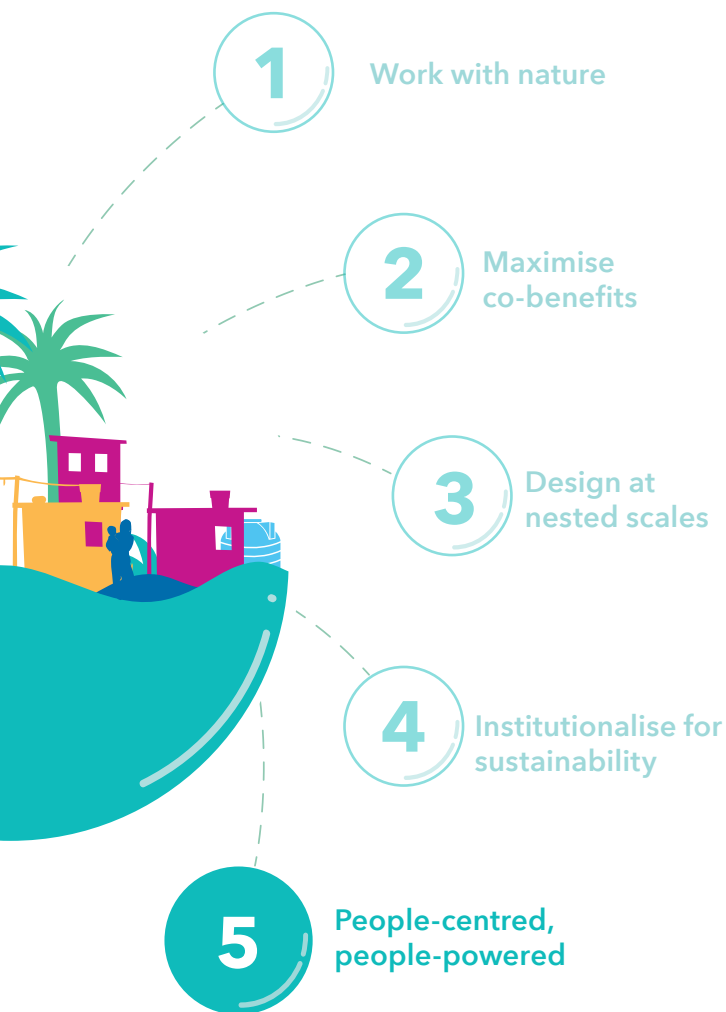
The long-term objective of a water-sensitive approach is to leapfrog from conventional institutional regimes for water supply and sewerage, towards cities that improve waterways, water-cycle and ultimately become water-sensitive cities. In developing countries with high rates of informal settlements it is therefore crucial to ensure institutional arrangements that have the capacity and ability to function in informal areas.¹¹ *Principle 4: Institutionalise for sustainability*, aims to:

- ✓ Build the institutional capacity of governments, service providers and community members to design and implement WSC approaches;
- ✓ Build human and institutional capacity for operations and maintenance of WSC infrastructure;
- ✓ Reform institutional arrangements to improve cross-government coordination of water and sanitation investments, at the horizontal level (cross-departments in each hierarchy) and vertical level (city, province, and central government level);
- ✓ Improve data on urban informal settlements and utilise data for evidenced-based decision-making;
- ✓ Promote land tenure regularisation to improve residents' tenure security and promote household investment in dwelling and settlement improvements;
- ✓ Strengthen local governance and relationships between communities and government for effective urban management;
- ✓ Institutional anchoring of water-sensitive upgrading into city spatial plans and investment plans, taking a long term view to leapfrog conventional approaches.





Urban water transitions, from conventional approaches of water supply and sewerage to water-sensitive cities (ref: Brown, R., Rogers, B., Werbeloff, L. (2016). *Moving toward Water Sensitive Cities: A guidance manual for strategists and policy makers*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.).



Training both community and government stakeholders is crucial to build local capacity for a water-sensitive approach.

Principle 5: People-centered, people-powered

The water-sensitive cities approach is underpinned by a non-negotiable commitment to human rights and a valuing of people's participation in all aspects of program and project design and implementation. Upgrading experience over the past six decades has shown that informal communities are key agents in upgrading decision-making. Community involvement improves project design, implementation, and increases the sustainability of interventions.

The WSC upgrading approach builds off existing social capital which exists in informal settlements and which is a powerful force for transformation. Due attention is given to understanding existing social dynamics, including uncovering and meeting the challenge of unequal power relations, including gender inequalities and elite capture of resources, to develop interventions that not only improve the physical environment but also strengthen livelihoods, social networks and gender relations. *Principle 5: people-centered, people-powered*, aims to:

- ✓ Empower informal settlement residents to play a role in the decisions affecting their lives and neighborhoods;
- ✓ Build on endogenous capacities and capabilities of informal settlement residents and networks, linking these with new initiatives and interventions;
- ✓ Engage the full range of relevant stakeholders in a meaningful co-design process to identify problems, co-create solutions, and implement upgrading projects;
- ✓ Uphold human rights, especially ensuring projects 'do no harm', do not cause or require forced eviction, and ensure compliance to transparent and fit-for-purpose social and environmental safeguards;
- ✓ Promote in-situ (on site) upgrading of informal settlements to retain livelihoods and social networks rather than large-scale relocation or redevelopment;
- ✓ Strengthen community relations and link communities with formal governance systems and processes to improve urban inclusion and tenure security.
- ✓ Through an intersectional lens, empower individuals and groups traditionally marginalised in upgrading projects, including women and girls, youth, and disabled persons.



Engaging with residents through community co-design is crucial to understand existing space use, values and priorities, to inform project design and interventions.



Women play a key role in revitalisation decision making as equal partners, including in understanding the existing conditions, co-developing and implementing solutions.

Box 3: Achieving multiple SDGs in an integrated way

One of the key aspirations of the Sustainable Development Goals is to 'leave no-one behind' and to 'reach first those who are furthest behind'. Evidence suggests, however, that those living in urban informal settlements are not benefitting from urban investments at a rate that can meet the SDGs, and not in an integrated manner as envisaged in the SDG framework.

Inherent in its holistic view, the WSC approach can help communities, cities and countries achieve multiple SDGs with a single investment. SDG 6, safe and universal access to water and sanitation, is an important goal which the WSC approach can deliver on. It is also intrinsically linked to issues related to sustainable cities (SDG 11), gender equality (SDG 5), life on land (SDG 15), good health and wellbeing (SDG 3), as well as reduced inequalities (SDG 10).



3. The 10 components of water-sensitive upgrading

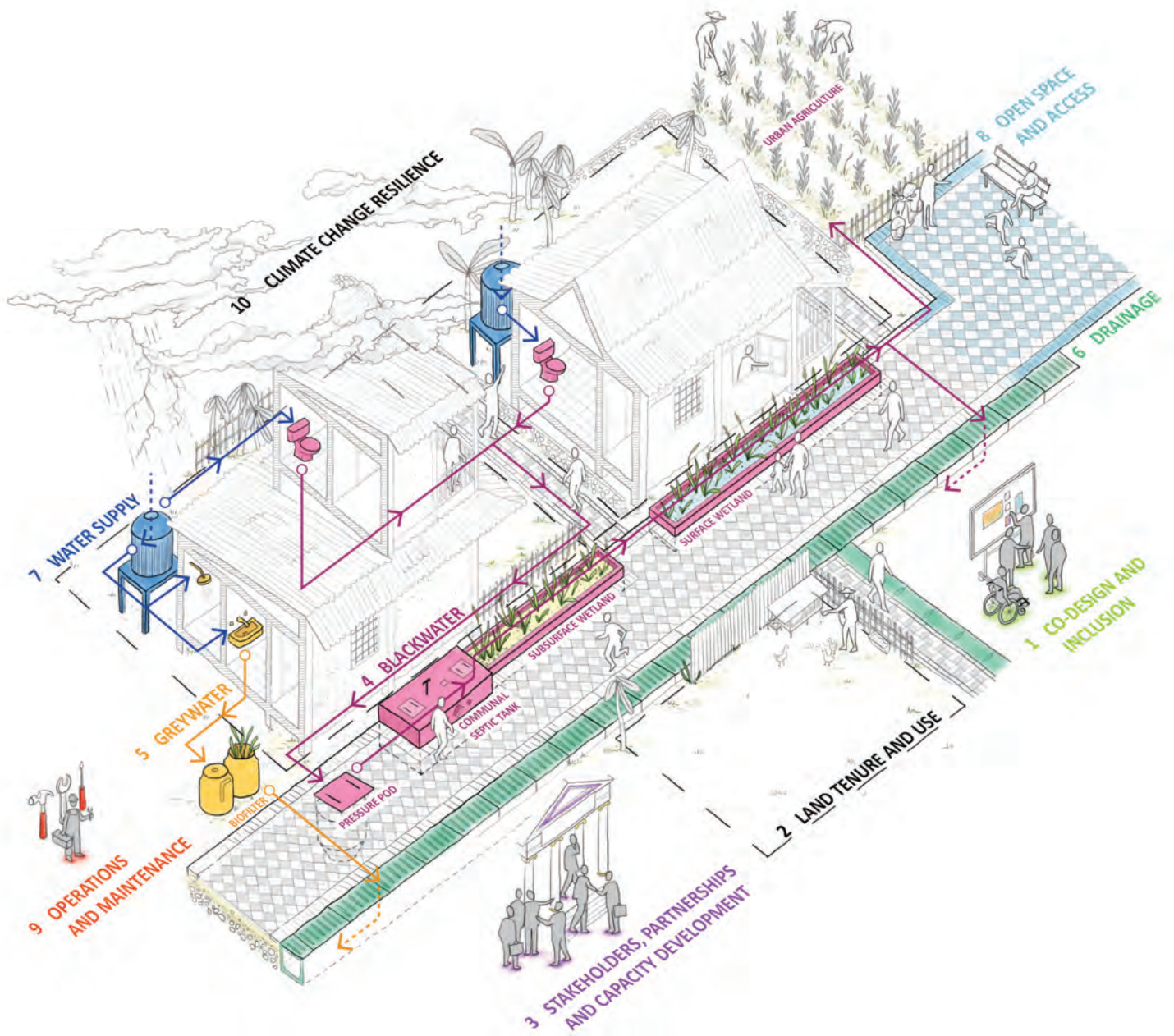
The WSC approach to informal settlement upgrading can be synthesised into having 10 key components. There are seven components that improve urban services and resilience through mainly engineering and urban infrastructure actions, and three components that are cross-cutting and address social, legal and broader partnership considerations. The five principles, discussed in the previous section, frame the design and implementation decisions under all 10 components.

Importantly, the 10 components are mutually interdependent and should not be seen as being isolated from each other. The three cross-cutting components are not 'optional add-ons' but components that need to be addressed and included throughout an entire upgrading process, especially when designing the infrastructure. For example, co-design and inclusion are not an optional add-on but are integral to the others, such as addressing blackwater and greywater treatment.

The 10 components will vary in how they are applied depending on the specific site conditions and the socio-technical and economic context of a city/country. Some may have greater precedence than others. For example, where potable water is already available but seasonal flooding and sea level rise is a major issue, investment may not be needed for potable water but rather addressing the contamination resulting from the flooding hazard. As with any upgrading intervention, project-based investments will need to be optimised to address the most critical items while also allowing for other local investments in the longer-term aligned with an overall water-sensitive masterplan for each settlement.

In most contexts where informal settlements exist there is a dearth of data and information upon which to base design and engineering decisions (e.g. flooding data). It is important, however, to have sufficient information to make reliable designs that function as intended. Rapid engineering testing, site surveying, and assessments can be done to garner the minimum data needed. Citizen science methods can also help overcome this data gap.

Aligning these 10 integrated components to maximum effect takes time, often more time than is needed than traditional, narrow, single-sector interventions. It is important that the process is not rushed as important trade-offs need to be surfaced, negotiated and reconciled for an integrated solution. Linked to the issue of time is that of interdisciplinarity. It is important within the WSC approach that the context, problems and opportunities are examined from multiple perspectives with a variety of lenses. The other two Reports in this Series explain in more detail how this multidimensional approach plays out with co-design (Volume 2) and the technical system components (Volume 3). Figure 10 outlines a system diagram of water and sanitation components (components 4-7).

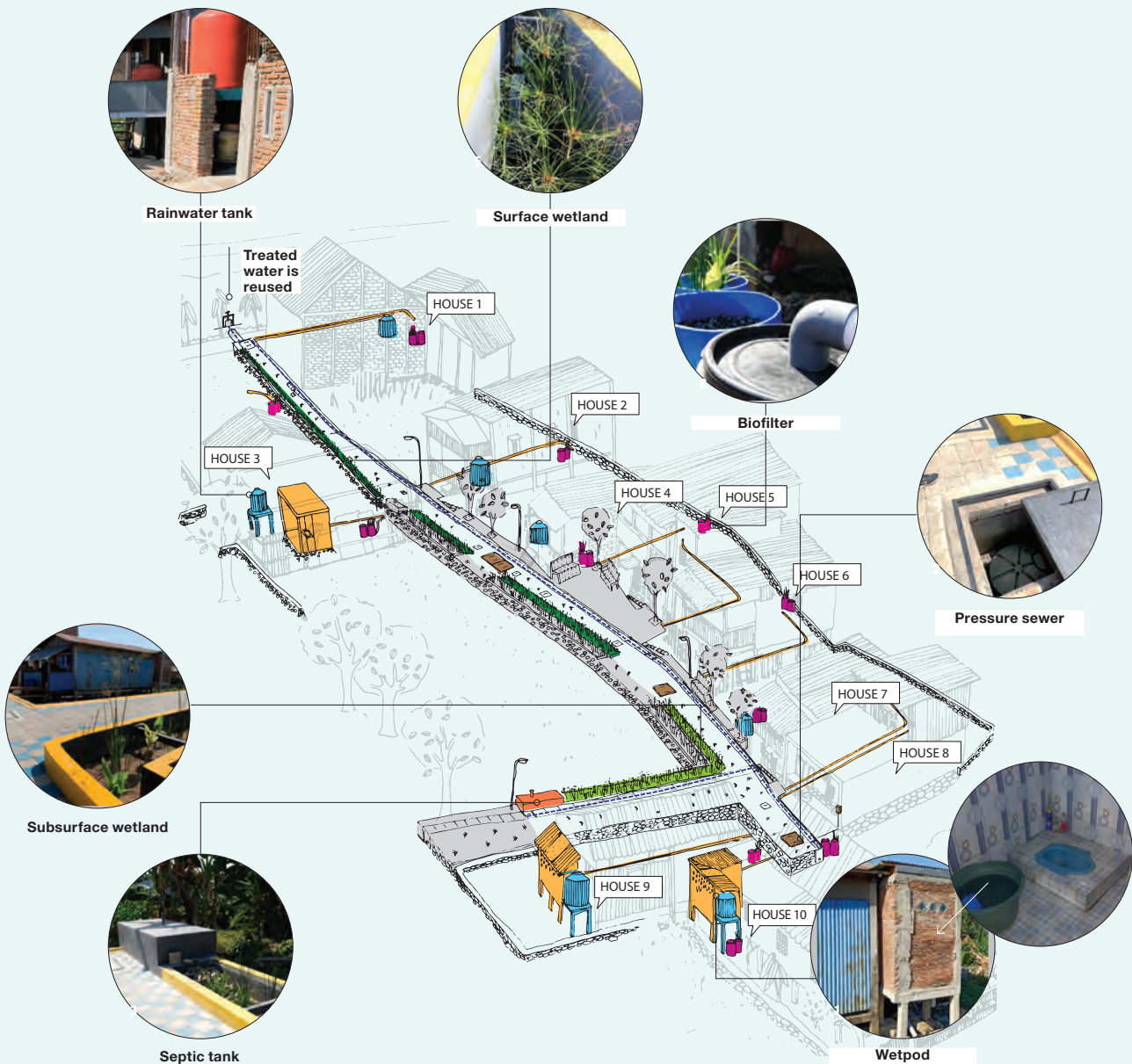


The 10 components of a WSC upgrading approach.

Box 4: Holistically integrating the 10 components

The WSC upgrading project at the Batua neighbourhood demonstrates the range of technologies that come together to improve the environmental quality of this informal neighbourhood in the city of Makassar. Batua has been a ‘living lab’ for the RISE program, supported by the Asian Development Bank through the Urban Climate Change Resilience Trust Fund (UCCRTF), where the WSC approach has been refined and codified through empirical research and praxis.

Although a relatively small neighbourhood, with only 13 houses at present, the design allows for the full 22-dwelling occupation of the settlement and thus enables flexibility for the community to expand and grow over time as vacant plots are incrementally occupied and developed, a common feature of urban informal settlements. Land tenure, community engagement, social safeguards, and co-design are key elements that have been addressed during the project through participatory mechanisms with community members as well as the City of Makassar, and Rukun Warga (RW), Rukun Tetangga (RT), Kecamatan and Kelurahan levels of governance.



Box 4: Holistically integrating the 10 components continued



A WSC upgrade project in Makassar, Indonesia

Component 1: Co-design and inclusion

Decades of informal settlement upgrading policy and practice has shown the critical importance of involving local residents and communities in the co-design of upgrading projects. Their participation is crucial at all phases of the project cycle, including conceptualising, designing, implementing and maintaining interventions. With almost one billion people living in informal settlements, the scale of the challenge means that solutions need to be implemented hand-in-hand with communities if interventions are to scale and have an impact as envisaged in the Sustainable Development Goals (SDGs).

As outlined in Volume 2 in this series, *Co-design of water-sensitive settlement upgrading*, co-design is a process, not an event. Co-design activities and tools should achieve genuine and meaningful engagement with all residents, particularly the poor and vulnerable who often do not have a voice within existing formal and informal governance structures within a community. Effective co-design recognises and takes into account existing power dynamics, vulnerabilities and social structures such as community organisation to ensure 'no one is left behind'.

Given the WSC approach involves decentralised infrastructure, it is particularly important to ensure a community's infrastructure literacy and capacity is developed through the engagement process. This includes building their understanding of the scope of the water-sensitive

approach, what each of the technologies are, their functions, and related operations and maintenance requirements, for which all residents and community members will likely have a lasting role.

Key considerations for co-design and ensuring inclusion include:

- ✓ Ensure co-design sessions, activities and tools are closely tied to- and run parallel to- the infrastructure implementation timeline so community inputs can be meaningfully incorporated into the design outcomes;
- ✓ Empower residents to co-assess of the existing social and environmental situation, ensuring that the lived experience and aspirations of diverse men, women, youth and children are heard and documented to feed into the design;
- ✓ Ensure participants gain a sufficiently deep understanding of the proposed solution to enable them to make informed choices regarding the location of any infrastructure and their operations and maintenance requirements;
- ✓ Design and set-up a co-design process that is context specific, resilient to change, can accommodate learning through the process, and reduce the burden and transaction costs on people's participation while not compromising quality engagement;
- ✓ Ensure the implementation team has a range of capacities and capabilities: social work, anthropology, design, engineering, and training in gender and social inclusion;
- ✓ Co-design does not finish with the community design workshops that result in the concept design/masterplan. Ensure that community are involved during the build and post-build components of the process.



Co-design is a process, not a single event. Co-design activities and tools should achieve genuine and meaningful engagement with all residents, particularly the poor and vulnerable.



Co-design involves exploring with community members potential spatial solutions in an interactive manner.



Open briefings and information sharing sessions are important to convey information to all residents and provide a forum for concerns to be raised and solutions co-developed.

Component 2: Land tenure

Many residents living in informal settlements have weak land tenure security and are excluded from formal municipal planning, development and land and property frameworks.

These frameworks are typically too complex, expensive, inflexible and inaccessible to low-income residents. Informal land tenure systems provide a faster and more affordable means for residents to access land and housing, however, as these remain outside formal urban governance processes, informal settlement residents are left underserved by basic services such as public space, reticulated water, access and infrastructure.

WSC upgrading projects aim to strengthen residents' rights to safe, affordable land and housing. The WSC approach recognises the complexity of land and property dimensions of upgrading. Key challenges for WSC projects include: (i) lack of clear formalised land boundaries, especially between public and private land; (ii) overlapping land claims and unresolved disputes; (iii) hazardous land where in-situ upgrading may not be possible; (iv) having suitable land/space availability to locate the infrastructure; and (v) involving the wide diversity of land owners, from individual households to government to reach agreements on land rights, use, and ongoing maintenance.

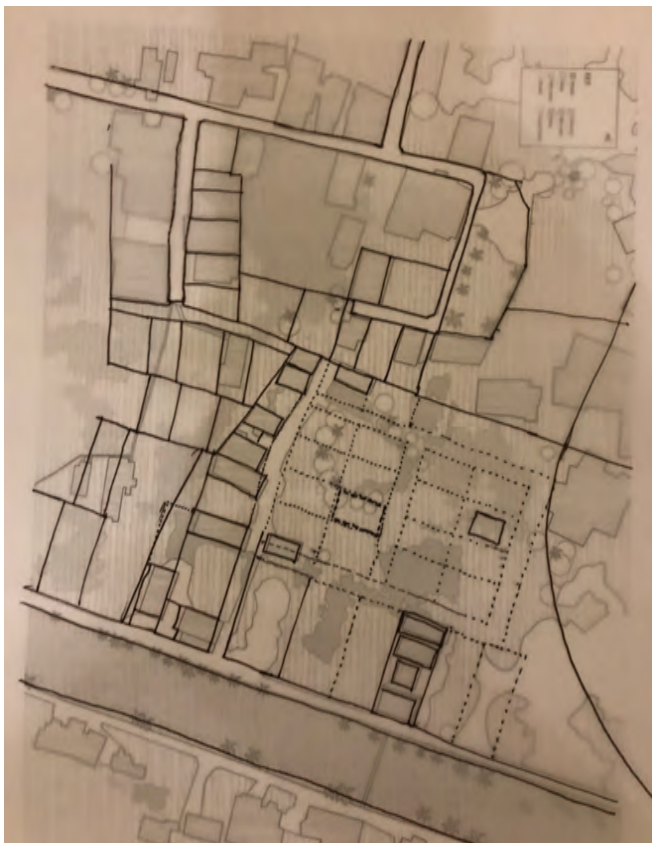
Land regularisation and formalisation requires delicate attention and adherence to social safeguards to ensure no harm is done. These safeguards principles should be informed by existing local and national laws and donor safeguard policies and be sufficiently flexible to support each resident's desired outcome for infrastructure locations. By regularising land tenure alongside physical upgrading project works, residents can benefit from secure access routes, improved services, increased property values and improved amenity of public and open space.

Key considerations when developing a land tenure strategy include:

- ✓ Aim to strengthen in-situ land and property rights concurrently with WSC infrastructure projects;
- ✓ All infrastructure located on private/communal land should be discussed and agreed with the relevant households, with sufficient information provided to enable them to fully understand the implications and to then make informed choices, in accordance with social safeguard principles;
- ✓ Involve relevant government agencies in designing and implementing legally recognised fit-for-purpose land agreement options that can help households strengthen tenure security and existing land tenure status and with sufficient flexibility to cater to the needs of individual residents;
- ✓ Include an assessment of residents' livelihoods that may be drawn from existing land use and access, and ensure the relevant safeguards are met;
- ✓ Consider potential compensation for any land used for the location of infrastructure to ensure the poorest are not left worse off from land use changes;
- ✓ Safeguards should be established, monitored and upheld to promote sustainability of project outcomes and to help mitigate potential adverse impact;
- ✓ Pay particular attention to existing and/or emerging land disputes and grievances, which often disproportionately affect the most vulnerable;
- ✓ Ensure sufficient land for public use, such as streets, accessways and gathering spaces, to improve mobility and urban amenity.



Community-based identification of property boundaries and delineation of public and private land is an early important step in WSC upgrading; Makassar, Indonesia.



In the absence of formal land and property cadastre, community-based mapping of de-facto property boundaries can identify project boundaries and potential land for project infrastructure; Makassar, Indonesia.



“We have learnt a lot of new things. We have been living our lives planting and fishing, not knowing the contamination and diseases that are in the environment surrounding us. We all want a good livelihood, and I always reassure [my community] that RISE will only work if we work together as a community”.

Ledua, RISE Community Engagement Council member, Suva, Fiji

Component 3: Stakeholders, partnerships and capacity development

The WSC upgrading approach requires novel institutional, technical and human capacity to design, plan, implement, and monitor programs and projects, not least because of the technical components and infrastructure which are new for many cities and countries.

Furthermore, the multi-dimensional approach requires a broader range of government stakeholders than conventional upgrading, including national, regional and city authorities responsible for a range of sectors, including: sanitation, water supply, drainage, community development, housing, solid waste, drainage, gender, urban planning, land management, city assets, and the environment.

The WSC approach relies on deep partnerships and stakeholder engagement across different stakeholder groups, including central and local government, communities, service providers, and civil society groups. Partnerships are required at two main levels: political (senior government, customary and community leaders) and technical (coordination of design inputs and co-development of implementation processes). The former cannot be underestimated as governors, mayors and local leaders need to demonstrate genuine political will for in-situ upgrading, to adopt new socio-technical approaches, to include WSC projects to mid-term development plans, and ensure financial support through on-budget means for construction and the ongoing operations and maintenance.

Capacity development is a crucial aspect that spans across all phases of the WSC project cycle. A demonstration project, or 'living lab' model, has proven to be an effective tool to build local capacity of all stakeholders through a 'learning by doing' approach. It also helps build political capital for scaling-up and enables stakeholders to see first hand the physical outputs and be involved in the implementation and problem solving. This provides an opportunity for testing, developing and implementing the technologies within the geographic and socio-cultural contexts.

Solid waste management is a significant issue in many informal settlements. Without regular formal waste collection services, solid waste accumulates, or is disposed of in improper ways, which can significantly compromise ecosystems. Solid waste can also compromise the functioning of the WSC infrastructure (e.g. if wetlands become full of solid waste). Therefore, ensuring solid waste is collected and properly disposed of should also be part of any WSC intervention and in many instances, this requires coordination with local authorities to institutionalise routine collection services.

Key stakeholder, partnership and capacity development considerations include:

- ✓ Forge new partnerships for WSC approaches that bring together relevant stakeholders in a collaborative spirit underpinned by a common vision and mission;
- ✓ Secure and maintain political will at all levels of government and communities. Foster the emergence of political and technical champions in each partner organisation;
- ✓ Design and implement dedicated training programs to build local institutional and human capacity for WSC technologies;
- ✓ Aim to institutionalise the WSC approach within existing governance structures and systems to promote replication and ensure ongoing O&M;
- ✓ Dedicate adequate time for meaningful consultation with relevant stakeholders to co-design, ensuring the tools and engagement modalities meet their needs and priorities;
- ✓ Include external stakeholders in the community co-design activities, for example government authorities and adjacent landowners;
- ✓ Consider demonstration projects to enable a fast 'learning by doing' approach and to build support for WSC scale-up;
- ✓ Build on existing organisational structures within the community and capitalize on the goodwill and trust that may already exist within the community.



Component 4: Blackwater

The safe collection, transport, treatment and discharge of the solid and liquid faecal waste (blackwater) is a critical health and environment challenge in informal settlements. Poor sanitation is a leading cause of faecal borne illnesses, such as diarrhoea, with negative impact on human health and wellbeing and leading to contamination of ecosystems.

A safely managed sanitation system is defined as an improved sanitation facility that is not shared with other households and where excreta is safely disposed of in situ or transported and treated off site.¹² Even when informal settlement households have access to a private, improved toilet the condition can be highly variable and fail to meet basic hygiene standards. Additionally, it is common for blackwater in informal settlements to be either discharged directly to drainage lines and thence the water environment or to an improper septic tank with impermeable walls, no outlet, and without a base to promote infiltration. This results in a significant risk for groundwater and/or water supply contamination where shallow wells are located nearby.

As Volume 3 in this series, *Water-sensitive informal settlement upgrading: Description of technologies*, explains the WSC approach aims to collect and treat blackwater to reduce on-site contamination and reduce exposure to faecal contamination. In sites where an existing sewerage network is available, priority can be given to connecting household wastewater (black and grey) to this. Where this is not an option, decentralised, nature-based technologies, such as constructed wetlands, can provide treatment to achieve this objective.

The WSC approach to decentralised wastewater management is based on a 'treatment train' approach. The blackwater component includes the following components and flows:

1. **Safely collect blackwater from each house**, which may require toilet renovations or 'wet pod' provision;
2. **Transfer the sewage from each house via gravity or a pressure sewer**;
3. Primary treatment of the sewage in a communal septic tank;
4. Discharge the primary treated effluent from the septic tank to a constructed **subsurface wastewater treatment wetland** for secondary treatment. A subsurface wetland is densely planted, and all effluent flows are below the surface of the gravel media. Key biological treatment processes occur in the plant root zone;
5. Discharge to a **surface flow wetland** for tertiary treatment. As the name suggests, surface-flow wetlands have water visible on the surface of the soil;
6. The effluent can then be safely **discharged to the environment** or reused for non-potable uses such as toilet flushing, agriculture or local economic development activities.

Key considerations when developing a local blackwater strategy include:

- ✓ Understand the condition and suitability of existing sanitation systems, septic tanks, open defecation, and toilet facilities (individual, shared, precarious toilet facilities);
- ✓ Aim to connect to the centralised sewer system if possible. If not possible in the foreseeable future, decentralised blackwater sanitation approaches using constructed wetlands can safely treat blackwater and discharge to the environment;
- ✓ Ascertain existing and future demand (number of households) requiring connections;
- ✓ Build on the existing social and spatial organisation to design the pressure sewer systems based on pressure-pod clusters.
- ✓ Understand existing wastewater discharge rates, which vary depending on contexts, and which are important for identifying and sizing potential decentralised treatment systems;
- ✓ Treating blackwater and greywater together is possible. If there is insufficient space to achieve the desired detention times, then treat separately to protect the integrity of blackwater treatment quality.
- ✓ Understand the existing site topography and gradients which will dictate whether a gravity-flow or pressure sewer system is needed.



Subsurface wetland at Batua, Makassar. All effluent flows are below the surface of the gravel media and key biological treatment processes occur in the plant root zone.

Component 5: Greywater

Greywater – wastewater from kitchens, bathrooms, laundry, and other uses – is a serious issue in urban informal settlements that has major impacts on environmental quality, and consequently human health, due to its high nitrogen load, oil, grease, and chemical composition.

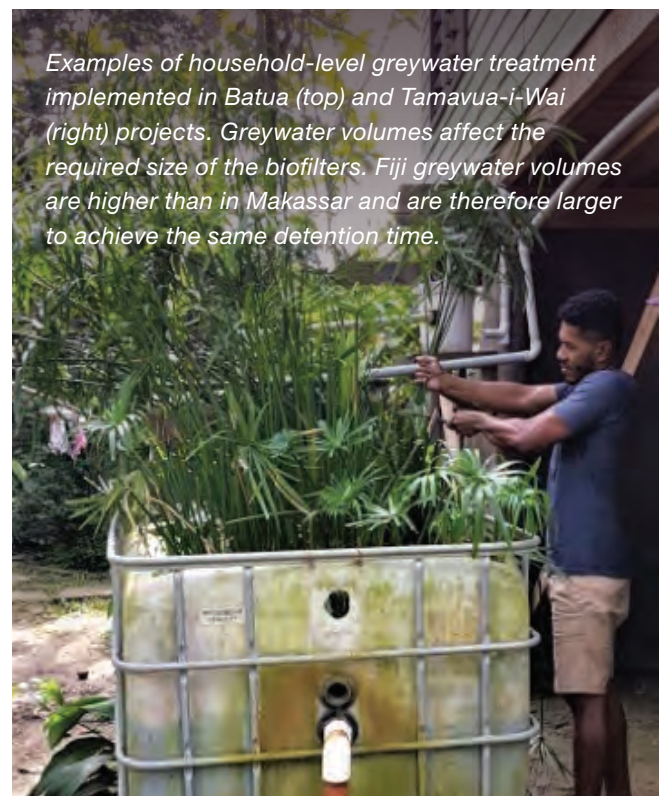
Poor or non-existent drainage and limited treatment of greywater in informal settlements exacerbate human health problems for residents and contribute to the contamination of local waterways and ecosystems with negative consequences for biodiversity, flora and fauna.¹³

The WSC approach aims to safely collect, treat, and discharge greywater in order to reduce human contact, avoid odour emissions, reduce stagnant water leading to breeding sites for mosquitoes, and ensure it can safely be discharged into the environment. Ideally greywater treatment would be combined with blackwater and treated together. Where this is not possible (e.g. space limitations), priority for rigorous communal-scale blackwater treatment is preserved and greywater can be collected and treated separately, ideally close to its source, through household-level biofilters or along drainage lines where space allows. In these cases, greywater drainage can be consolidated with stormwater drainage (see: Component 6, below). Primary treatment to remove oil, grease and grit should be implemented as a minimum before discharge. Safely managed greywater treatment also offers the opportunity for reuse, for example to water plants, depending on the occupants' willingness and capacity to operate the treatment system, and their demand for non-potable water for domestic activities.



Key considerations when developing a local greywater strategy include:

- ✓ Understand existing greywater discharge rates based on local consumption patterns;
- ✓ Map the available space in the settlement, around the household or along access routes to locate greywater infrastructure;
- ✓ Survey the difference in elevation from the house finished floor level to the drainage or greywater treatment system (for treatment systems that require gravity head to operate);
- ✓ Scope the works (and space) required at household level for collection of greywater;
- ✓ Assess the ability to connect flows to a neighbourhood-level drainage system;
- ✓ Assess the local soil properties (infiltration capacity and soil structure), and the groundwater table and flood elevation level;
- ✓ Engage communities to understand community/household willingness, demand, and capacity to operate and maintain household-level biofilters.



Examples of household-level greywater treatment implemented in Batua (top) and Tamavua-i-Wai (right) projects. Greywater volumes affect the required size of the biofilters. Fiji greywater volumes are higher than in Makassar and are therefore larger to achieve the same detention time.

Component 6: Drainage

Flooding is a natural phenomenon that occurs when water overflows onto land that is normally dry. There are different types of flood events: those that occur from prolonged or intense rainfall (such as a river breaking in banks or large flows of water coming off the land) and those that occur from tidal or storm-driven coastal events (including storm surges).

Flooding can have severe impacts for the health and wellbeing of communities and the physical neighbourhood. In addition to physical safety from flood hazards, flooding introduces contaminated water from upstream communities. Informal settlements are generally located in areas of high flood risk such as along steep hillsides and in low lying flood plains and coastal areas and are exposed to increased frequency of flooding, in some cases on a weekly or monthly basis. Vulnerability to flooding is particularly increased where inappropriate, or inadequately maintained infrastructure, low-quality shelters, and lower resilience of the urban poor intertwine.

Drainage is the series of structures that transport water away from its source. Very flat terrain is difficult to drain causing water to pond becoming a breeding habitat for mosquitoes. Likewise steep terrain causes water to flow very fast, causing soil erosion, damaging buildings and increasing the likelihood of landslides. Drainage within informal settlements is highly variable, ranging from large concrete lined channels through to small, hand-dug channels and in some places non-existent. Grey-water and solid waste typically accumulates along these same drainage routes.

Water runoff and flooding patterns do not necessarily follow project boundaries and therefore a site may be impacted by upstream runoff and flooding that originates far away. It is important to investigate all sources of flooding to a site, including its likelihood of occurrence and the vulnerability and impact on the site's community. While severe flooding issues require a regional or watershed level response, localised interventions can help to reduce human exposure to floodwater and avoid damage to buildings and household assets.

Key considerations when developing a flood and drainage management strategy include:

- ✓ Developing a detailed understanding of existing stormwater catchment areas based on ground contour information obtained through drone or topographical survey and verified through site walkovers;
- ✓ Mapping the existing dimensions, levels and conditions of existing drainage systems and opportunities for retrofit and/or redesign, and existing site conditions and constraints such as the capacity and/or level of downstream drainage systems and geological conditions;
- ✓ Utilising data and community inputs to understand flood frequencies and depths from all sources of flooding. In data-poor environments this type of information is often unavailable and therefore evidence compiled from local knowledge and visual markers may form the basis for design;
- ✓ Understanding residents' knowledge of local flood history, impacts, coping strategies and construction techniques. In particular, consultation should include vulnerable groups that may be disproportionately impacted by flooding or poor drainage;
- ✓ Identifying opportunities to replace existing drainage with nature based systems such as swale, rain gardens and wetlands should be identified.



Stormwater flows and associated flooding patterns do not necessarily follow project boundaries. Therefore, it is important to investigate all sources of flooding to a site, including its likelihood of occurrence and the vulnerability and impact. Example from Makassar, Indonesia.

Component 7: Water supply

Access to safe drinking water – freshwater that is chemically and biologically safe for human consumption – is a key indicator of progress for many of the SDGs targets.

While urban populations are more likely to have access to a drinking water supply than rural populations, access has stagnated and large disparities are apparent between high- and low-income groups in urban areas.¹⁴ In rapidly growing cities, the combined effects of population growth, urbanisation and climate change lead to overwhelming of the city's existing system capacity for safe reticulated water supply. Piped water supply in informal settlements may be intermittent or unavailable, causing residents to rely on alternative sources which may not meet basic water standards for consumption. Intermittent water availability has been associated with lower microbial quality and a higher risk of waterborne disease; it also forces households to store water, which can introduce contamination.¹⁵

Multiple water sources play an important role in increasing the resilience of communities during periods of water scarcity and reducing household bills by reducing municipal water or bottled water usage. A WSC approach includes an assessment of a site's various water sources including availability, sustainability, long term viability and likely water quality. Interventions should ensure that water supply demands can continue to be met, even where existing water supply options are less favourable.

Assessment of potential options should include a fit for purpose water supply based on their quality and availability. Preference should be given to providing access to municipal water supply networks and increasing local rainwater harvesting capacity. In the absence of new alternatives (e.g. connection to reticulated supply), groundwater is often an important existing source that should be maintained and protected, even though it is a less desirable water source due to its potential low quality and environmental consequences of unsustainable extraction and consequently depletion of groundwater resources. Where drinking water quality standards are not intermittent or not met, localised water treatment systems should be investigated as part of the invention.

Demand management (i.e. encouraging households to reduce consumption and take energy efficiency measures) is becoming an increasingly important part of formal water suppliers' strategies to safeguard supply access into the future. In informal settlements where piped water supply is readily available, demand management should be considered as part of a holistic approach.

Key considerations when developing drinking water strategy include:

- ✓ Understanding existing water use patterns, costs, quality, and the burden associated with water-related activities (i.e. burden on women and girls);
- ✓ Identify existing barriers for connection to reticulated water supply and identify where access to the municipal water supply network is likely to become available in the future;
- ✓ Assessing a wide range of fit for purpose water source alternatives, including the requirements for point-of-use water disinfection;
- ✓ Securing feedback during co-design on the preference for household or family cluster scale interventions, particularly in relation to water supply sources and disinfection types;
- ✓ Promote and preserve a diversity of water supply sources, in line with best practices for increasing climate change resilience;
- ✓ Affordability of water sources and cost implications of connections to reticulated water supply;
- ✓ Providing rainwater tanks for rainwater harvesting (based on climate and demand) to improve water security;
- ✓ Ongoing operation and maintenance burden of proposed water treatment systems.



Rainwater tanks can provide buffer storage, reduce stormwater runoff, and increase water security, to complement reticulated supply.

Engaging community in water sampling and analysis can help build local capacity and understanding of water quality and its implications on health and environment.



Component 8: Open space and access

Open spaces and access are important community assets providing important spatial linkages within neighbourhoods and for social, cultural and economic activities.¹⁶

They are also important spaces for engineering infrastructure such as pipes, wetlands and drainage services. Formalisation of open spaces and accessways (by physical upgrading and land tenure regulation) can be of high priority among residents, particularly those living in high-density settlements where open space is limited, informal, and in many cases flood prone and polluted by solid waste and contaminated water. Open spaces and accessways such as streets and laneways carry significant social-cultural value for men, women and children. They can strengthen community cohesion and promote a sense of common identity. They are important places for children to play, and therefore where environment quality is poor, there is a high risk of exposure to pathogens.

The WSC approach recognises the social, economic, ecological or cultural functions associated with physical space and community's values and aspirations for these places. Through a co-design process, residents' inputs to identify positive and negative elements of their environment and visualize how these spaces can be re-created should be sought. New or upgraded infrastructure elements are marked out by residents in response to the existing use of space and the technical requirements of the infrastructure. Once elements have been located, the choice of details, materials and finishes can further enhance function, enjoyment, safety and urban amenity.

Improving urban services and amenities can lead to an increase in the population through inward migration to settlements; therefore, WSC infrastructure should be designed with sufficient capacity to accommodate anticipated future population growth.

Predictions on future population growth (how many and where) should be done together with community leaders and informal governing bodies, as they will be key in managing and controlling future growth.

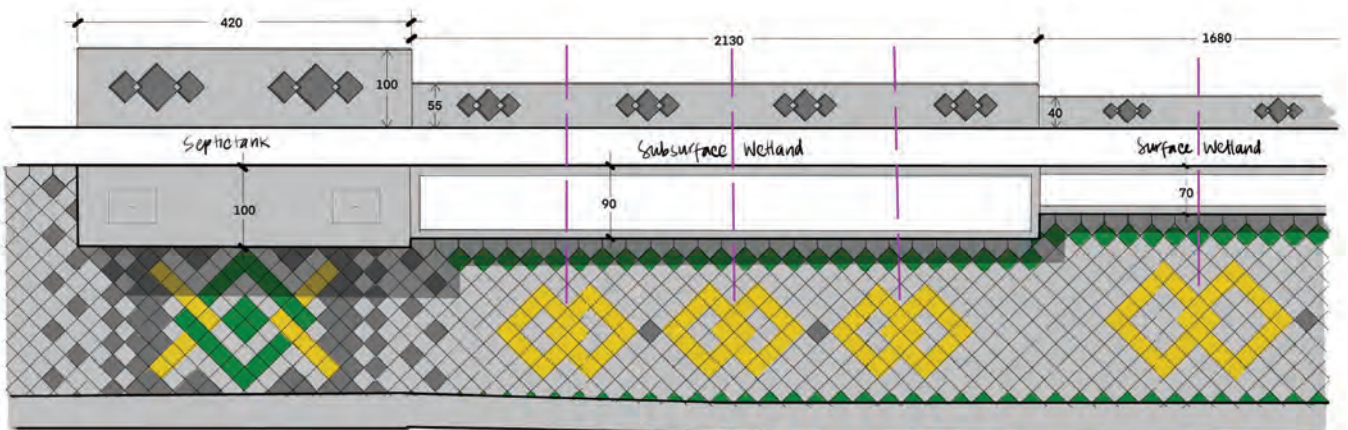
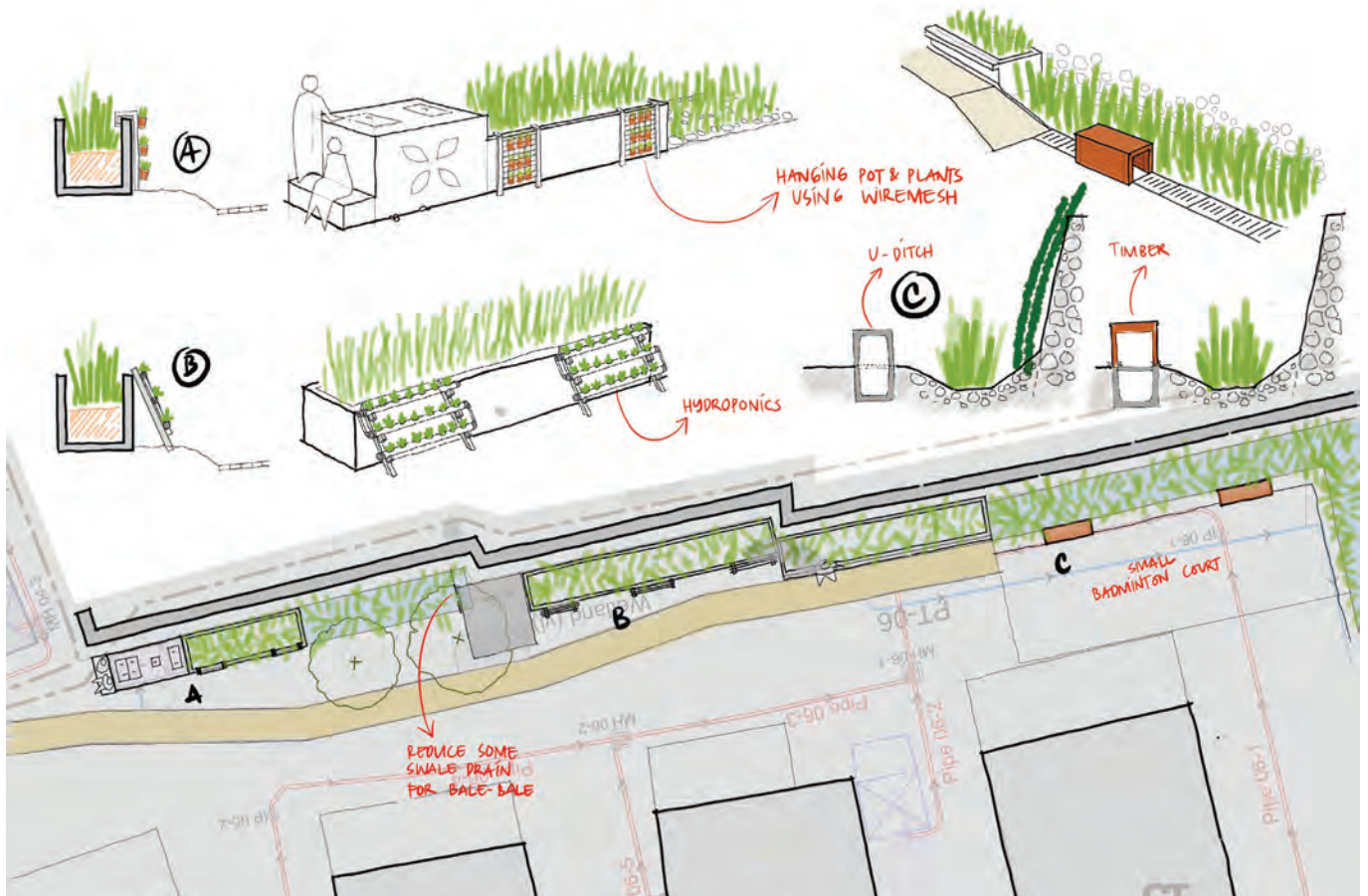
Key considerations when developing an open space and access strategy:

- ✓ With all residents and community members, undertake a detailed audit of existing space use, values and aspirations to feed into the design of the WSC intervention;
- ✓ Encourage increasing and formalising open space and accessways to improve mobility and urban amenity;
- ✓ Design for a diversity of space uses and functions, that can provide for the wide range of leisure, cultural and economic activities as well as the technical requirements of the infrastructure;
- ✓ The size and scale of infrastructure should be marked out with residents to help them easily visualise and decide how it can be best integrated into the existing spaces;
- ✓ Infrastructure elements should reference neighbourhood identities and support individual customisation, in order to generate a strong relationship between people and space;
- ✓ Design for projected expansion and growth (i.e. street networks that can be extended over time);
- ✓ Ensure materials, finishes and detail choices are durable and minimise ongoing maintenance burden for communities;
- ✓ Encourage appreciation of green infrastructure by showcasing its attractiveness and adaptability for open space design and potential co-benefits such as improved well-being and urban heat island cooling effects.



“Before RISE, this place was always flooded. We needed to ride on a bamboo raft to go out, for which everyone had to pay. I’m so happy. With the RISE project, we can now walk easily”.

Ibu Suneti, RISE Community Engagement Council member, Makassar, Indonesia.



A WSC approach aims to integrate the engineering infrastructure with open space and access, as well as contribute to local identity and sense of place. Example from Makassar, Indonesia.

Component 9: Operations and maintenance

As with any informal settlement upgrading intervention, operations and maintenance (O&M) is a crucial aspect that needs to be designed into upgrading programs and projects from the beginning to ensure their local institutionalisation and sustainability.

History has shown that many water supply and sanitation projects have failed prematurely due to poor service levels soon after construction. Operation and maintenance is crucial to deliver continued health and environmental benefits to the community.

The WSC upgrading approach presents unique challenges in terms of the governance requirements for O&M, as well as the technical operational requirements for the WSC treatment train components, notably the pressure sewer system and wetlands. Their installation in cities in developing countries presents additional challenges regarding technology transfer given that these systems are new to such contexts and local capacities for decentralised systems need to be nurtured and developed over time. Furthermore, O&M requirements may change overtime (i.e. due to seasonality or population growth and inward-migration to settlements). At the end of a rainy season or heavy storm, minor repairs may also be needed to repair damage or to ensure the system is working properly. Clear asset ownership (roles and responsibilities) are crucial as is sustainable finance for O&M within government budgets.

Key considerations when developing O&M strategy include:

- ✓ Integrate O&M into the design of WSC programs and projects from their inception, rather than see O&M as something to be agreed upon during infrastructure completion/handover;
- ✓ Include structured training and capacity development activities into programs and projects to build local human and institutional capacity and capability for WSC technologies;
- ✓ Institutionalise O&M within formal and informal governance structures at the right level (i.e. communities can do some elements, and the more technical and expensive elements should be the responsibility of formal authorities with the requisite expertise);
- ✓ Ensure the right stakeholders are engaged and involved in co-developing a common understanding of the required capacities and skills to effectively deliver the O&M activities;
- ✓ Formalise handover of infrastructure upon completion and integrate it with other city water, sanitation, and public assets and infrastructure registries;
- ✓ Ensure an operating budget line item is allocated in future budgets of the responsible authorities for O&M expenditures.

Building local capacity, facilitating technology transfer, and institutionalising WSC programs and projects into local government systems is crucial for ongoing operation and maintenance.



Component 10: Climate change resilience

The urban poor living in informal settlements stand to suffer most from some of the impacts of climate change. Informal settlements are more vulnerable to the impacts of climate change due to their limited access to formal services, utilities and infrastructure, low lying conditions, existing and protracted service deficiencies and vulnerabilities, and limited coping capacity.¹⁷

Climate change hazards facing informal settlement residents include higher and increasing average temperatures, increasing rainfall intensities, reduced potable water availability, sea level rise, and increasing extreme weather events, and a deterioration of ecosystem services. Upgrading interventions, therefore, need to design in resilience to climate change effects.

The WSC approach offers potential to mitigate and adapt to the major threat of climate change by: (i) supporting a diversity of water supply sources within communities; (ii) providing disinfection technology that allows all water sources to be used for a greater number of end uses, including potable demand; (iii) providing treated wastewater as an alternative water source, especially for non-potable use; (iv) providing raised pathways to reduce flood depths in trafficable areas; (v) reducing reliance on

stressed groundwater resources; and (vi) reducing the associated contamination of flood waters by treating wastewater prior to discharge into the environment.

Beyond the physical interventions, which strengthen resilience, other measures in the WSC approach also strengthen resilience, especially those related to community cohesion, communication, and leadership. These are also crucial elements that help communities respond to disaster events and climate change impacts.

Key climate change resilience considerations include:

- ✓ Assessing the likely impact of climate change impacts on a project settlement (i.e. rising sea levels) and tailoring the design as best possible for adaptation and/or mitigation;
- ✓ Building community understanding of climate change and its potential local and regional impacts;
- ✓ Increasing water supply diversity, reliability and quality, including potentials for treated wastewater for non-potable uses;
- ✓ Improving the drainage system in line with projected risks of future flooding because of predicted sea level rise;
- ✓ Designing to reduce the urban heat island effect through increasing urban greenery to improve public amenity, liveability and the potential for heat stress, and improve urban biodiversity.



The smart pressure sewer technology helps build climate resilience by enabling wastewater flows to be moderated based on climatic events and extremes, notably peak rainfall and flooding events



Sea level rise is a critical issue for many informal settlements and needs to be accommodated in the design of WSC upgrading projects

4. The Dos and Don'ts of water-sensitive upgrading

	Do	Don't
Component 1: Co-design	<ul style="list-style-type: none"> ✓ Involve all members of the community in decision-making. ✓ Ensure that the needs and abilities of marginalised groups are recognised in the design of an engagement process. ✓ Include all stakeholders: government, industry, community members, women's groups, etc. ✓ Build on existing groups and networks. 	<ul style="list-style-type: none"> ✗ Undertake token 'consulting' workshops to get a community to endorse previously-decided plans. ✗ Only speak with the vocal members of a community and/or those who hold formal positions of authority. ✗ Ignore existing efforts and community organisations operating. ✗ Rush or ignore complexity or conflict.
Component 2: Land tenure	<ul style="list-style-type: none"> ✓ Recognise the variety of land tenure types that exist and the need to be flexible with infrastructure locations. ✓ Ensure that any land donations for infrastructure are voluntary and the poorest are not disproportionately affected. ✓ Seek to strengthen land tenure and property rights through the upgrading process. 	<ul style="list-style-type: none"> ✗ Focus on formal land titles; they are only one tenure modality among many. ✗ Force residents to utilise their land and productive/ livelihood assets against their will for WSC infrastructure. ✗ Ignore the important economic and livelihood dimensions of land and property in informal settlements.
Component 3: Stakeholders and partnerships	<ul style="list-style-type: none"> ✓ Ensure stakeholders responsible for O&M are involved from the start, not included once the projects are ready for handover. ✓ Recognise the range of skills and capabilities needed: engineering, urban design, planning, social sciences, and project management. ✓ Build mission-based partnerships and coalitions for innovation. 	<ul style="list-style-type: none"> ✗ Don't keep stakeholders apart or only within their sectors/silos, encourage cross-fertilisation and collaboration. ✗ Include stakeholders in a transactional manner, only consulting them for sign-off. ✗ Create competition for project resources or for political gain.

The Dos and Don'ts of WSC upgrading continued

Component 4: Blackwater	<ul style="list-style-type: none"> ✓ Connect to a formal centralised system if available and possible. ✓ If not, utilise a nature-based treatment train to safely collect, treat and discharge blackwater. ✓ Prioritise gravity flow where possible, otherwise use pressure sewer and 'pump once'. ✓ Ensure all households are connected to safe sanitation, which may require toilet renovations or wet pods. ✓ Understand cultural norms and sensitivities related to wastewater management 	<ul style="list-style-type: none"> ✗ Don't ignore opportunities for complementary solutions by connecting to the centralised sewer system. ✗ Ignore the household-level toilet conditions and behaviour, which impact human health and exposure pathways. ✗ Ignore existing social and family relationships in establishing the servicing (wastewater treatment) 'clusters'.
Component 5: Greywater	<ul style="list-style-type: none"> ✓ Treat greywater together with blackwater where possible. ✓ If not, treat greywater close to its source (i.e. household-level biofilters or along drainage lines). ✓ At a minimum, ensure primary treatment to remove oil, grease and grit before discharge. 	<ul style="list-style-type: none"> ✗ Don't design without a detailed understanding of existing and projected greywater discharge rates based on local consumption patterns. ✗ Don't implement biofilters if the community/household are not willing to operate and maintain them.
Component 6: Drainage	<ul style="list-style-type: none"> ✓ Undertake detailed stormwater and flood assessments at catchment, precinct and settlement level. ✓ Utilise residents' knowledge of historic and recent flood events. ✓ Utilise nature-based systems such as swales, rain gardens and wetlands to treat stormwater runoff. 	<ul style="list-style-type: none"> ✗ Don't ignore relevant catchment level stakeholders where interventions may be needed (e.g. upstream drainage). ✗ In a data poor environment, don't wait for 'perfect' flood modelling data to design with. ✗ Exacerbate flooding and contamination in downstream areas.

The Dos and Don'ts of WSC upgrading continued

Component 7: Water supply

- ✓ Understand existing water use patterns, costs, quality.
 - ✓ Connect to safe reticulated supply where available and affordable.
 - ✓ Improve water diversity and affordability.
 - ✓ Reduce unsustainable extraction of groundwater sources.
 - ✓ Promote fit-for-purpose water use and demand management.
- ✗ Don't rely on single-source solutions.
 - ✗ Don't ignore existing water practices and the affordability and gender-burden of potential options.
 - ✗ Don't ignore potential connections to reticulated supply; design for future connections.

Component 8: Open space and access

- ✓ Design to ensure comprehensive upgrading, including streets and accessways to improve urban liveability.
 - ✓ Align WSC infrastructure to achieve multiple co-benefits.
 - ✓ Seek to expand/increase open space and street network to improve mobility and access.
- ✗ Don't design purely technical engineering projects without consideration of urban conditions and livability.
 - ✗ Don't ignore the important social and cultural aspects of space use.
 - ✗ Don't ignore the gender dimensions of open space use and function.

Component 9: Operations and Maintenance

- ✓ Design O&M into the program and projects from the beginning.
 - ✓ Build local human and institutional capacity for ongoing O&M.
 - ✓ Ensure financing for O&M costs is available and sustainable.
 - ✓ Educate community about the infrastructure below the accessways (pipes, etc.) to avoid overloading (e.g. trucks).
- ✗ Don't burden communities with complex O&M requirements and costs.
 - ✗ Don't complete construction before O&M roles are agreed.
 - ✗ Assume that the infrastructure will 'look after itself' once built.

Component 10: Climate resilience

- ✓ Utilise evidence of projected climate change impacts to design a climate-resilient upgrading plan.
 - ✓ Strengthen long-term water security, access and affordability.
 - ✓ Build community understanding on climate change and potential impacts.
- ✗ Don't design an intervention that does not account for long-term projected impacts (e.g. rising sea levels).
 - ✗ Don't exacerbate urban heat island effects and continued extraction of precious groundwater.

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