

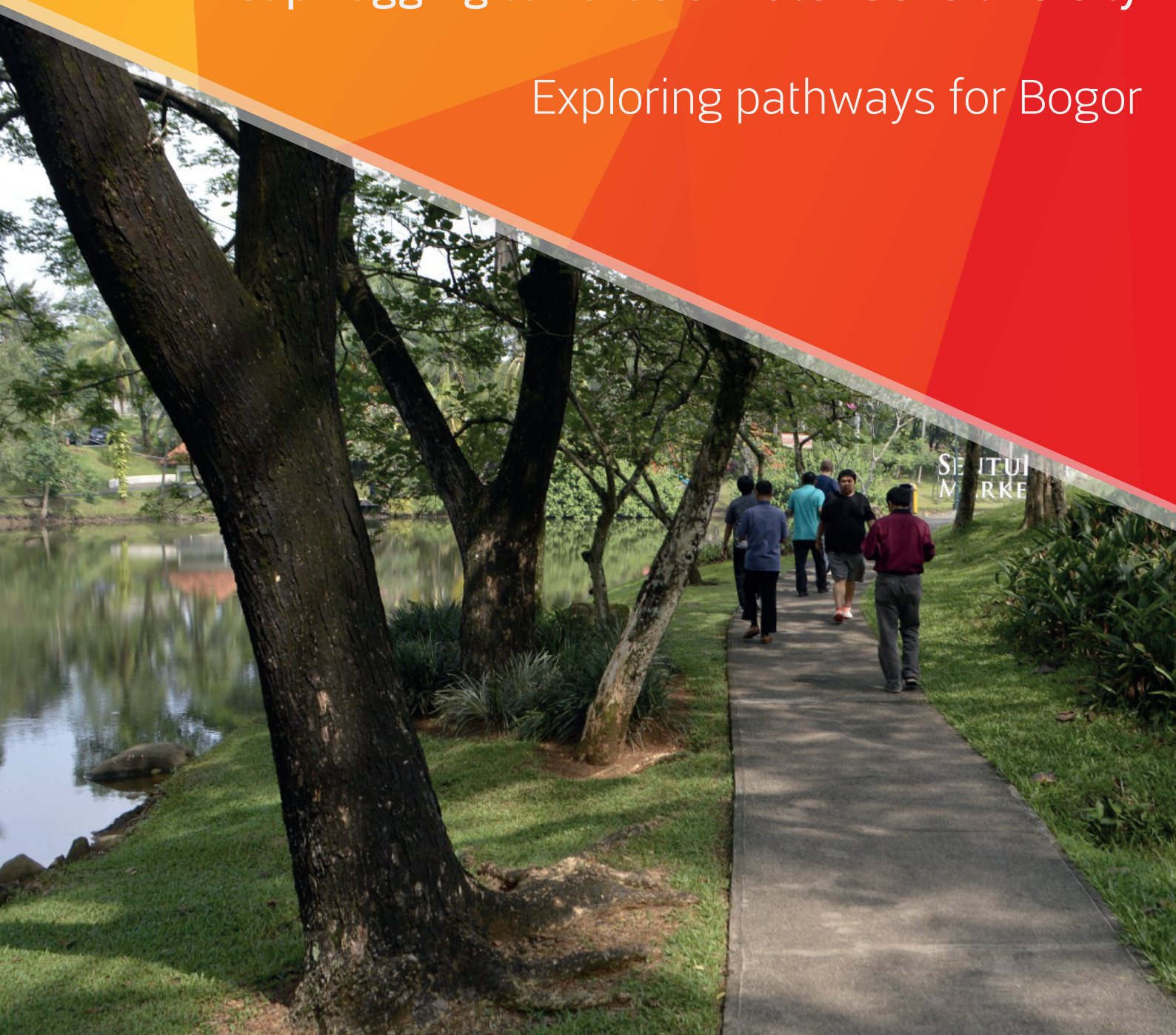


The
Australia-Indonesia
Centre

URBAN WATER
RESEARCH
CLUSTER

Leapfrogging towards a Water Sensitive City

Exploring pathways for Bogor



MONASH
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About the Australia-Indonesia Centre

The Australia-Indonesia Centre is supported through federal funding from Australia's Department of Education and Training and Department of Foreign Affairs and Trade, with the support of Indonesia's Ministry for Research, Technology and Higher Education (RISTEK-DIKTI).

The Centre, hosted by Monash University, is a collaboration between Monash University, the Australian National University, The University of Melbourne and The University of Sydney, working with seven leading Indonesian universities.

The Indonesian academic institutions are Institut Pertanian Bogor, Institut Teknologi Bandung, Institut Teknologi Sepuluh Nopember, Universitas Airlangga, Universitas Gadjah Mada, Universitas Hasanuddin, and Universitas Indonesia.

Valued corporate partners include the Pratt Foundation, PwC, and ANZ.

The Australia-Indonesia Centre has three Core Objectives set in consultation with the Australian Government:

RESEARCH: Pursuing solutions to shared national challenges in areas such as Energy, Infrastructure, Health, Urban Water, and Food & Agriculture via highly collaborative research.

LEADERSHIP: Strengthening and deepening Australia-Indonesia networks, developing leadership skills and fostering the exchange of knowledge.

INSIGHT: Promoting greater understanding and cultural awareness – Australians of Indonesia, and Indonesians of Australia.

About the Urban Water Cluster

The Australia-Indonesia Centre Urban Water Cluster research project is a transdisciplinary research collaboration between Monash University, Institut Pertanian Bogor (IPB) and Universitas Indonesia (UI) that has been addressing the social, political and biophysical aspects of the water system in Greater Bogor throughout 2017-2018.

Through the establishment of an Urban Water Learning Alliance, the research partners have worked with key water sector stakeholders in Kota Bogor and Kabupaten Bogor, to understand local knowledge of the urban water system and to build capacity in the concept of a water sensitive city (WSC) and its role of water in building resilient and liveable cities of the future.

Through these collaborations the Cluster has developed a deep insight into the pathways available to Greater Bogor to leapfrog to a more sustainable and water sensitive future city. The research outputs are a resource for Bogor to inform and guide city and regional development in

sustainable water practices and also deliver general insights for leapfrogging towards a Water Sensitive City (WSC) in other Indonesian cities more broadly.

The Urban Water Cluster has also funded two smaller tactical projects;

- » a collaboration between Australia National University (ANU) and UI addressing the socio-economic impacts of Flooding in Jakarta, and
- » a collaboration between The University of Melbourne (UoM) and Institut Teknologi Sepuluh Nopember (ITS) that has developed a new regulatory approach to ensuring potable water quality and pollution control in Surabaya.

Researchers of these partnerships are sharing key insights from Jakarta and Surabaya contributing to the broader Learning Alliance in Greater Bogor.

Our Research Aims

Specific objectives of the AIC Urban Water research collaboration include:

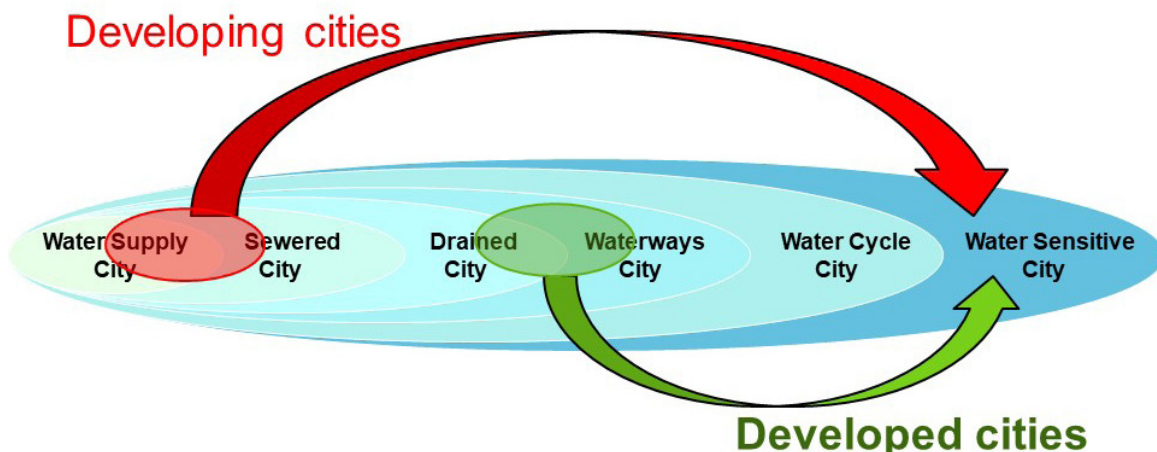
- » Applying a **benchmarking** framework to assess the current water sensitivity of Bogor and identify its leapfrogging needs and opportunities
- » Identifying social and institutional structures and processes for creating **governance** conditions that enable Bogor to advance its WSC transition
- » Examining broad infrastructure adaptations, using **modelling** and other tools, to address Bogor's geophysical, urbanisation and societal challenges
- » Exploring the role of **green infrastructure** as affordable systems for treating and recycling wastewater and stormwater in Bogor
- » Demonstrating the potential of WSC approaches through water sensitive urban design (WSUD) innovation focused on four **case study sites** that reflect a range of development types in Bogor
- » Developing an active **urban water learning alliance** involving stakeholders from universities, government, industry, business and community.
- » Integrating the key insights gained from across all disciplines into a **Leapfrogging Strategy** that defines the road map for Greater Bogor to transition towards a water sensitive future

Our Research Program in Bogor Raya

The Urban Water Cluster has applied a WSC framework to Greater Bogor, at city and neighbourhood levels, to substantiate and facilitate its sustainable water aspirations. The WSC approach embraces cross-cutting and integrated solutions that deliver multiple benefits such as healthy environments, secure water resources and connected communities. This is expected to provide a strong foundation for tackling the multidimensional challenges required of Indonesia's commitment to the Sustainable Development Goals (SDGs).

Our research is founded on the concept that a city moves through a range of water systems in its journey towards a WSC, and that it is possible to 'Leapfrog' from early stages of urban water development to a WSC.

Leapfrogging is a phenomenon in which less-developed cities — whose socio-technical systems are not yet fully-established — can adopt more advanced approaches to address pressing sustainability issues. Leapfrogging to a WSC may help Greater Bogor avoid features of water servicing models seen in developed cities that have proved unsustainable, and instead adopt more integrated and sustainable water technologies and practices that are based on WSC principles.



To leapfrog towards a WSC requires change in key spheres of operation such as system design and planning, professional practice, technological solutions and community behaviour. Both technical innovation and social and institutional restructuring are needed to overcome entrenched unsustainability.

Our research collaboration has drawn on a range of disciplines and methodological approaches to develop guidance on how leapfrogging pathways can be driven across each of the spheres of operation. To understanding local

context and knowledge, the cluster has also established a Learning Alliance with over 400 local participants from with government, industry, academia, media and community, and delivered 66 days of engagement with over 400 local participants including site visits, workshops, focus group discussions, interviews and masterclasses.

A Vision of Bogor as a Water Sensitive City in 2045

Greater Bogor, like most Indonesian cities, is experiencing rapid growth. The increased pressure on essential services as a result has been further complicated by the impacts of climate change. In recent years, Bogor has demonstrated environmental commitment by pursuing green agendas, and has now embraced a vision of transition towards holistic and sustainable approaches to urban water management.

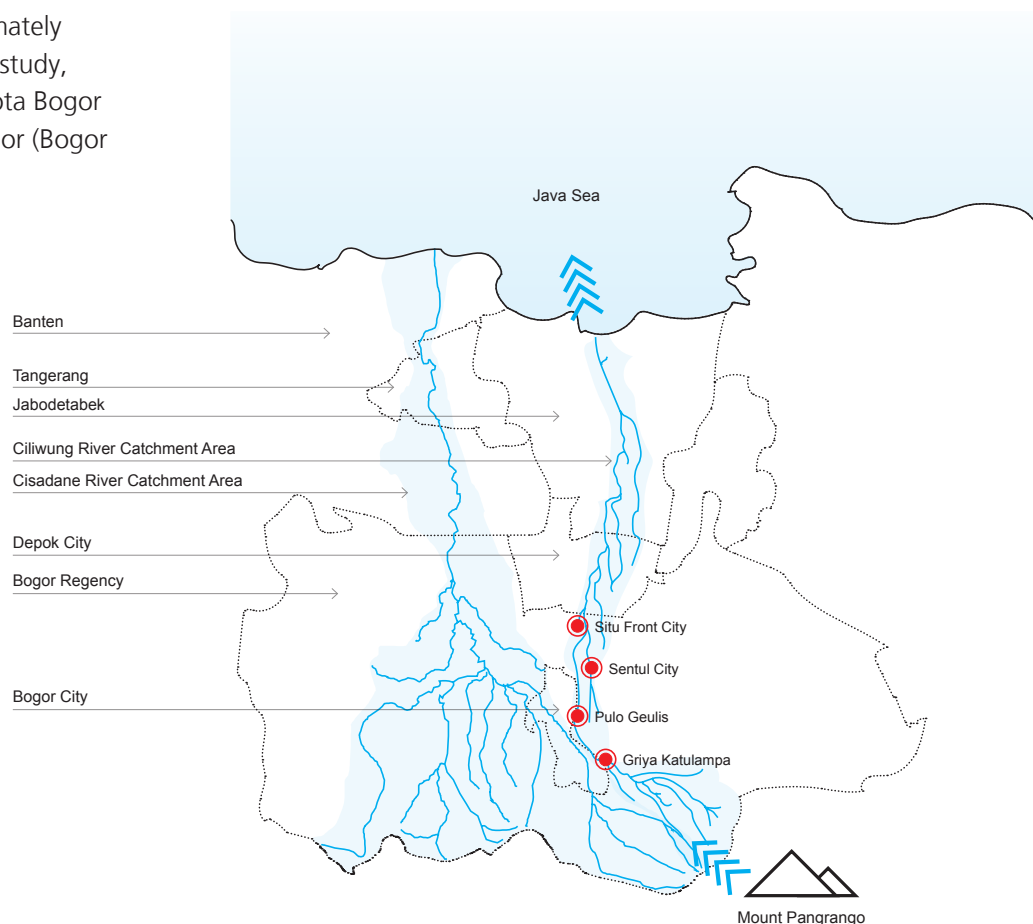
In 2045, Indonesia will celebrate a century of independence; an important moment for the country to reflect and celebrate its developmental achievements. Setting the ambition for Greater Bogor to become a Water Sensitive City (WSC) in this timeframe creates a powerful drive to rapidly transform water management technologies and practices.

Imagine a water sensitive Bogor in 2045, in which:

- » People are healthy, enjoying safe, secure and affordable water supply and sanitation
- » Urban environments are thriving, supported by clean waterways and high biodiversity
- » Rainwater, wastewater and stormwater is captured and treated to augment water supplies
- » People and property are safe from flooding and landslides, both locally and downstream, including in Jakarta
- » Water system services are resilient to challenging and extreme climate conditions and urbanisation
- » Green space makes urban areas attractive and reduces the impacts of extreme heat
- » Economic productivity is driven by innovative water systems that use resources efficiently
- » Communities connect with each other and their local environments as active water stewards
- » Water decisions are made through collaborative, inclusive and transparent processes
- » Urban development reflects local cultural character and drives sustainable urban water practices across the catchment
- » Water governance arrangements promote shared responsibility across government, universities, private sector, civil society, and community members

Greater Bogor

The Greater Bogor metropolitan area is located in West Java, approximately 60 km south of Jakarta. For this study, 'Greater Bogor' encompasses Kota Bogor (Bogor City) and Kabupaten Bogor (Bogor Regency).



Greater Bogor's city water supply and sanitation services rank highest amongst local government areas across Indonesia but there remains a number of urban water related issues. For example, Bogor experiences localised flooding during heavy rain events and has areas of informal settlements that are built on highly vulnerable land, with issues of poor sanitation, low availability of clean water and the associated health impacts.

Several rivers flow from the south towards the north through Bogor, before terminating entering at the Bay of Jakarta. These fulfil many functions, such as drinking water supply, irrigation water, fish production and drainage. The two largest rivers are the Ciliwung and the Cisadane rivers which run next to the historic centre of Bogor. Both rivers have had their water quality and flow impacted by land use changes in their catchment areas as a result of population growth and urbanisation.

There are also numerous *situ* (artificial and natural lakes) across Greater Bogor, including several in Bogor City and 95 across Bogor Regency. These *situ* are important for irrigation and water retention purposes, as well as for recreation.

City level Research

The Urban Water Cluster research program has selected Bogor City and Bogor Regency in the Ciliwung catchment to explore their potential to leapfrog to a water sensitive

future through socio-political and biophysical pathways.

By benchmarking diagnosing the water challenges and opportunities of Greater Bogor against other developed cities, the research aims to understand the current state of the water system and develop guideancelines for moving Greater Bogor towards a water sensitive future.

Neighbourhood Level Research

At the neighbourhood level, the research program looks at four sites in Greater Bogor located within the Ciliwung River catchment area, Pulo Geulis, Griya Katulampa, Cibinong Situ Front City and Sentul City. These sites reflect a range of spatial, social and economic conditions within the broader city and provide a comprehensive assessment of the different ways in which a city can develop and transform over time, especially in developing countries.

Research Publications

The Urban Water Cluster suite of nine research reports aim to guide the Cities and Neighbourhoods within Greater Bogor to leapfrog towards a WSC. These reports present the key insights of our multidisciplinary research program and are built on a foundation of our partners research in Indonesia and Australia over many years.

The UWC Research reports are structured to cover each of the research aims, and include:

1. "Benchmarking Bogor's Water Sensitive performance"
2. "Governance for a Water Sensitive Transition in Bogor Raya"
3. "Review of the application of green infrastructure for water management in Bogor"
4. "Guidance on developing infrastructure adaptation scenarios for Bogors water sensitive transition"
5. "Pulo Geulis Revitalisation 2045"
6. "Griya Katulampa: Lessons Learned"
7. "Cibinong Situ Front City: Transition to WSC 2045"
8. "Sentul City: Lessons Learned"
9. "Leapfrogging pathways for a water sensitive Bogor"

All reports will be available online in 2019.

This booklet aims to present the key insights and recommendations of each report. For more detail please refer to the full reports.



About the Urban Water Learning Alliance

Established in 2017, the AIC Urban Water Learning Alliance is a network of leaders, thinkers and practitioners across academia, government, industry, donors, NGOs, social enterprises and communities, who are involved in water and water infrastructure research, policy, supply, design, planning, construction and also community programs.

The aims of the Learning Alliance are:

- » To provide governance of and strategic direction for the Urban Water Cluster research collaboration through the Urban Water Advisory Board.
- » To inform the development of the WSC tools, guidelines and pathways for Greater Bogor, by
 - » sharing local experience, expertise and organisational settings relevant to urban water management practice in Bogor
 - » evaluating the lessons learned from the integrated urban water management practices in Australia
 - » understanding the complexities of different neighbourhood typologies and associated impact on city level development strategies
- » To engage with government agencies to inform Greater Bogor city development plans and integrate research recommendations
- » To provide a platform beyond the research collaboration, for stakeholders to develop a shared vision, build capacity and leverage resources to leapfrog traditional, capital intensive solutions

To achieve this, the Learning Alliance has delivered 66 days of network engagements and events, including masterclasses, focus group discussions, co-design workshops, community visioning workshops and interviews, and represents the contribution of over 400 participants.

While the Learning Alliance is predominantly focused on developing pathways to transition Bogor towards a water sensitive future, it recognises that insights developed in Bogor may also inform the development of other cities in Indonesia.

In its first years, the Learning Alliance was designed and set-up by the AIC Urban Water Cluster.

Beyond 2019, it is envisaged that the Learning Alliance will evolve into a 'Water Forum' that supports city and catchment water governance frameworks, and expands to include cities of Depok and Jakarta within the Ciliwung catchment.

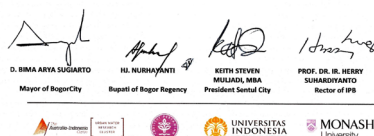
Deklarasi Water Sensitive City / Kota Ramah Air

Kami, mewakili Kota Bogor, Kabupaten Bogor dan Sentul City, menyatakan komitmen untuk mendukung:

- 1) Pembentukan aliansi pengetahuan air perkotaan dan
- 2) Kegiatan para *Water Champions* dalam menciptakan jalur untuk lompatan menuju *Water Sensitive City*

ditandatangani

Pada 30 November 2017 di Grand Savero Hotel Bogor



The Urban Water Cluster Learning Alliance was launched in Bogor on 30 Nov 2017 at Grand Savero Hotel and was attended by 82 stakeholders from local government, industry, community leaders and academia. Keynote speakers emphasised the different perspectives of government, academia and industry and their individual water agendas, and set the scene for inter-country collaboration, defining the local context and envisioning future city development. The Learning Alliance was formalised by the signing of a Declaration of Water Sensitive Cities pledging the commitment of government, industry, community and academia to establishing the Learning Alliance and supporting the activities of Water Champions in creating pathways to leapfrogging to WSC.

Recognising the cross-sectoral commitment and raising the profile of Water Champion aims to build momentum for a shift to a new paradigm of water management and places advocates of WSC at different levels within organisations and institutes.



Benchmarking Greater Bogor's Water Sensitive performance

Water Sensitive Cities Index

As cities seek to adopt a water sensitive approach, they often need a better understanding of their current system and how it compares to best practice. This will help establish their short and long-term priorities for achieving their sustainability goals.

The Greater Bogor region of Indonesia has been benchmarked and profiled as part of The Australia-Indonesia Centre's Urban Water Cluster (UWC). Greater Bogor was benchmarked against water sensitive city performance standards using a new tool developed for this purpose – the Water Sensitive Cities (WSC) Index.

Benchmarking approach

The WSC Index was developed by the Australian Government's Cooperative Research Centre (CRC) for Water Sensitive Cities with a holistic and integrated approach to water system benchmarking.

The WSC Index measures performance against 34 indicators reflecting WSC attributes that support a city's resilience, liveability, productivity or sustainability. These indicators are organised under 7 thematic goals to help compartmentalise the scoring process.

Scoring involves engagement with key sectoral stakeholders, expert judgement and evaluation of evidence to determine a score out of 5 for each indicator.

Benchmarking using the WSC Index not only generates important insights into Greater Bogor's water system, but also ways the WSC Index itself can be refined for developing economies.

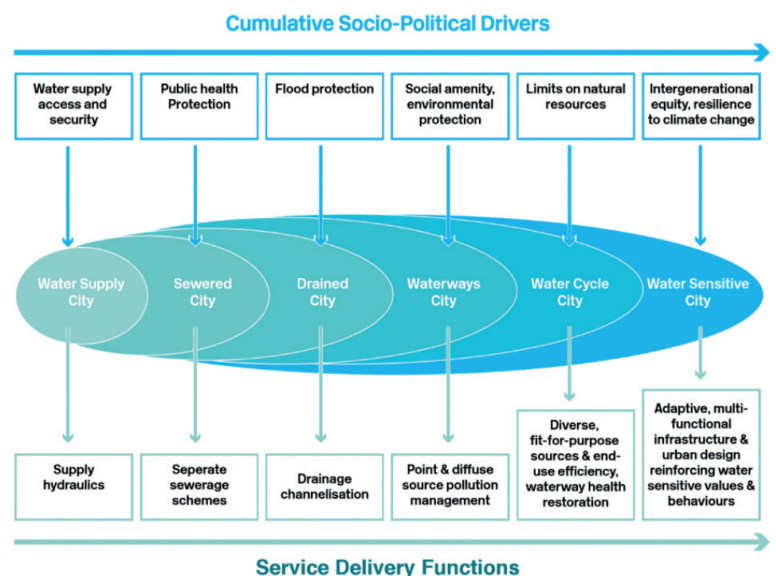


Fig. 1 Six stages of Urban water management (Brown, Keith and Wong 2009)



Fig. 2 Participants scoring Greater Bogor WS stage at workshop in November 2017

CRC WSC Index results for Greater Bogor

The following figure summarises the performance of Greater Bogor, averaged across the indicators for each of the 7 goals of a WSC. The average scores are relatively even for the goals, mostly in the range of 2.4–2.8. The highest average goal score was for **Increase community capital (2.7)** and the lowest was for **Ensure quality urban space (2)**. A brief rationale for these indicators' scores is provided here.

Fig. 3 7 Goals of a WSC

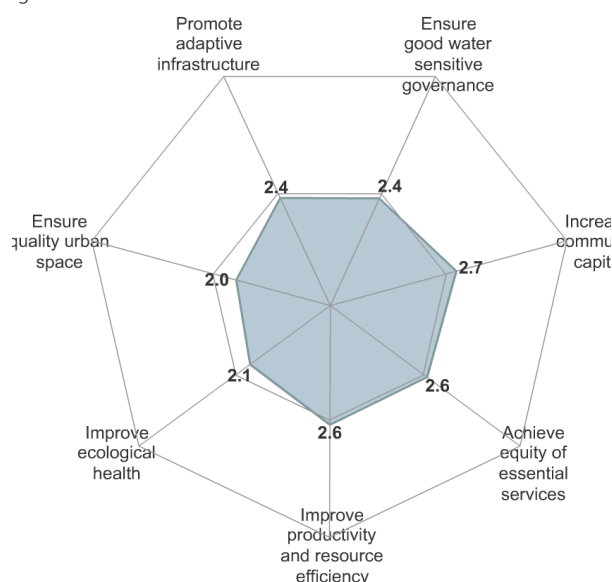


Image credit: CRC for Water Sensitive Cities

Increase community capital (2.7 out of 5)

There is increasing community participation in water-related education activities. Environmental education is institutionalised at different levels of schooling. Some parts of the community in Bogor have strong connections with their local waterbodies and environments, such as residents of Pulo Guelis, which lies between two river streams, or of Griya Katulampa, which relies on locally sourced groundwater. There is a high level of community management of water assets such as wells and wastewater distribution systems, though there are gaps in responsibility for resource management and maintenance that have affected groundwater supplies in the city.

Disaster response is generally well planned and coordinated. Social media and other messenger services strengthen community responses to disaster as they are used to share information about imminent events or to assist in disaster responses. Some agencies facilitate flood preparation and mitigation, including large-scale community operated rainwater infiltration wells. Public awareness of disaster response plans should be increased.

Ensure quality urban space (2.0 out of 5)

Pleasant urban green space is scattered throughout the city, but is difficult to access and not well-connected. There is policy to improve connectivity and accessibility, centred on the botanical gardens. There has been some implementation of green infrastructure, though overall only a small proportion of urban space functions as an integral part of the water system.

Focus on Bogor: The Urban Water Transitions Framework

The indicators of the WSC Index are mapped to six states of water system performance (see Fig. 2), reflecting the Urban Water Transitions Framework. Cities achieve certain performance markers associated with the priorities of the six developmental states of the Urban Water Transitions Framework as they journey towards a water sensitive city. This transition journey is not necessarily linear, as a city may show indicators of later developmental states (e.g. waterways, water cycle and water sensitive city) while not fully satisfying earlier states (e.g. water supply, sewerage and drained city).

Fig. 4 summarises the benchmarking results for Greater Bogor analysed and measured against progress represented by the city-states.

Fig. 4 Assessment by Urban Water Transitions Framework developmental state

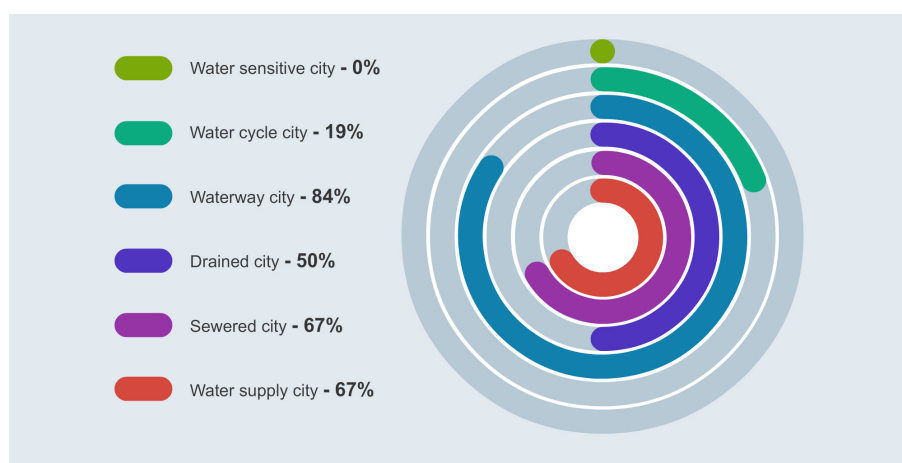


Image credit: CRC for Water Sensitive Cities

Most cities begin their progression to a water sensitive city by achieving high levels of equity in access to safe and secure water supplies and safe sanitation. For Bogor to leapfrog to a water sensitive city, its challenge is to invest in water infrastructure and institutions that will not only meet basic water supply and sanitation needs, but also deliver broader benefits. These include ecosystem protection and restoration, security of supply, flood control, public health, amenity, liveability and economic sustainability, among others.



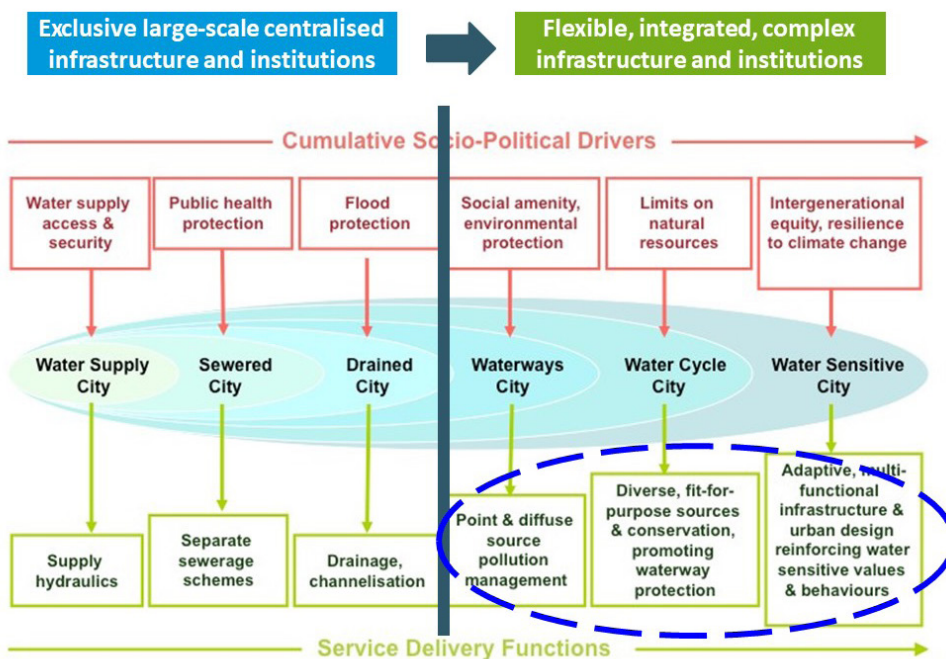
Governance For a Water Sensitive Transition in Bogor

Transforming urban water practices to more sustainable systems is widely regarded as a water governance challenge, which involves working within and across the different social, political and economic frameworks where urban water management takes place. Achieving a Water Sensitive City requires a rethink in the way urban water governance is conceived of and delivered – moving beyond traditional single-service delivery models, to incorporate more flexible, integrated and complex institutional designs to respond to and accommodate multi-functional and adaptive infrastructures.

As a result, broad urban water governance transitions involve conceptualising change as a coordinated, multi-staged set of processes. To work towards a common vision, in this case a water sensitive Bogor in 2045, those processes must involve engaging:

- » with multiple actors
- » across multiple scales (e.g. local and catchment), and
- » across multiple sectors (e.g. planning, environment, health, agricultural, urban design, among others).

Governance in a water sensitive city would involve establishing core structures (e.g. regulatory and policy frameworks) and processes (e.g. leadership and facilitated platforms for interaction). These can be used to guide and steer the formal and informal engagement and cooperation among government and non-government actors involved in implementation, service delivery partnerships and/or research collaborations.



Our governance research

To generate guidance for future water governance reforms the UWC's governance research team examined the historical and contemporary governance structures and processes of urban water systems in Greater Bogor. This involved a series of focus group discussions and research interviews with key urban decision-makers to gain insight into the current water system structure and into how the system works, to identify opportunities to improve current interventions.

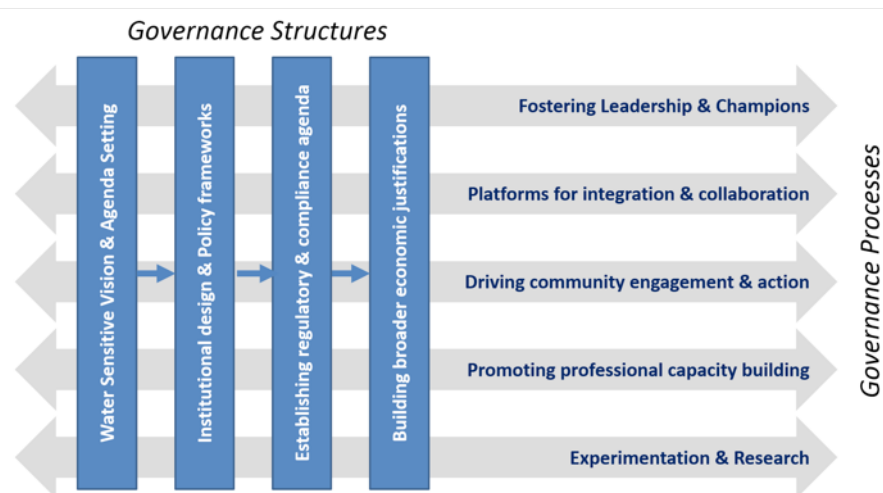
The Transition Dynamics Framework was used to guide group discussions and interviews to unpack the key structures and processes at play. This is a useful approach when examining contemporary practices while also identifying structural, agency and learning opportunities for future governance interventions.

Transition Dynamics Framework: domains of change¹

	Actors	Bridges	Knowledge	Projects	Tools
Domain of change	Key networks of individuals (vertically and horizontally) Engage both leaders and practice champions Support multiple networks including technical, policy and multi-agency networks	(semi) formalised organisations, structures and processes for coordination and alignment Aim to bring science, industry, policy and capacity building efforts together. Foster social capital	Conduct research into the physical and social sciences to generate localised, contextualised knowledge to inform decision-making. Translate to capacity building efforts	Generate multiple experiments (at varying scales) to build technical feasibility and confidence. Frame experiments as dedicated learning opportunities Generate profile and connect to science	Generate, disseminate and train practitioners on best-practice guidelines (e.g. engaging with community, co-design, flood modelling, etc.) Create legislative amendments, appropriate regulatory modes

¹Modified from Brown, R., Farrelly, M.A. and Loorbach, D. (2013) Actors working the institutions in Sustainability Transitions: The Case of Melbourne's Stormwater Management, Global Environmental Change 23(4), pp. 701-718; Brown, R., Rogers, B.C., and 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.

Working towards achieving 'water sensitive' governance



Adapted from: Farrelly, M.A., Brown, R.R and Rijke, J. (2012) Exploring operational attributes of governance for change. Proceedings of the 7th International Water Sensitive Urban Design Conference, February 21-23 2012 Melbourne, Australia

Urban water governance in Indonesia is complex and traditionally fragmented on a number of levels: bureaucratically, socially, politically and spatially. Combined, this poses significant challenges to key institutional structures and dynamics. Furthermore, it is important to recognise that there is no one-size-fits-all approach to governance or institutional design, rather these need to relate to the relevant social, environmental and development contexts.

The recommendations outlined here (and further developed in the full report) are derived following reflections arising from numerous detailed discussions with urban

water practitioners. The recommendations are delineated as 'governance structures' – which may be relatively stable over longer timeframes but remain subject to ongoing reinterpretation through 'governance process' – which can adapt more readily to changing circumstances. It should be noted that the recommendations of our governance research are designed to be interrelated and not stand alone.

Recommendations For Water Sensitive Governance

Water Sensitive Vision & Agenda Setting

A significant first step in achieving water sensitive governance involves generating a collective vision across all actors and multiple scales, regarding what is possible/desired for Greater Bogor and also in Bogor Regency and Bogor City individually. Efforts in this space are underway, but require alignment.

The process of creating the vision is, in itself, an important intervention in bringing a broad range of actors together to build a common understanding of what is desired and what is possible within a water sensitive scenario. A major component of establishing this vision would be to align core political, organisational and community agendas, and to inform an agreed-upon trans-disciplinary, co-designed research agenda to guide future developments. Generating 'water sensitive insights' like this would involve experts in law, policy, geography, sociology, community development, engineering, economics, urban design and other fields.

Institutional Design & Policy Frameworks

While conventional command-and-control approaches will continue to suit certain scenarios (e.g. regulating groundwater extraction or controlling effluent discharge into waterways), looking ahead to water sensitive governance requires a more cooperative and coordinated approach to institutional design. The contemporary water governance system is relatively decentralised and has multiple centres of decision making. While this approach is supported, it is further recommended that the roles and responsibilities amongst the multitude of organisations (including the provincial government) which play a part in the functioning of Greater Bogor's urban water systems be further clarified. For example, having the provincial government engage in discussions with city and regency governments prior to key decision-making (e.g. issuing permits).

In addition, it is recommended that:

- » the formal and informal organisational routines, practices and assumptions used to shape current and emerging water initiatives be studied to identify possible future interventions and redesigns.
- » actors promote engagement and cooperation (formal and informal) within geographic areas of mutual interest across relevant organisations (e.g. through MoUs or project partnership agreements) – here it is wise to utilise and adapt (where necessary) existing arrangements.

"The challenge for us is that the one who really understands and knows exactly the condition is in the city/regency; yet, the permit and regulations are issued under the provincial government. There should be consultation with the city or regency government prior to determining the outcome of these permit applications, and also notification of permits issued by the provincial government to facilitate our decision-making."
[Bogor City representative]

Establishing Regulatory & Compliance Agendas

At present, the national water legislation does not provide a contemporary framework for guiding decision-making authorities towards delivering more water sensitive systems. National leadership for advancing more sustainable urban water servicing is an important element in generating more formalised authority for decentralised decision-makers, freeing them to act to create change. Aspirational targets are useful for illustrating what water sensitive initiatives can deliver, but to be effective in driving on-ground action, the targets should be locally-relevant, realistic, clear, measurable and scientifically-derived. Targets should also be guided and monitored by dedicated, trained staff.

Building Broader Awareness Of The Multiple Benefits Of Green Infrastructure

Diverse and integrated urban water systems can deliver multiple benefits to communities and their environments. However, our research found there is limited awareness and appreciation of the many social and environmental functions and services provided by multifunctional green infrastructure (such as rainwater tanks and raingardens). Awareness of and the financial value of these outcomes needs to be embedded across the multiple layers of decision-making, for example, in national and regional strategic priorities, planning requirements and within the various budget allocations.

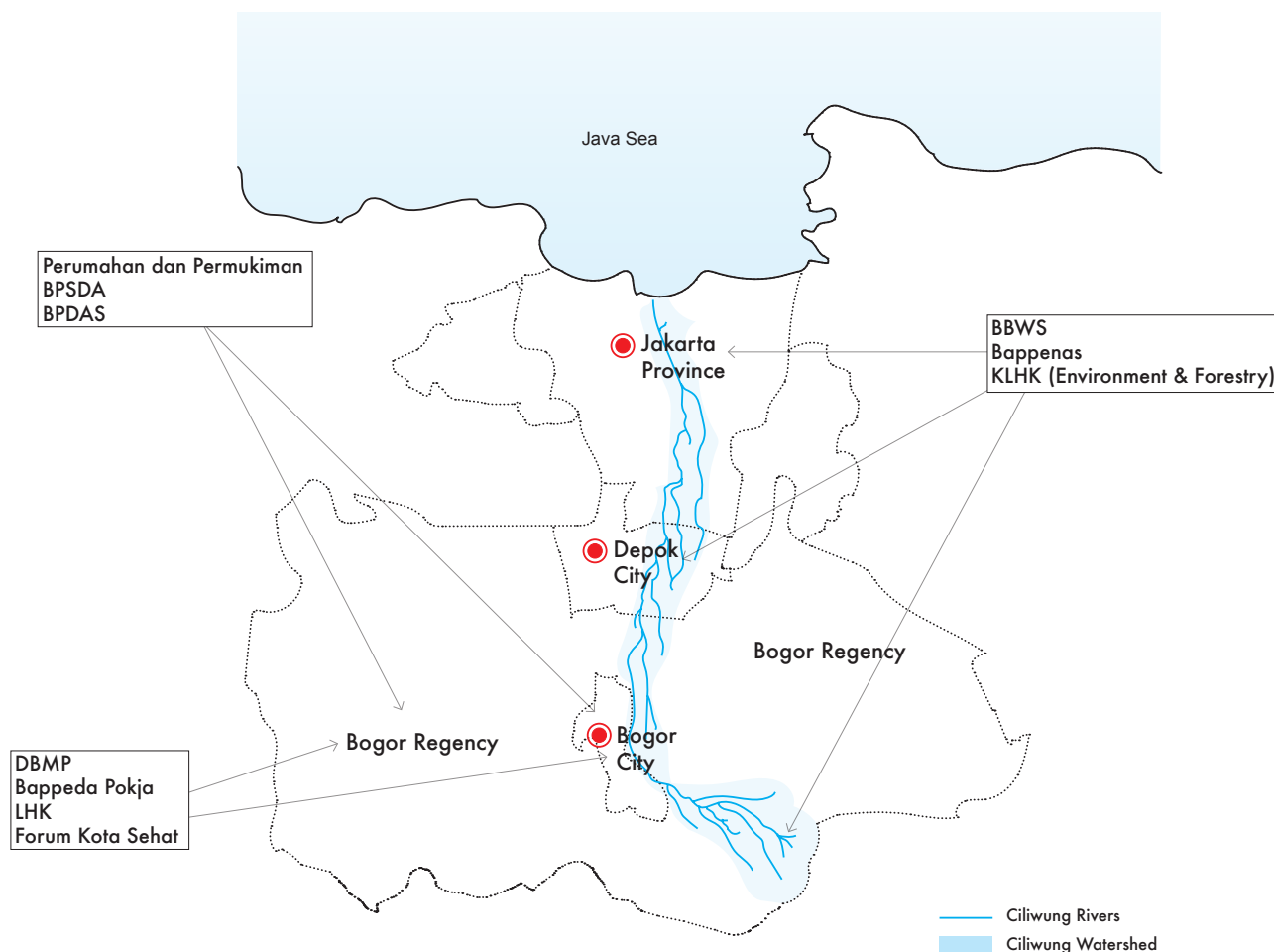
Fostering Leadership And 'Water Champions'

Over the course of the research, water leaders were located in all decision-making hierarchies, from community leaders through to city, regency, provincial and national governments. Fostering distributed leadership, i.e. shared, collective and extended leadership practice, is important for building capacity for change and needs to be reinforcing and aligned towards a common agenda. Within and across organisations, executive level support is key to distributing decision-making authority for 'advancing water sensitive practices'. There are also key roles for 'water champions' within various organisations. If supported appropriately, these champions could drive internal organisational change and foster inter-organisational relationships and on-ground delivery of alternative systems.

Platforms For Administrative Integration And Collaboration

The research workshops themselves were a useful platform for bringing together multiple actors involved in urban water decision-making in a structured but open discussion regarding current and future water practices. Looking ahead, similar coordinated, facilitated, formal and informal processes are required, whereby actors from different organisations can come together to shape innovative and alternative water practices. Here decision-makers from planning, urban development and water resources, among others, should be involved in tailored and facilitated discussions to share data, build trust and ultimately build (and improve) decision-making capacities. When designed well, this can generate networks capable of promoting a cohesive plan for change within future urban developments.

Many excellent platforms already exist, but may require a reconfiguration around roles, responsibilities and working towards a common catchment-wide agenda. For example, initiating an 'integrated water forum' could be instrumental in beginning the conversation to develop an alternative water narrative and vision. In addition, identifying and designing demonstrations can be opportunities to work collaboratively to a common end-point and can bring multiple actors together to share experience and insights.





Deep engagement among many water-related actors during a facilitated Focus Group in Kota Bogor (July 2018)

Capacity Building

Having multiple actors (individuals and organisations) involved in delivering a water sensitive vision for Greater Bogor will require a dedicated and tailored capacity building program. This will require building on existing opportunities and developing new knowledge-sharing programs (e.g. learning alliances, study tours, seminars and workshops). These should be made for different scales and actors, and be aimed at shaping their professional knowledge in relation to delivering water sensitive technologies and practices.

Driving Community Engagement & Action

The research identified many excellent initiatives already underway across the diverse local community structures within Greater Bogor that could be leveraged and expanded (e.g. environmentally-friendly communities and eco-villages). These programs warrant further study to understand how best to continue raising community awareness and gaining individual and community commitments to 'cleaner, healthier environs' (by maintaining drainage channels and septic tanks, paying for piped drinking water, reducing rubbish output, etc.) which are key components of driving water sensitive change. Careful attention is required to ensure there is broad community participation, not just community elites. Indeed, the Pulo Geulis community co-design process developed by UWC researchers is a key example of fostering and building community capacity.

Our research has also revealed there is great scope for key decision-making actors to engage with and promote the growing work of existing water-based social entrepreneurs through co-designing future projects and programs aimed at improving community equity within water servicing.

Experimentation & Research

Co-designing a joint industry, community and academic research agenda that is policy relevant is a key step to developing and testing new innovative, place-based approaches and technologies. Water sensitive demonstration projects would create a platform for showcasing not only new technologies, but also governance processes and mechanisms needed to facilitate stakeholder integration and collaboration. When designing experiments it is important to embed a dedicated learning agenda that looks at how to manage delivery and maintenance of the experiment (particularly if new interventions are trialled), alongside technical feasibility and confidence building.

Additionally, research-designed evaluations of contemporary water-related innovations are required to develop sound, empirical insights regarding their efficacy.

Review of the application of green infrastructure for water management in Bogor

The Australia-Indonesia Centre

URBAN WATER RESEARCH CLUSTER

What is Green Infrastructure?

Green and blue infrastructure also known as green infrastructure (GI), is a suite of nature-based technologies using plant and water systems, that can be used in urban designs to deliver a range of essential water management outcomes. In a water sensitive city model, GI is used for storm water treatment, flow attenuation (control) and storage for re-use. GI can also provide secondary benefits such as improving the look and value of the landscape, urban cooling and flood mitigation. Most green technologies are multi-functional, and can be applied at a range of scales and used for a range of applications. With these benefits, GI can help strengthen Bogor's economy and improve the health and quality of life of its residents. Several countries across the globe now recognise that GI is critical to the health, liveability and sustainability of urban environments.

Green infrastructure in Bogor, and in a tropical climate

Bogor's abundant natural greenery, hundreds of natural lakes, famous botanical gardens, and reputation as the 'Rain City' suggest it is ideal for transformation to a Water Sensitive City through the integration of GI into city development plans to tackle the city's challenges such as dry season water shortages, flooding and water management.

Bogor's tropical climate offers both opportunities and challenges for water management, for example:

- » The warm and humid climate allows for rapid plant growth and generally higher biological activity all year, but also provides favourable conditions for mosquitoes and various diseases.
- » Tropical rain patterns (high intensity) provide ample rainwater for many uses, but seasonally too much rain for the landscape to process causing erosion, flooding and pollution.

See the front section of this booklet for more discussion of Bogor's particular characteristics and trends and see the full Green Infrastructure report for an in-depth look at the challenges and opportunities in applying green infrastructure to Bogor.

The multiple benefits provided by Green Infrastructure

Environmental

- » **Water quality** treatment (through pollutant removal)
- » **Flood mitigation** (by reducing flow)
- » Protecting **human and ecological health**
- » Providing a **source of water** for re-use (through stormwater harvesting or greywater treatment & re-use)
- » Enhancing **water security**, resilience & reducing demand on other water sources
- » **Urban greenery, biodiversity & amenity**
- » **Groundwater recharge** through infiltration

Socio-Cultural

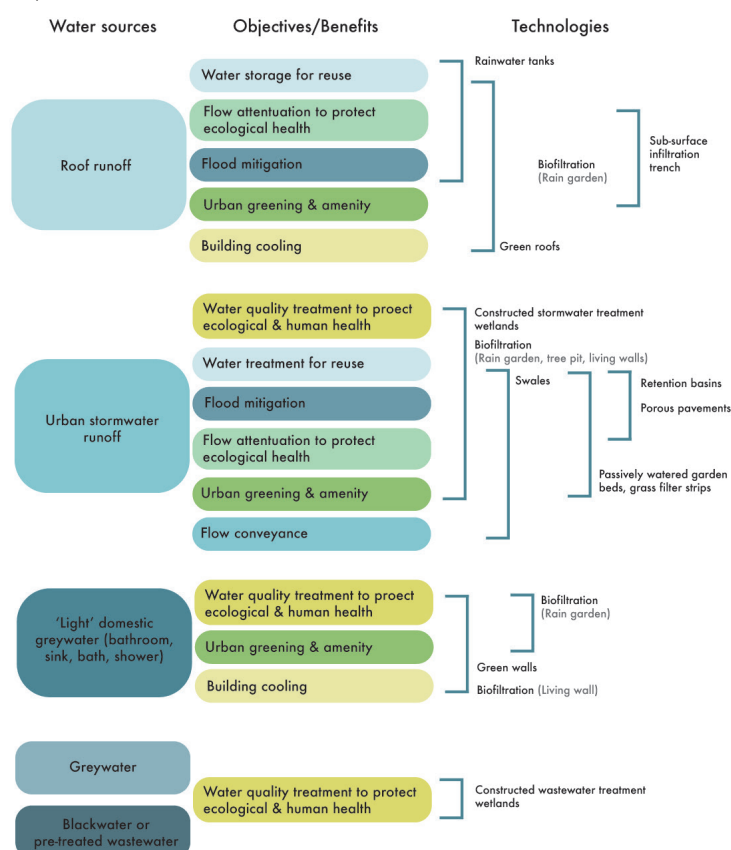
- » Enhancing **human wellbeing and health**
- » **Cooling** the city's microclimate & buildings
- » Providing **habitat** for flora and fauna

Economic

- » Increased **property values and avoiding future costs** for remediation and grey infrastructure
- » Possible **economic benefit** from harvested plants for products or food

Selecting which Green Infrastructure systems to use

Green infrastructure measures to treat, control or store water sources, should be selected based upon the individual site characteristics, urban planning, objectives and/or co-benefits that are important for the community or city to achieve (see chart below).

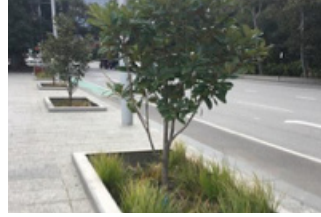


Descriptions of green infrastructure (GI)



**Biofiltration/bioretention/
raingardens**

Vegetated filters, designed to capture, detain and infiltrate stormwater or greywater before it is either collected for appropriate reuse, infiltrated into surrounding soils or discharged into the drainage or sewer system.



Treepits

A type of raingarden planted with trees, often located along streets collecting runoff from the road or pavement. This provides stormwater treatment, reduced runoff, passive irrigation of the trees, amenity, shading and cooling of the streetscape.



Constructed wetlands

Man-made shallow and densely-planted water bodies that retain and filter water for discharge into lakes and rivers or for re-use.



Living walls (or green façades)

A type of vertical greening system consisting of climbing plant species growing directly onto a building façade or on an external structural supporting system adjacent to the wall. They are a type of biofiltration system with plants growing directly into the soil or in planter boxes at the base of the wall.



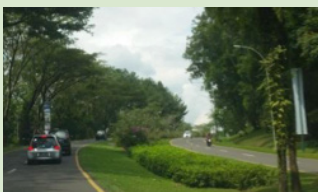
Green roofs (or living roofs / roof gardens)

Roofs covered with vegetation growing in a specifically designed growing medium and separated from the roof structure via a waterproof membrane.



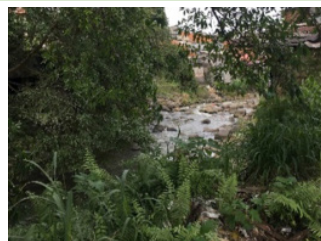
Green walls

Vertical gardens with shallow-rooted plants grown in compartments or modules filled with light-weight growing substrate and attached onto wall surfaces. They provide thermal insulation and cooling but need a substantial amount of water to remain lush and green. Harvested roof runoff or greywater generated by the building can be used to water the green wall, and in turn receive treatment by the green wall if in excess of its irrigation demands.



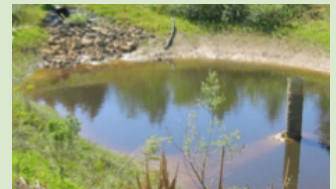
Swales/buffer strips

Vegetated channels that convey rainwater to the drainage/sewer system. During the process, they help to slow down and partially infiltrate rainwater. They are often used alongside roads and as a pre-treatment measure for downstream GI systems such as bioretention systems.



Riparian buffers

Vegetated areas along the banks of rivers and lakes to protect the water quality of the water body. They help prevent erosion and are an important food source for fish populations. They include trees, grasses, groundcovers.



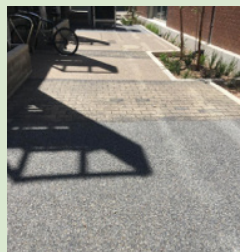
Sedimentation ponds/basins

Water bodies that capture coarse sediments and litter washed off during storm events. They are usually employed as a pre-treatment measure to wetland systems.



Retention ponds or retarding basins

Artificial water bodies, lakes or empty depressions that help retain water during a storm event to prevent downstream flooding and erosion. Ponds usually retain some water permanently. Retarding basins may be empty, or partially empty, between storm events which can allow recreational use of the space.



Porous pavements

Alternative paving surfaces that allow water to percolate through permeable layers. Water can either infiltrate into the surrounding soils or be discharged into the drainage system.



Rain barrels/tanks

Above or under-ground storage facilities, typically used in residential lots to retain rainwater from roofs on-site. The rainwater collected can be re-used for non-potable domestic use or irrigation, discharged to the drainage system or infiltrated into the surrounding soil.

Functions of GI

The functions of each technology are illustrated to the right, while examples of their application to solve common problems in Bogor's urban environment can be found below.

	Biofiltration	Tree pits	Constructed wetlands	Living walls	Green walls	Green roofs	Swales	Riparian buffers	Sedimentation ponds	Retention ponds	Porous pavements	Rain barrels/tanks
Green infrastructure												
Water quality treatment												
Flow attenuation												
Groundwater recharge												
Landscape value												
Urban cooling												
Food production*												
Storage												
Thermal buffer												
Flow conveyance												
Erosion control												
Harvesting												

*(if receiving roof runoff only)

Applications of GI

Example problem/s	Example GI	Example application as a solution
Impervious surfaces & concrete drains » Flooding » Poor water quality & erosion in local streams, rivers or situs » Minimal urban greenery 	» Biofiltration/ bioretention/ raingardens » Tree pits » Constructed wetlands	» Reduced runoff volume for reduced flooding & erosion downstream » Stormwater treatment for reduced pollution, healthier waterways » Groundwater recharge if system unlined to promote infiltration » Urban greenery & amenity for enhanced community well-being & real-estate value » Wetlands can provide storage for stormwater harvesting 
» Impervious surfaces leading to flooding, pollutant conveyance » Growing water demand and limited supply 	» Sedimentation ponds/ basins » Retention ponds or retarding basins	» Storage for flooding mitigation, some water treatment » Ponds provide storage for stormwater harvesting 
» Impervious surfaces and concrete drains leading to flooding » Conveyance of urban pollutants downstream 	» Swales/buffer strips	» Vegetated swales and biofilters for water treatment, flood mitigation, urban greenery 

Selecting Plant Species for Green Infrastructure

An abundance of healthy plants are the key to effective functioning of green infrastructure. In Bogor, there are many local and widely cultivated plant species available to drive many of the benefits delivered by green infrastructure; water quality treatment, flow attenuation, greenery, amenity, biodiversity, urban cooling and human health and wellbeing. Some plants also have economic uses.

Plant species will vary in their capacity to survive, grow and provide these different functions. Desirable plant characteristics and some examples are illustrated in the figure to the right. For more information, including a comprehensive list of plant species recommendations across technologies (including plants to generally avoid), see full Green Infrastructure report and its Appendix.

- ✓ Locally available from nurseries
- ✓ Suited to local climate
- ✓ Tolerant of conditions expected within the system:
 - » Expected dry periods (in biofilters, green roofs)
 - » Temporary inundation (in biofilters, swales)
 - » Inundation regime and water level changes (wetlands)
 - » Flow velocity (Swales, entrance of biofilters, wetlands)
 - » Capacity to grow in media (sand in biofilters)
 - » Suited to the particular site/location and media depth
- ✓ General desirable plant characteristics:
 - » Appropriate size for green infrastructure
 - » Hardy
 - » Adaptable to a wide range of conditions
 - » Relatively high growth & plant productivity
 - » Extensive root systems
 - » Low maintenance
 - » Useful economic purposes
- ✓ Select multiple species (diversity) and various plant types/growth forms



Biofiltration systems:

Syzgium polyanthum
(Salam, Indonesian bay leaf)
Tree
Myrtaceae

✓ (Easy to grow, adaptable, grows on roadsides, economic uses)



Living walls:

Bougainvillea
'Sakura Variegata'
(Bougainvillea)
Climber, shrub
Nyctaginaceae

✓ (Popular, common, hardy, ornamental, very effective for nitrate removal in Singapore testing. *Note – potential to damage buildings with thorns)

Key findings:

- » Green infrastructure has been demonstrated to be effective in tropical climates for water quality treatment, flow attenuation and other benefits.
- » GI has been successfully adopted in other tropical locations such as Singapore, Malaysia and northern Australia, and local guidelines have been developed for handling the advantages and challenges presented in those areas.
- » There are solid foundations for the adoption of GI in Bogor, with examples to build upon, existing local skills and resources, and natural green and blue assets. The four case studies have also highlighted how multiple issues can be mitigated by green infrastructure.
- » With high rainfall, rainwater harvesting for non-potable uses offers significant potential to diversify Bogor's water sources – helping to ensure a more sustainable and resilient water supply. For example, roof runoff can be used for irrigation of urban agriculture while simultaneously reducing flooding and demands on traditional water sources and improving urban greenery, nutrition, the local economy and community resilience.

- » Treated greywater through GI systems could also provide an alternative water source, for toilet flushing, irrigation or other appropriate end-use applications and would help reduce wastewater discharge into rivers and lakes.
- » Plants are critical to many functions within GI systems. In Bogor there are many local plant species that offer potential with many plants also associated with potential economic uses. Plant selection is vital.

Recommendations for future work include:

- » Further testing of the performance of GI systems under local conditions to help refine design and plant species selection.
- » Development of a standardised document to facilitate implementation and design of green infrastructure in Bogor, including target design objectives.
- » Further investigation of the potential for stormwater or greywater systems to be safely used for food production.

Guidance on developing infrastructure adaptation scenarios for Bogor's water sensitive transition

Scenario Modelling to shape Urban Planning

For Greater Bogor to leapfrog towards a WSC, the primary challenge is overcoming the business-as-usual mindset to water management, and understanding the compounding effects of population growth and climate change stresses on business-as-usual practices.

This factsheet explains the role of infrastructure scenario modelling in the planning process and how decisions on city development infrastructure investment can be supported by a focus on quality data and modeling. Used effectively, modelling approaches can drive a deeper understanding of the connection between the water system, land use, urban design and technology. Furthermore, our research has found that involving stakeholders early on in the modelling process can improve the quality of options developed, increase water literacy and significantly influence the success of water resource management projects.

Future Scenarios: Impact of population growth and urbanisation on water systems in Greater Bogor

Impact on water system	Example causes
Increasing propensity for flooding due to:	<ul style="list-style-type: none"> » Loss of situ (lakes) & reduced capacity of the system to retain floodwaters » Increased runoff volumes due to increases in impervious surface » Increasing levels of litter clogging drainage channels & rivers » Irrigation and drainage channels designed for agricultural purposes perform poorly as storm-water drainage networks
Increasing pollution of the water system and increasing risk of chronic exposure to pathogens and toxins due to:	<ul style="list-style-type: none"> » Greywater & sewage discharges into the open channel drainage rivers & local waterways » Leaky septic tanks & infrequent desludging results in leaching sewage into adjacent soils & underground water and then into rivers, situ, etc. » Higher levels of surface flow, which collects pollution from many sources
Diminishing capacity to meet water supply demands due to:	<ul style="list-style-type: none"> » Increases in impervious surface coverage reducing levels of groundwater recharge » Demand increase through population growth
Increasing environmental degradation due to:	<ul style="list-style-type: none"> » Increased urban runoff contributing to increased stream erosion & higher levels of surface flow » Reduction of green and blue spaces and loss of ecosystems and biodiversity
Reduced urban amenity	<ul style="list-style-type: none"> » Loss of situ as well as smaller green and blue recreational spaces diminishes the liveability, attractiveness and value of the urban landscape & impacts quality of life, health & well-being of communities

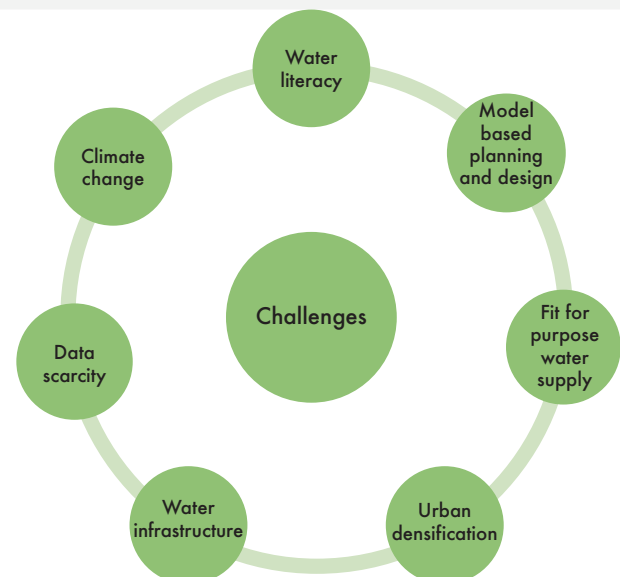


Fig. 1: Key challenges for Bogor's leapfrogging strategy from an infrastructure adaptation perspective

Opportunity 1: Establishing Robust Data Platforms

For city development planners to tackle climate change and population growth they need access to robust data platforms and quality standards and guidelines that are locally appropriate. Throughout Indonesia, the Meteorology, Climatology and Geophysical Agency (BMKG) is responsible for the collection, quality control and storage of meteorological and climatological data. Local government agencies and research bodies also collect and hold localised data sets. For Greater Bogor, a coordinated approach to data collection, quality control, interpretation, storage and dissemination will better inform water policy, city development and infrastructure design, and is critical for Bogors transition to a WSC. In particular, our research suggests that establishing a detailed understanding of drainage, sewage and water monitoring networks and their performance under the future burdens of climate change and population growth, could be achieved through the guidance of a government-industry-academic task force of 'Water Champions'. In addition, the surging capability of mobile devices presents an opportunity for crowd sourcing of data for Great Bogor. Examples include, monitoring river gauge height through mobile photography, calculating streamflow through videos, determining real time flood extent and depth via geo-located photos, and monitoring rainfall through interference signals of mobile phone towers.



Figure 2: Flooding in Bogor may become increasingly common ("Bogor Flooded, Three People Killed," 2017)

Opportunity 2: Data driven improvements in Water Literacy and Community Capital

Water literacy is the measure by which community, water professionals and government stakeholders understand the connections between water, climate change, population growth, and other water related issues. Access to data relating to drought, flood, litter and water security supports water literacy and helps stakeholders make informed decisions to improve preparedness for and responsiveness to severe weather conditions and extreme events. Developing water literacy around contamination of key water assets by domestic solid waste and waste water, would help ease maintenance requirements, improve the effectiveness and efficiency of key water assets, and improve the capacity of drainage systems to convey water. Developing a better understanding of the relationship between urban development, climate change and the effective implementation of water sensitive urban design (WSUD), can also help to tackle issues of sanitation, increased urban flooding, environmental degradation, stress on water resources, and loss of urban amenities.



Fig. 3: Solid waste polluting and blocking waterways



Fig. 4: An unhealthy Ciliwung River near Pulo Geulis, (Photo:Raul Marino)

Modelling communities’ receptivity to implementation of green infrastructure

By asking questions about community members’ perceptions of major water issues, researchers were able to establish their perceptions on how litter, rainwater harvesting, and control of urban densification can contribute to flood mitigation strategies, and also their perceptions on the ability of technology or policy to contribute to flood mitigation. Using an interactive tool, participants then visualised flood impacts for different climate scenarios and storm intensities. By testing a range of percentages of litter and rain tank adoption scenarios, participants were found to alter their thoughts about potential flood mitigation strategies, and some showed high levels of water literacy by proclaiming that an “integrated solution that considers litter, rainwater harvesting and managing urban densification will provide the best solution”.

Receptivity Modelling

Through receptivity modelling workshops and other forums, participants have expressed concerns about the use of rainwater tanks to harvest rainwater. Community perceptions are significant barriers to implementing rain tank solutions and improving understanding of potential solutions will help to improve receptivity and uptake.

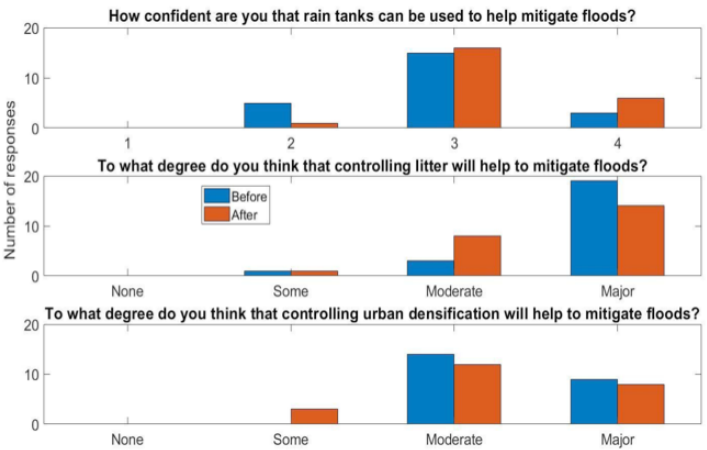


Fig. 5: Stakeholders’ perceptions on flood mitigation options before and after interaction with visualisations

Concerns	Solution
Mosquito breeding ground.	First flush, mesh screen. Maintenance every 2 to 3 years.
Roofs are dirty and home of the animals, won't the water be dirty?	First flush separator will remove organic material. Not all roof types are suitable though.
Why use rainwater when we can use groundwater?	Reduce stress on city water supply systems and local aquifers. If used correctly quality may be better than groundwater.
Take up too much space.	Water balance modelling has shown that for a typical house, a small 400-litre tank can make a big impact.
Acid rain.	Rainwater would not be proposed for drink water. It is good for toilet flushing.

Opportunity 3: Modelling performance of Green Infrastructure interventions

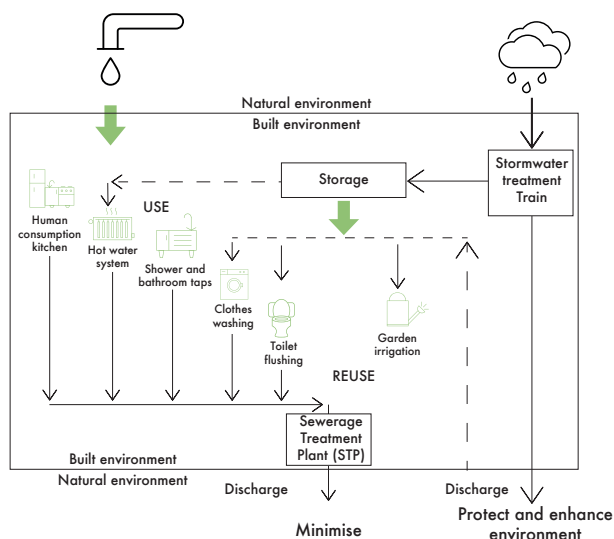


Fig. 6: Representation of a fit-for-purpose water supply system courtesy of (T. Wong, 2006)

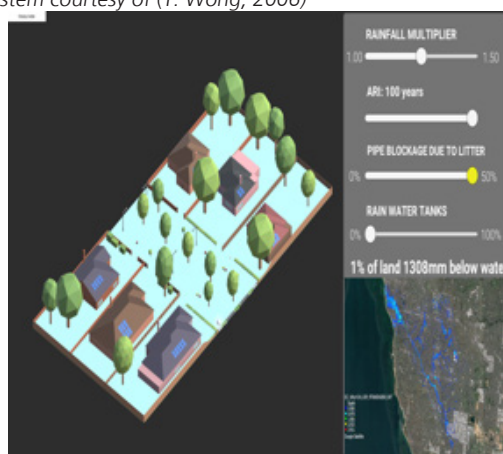


Fig. 7: Interactive display of flood mitigation options under various scenarios

The security of Greater Bogor's future water supply is challenged by decreasing water quality and increasing demand. To design infrastructure options that are resilient under various climate change and urbanisation scenarios, opportunities exist for Bogor to promote adaptive water sensitive infrastructure by modelling numerous uncertain scenarios and testing possible adaptation pathways where integrated multi-purpose infrastructure elements are installed. For example, to reduce stress on the piped city water supply, adopting a fit-for-purpose water usage approach is recommended, where the quality of water supplied for a given demand need only meet the minimum quality requirements for that purpose (Figure 6). For example non-potable water sourced from greywater is fit for the purposes of toilet flushing.

Green infrastructure interventions such as rain tanks, wetlands and retention ponds can also be used to offset the increase in impervious surfaces and adapt to changing runoff regimes. Our modelling research demonstrates that flood waters can be mitigated through the implementation of green infrastructure technologies and proper catchment management strategies (see info boxes).

Water Balance Modelling

To develop urban designs and recommendations for the selected case study sites our researchers applied a water balance model, or WBM, to evaluate the water cycle at each site and quantify the current demand for drinking water and sanitation, incorporating population growth and rain tank interventions. Assuming an increase in rainfall of 25% and city population more than doubling from 12,258 in 2018 to 26,631 in 2045, water balance modelling of Cibinong Situ Front City found that retrofitting each residential building with small 400-litre rainwater tanks (which would collect enough rainwater for flushing toilets for 75% of the year) could reduce household imported water demands by 35%. This strategy would significantly reduce the stress placed on the city water supply and local groundwater aquifers. Water balance modelling also demonstrated that between 2018 and 2045 Greater Bogor will face significant increases in imported water, stormwater runoff and wastewater discharge due to the impacts of climate change and urban densification. Consequently, strategies to offset these increasing stresses need to be developed.

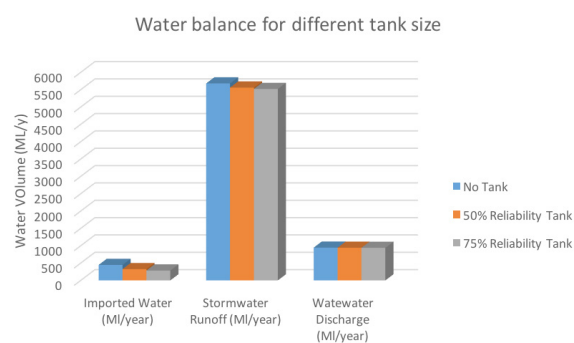


Fig. 8: Water balance for different tank sizes in Cibinong situ front city Aquacycle model

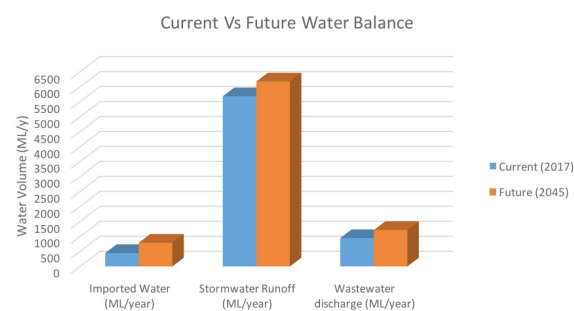


Fig. 9: Comparison of current and future water balances for Cibinong situ front city



Fig. 11: Breakdown of areas for Cibinong Situ Front City aquacycle model

Modelling tools to evaluate the performance of green infrastructure and optimise its design and location

Our researchers have developed a GIS based tool called 'Green Infrastructure Tool Based on Location Analysis' or GITBoLA for short, that uses spatial multicriteria decision analysis of several variables to determine the suitable placement of green infrastructure within a catchment. Data needed for the tool includes digital elevation models, land use, impervious cover, land ownership, river network, soil type, and depth of groundwater. GITBoLA has been used by UWC researchers to model the ideal locations for wetlands, bioretention systems and green roofs for the master plan of Situ Front City (see Figure 10).

The Storm Water Management Model (SWMM), developed by the US EPA, has also been used to evaluate the effectiveness of selected green infrastructure in managing and controlling urban stormwater.

Using several rainfall scenarios, the SWMM simulated stormwater scenarios in Situ Front City, Cibinong, and showed that:

- » Constructed wetlands have the most capacity to reduce stormwater discharges;
- » Grassed swales can also reduce stormwater discharges but are the least effective technology analysed; and
- » Bioretention systems, which are spread out all over the catchment, are able to most effectively reduce stormwater discharges per square metre occupied.



Fig. 10: GITBoLA output Map of Constructed Wetland, Bioretention, and Grassed Swales for Situ Front City Cibinong

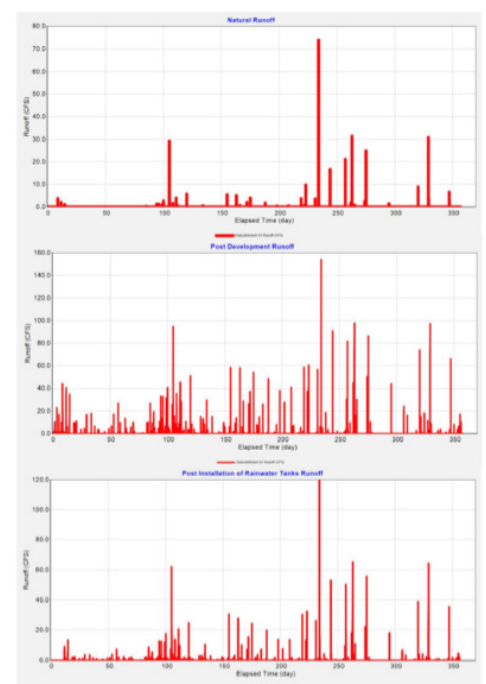
Opportunity 4: Scenario Modelling to inform city development, planning and design

Modelling numerous adaptation pathways under a variety of climate change, population growth and urbanisation scenarios allows urban planners to develop contingency plans for an uncertain future and advise policymakers on how to regulate new development to ensure a water sensitive approach is applied. Modelling can also be used to assess the security of safe and secure water supplies given a variety of supply and demand scenarios. Including stakeholder input in planning, modelling and design processes increases water literacy and the community's all-important connection with water.

Modelling Impacts of Urbanisation on the Water System

To assess and understand the impact of land use on the water system, our research has tailored the DAnCE4Water model, developed by the CRCWSC, to the context of Bogor. Based on open data and various tools, DAnCE4Water enables stakeholders to assess the impact of a range of urban planning decisions on the urban water system and identifies potential adaptation options. Using DAnCE4Water modelling to demonstrate the impact of urban development for Cibinong and Great Bogor areas, researchers observed both increases in future water demand and growing fraction of impervious surfaces linked to population growth. Combined with increasing rainfall frequency and resulting increasing magnitude of runoff events, urban development modelling showed a greater future propensity for flooding in Bogor. By retrofitting each house with a rain tank, DAnCE4Water modelling demonstrated that peak flows and frequency of runoff could be reduced through this infrastructure intervention.

Fig. 13: Annual runoff for sub-catchment in Cibinong (a) Prior to any development (b) Post development, and (c) Post development and the inclusion of rainwater tanks.



Pulo Geulis Revitalisation 2045

Urban Design and Implementation Roadmap

Pulo Geulis

The island of Pulo Geulis is an informal settlement located in the middle of the Ciliwung River's catchment area, with major environmental issues related to water management and sanitation. However, Pulo Geulis also has great potential to become more water sensitive if Water Sensitive Urban Design concepts are adopted.

Only around 60% of the island has access to city water service, and waste water management is poor, and most houses on the island's perimeter discharge untreated black and grey water and other domestic waste directly into the river via small pipe. This is the result of dense configuration of small houses, often without sufficient room for individual septic tanks, and a lack of awareness of environmental impacts of such actions.

The Cluster aims to provide the necessary infrastructure to improve the community health and environmental performance of the island and their liveability with new multifunctional public space. The revitalisation proposal also aims to uplift the local economy by providing additional food sources in vertical gardens and open spaces for the community and tourists to visit the island and support the local economy by acquiring the local handcrafted products. Also the island has important cultural landmarks (Vihara and others), diverse local food offers and the striking landscape of the island in the Ciliwung River.



POPULATION
2,640



AREA
3.04 Ha



POPULATION DENSITY
700 / Ha



NUMBER OF BUILDINGS
624



NUMBER OF HOUSEHOLDS
681



ISSUES



RIVER POLLUTION

Direct discharge of waste water into the river, open defecation, and other pollutants are polluting the river.



INSUFFICIENT WATER MANAGEMENT SYSTEMS

Pulo Geulis is in need of an efficient wastewater treatment system.



LIMITED ACCESSIBILITY

There are only 2 vehicular access points to the island.



RETAINING WALL EROSION

River flow is constantly eroding the retention walls of the island.



LIMITED PUBLIC SPACES

The settlement lacks open, green spaces, with the only green space in existence being a private property.

SPATIAL AND SOCIAL ANALYSIS TOOLS

1

VISIONING FGD

- » Community Mapping,
- » Problem-solution Tree,
- » Transect Walk,
- » SWOT Analysis

2

DRONE MAPPING

- » Ortho-rectified Imagery
- » Digital Elevation Model

3

DRONE MAPPING RESULTS POST-PROCESSING

- » 3D Model Pix4D
- » Site Sections (Revit)

4

HYDROLOGY MODELLING

- » Water Balance Model
- » Rainwater Tank Sizing and Reliability Analysis

5

URBAN SCENARIOS FGD

- » Feedback on Scenarios for Public Space Allocations and Uses

6

SCENARIOS FOLLOW-UP SURVEYS AND INTERVIEWS

- » Refining the Scenarios and Selection of Sites for Pilot Projects

7

URBAN DESIGN FGD / WSUD MASTERCLASS

- » Feedback on Proposals
- » Feedback on Development, Implementation and Maintenance

8

LEAPFROGGING SHOWCASE

- » Showcase of Project Findings and Strategies
- » Display of Pilot Site Designs

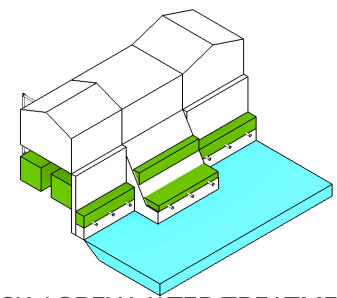


Social Analysis Tools

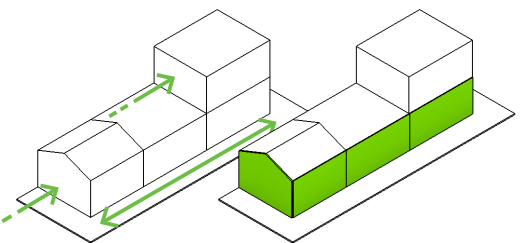


Spatial Analysis Tools

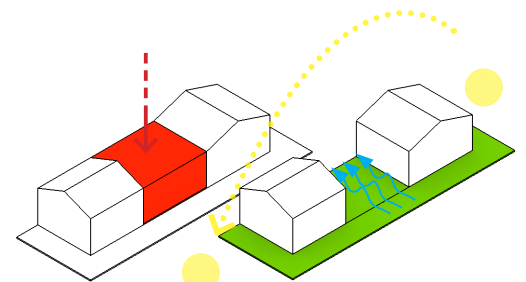
URBAN DESIGN STRATEGIES



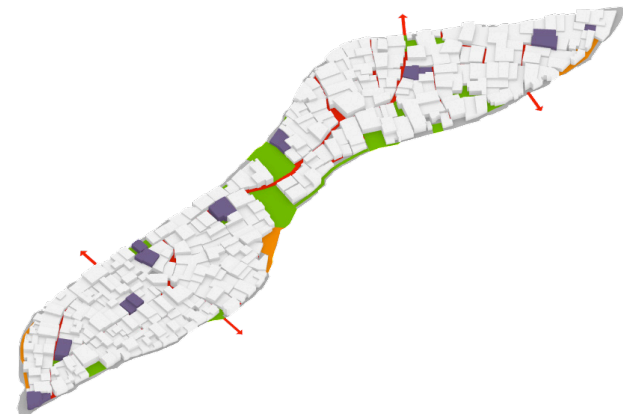
BLACK / GREY WATER TREATMENT:
Integration of Green Infrastructure into the Existing and Proposed Urban Fabric



GREENERY INTENSIFICATION:
Integration of Green Elements such as vertical gardens into the existing and proposed buildings and public spaces



EXPANSION OF PUBLIC SPACE NETWORK:
Addition of Multi-functional Public Spaces to improve access to sunlight and wind flows



NETWORK OF PULO GEULIS INTERVENTION SITES
The design interventions form a network of well-connected public spaces

GREEN INFRASTRUCTURE RECOMMENDATIONS

- ✓ Harvest roof runoff for urban farming, non-portable or outdoor uses
- ✓ Biofiltration systems with climbing plants and / or constructed treatment wetlands
- ✓ Biofiltration or treatment of stormwater-runoff and light domestic greywater
- ✓ Vertical gardens (Self-standing)
- ✗ Green roofs and greywater treatment green walls

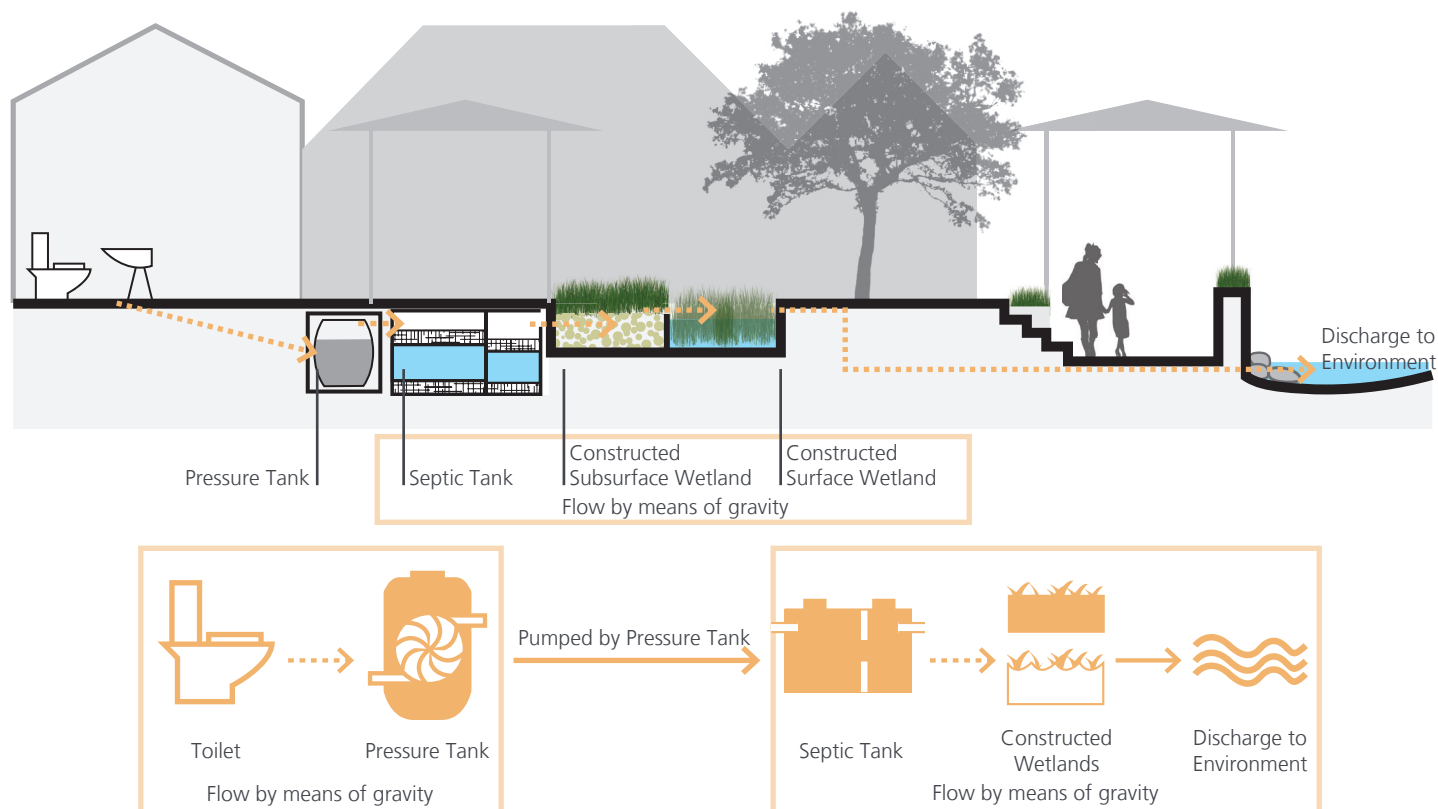
PLANNING RECOMMENDATIONS

- » Integrate informal settlements in the Local Government Implementation Plans (RKP) and Regional Medium-Term Development Plans (RPJM)
- » Take existing local communities under consideration and integrate them into the process when transforming informal settlements in order to utilise their local knowledge in the social construction of their habitats
- » Standardise methods used to elaborate Environmental Impact Assessment (EIA) studies and include a review of the larger impact of human activities in a given area when preparing EIA studies

URBAN DESIGN RECOMMENDATIONS

- » Take into consideration the social impacts of relocation when transforming communities into more water sensitive ones
- » Understand the value of social capital in the collective construction of communities and explore options to reduce massive relocation
- » Governments can benefit from working with the communities to use their potential as agents for positive transformation of their environments
- » Understand the importance of public spaces in very densely populated areas, and ensure they are multifunctional to accommodate social, environmental, and economic functions
- » Establish guidelines for designing public spaces such as parks, sidewalks and riverfronts, and ensure they comply with Water Sensitive Urban Design concepts adapted to the Indonesian context

PROPOSED CONSTRUCTED WETLAND SYSTEM



SITE
1

Service Area: 1,416 m²
Buildings Served: 15
Wetland Area: 32 m²
Wastewater Treated: 5.47 m³ (5,470 L) / day

SITE
2

Service Area: 1,024 m²
Buildings Served: 10
Wetland Area: 23 m²
Wastewater Treated: 3.67 m³ (3,670 L) / day

SITE
3

Service Area :1,273 m²
Buildings Served : 13
Wetland Area: 29 m²
Wastewater Treated: 4.75 m³ (4,750 L) / day

Griya Katulampa

Lessons Learned

Griya Katulampa

Griya Katulampa is a community with great potential in relation to water and a privileged position between the Kali Baru River and the Ciliwung River. The community in Griya Katulampa has shown strong mutual cooperation in protecting the environment and initiative in taking care of the environment, especially in the case of water resources, such as using alternative water sources from existing springs and building a distribution system.

With its potential, Griya Katulampa can offer some valuable lessons in water resources management to become a water sensitive city. There is an opportunity to provide advice for better waste management in Griya Katulampa, using Green Infrastructure such as constructed wetlands, biofilters and bioswales to reduce water pollution to the river and stormwater runoff.

Currently, Griya Katulampa has implemented pilot projects for bioretention at communal and household scale. These pilot projects have been successful in reducing the stormwater runoff in the area. The Urban Water Cluster has also explored the capability of rainwater harvesting at the communal and household levels and finds that it has great potential for decreasing the reliance on city water for non-drinking purposes, such as irrigation, toilet flushing and fish ponds.



POPULATION
2,257



AREA
14.1 Ha



POPULATION DENSITY
160 / Ha



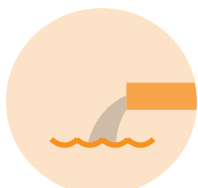
NUMBER OF DWELLINGS
460



AVERAGE HOUSEHOLD SIZE
4.9 People
/ Dwelling



ISSUES



WASTE WATER TREATMENT

Most dwellings have septic tanks to treat blackwater, however, some do not function well.



FLOOD RISK

The settlement is located on a slope between two rivers, therefore there is flood risk from the river located in the upper part of the settlement.



THREATS TO SPRING WATER ACCESSIBILITY

Land Use changes may compromise the ongoing reliability of the spring water access and quality.



WATER POLLUTION

Untreated stormwater and greywater are being discharged into the drains and river.



SOLID WASTE MANAGEMENT

The drains in the springwater distribution network are blocked by solid waste.

PLANNING RECOMMENDATIONS

- » Protect the current agricultural land in the area by promoting sustainable mixed land-use models
- » Katulampa is a strategic area of development for Kota Bogor and special attention should be placed for the future transformation of the village's social and economic systems.
- » Reduce flooding and landslide risks for communities living near river banks by regulating the use of riverbank areas
- » Promote low and medium density residential developments with integrated open public spaces and easy access to public transport networks
- » Include participatory planning strategies in the development of new residential and commercial areas to provide a more active involvement of residents in the planning process.

G.I EXISTING INITIATIVES

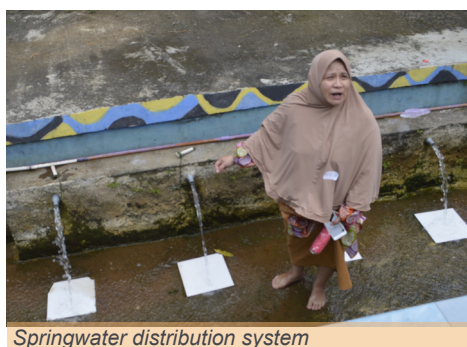
- » Community-led springwater collection and distribution system, including fish ponds
- » Celebration of water - The annual Festival of boats
- » Existing Garbage bank and composting site
- » Community vegetable garden / urban farming
- » Demonstration biofiltration system for greywater treatment
- » Abundant communal green open space
- » Community recreation facility – basketball court
- » Waste separation initiatives in place

URBAN DESIGN RECOMMENDATIONS

- » Ensure public spaces are multi-functional to ensure they are providing a better community life and environmental performance.
- » Green Infrastructure such as biofilters, bioswales, constructed wetlands and vertical gardens could be integrated in public spaces in order to reduce stormwater runoff and water pollution.
- » Griya Katulampa could benefit from implementation of rainwater harvesting mechanisms at the household or communal levels to reduce dependency on city water supply system.

G.I RECOMMENDATIONS

- » Diversify water sources (e.g. by promoting rainwater harvesting using rainwater tanks)
- » Characterise the springwater - Determine the spring catchment and test the water quality
- » Treatment of the springwater using constructed wetlands (surface flow and/or floating)
- » Vegetate the perimeter of the existing fish pond, washing pond & channels to enhance water quality
- » Urban farming using rainwater
- » Biofiltration (raingardens) in backyards and communal area treating stormwater & greywater
- » Enhance efficiency of spring water collection system



Springwater distribution system



Pilot Bioretention System Implemented

Cibinong and the Situ Front City Project

The city of Cibinong is the capital of the Kecamatan of Cibinong and Bogor Regency, covering an area of 57 Ha. The district incorporates a number of large lakes (situs) and a population of 357,000 people. Within Cibinong, there is a large development planned along the lake-front of the situ Cikaret and Bentenan by the Bogor Regency Planning Department called the "Situ Front City". This project is one of the main urban development areas in Bogor Regency. The Masterplan design is completed based upon the winning design from a competition, and construction is due to commence in 2020.

The SFC Masterplan included basic WSUD principles in the landscape design and public space design using Green Technology tools to offer a better environmental performance of the urban development. However, the SFC Masterplan did not base their recommendations on hydrological and hydraulic modelling, which are essential to provide a more refined implementation of Green Infrastructure and to understand the water systems of the area.

The Urban Water Cluster provided a set of recommendations for the adaptation of the SFC masterplan to be more water sensitive and support the transition of Cibinong to a Water Sensitive City.



POPULATION
12,258



AREA
209 Ha



POPULATION DENSITY
58.6 / Ha



NUMBER OF DWELLINGS
2,724

ISSUES



POLLUTED LAKES

Dwellings surrounding the lakes are discharging wastewater directly into the lake



DISCONNECTION BETWEEN LAKES' WATER FRONTS AND THE SURROUNDING

Water fronts are not being actively used by the locals.



LACK OF HYDROLOGICAL MODELLING IN THE MASTERPLANNING PROCESS

Major changes to the water bodies are proposed, and therefore, hydrological analysis of the area is essential.



LACK OF WATER DISCHARGE CAPACITY STUDY

Major changes to the water bodies are proposed, and therefore, a water discharge capacity study is necessary.

SPATIAL AND SOCIAL ANALYSIS TOOLS

1

VISIONING FGD

- » Community Mapping,
- » Water Sensitive City Index
- » SWOT Analysis

2

LAND USE MAPPING

- » GIS Mapping of Land Use

3

LAND USE MAPPING POST-PROCESSING

- » GIS Files Preparation and Verification

4

HYDROLOGY MODELLING

- » Water Balance Model
- » BIM Siting Tool for Green Infrastructure Allocation

5

URBAN SCENARIOS FGD

- » Feedback on Scenarios for Public Space Allocations and Uses

6

STAKEHOLDERS INTERVIEWS

- » Collecting Information on Government Processes for Water Management and Green Infrastructure Allocation

7

URBAN DESIGN FGD / WSUD MASTERCLASS

- » Feedback on Proposals
- » Feedback on Development, Implementation and Maintenance

8

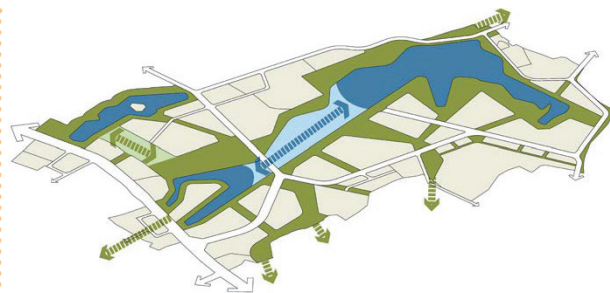
LEAPFROGGING SHOWCASE

- » Showcase of Project Findings and Strategies
- » Display of Demonstration Site Designs

Social Analysis Tools

Spatial Analysis Tools

URBAN DESIGN OVERVIEW



CREATION OF LINKS BETWEEN BLUE AND GREEN ELEMENTS

Connections between water bodies and the surrounding greenery are established and strengthened.



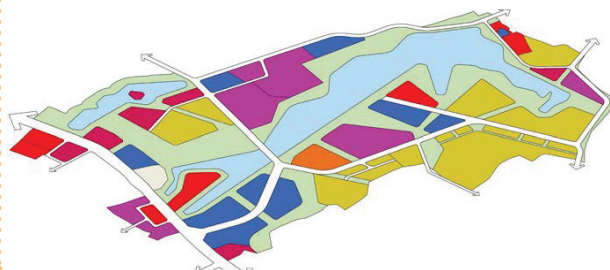
PRESERVATION OF EXISTING BIODIVERSITY

The rich biodiversity of the project site is valued and preserved.



INTENSIFICATION OF DEVELOPMENT

Vertical expansion is intensified to cope with the increasing population of the site.



PROVISION OF DIVERSE LAND USE

A diverse range of programs is implemented within the site.

GREEN TECHNOLOGY RECOMMENDATIONS



Promote infiltration of stormwater where soil is suitable



Havest and reuse rainwater for suitable purposes



Protect situs using constructed wetlands



Greywater treatment and recycling



Promote runoff onto pervious surfaces (such as garden beds and grassed areas)

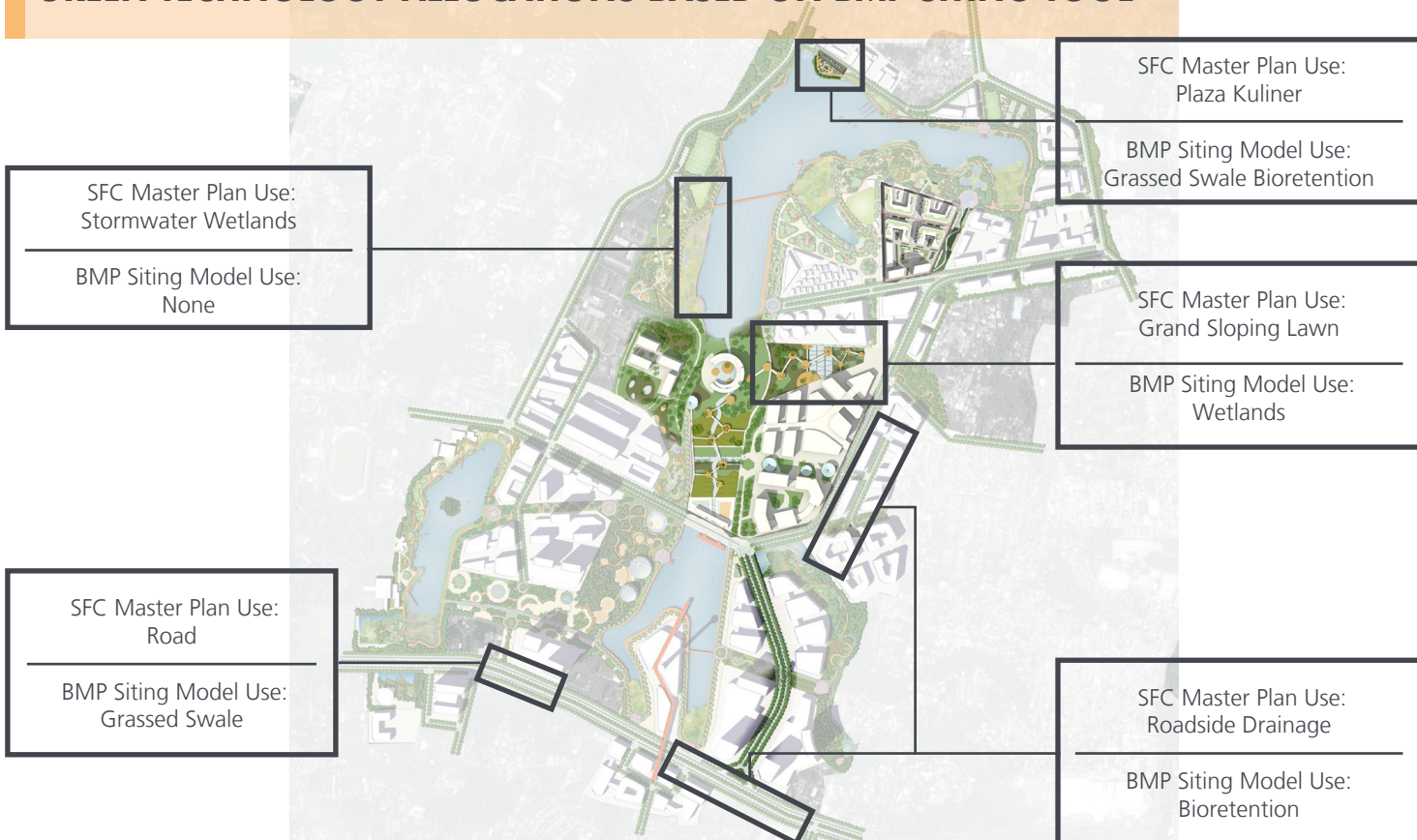
PLANNING RECOMMENDATIONS

- » Governments need to regulate and control existing and future developments to ensure a sustainable relationship between the built and natural environments.
- » Ensure easy access to information necessary to take informed decisions related to urban planning and environmental care. Conduct studies and research where necessary to create spatial and socio-economic databases.
- » Collect and provide information at disaggregated geographical levels (such as Desa, RW and RT) to facilitate modelling analysis
- » Promote integrated Urban Planning initiatives to deal with the coordinated tasks that are essential to sustainable urbanisation.

URBAN DESIGN RECOMMENDATIONS

- » Integrate Green Infrastructure designed based on hydrological and hydraulic modelling
- » Provide alternative plans to cope with challenges related to change in climate patterns that can affect the water balance of the developed area
- » Explore alternative water sources to reduce dependency on PDAM water for non-drinking purposes
- » Integrate the Water Sensitive Urban Design guidelines prescribed by the SFC masterplan in the existing planning regulations so that other similar projects can benefit from them
- » Monitor the performance of the Green Infrastructure implemented in the new urban developments to adjust or revise their functioning and environmental benefits

GREEN TECHNOLOGY ALLOCATIONS BASED ON BMP SITING TOOL



INTERVENTION SITES

The urban design team selected 5 intervention sites for pilot projects to showcase a range of possible applications of Green Infrastructure and Water Sensitive Urban Design strategies in the SFC Masterplan. The sites range from residential to commercial and mix use areas at different scales.

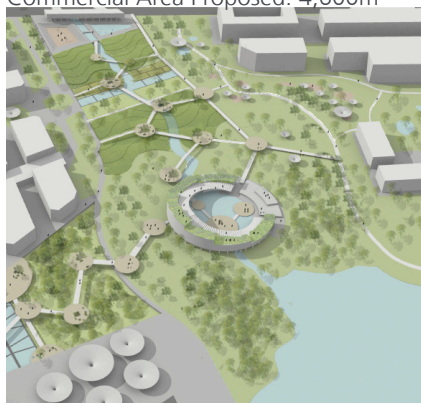


Location of Intervention Sites

1. FORMER LAKE AREA

This design intervention involves transformation of the former lake connection area into a series of connected public spaces, and addition of new commercial areas. Existing rice paddy fields are preserved in an attempt to retain local identity and promote local economy. A green buffer zone between the proposed commercial area and the existing hospital precinct is also added, and features therapeutic gardens and children's playgrounds.

Total Area: 100,000 m²
Commercial Area Proposed: 4,600m²



Proposed Lake Area Design

2. SLOPING LAWN AREA

In this intervention, the site of Master Plan's proposed sloping lawn is replaced by a series of constructed wetlands and a vast rain garden, with a series of viewing decks and connecting paths above. While no additional commercial area is proposed, the site is surrounded by the commercial / retail zones proposed in the Master Plan, and is designed to maximise connection and accessibility with the surrounding urban fabric.

Total Area: 25,000 m²



Proposed Sloping Lawn Area Design

3. PLAZA KULINER

In this intervention, recommended green technologies are installed within the the existing Plaza Kuliner, an alfresco food court by the lake, while its local character is preserved and celebrated. A bio-retention pond is proposed, and is intended to support the integrated aquaponics system. Vegetables and fish produced on site are intended to be served fresh to the visitors of Plaza Kuliner.

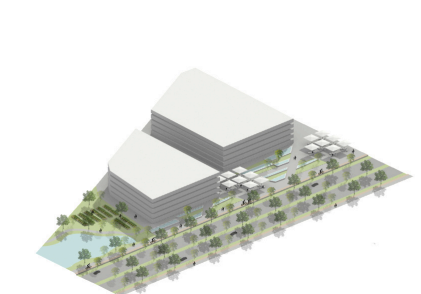
Total Area: 4,000 m²



Proposed Plaza Kuliner Design

4. ROADSIDE BIOSWALES

As recommended by our BMP Siting Tools Analysis, a series of roadside bioswales are proposed, while the Master Plan's eco-pond and community gardening proposals are integrated into the design.



Proposed Roadside Bioswales

5. HOUSING CLUSTER

A number of Green Infrastructure are incorporated into the proposed design of the housing cluster demo site, to maximise water sensitivity.

Total Area: 40,000 m²



Proposed Housing Cluster Design

Sentul City

Sentul City is a greenfield development by the Sentul City PT. Located in a mountainside region, close to Mount Salak and Mount Mas, it is also conveniently close to the toll road, and it is home to 8,000 permanent residents who live and work in Jakarta or Bogor. It also functions as a resort and hotels area, with approximately 2,000 residents living in Jakarta during the week and using Sentul City as a weekend retreat. 9 villages are also located within the Sentul City area, and many local villagers are employed to work in the commercial areas of the city. A large part of the Master Plan has already been built and additional housing and commercial projects are currently under construction.

High quality, sustainable and green living is an integral part of Sentul City's development plan. The overall aspiration is to become a pioneering Global Green City embodying Water Sensitive Urban Design. However, the area faces challenges related to water scarcity and increase in stormwater runoff due to land use changes. The cluster provided a set of recommendations for the adaptation of the Master Plan towards a more water sensitive city. The project proposes to upscale the pilot initiatives currently in use in Sentul City such as V-drains and vertical gardens and assess the potential of alternative water sources such as rainwater harvesting to reduce the need for city water supply.



POPULATION
11,000



AREA
3,100 Ha



POPULATION DENSITY
3.54 / Ha



DEVELOPERS
SENTUL CITY PT

ISSUES



STORMWATER RUNOFF

Rainwater is not absorbed due to the impervious nature of the soil, and therefore flushes down the streams and causes floods downstream.



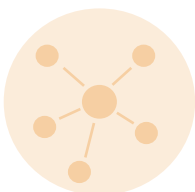
WATER SCARCITY

Underground water wells are not sufficient to support the current and future population.



RIVER POLLUTION

Water bodies in the area are exposed to waste water discharge from some dwellings and commercial buildings.



INTEGRATION OF THE LAKES WITH OTHER WATER CONNECTIONS

Some lakes in the area are disconnected from the surrounding.



WASTEWATER MANAGEMENT

The existing wastewater plant is not operational, therefore, treatment relies on septic tanks.

PLANNING RECOMMENDATIONS

- » Integrate WSUD principles more actively in the master planning of the current and future areas of Greenfield development.
- » Include alternatives for water harvesting in large commercial building areas to reduce dependency on city water supply and reduce stormwater runoff.
- » Integrate public and active transport options in the masterplan to reduce the need for private cars and motorcycle use.
- » Promote sustainable land use alternatives integrating green and blue open spaces into the design and planning process.

URBAN DESIGN RECOMMENDATIONS

- » Develop guidelines for developers to integrate WSUD in the public and private open areas for residential and commercial projects.
- » Promote the active use of public open spaces as a places for community interaction, offering alternatives different that shopping malls and other private spaces.
- » Connect public spaces with well design pedestrian and bicycle lanes to promote more active transport and community wellbeing.
- » Integrate native species into the landscape design of public and private spaces

G.I ADAPTATION RECOMMENDATIONS

- » Upscale current initiatives to promote stormwater treatment and flow attenuation such as V-Drains and Raingardens
- » Develop incentives for developers and residents to incorporate rainwater harvesting in their buildings (reduction in water prices or tax incentives).
- » Integrate vertical gardens in large commercial surfaces (i.e. Aeon mall) to treat light sources of greywater and increase greenery and reduce CO₂.
- » Develop assessment guides to evaluate the impact of Green Infrastructure in the environmental performance of Sentul City (i.e Cost-benefit analysis). This can provide support for the business case proof for further adoption of GI.

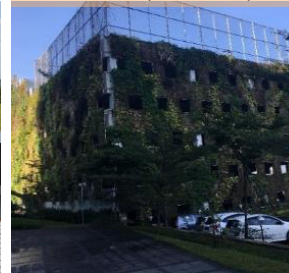
G.I REPORT MAIN FINDINGS

- » Sentul City has developed small scale pilot projects for GI that are a valuable first step in the progress towards WSC.
- » The V-Drain along the main road in Sentul City is one of the largest GI implementation projects in Indonesia and can provide good support for wider adoption
- » The use of large vertical gardens and green roofs in some hotels show that these systems can be implemented successfully in the Indonesian context.
- » Despite water scarcity, alternatives such as rainwater harvesting and greywater reuse are not currently used. There is potential to introduce green infrastructure systems to address this issue.

Green Roof (Neo Green Savana Hotel)



Vertical Garden (Aston Hotel)



V-drain on the main access road





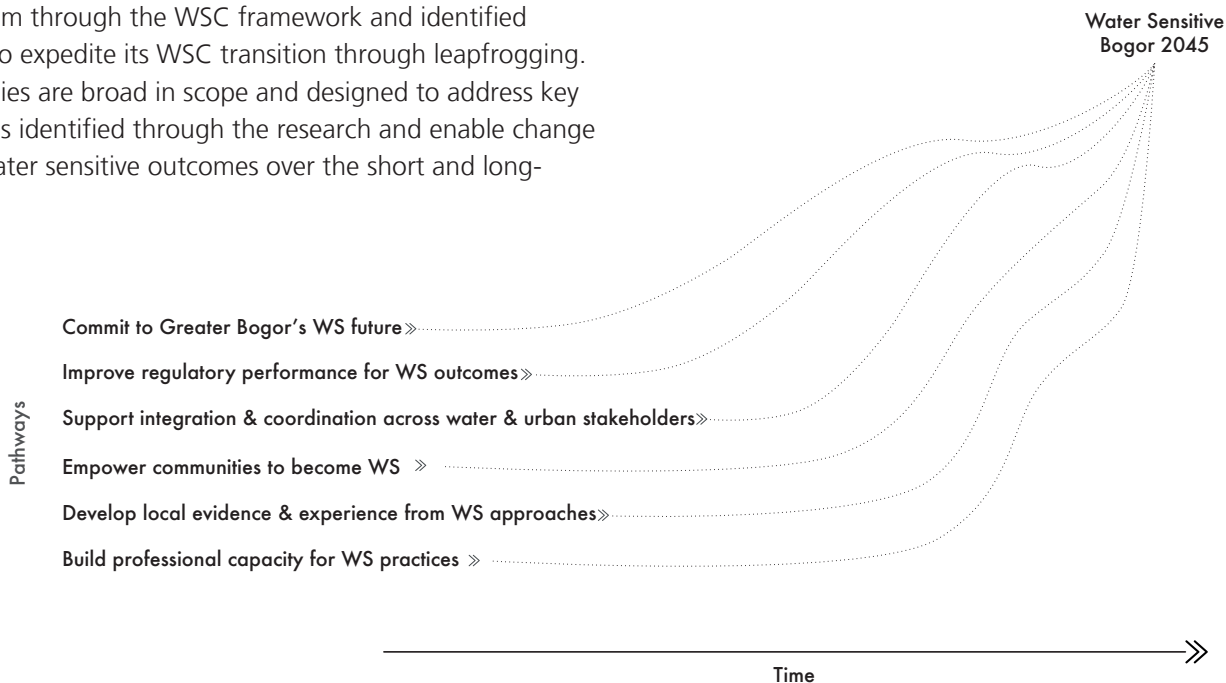
Leapfrogging pathways for a water sensitive Bogor

WSC Leapfrogging Pathways

Leapfrogging is a phenomenon in which developing countries—whose socio-technical systems are typically not yet fully-established—can adopt more advanced approaches to address pressing needs. Leapfrogging to a WSC may help Bogor avoid features of water servicing models seen in developed economies that lead to unsustainable outcomes, and adopt more integrated and sustainable water technologies and practices that are based on WSC principles.

The Urban Water Cluster has assessed Greater Bogor’s current water system through the WSC framework and identified strategies to expedite its WSC transition through leapfrogging. The strategies are broad in scope and designed to address key water issues identified through the research and enable change towards water sensitive outcomes over the short and long-term.

The recommended strategies are organised into six leapfrogging pathways (figure below). The pathways are intended to be considered for investment as a whole, as the underlying strategies are often inter-related and mutually reinforce achievement of Greater Bogor’s water sensitive aspirations. The alignment of each strategy indicates the likely time horizon for it to be feasibly implemented. Going from left to right: short-term (0-3 years), medium-term (3-10 years) and long-term (10 years onwards).



Short-Term Priorities

The recommended short-term strategies provide guidance on initiatives to progress as a priority in the coming years to rapidly advance Greater Bogor’s water sensitive city leapfrogging journey.

It is recommended that the momentum of this Urban Water Cluster research be built upon to immediately establish a governance framework for implementing this WSC leapfrogging strategy (1.1). This framework would become a key driver of collaboration within and across organisations (3.2), underpinned by a strategic water sensitive city vision for Greater Bogor collectively developed by diverse government, industry, community and research stakeholders (1.2). The framework would also support the WSC Learning Alliance (6.1) established as part of this research to build capacity to adopt

water sensitive practices amongst Bogor’s water and urban professionals.

Priorities for on-ground action include learning from previous experiences as well as creating opportunities for new learning from laboratory testing and field demonstrations (5.1-5.3). Greater understanding of data requirements for optimal water system planning (6.2) and of the barriers for households to adopt water sensitive practices (4.1) will improve the effectiveness of policy implementation at different scales. Processes for inclusive and participatory strategic planning (3.3) and meaningful community engagement (4.2) are also important foundations of sustained support for the water sensitive agenda in Greater Bogor.

Pathway 1. Commit to Greater Bogor's water sensitive future

1.1 Establish a governance framework for implementing the WSC leapfrogging strategy

1.2 Collaboratively develop a strategic water sensitive city vision

1.3 Create and align government strategies and plans with the vision

1.4 Monitor progress towards the water sensitive city vision

1.1 Establish a governance framework for implementing the WSC leapfrogging strategy

Immediate establishment of a working party to review and discuss in more detail the outcomes and recommendations of WSC research would help to co-develop a forward plan for addressing key priorities. From there, ongoing coordination and support from key agencies is needed to shape the innovative and adaptive strategic water management approaches promoted in this WSC leapfrogging strategy. A governance framework that addresses collective roles and responsibilities, shared learning needs, leadership capacity-building, and other directions for implementing key enablers of the water sensitive transition will be useful to drive and guide collective strategic action.

1.2 Collaboratively develop a strategic water sensitive city vision

A strategic vision for Greater Bogor, founded on water sensitive principles and building on pride in the city's existing attributes, will help build broad political and policy support for transforming practices and urban spaces to become water sensitive. Visioning processes are powerful when they engage with diverse stakeholders, have a cross-sectoral focus and capture the values and priorities expressed by the community.

1.3 Create and align government strategies and plans with the vision

Embedding Greater Bogor's strategic water sensitive city vision in government strategies and plans will help to institutionalise the commitment and clarify responsibilities for delivering the vision. Translating the vision into formal planning processes can also help coordinate resource allocation to support implementation.

1.4 Monitor progress towards the water sensitive city vision

The WSC Index is a useful tool for structuring evidence of the current performance of Greater Bogor with respect to a wide range of water sensitive city aspirations and diagnosing the pressing needs and priorities to inform policy and strategy. Periodic assessment with the WSC Index may be useful for accumulating system information and tracking progress towards Greater Bogor's water sensitive leapfrogging goals.

For more information see:

Establishing water sensitive governance in Greater Bogor
How water sensitive is Bogor? Benchmarking Bogor's water sensitive performance

Pathway 2. Improve regulatory performance for water sensitive outcomes

2.1 Evaluate the impact of water, environment and land use planning regulations

2.2 Develop standards and targets based on water sensitive city vision and objectives

2.3 Protect and leverage existing water system assets as a foundation for green infrastructure

2.1 Evaluate the impact of water, environment and land use planning regulations

Overcoming challenges to implement regulations will ultimately need to involve aligned action by all levels of government. Local government can take steps in the short-term to develop its regulatory practice by evaluating the performance of current regulation in meeting the intended outcomes, and its potential for enabling and driving the aspired water sensitive outcomes.

2.2 Develop standards and targets based on water sensitive city vision and objectives

Water system and land use standards and targets that reflect Bogor's WSC priorities, accompanied by technical guidance for their achievement, will help drive implementation. Standards and targets are best established through negotiated processes that capture community values and reflect local system data. However, in the short-term there may be value in reviewing those in use in other similar jurisdictions to determine their potential suitability for interim use in Greater Bogor.

2.3 Protect and leverage existing ecological and infrastructure assets as a foundation for green infrastructure

Existing ecological assets in Greater Bogor can provide an important base for expanding and enhancing green infrastructure in the city. This includes preventing loss and degradation of areas of ecological value, such as situs and green space, through stronger land use regulations and commitment to enforcement. In addition, existing infrastructure such as drainage channels has the potential to

be repurposed or reconfigured to deliver broader benefits, including flood mitigation, water treatment, ecological functioning, and urban liveability.

For more information see:

Governance for a water sensitive transition in Greater Bogor
Review of the application of green infrastructure for water management in Bogor
Water sensitive design interventions for City Masterplan: Cibinong Situ Front City



Pathway 3. Support integration and coordination across water and urban stakeholders

3.1 Facilitate collaboration within and across organisations

3.2 Conduct inclusive, participatory strategic planning processes

3.3 Develop platforms for sharing data

3.4 Advocate for more coherent urban water system management

3.5 Coordinate urban planning and the provision of water infrastructure

3.6 Strengthen integrated catchment management in land use planning

3.1 Facilitate collaboration within and across organisations

Platforms that bring together government agencies, non-government organisations, academia and the community to collaborate will help to drive coherent city-wide action. Such platforms could include policy forums that can promote reform in the mono-disciplinary cultures of agencies to introduce innovations and multi-agency project teams that break down barriers between organisations. Professionals with specialist skills and an ability to cross organisational and disciplinary boundaries can be valuable team members in infrastructure and planning units.

3.2 Conduct inclusive, participatory strategic planning processes

An inclusive approach to setting the long-term water sensitive vision and leapfrogging objectives will be important. Dedicated resources are needed to identify and target important stakeholders, develop attractive messages to encourage effective engagement, and to facilitate forums for capturing useful feedback for strategic planning purposes.

3.3 Develop platforms for sharing data

Mechanisms for sharing data and information are crucial to achieve coordinated planning and infrastructure development. New systems and policies can enable data to be accessed and analysed by users across organisations to create integrated outcomes in system planning. This would need investment in systems for standardising data quality control procedures and data management across Greater Bogor, and the development of accessible platforms for sharing data and analysis.

3.4 Advocate for more coherent urban water system management

Institutional reforms to achieve more effective water system management need careful consideration and direction from central and provincial government. Local government can help to build the case for reform by collecting and reporting

supporting evidence, engaging with the community about water management and bringing issues and opportunities to high-level forums.

3.5 Coordinate urban planning and the provision of water infrastructure

Local, provincial and central government agencies have a role to play in the planning and implementation of water sensitive solutions. Urban planners and landscape architects should engage with those involved in water sensitive solution design at the outset of development planning to make the best use of available assets and to create multi-functional systems.

3.6 Strengthen integrated catchment management in land use planning

Efforts to strengthen catchment-based strategic planning would enable settlement planning to achieve integrated outcomes agreed to by all urban and water stakeholders. Outcomes may include protecting flood prone areas from inappropriate development, consistent measures to reduce stormwater flows from impervious surfaces, coordinated planning for effective solid waste management, and efficient funding of flood management works.

For more information see:

Governance for a water sensitive transition in Greater Bogor
Review of the application of green infrastructure for water management in Bogor

Guidance on developing infrastructure adaptation scenarios for Bogor's water sensitive transition

Water sensitive design interventions for Bogor neighbourhoods: Pulo Geulis

Water sensitive design interventions for City Masterplan: Cibinong Situ Front City



Pathway 4. Empower communities to become water sensitive

4.1 Understand barriers to the adoption of household water sensitive practices

4.2 Implement meaningful community engagement processes for water projects

4.3 Develop knowledge and skills in citizens to adopt water sensitive practices

4.4 Support water sensitive greening of the private realm

4.1 Understand barriers to the adoption of household water sensitive practices

To increase the impact of community interventions, it is important to better understand the barriers to adoption of water sensitive practices such as rainwater capture or effective waste disposal. Information gained from community social research can be used to design more effective strategies to enlist the community to undertake desired behaviours.

4.2 Implement meaningful community engagement processes for water projects

Consistent and open consultation practices early in the planning and design process would help support community participation in water planning. Effective approaches embrace the social and commercial use of public space by providing integrated solutions that can accommodate the current activities while providing ecological services and amenity for users.

4.3 Develop knowledge and skills in citizens to adopt water sensitive practices

Several critical knowledge and skills gaps will need to be addressed to support citizens to implement water sensitive solutions. These include what citizens should do before, during and after floods, how to increase the productivity of local urban farming, water-related small business and other sustainability activities, and how to sustainably adapt to climate change.

4.4 Support water sensitive greening of the private realm

Water sensitive greening of the private realm is critical for Bogor to achieve its vegetation cover target and other local water sensitive aspirations. A range of linked socialisation and behavioural change strategies are recommended alongside planning controls. These could include information sessions, competitions for greening kampungs, programmes to support local residents' urban greening groups, whole-of-city mobilisation behind a 'Green Bogor', and technical support from international NGOs and development assistance agencies.

For more information see:

Governance for a water sensitive transition in Greater Bogor
Review of the application of green infrastructure for water management in Bogor

Guidance on developing infrastructure adaptation scenarios for Bogor's water sensitive transition

Water sensitive design interventions for Bogor neighbourhoods: Pulo Geulis

Pathway 5. Develop local evidence and experience from water sensitive approaches

5.1 Introduce initiatives to facilitate learning from project experiences

5.2 Coordinate green infrastructure testing under laboratory and local field conditions

5.3 Develop technology demonstrations and proofs-of-concept

5.4 Collect evidence of the multiple benefits achieved by water sensitive systems

5.5 Develop locally-specific business cases for water sensitive approaches

5.6 Develop and implement plans for scaling and replication

5.1 Introduce initiatives to facilitate learning from project experiences

It is important to capture detailed documentation of (previous and current) projects at key stages of development and host databases and case studies in central repositories that are widely accessible to decision-makers, practitioners and researchers. It is also important to promote learning from specific projects in place, for example through use of signage and site tours to explain water sensitive projects.

5.2 Coordinate green infrastructure testing under laboratory and local field conditions

Green infrastructure needs to be tested under a variety of conditions to enable designs to be adapted to best suit local conditions and to develop an understanding of appropriate local construction, operation and maintenance procedures and costs. Such work is key to providing a foundation for local adoption guidelines for green infrastructure. Although several organisations in Bogor already undertake testing, its significance needs to be bolstered and its coordination would realise more strategic contributions to practice.

5.3 Develop technology demonstrations and proofs-of-concept

Demonstration projects that provide on-ground examples of an innovative water sensitive solution are critical for local proof-of-concept and as a learning opportunity for stakeholders. It is important to capture all potential lessons from demonstrations, including social, technical and economic evidence and insights, through detailed documentation and dissemination.

5.4 Collect evidence of the multiple benefits achieved by water sensitive systems

Information that quantifies the multiple benefits of water sensitive systems or improves understanding of system costs is important to collect. It may be useful to build partnerships

with the community sector, academia or international organisations to apply evaluation techniques that capture social, environmental and economic benefits.

5.5 Develop locally-specific business cases for water sensitive approaches

Model business cases for multi-functional water sensitive infrastructure for the local Bogor conditions will be important to show why diverse stakeholders benefit from and should contribute towards initiatives such as rainwater harvesting or stormwater runoff diversion and treatment in parks and public open space.

5.6 Develop and implement plans for scaling and replication

Demonstration projects can create significant momentum amongst stakeholders and potential investors. It is important to develop and implement plans to harness this momentum for scaling and replication of water sensitive projects across Bogor. Dedicated resources to review lessons from demonstration projects will help inform plans to do this efficiently and effectively.

For more information see:

Governance for a water sensitive transition in Greater Bogor
Review of the application of green infrastructure for water management in Bogor

Guidance on developing infrastructure adaptation scenarios for Bogor's water sensitive transition

Water sensitive design interventions for Bogor neighbourhoods: Pulo Geulis

Pathway 6. Build professional capacity for water sensitive practices

6.1 Formalise and support the Water Sensitive City Learning Alliance for Bogor's water and urban professionals

6.2 Understand data requirements for optimal water system planning

6.3 Develop guidance and training for planning and designing water sensitive solutions

6.4 Develop professional skills for implementing social and economic solutions

6.5 Develop decision-support tools that overcome lack of data availability and reliability

6.6 Build maintenance needs into water sensitive project planning and design

6.1 Formalise and support the WSC Learning Alliance for Bogor's water and urban professionals

Leapfrogging to a water sensitive city will involve the adoption of new practices and diffusion of water innovations. Professionals involved in these changes, across government, industry and academia, need the opportunity to learn together to build collective knowledge and experience. Agency leadership is important for formalising the Learning Alliance and facilitating networks that can cut through silos both within and between organisations. Individual water sensitive city champions are important participants in the Learning Alliance to build momentum and influence. Local and international universities, and other research centres with expertise in water sensitive approaches, would be valuable for the Learning Alliance to engage and partner with.

6.2 Understand data requirements for water system planning

A framework for prioritising investment in data collection and analysis should be developed to inform long-term data resourcing decisions. A data management framework would describe the data requirements for integrated water system planning, identify foundational datasets that are critical in the short-term, and define the degree of aggregation suitable for effective decision-making.

6.3 Develop guidance and training for planning and designing water sensitive solutions

While comprehensive guidance based on local evidence is desirable over the long-term, initial steps could focus on assessing the suitability of existing guidance from other jurisdictions and making adaptations for local use. Technical advice from universities and international agencies may be useful to inform planning and design guidance. Relevant agencies may find it useful to promote general training and capacity building in the application of existing planning and design tools.

6.4 Develop professional skills for implementing social and economic solutions

Improving the capacity to deliver social and economic interventions can create new pathways for delivering water

sensitive outcomes. Such solutions could include incentive schemes, regulation, participatory processes and community engagement campaigns. Building public sector skills and capacity to evaluate the full range of implementation options may reveal the most cost-effective means of achieving water sensitive policy objectives. A particular focus on skills to engage in multi-disciplinary programs and innovative multi-stakeholder water projects is important for Bogor.

6.5 Develop decision-support tools that overcome lack of data availability and reliability

For Bogor, it is useful to understand deficiencies in data quality to reinforce advocacy for improvements. In the meantime, it may be useful to develop robust tools that consolidate and integrate different sources of data, including contextual knowledge as well as new data capturing techniques (e.g. drone surveys), to support planning and decision-making until more comprehensive data can be established.

6.6 Build maintenance needs into water sensitive project planning and design

Improved water infrastructure maintenance is a pressing need for Greater Bogor's existing system. This will continue to be important as green infrastructure is deployed as part of Greater Bogor's transition to a water sensitive city. Maintenance needs should be incorporated during project planning and design. Key considerations are the degree of sophistication of the system, the scale of its operation and the likely responsible stakeholder and budget allocation for implementing the maintenance regime.

For more information see:

Governance for a water sensitive transition in Greater Bogor
Review of the application of green infrastructure for water management in Bogor

Guidance on developing infrastructure adaptation scenarios for Bogor's water sensitive transition

Water sensitive design interventions for City Masterplan: Cibirong Situ Front City

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Other research:

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Research in Surabaya

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