The Australia-Indonesia Centre
URBAN WATER RESEARCH CLUSTER

Green-Blue Technologies

Masterclass & FGD

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4th July 2018

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Research collaborations in:

- Infrastru cture
- Energy
- Food & Agro
- Health and Med
- Urban Water

Objectives

1. Provide an overview of the benefits and adoption of green technologies in a Masterclass,
2. Discuss and gather feedback on the key outcomes of the literature review into green technology adoption in Bogor,
3. Discuss potential technological solutions at the case study sites.

Agenda

Masterclass 9:40 – 10:50

- Why is there a need for green technologies and water sensitive urban design?
- What are the multiple benefits provided by different technologies?
- Examples of green technologies in action
- Key outcomes from the review

Focus Group Discussion 10:50 – 12:30

- Discuss the key outcomes of the review and gather feedback on any ways to improve its usefulness
- Discuss current examples of green technologies in Bogor
- Discuss potential future solutions for Bogor

Masterclass

Green technologies to enhance urban water management, human health, greenery, ecosystems & amenity

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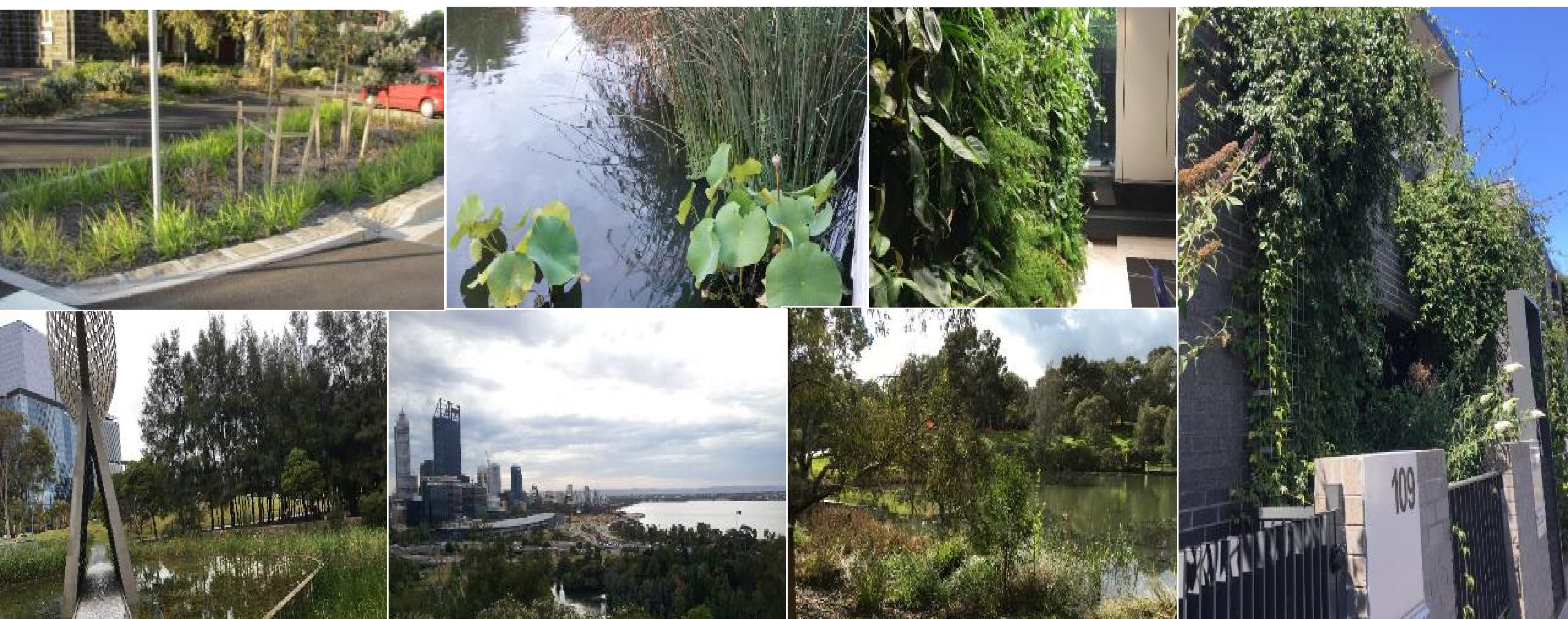


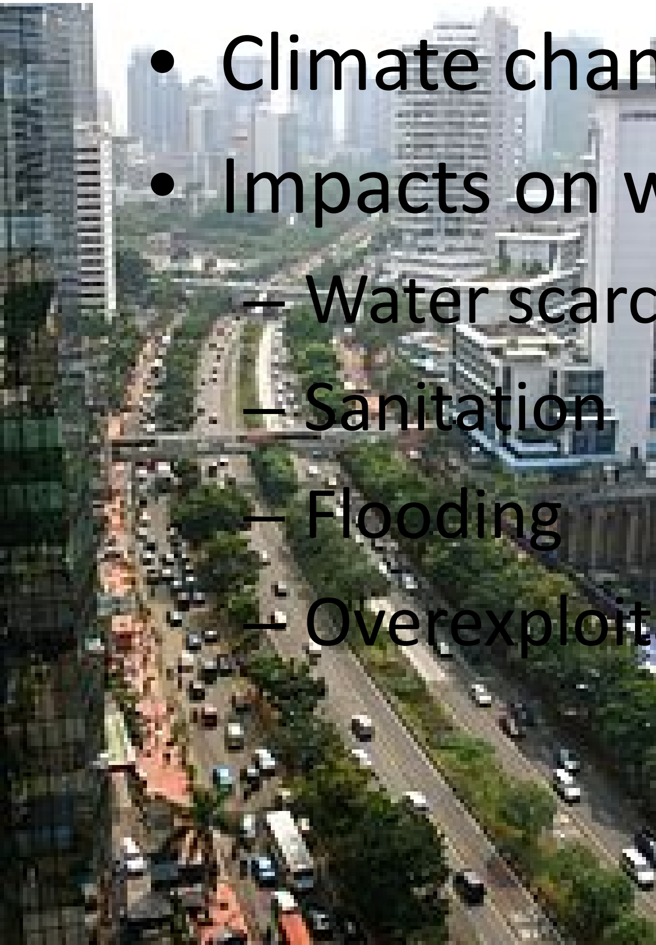
Overview of WSUD

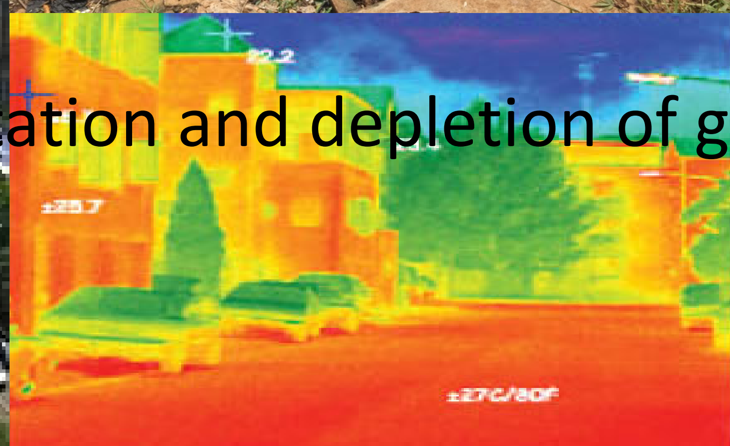
- https://youtube/LMq6FYiF1mo

- https://youtu.be/7bgp3E0gUAQ

Urban challenges

- Population growth
- Climate change
- Impacts on water resources
  - Water scarcity during dry season
  - Sanitation
  - Flooding
  - Overexploitation and depletion of groundwater






Bogor's sustainability goals

Source: Presentation by Naufal, Isnaeni, BAPPEDA

- Be a **sustainable city**
- Mid term Strategic Plan of Bogor (2015) aims to retain '**garden city**' reputation by promoting 'green networks' – open spaces of parks, green belts, urban forest/protected areas, agricultural land. Aiming for **30% green and open space** on both public and private land (Government Law No. 26/2007)

How to become a more sustainable and productive city?

Green technologies

- Also commonly referred to as blue-green infrastructure or simply green infrastructure
- Comprise a network of green and open space and nature based treatment technologies
- Concept of WSUD – integration of urban design with water resources management – learn more in afternoon session
- In this session, run through the different technological options and provide a basis of how to choose between them

Image: Green Infrastructure Ontario

Image: Living Community Lab

GI – Performance objectives

Water quality improvement

Water security

Water quantity control – flow attenuation – reduce the impacts of flooding

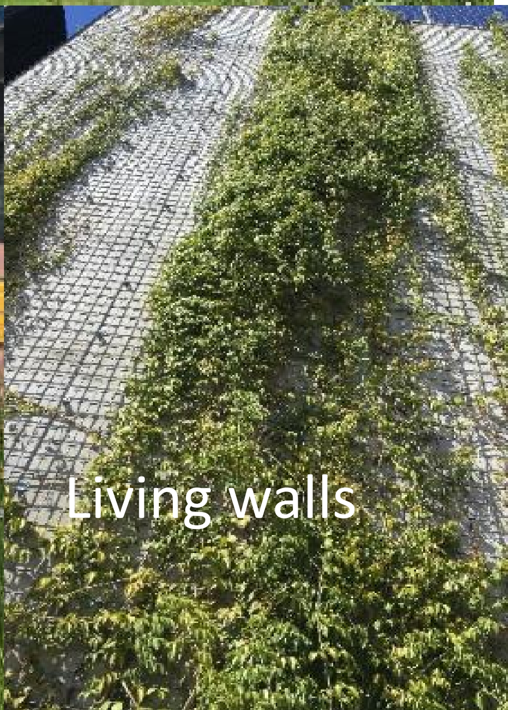
Protection of situs and river health

Erosion control

Green technologies – different functions

- Water treatment
- On-site detention and storage
- Promote groundwater recharge through infiltration
- Rainwater harvesting/greywater recycling
- Flow conveyance
- Food production – Urban farming

Green & water sensitive treatment technologies



Green & water sensitive treatment technologies

The different socio-economic and ecological benefits of GI

GREEN INFRASTRUCTURE

Economic benefits

- Commercial vitality
- Increased property value
- Local economic productivity

Social benefits

- Human health & well-being
- Community engagement and inclusion
- Visual & aesthetics

Environmental benefits

- Urban cooling
- Climate change mitigation
- Air quality improvement
- Biodiversity
- River and lake health
- Water supply
- Flow control, flood reduction
- Greywater treatment and re-use

OVERVIEW OF THE DIFFERENT TECHNOLOGIES

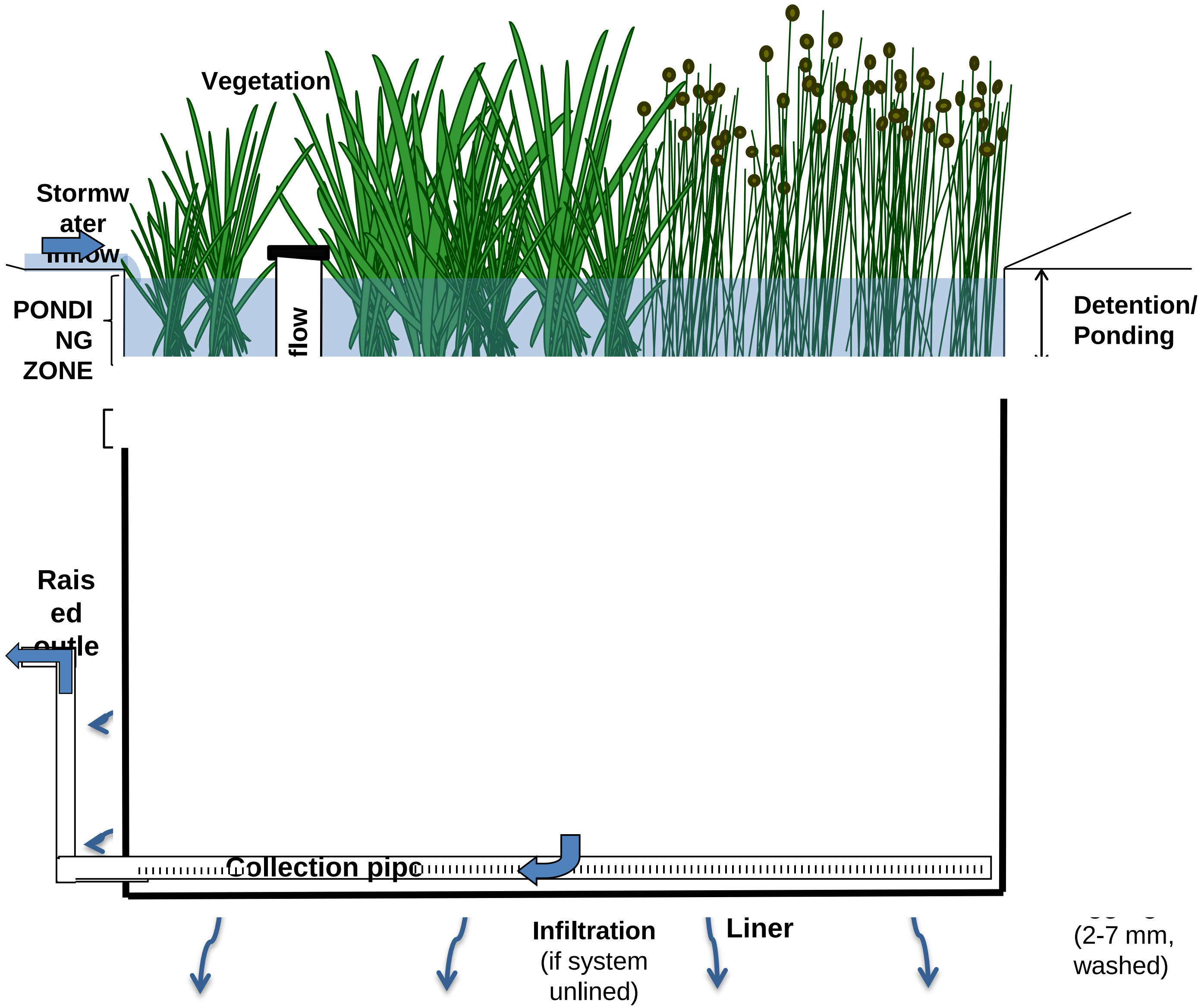
Biofiltration systems

Biofilters, also commonly known as biofiltration systems, bioretention, raingardens or tree pits…

Biofilters

- Treatment of stormwater runoff and ‘light’ greywater
- Can be applied at a range of scales (street tree, streetscape, backyard, park or larger)
- Passive treatment systems – water quality, flow retention, amenity, greenery, biodiversity…
- Flexible in design to suit site conditions and objectives
- Design can be simple or complex
- Successfully tested & used in Singapore

Biofilters – how do they work?



[Biofilter video]

Treatment performance

Stormwater

If designed properly vegetated, soil-based biofilters will reduce

- Over 95% of TSS,
- Over 65% of TP,
- Over 50% of TN (even over 70% for some configurations)
- Over 90% of heavy metals
- High level of pathogen removal (>90%)

Note: Biofilters tested under Victorian conditions/temperate climate

Treatment performance

Light greywater

- Over 90% of BOD
- Over 70% of TOC
- 20 – 80% of TP and TN (depending on plant selection)
- 2-3 log reduction of pathogen removal

Note: Biofilters tested under Victorian conditions/temperate climate

Constructed wetlands

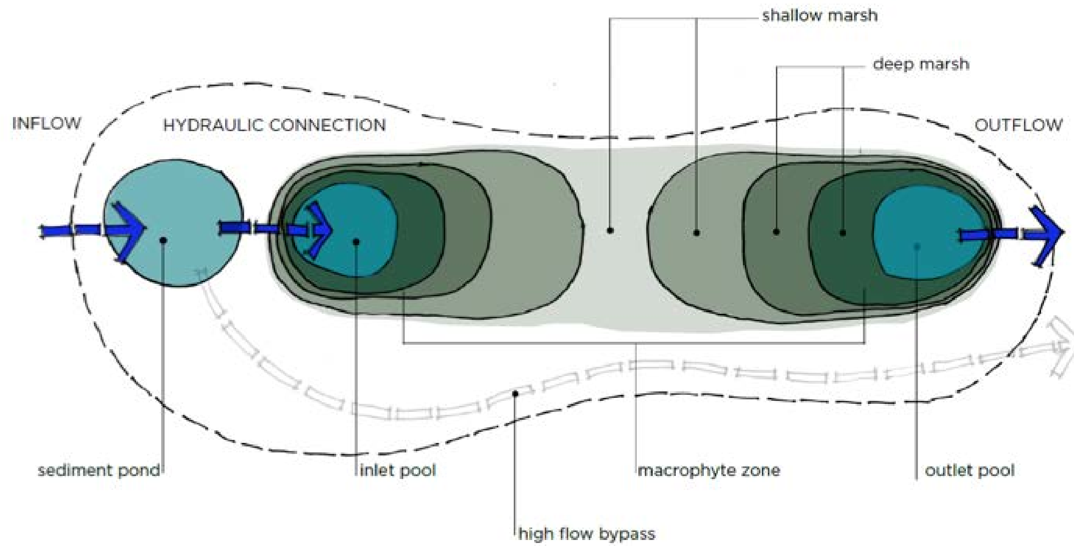
Constructed wetlands

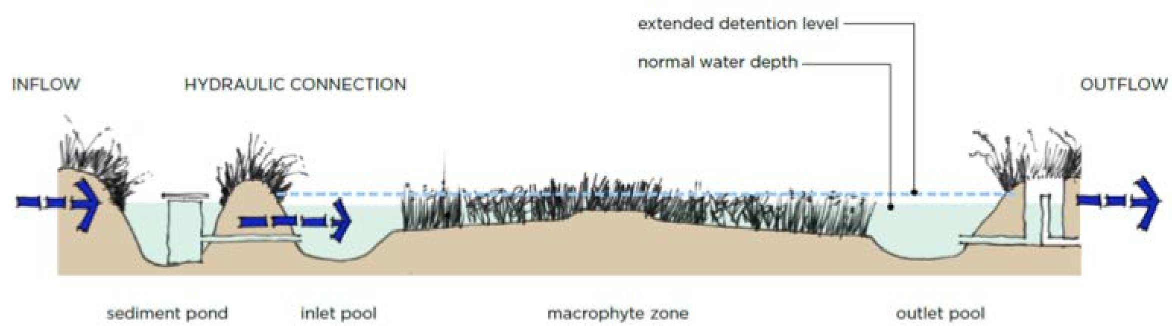
Constructed wetlands

- Used globally to treat various water sources – stormwater runoff and various wastewaters (domestic, partially treated, industrial effluents)
- Provide a range of benefits – water quality treatment, flow attenuation & water storage, landscaping & amenity, habitat/biodiversity, property value…
- Effective for sediment and nutrient (nitrogen & phosphorus) removal
- Can be applied at small to larger scales
- Various designs – subsurface flow (horizontal or vertical flow), free water surface, floating treatment wetlands -> vary in cost and performance

Stormwater Wetlands – how do they function?

- High plant cover
- High level by-pass
- Strategies in place to prevent mosquito breeding
- Even distribution of flows
- Not too much open water – differ from ponds





Water by design, 2017

Wastewater Wetlands – how do they function?

- Different types
  - Surface flow
  - Sub-surface flow
  - Floating wetlands

Floating wetland

Image: Dr Cynthia Henny, Puslit Limnology- LIPI

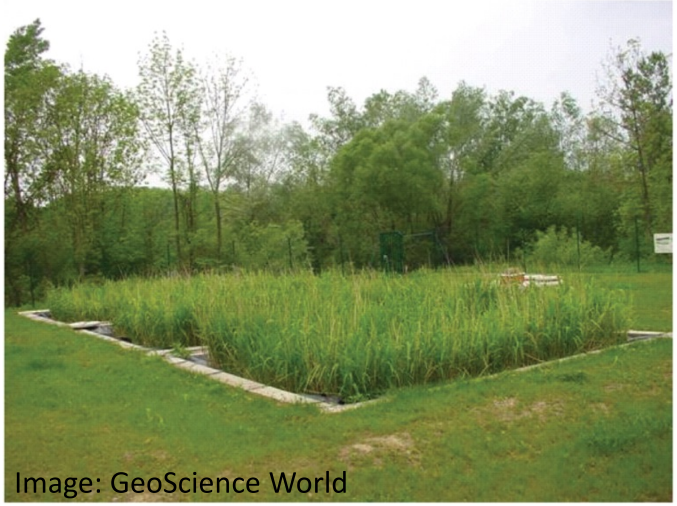


Image: GeoScience World

Sub surface flow wetland

Surface flow wetland

Treatment performance

Studies in tropical climates

FW CWs	SSF CWs
TSS, COD and BOD: 70-80% TN: 60 – 75% TP: 13-75%	TSS: ~80% BOD : 78-88% COD: 64 – 71% NH4: 60-70% NO3: 40% (HSSF) – 70% (VSSF) TN: 50% TP: 60-70%

Zhang et al., 2015

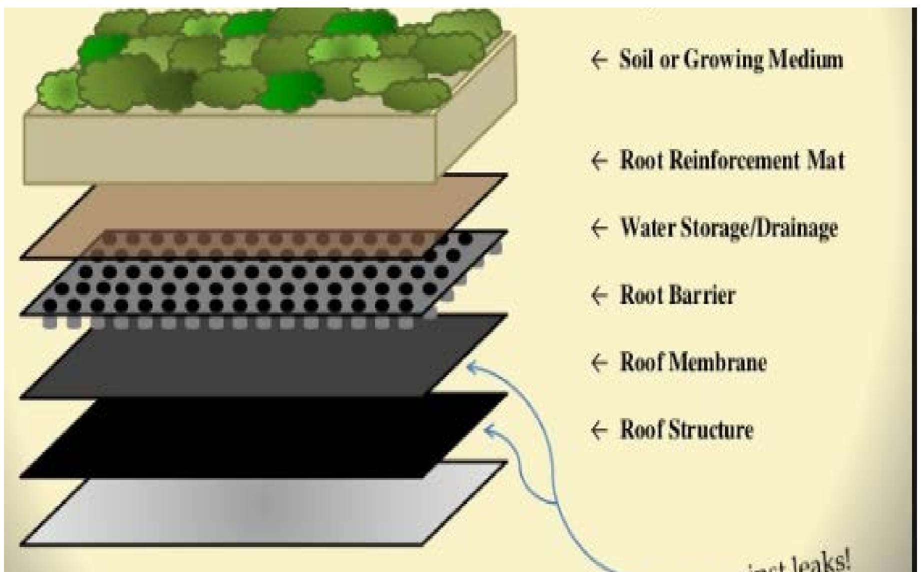
Green roofs

Green roofs

- Provide multiple benefits – runoff attenuation (e.g. in Malaysia peak runoff ↓26%), greenery, building cooling (e.g. in Malaysia indoor air temp ↓ by 5^{o}C)
- Performance influenced by substrate composition, pollutants, depth, plant species

Green roofs – how do they function?

Source: Greentumble, https://greentumble.com/how-do-green-roofs-work/



Source: Slideshare, https://www.slideshare.net/themarkofpolo/intro-to-green-roofs-for-educators

City of Melbourne

Performance

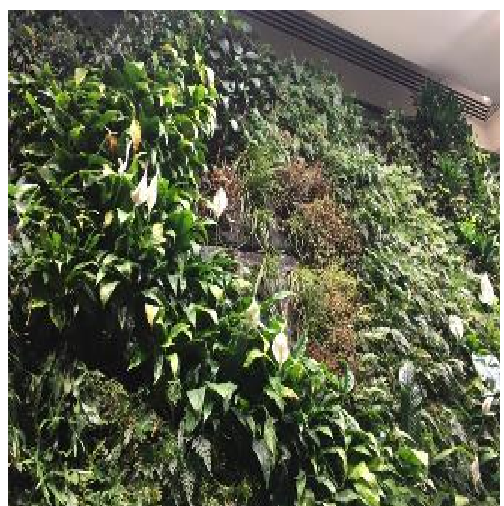
- Delay in runoff (peak to peak) by approx. 10 mins (Simmons et al., 2008)

- Retention by the vegetated roofs varied between 39 – 45% depending on designs (mean of all events) (Wong and Jim 2014)

- International studies:
  - 49-80% of precipitation retained over extended periods of data collection (Auckland city council, Technical report, 2013).

Green walls & Green facades

Green walls or living walls (using climbing plants) for water treatment



Green walls for greywater treatment – how do they function?

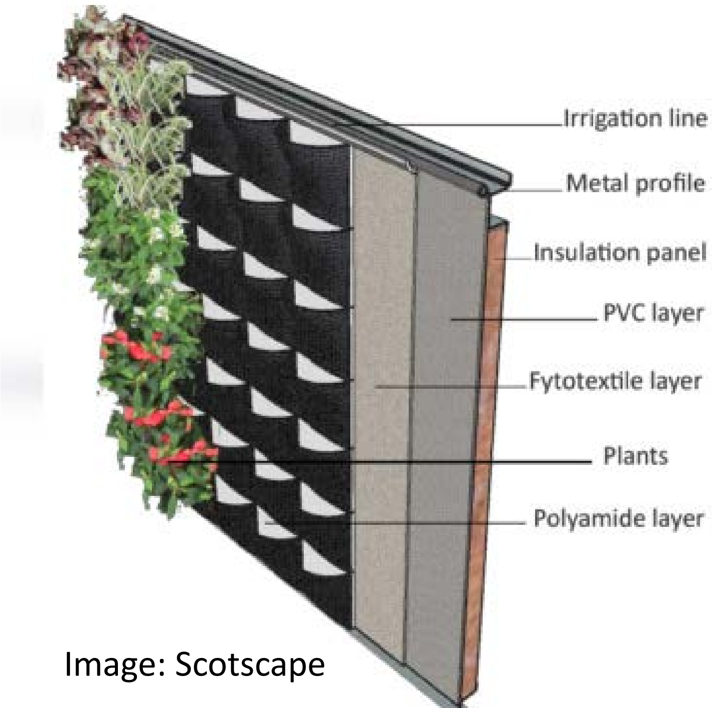


Image: Scotscape

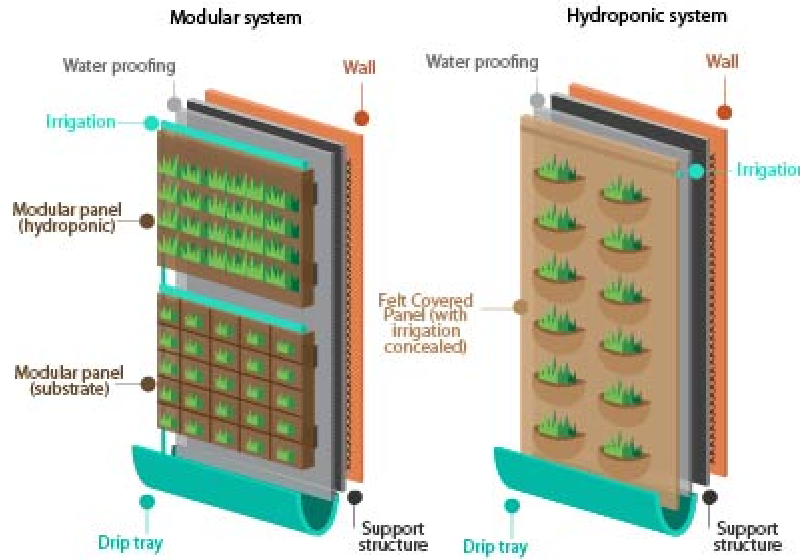
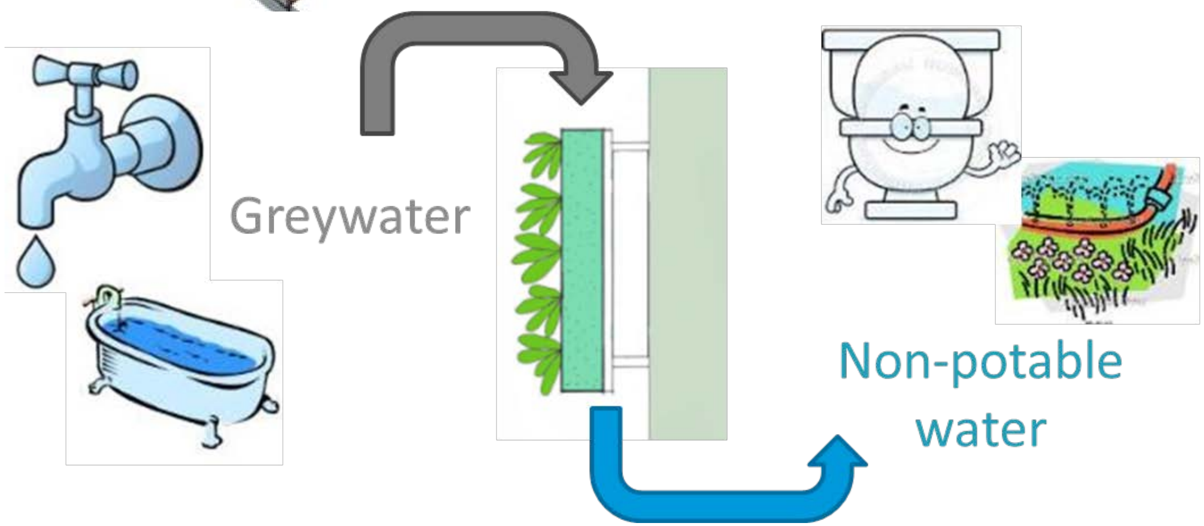


Image: Growing Green Guide



Performance

- Mean COD and BOD reduction: approx. 50% (Masi et al., 2016)
- Effluent from the green wall system complied with local regulations for irrigation.
- Pre-treatment recommended to avoid premature clogging

Masi et al., 2016

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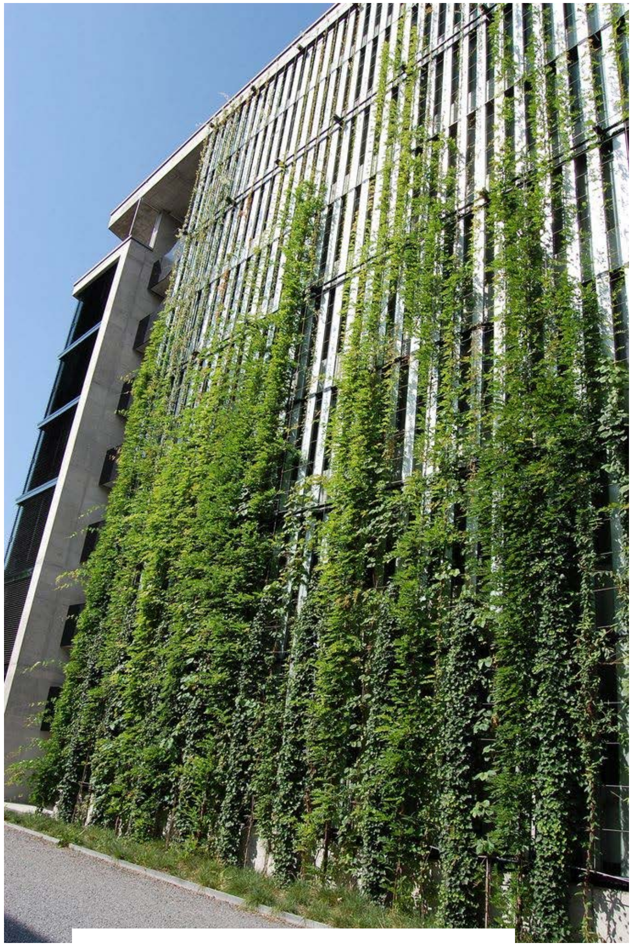
Green facades (Living walls) – how do they function?



Underground trench

biofilter

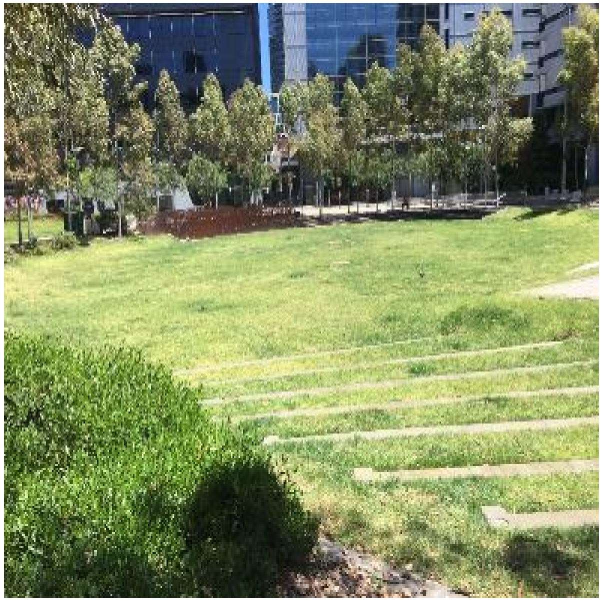
Above ground planter box

Ponds and lakes

(retention ponds, detention ponds)

Stormwater retention / retarding basins

- Can provide multifunctional community open space
- Flood during storm events
- Providing temporary storage and flood mitigation
- May include a pond which expands during large storm events



Stormwater detention / retarding basins – how do they function?

Image: Melbourne Water

Stormwater retention ponds

- Includes a permanent pool of water

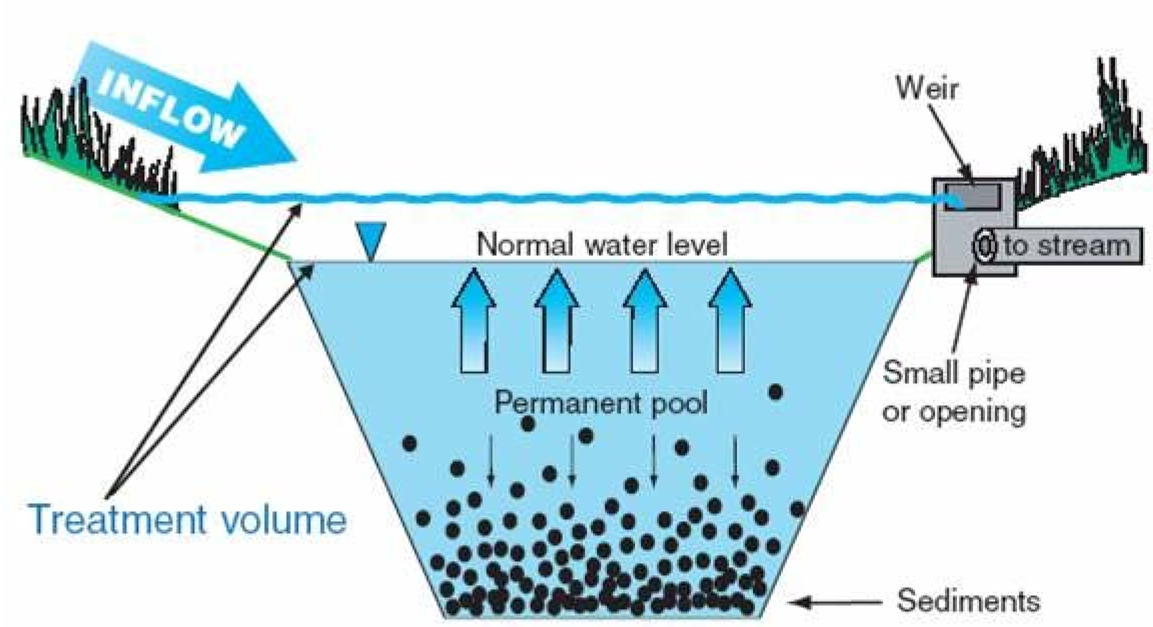


Image: Charles Center Summer Research Blog

Ponds – how do they function?

- Primarily open water, deeper and less vegetated than wetlands
- Slow flow and provide water storage – flood mitigation and potential water supply
- Promote sedimentation – removing sediment and attached pollutants

Swales & buffer strips

Swales – how do they function?

- Vegetated open channels, underlain by porous media (sand, gravel) and possibly an underdrain
- Provide flow conveyance, but unlike concrete drains, vegetation and infiltration slow and reduce flow
- Provide flood mitigation, some pollutant removal (sediment, attached pollutants), amenity and greenery
- May be grassed or larger vegetation (which provides greater flow attenuation)

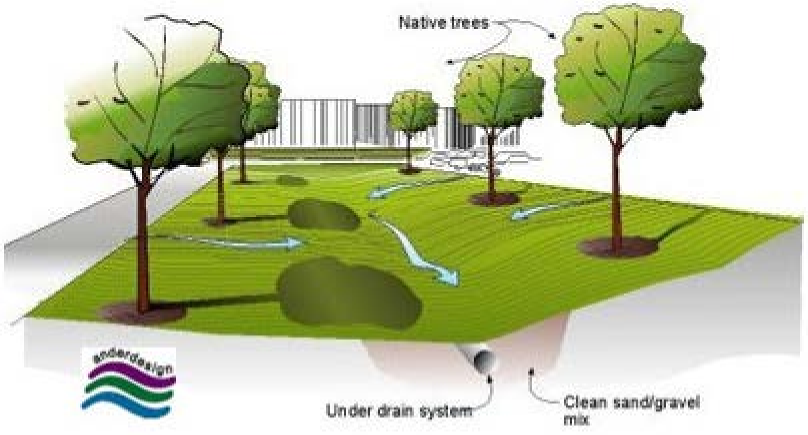


Image: SuDS Wales

Image: No Tech magazine

Vegetated drains in Bogor (potential swales)

- Long V-drain along Ciliwung street in Sentul City – potential adaptation for greater flow attenuation (Prof Hadi, UI current research)





Porous pavements

Porous pavements – how do they function?

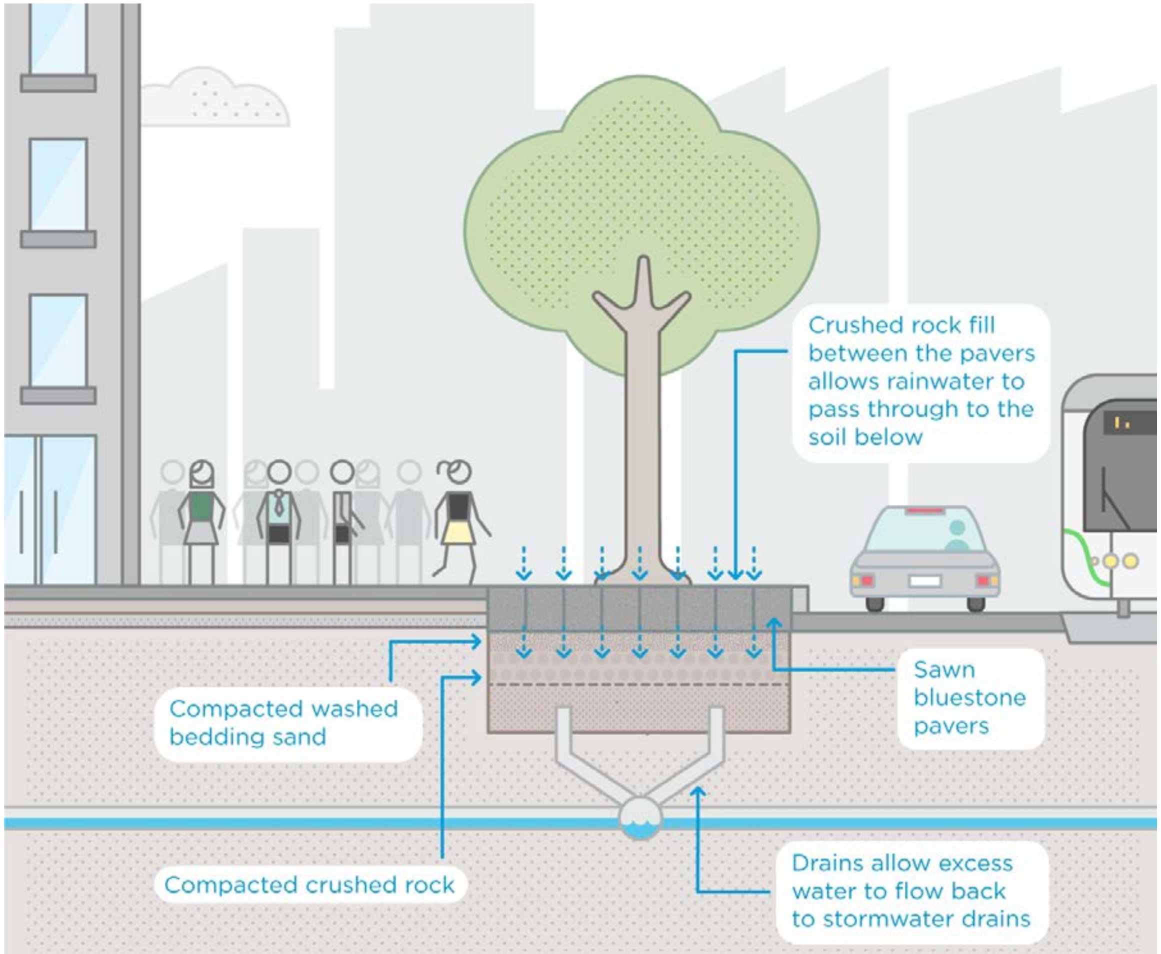
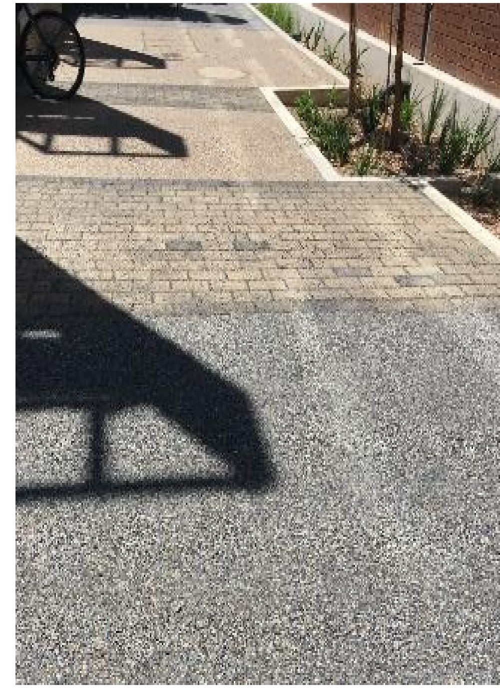
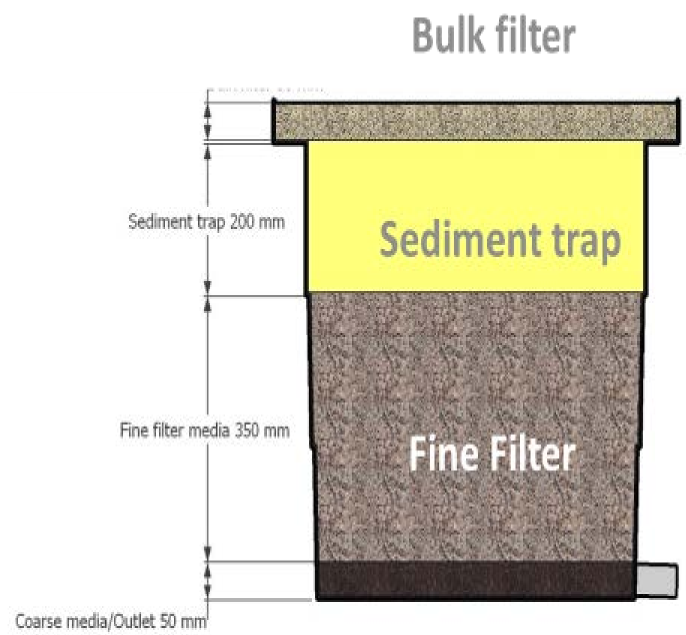


Image: City of Melbourne





Porous pavements in Bogor

- Extent of any adoption unknown? Some plans to use porous pavements reported for carparks
- Research by Dr Dwinanti and students modelling porous pavement performance
- An example of a porous area interwoven with impervious in Sentul City (below)

Rainwater tanks

Rain water tanks

- Provide water storage - water source to increase water security and flood mitigation
- Ancient technology, used for centuries
- Narrow designs possible in dense environments
- Particulates, metals, acidity, pathogens can be pollutants from atmosphere or roof surfaces
- Need to match an appropriate water use with the water quality required

Infiltration systems

Infiltration systems

- Promote infiltration of stormwater runoff into surrounding soils
- Reduces stormwater runoff – providing flood mitigation, reduced pollutant load, and groundwater recharge
- Technologies to infiltrate can include
  - porous pavement,
  - biofiltration (if unlined),
  - groundwater recharge wells,
  - infiltration trenches
  - passively watered garden beds (i.e. directing water onto impervious surfaces)…

Examples of green technologies in Bogor

What are the opportunities?

Biofilters

- Demonstration biofiltration projects in Pulo Geulis and Griya Katulampa treating domestic greywater (Prof Hadi, UI)

Prof Hadi's pilot biofilters in Griya Katulampa

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Constructed wetlands

- Focus of significant research and pilot projects at LIPI, UI, IPB…
- Effective performance demonstrated treating various wastewaters
- Includes floating treatment wetlands for situ or channel restoration of ecological function

Images from Dr Cynthia Henny, Puslit Limnology- LIPI (November FGD presentation)

Green roofs

- Green roof at Hotel Neo Green Savana, Sentul City
- Green roof planned for Aeon Mall



Photos: Raul Marino

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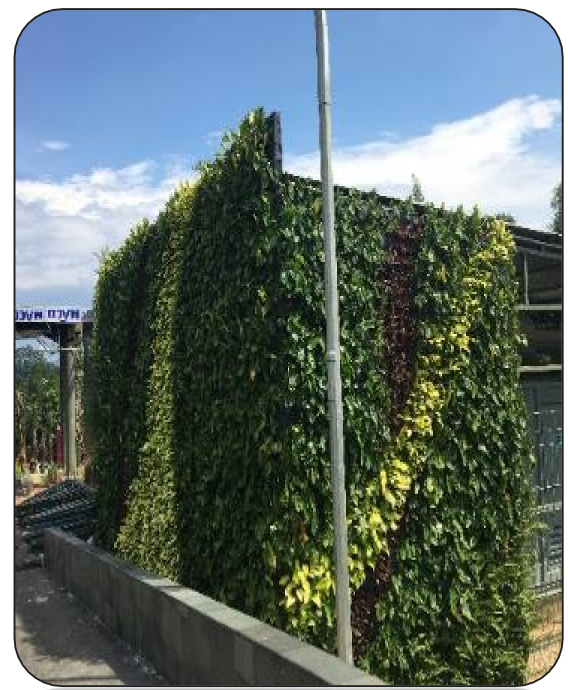
Green walls

- Green wall at Aston Hotel covering car parking buildings
- Green wall covering pump station at new Sentul City hotel
- Primarily for aesthetic purposes. Watered with fresh water supply.



Ponds and lakes

- Two retention ponds in Sentul City – primary provide amenity & recreational benefits, also store rainwater and provide emergency water supply
- Hundreds of natural situs throughout Bogor

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Swales

- Swales at Jakarta airport

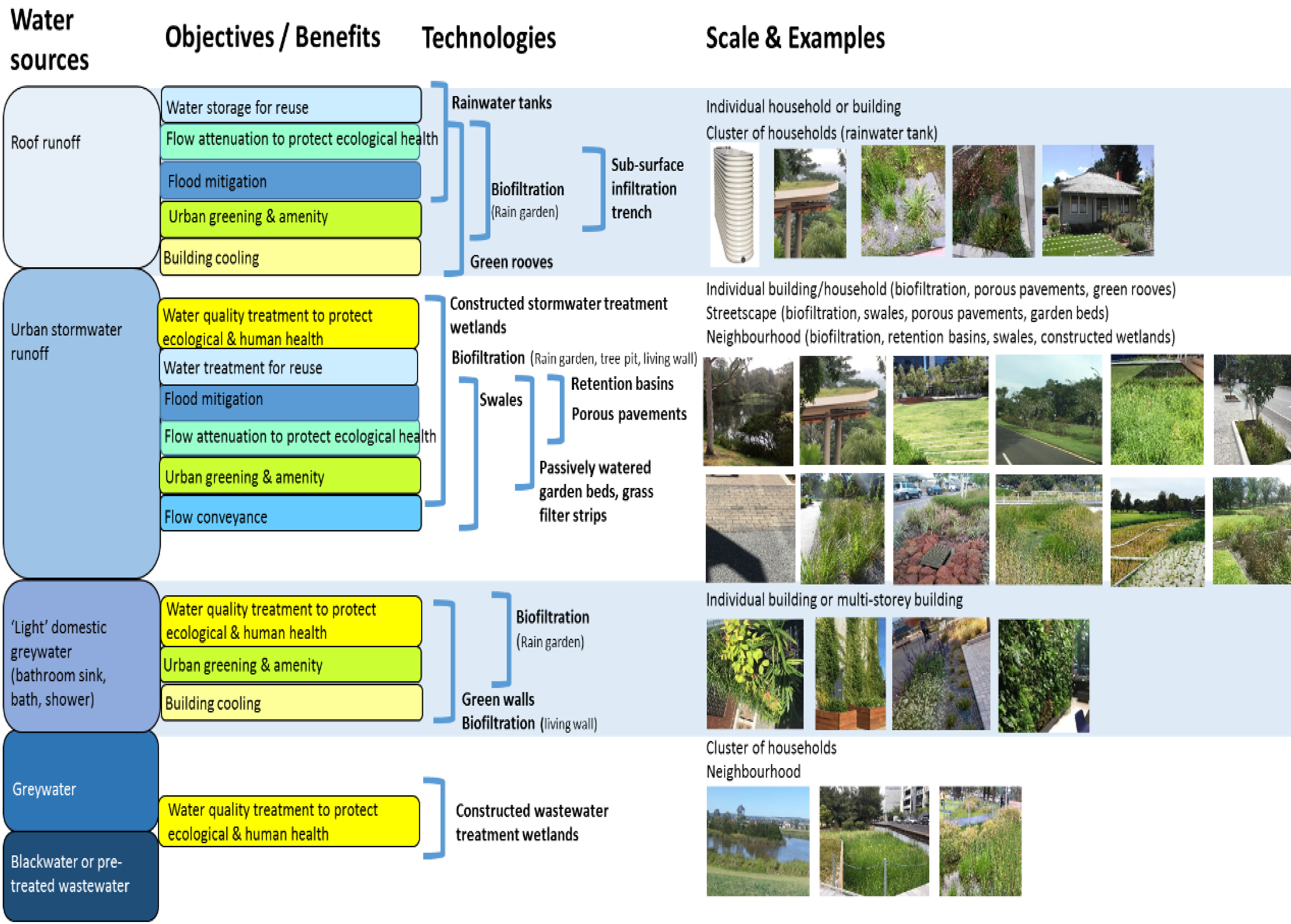
Rain water tanks / harvesting in Bogor

- Some areas of implementation – private residences, new developments, some government buildings (e.g. Bappeda's buried rainwater tank)
- Traditional architecture incorporates capture of roof runoff in ponds (photos)
- However community preference for groundwater reported
- Water quality issues due to acidification of rainfall after dry periods
- Design features can enhance water quality, including selecting end uses appropriate to the water quality

Infiltration systems

- Concept of zero runoff established
- Runoff retention currently achieved by several technologies -
  - Groundwater recharge wells (somurasokan),
  - Ecodrains alongside roads, and
  - Biopori (holes filled with compost in backyards, receiving runoff from garden)

TECHNOLOGY SELECTION – WHICH TECHNOLOGY TO USE?


Water sources
Objectives / Benefits
Technologies
Scale & Examples
Roof runoff
Water storage for reuse
Flow attenuation to protect ecological health
Flood mitigation
Urban greening & amenity
Building cooling
Rainwater tanks
Biofiltration (Rain garden)
Sub-surface infiltration trench
Green rooves
Individual household or building
Cluster of households (rainwater tank)
Urban stormwater runoff
Water quality treatment to protect ecological & human health
Water treatment for reuse
Flood mitigation
Flow attenuation to protect ecological health
Urban greening & amenity
Flow conveyance
Constructed stormwater treatment wetlands
Biofiltration (Rain garden, tree pit, living wall)
Swales
Retention basins
Porous pavements
Passively watered garden beds, grass filter strips
Individual building/household (biofiltration, porous pavements, green rooves)
Streetscape (biofiltration, swales, porous pavements, garden beds)
Neighbourhood (biofiltration, retention basins, swales, constructed wetlands)
'Light' domestic greywater (bathroom sink, bath, shower)
Water quality treatment to protect ecological & human health
Urban greening & amenity
Building cooling
Biofiltration (Rain garden)
Green walls
Biofiltration (living wall)
Individual building or multi-storey building
Greywater
Blackwater or pre-treated wastewater
Water quality treatment to protect ecological & human health
Constructed wastewater treatment wetlands
Cluster of households
Neighbourhood

Step 1: Understanding your catchment

- Bio-physical characteristics
  - Soil properties
  - Water resources, incl. groundwater
  - Land use
  - Available space, etc…

- Socio-cultural characteristics
  - Heritage
  - Landscape value
  - Future projects, etc…

- What are the pollutants of concern?
- What are the characteristics of runoff/greywater in the catchment?

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Step 2: Defining your objectives

- What do we want to achieve – performance targets, i.e. level of pollutant retention required

- Important to have defined performance targets, water quality and discharge limits
  - Will form regulatory requirements

- Design to maximise benefits – have a higher return on investment

Step 3: Selecting options

- Taking into consideration findings of step 1 and 2
  - Matching technology with site characteristics
  - Matching technology with performance objectives

- Following best practice water management principles

Best practice water management

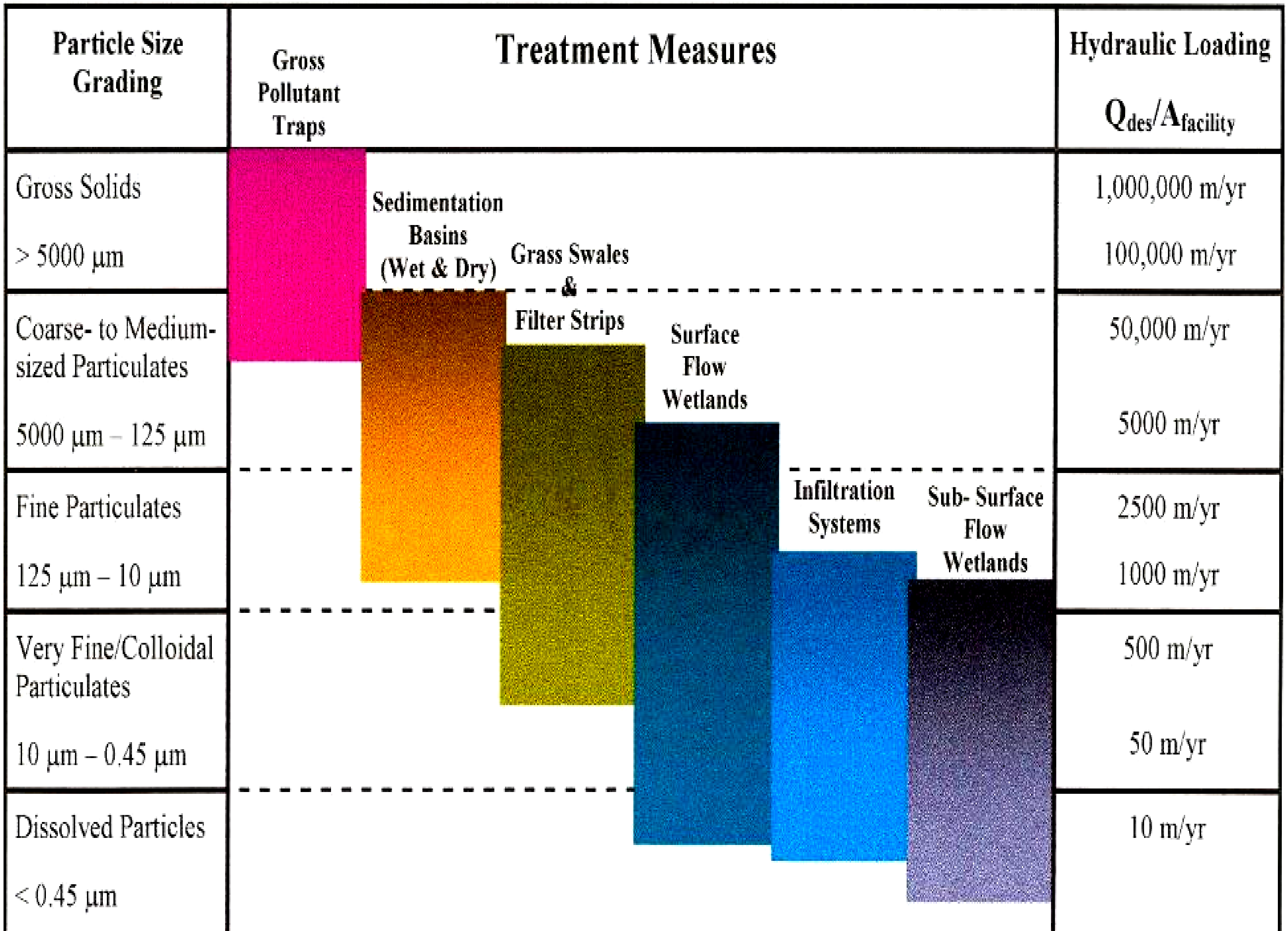
Treatment train approach

- A sequence of multiple treatments – targeting various pollutants or sediment sizes
- Provides optimal treatment
- Trap large pollutants and sediment upstream,
- Protect wetlands and biofilters downstream and allow them to treat fine and dissolved particles

Examples of treatment trains

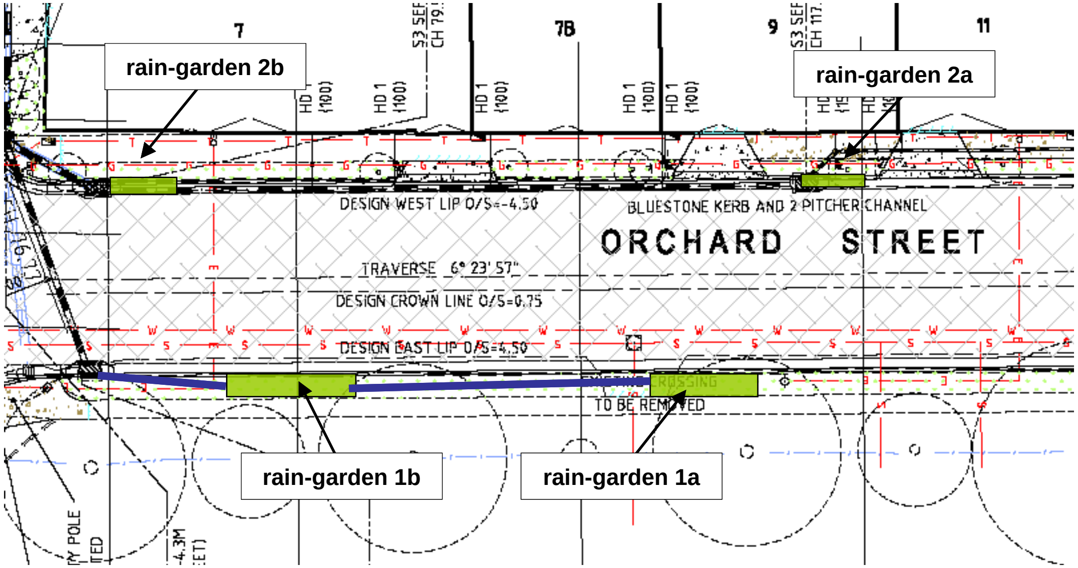
Source: Melbourne Water

Treatment trains – using combinations of technologies matched to flow and particle size



Best practice water management

- **At-source** management
- Using a **decentralised approach** where possible as opposed to a centralised one



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Best practice water management

- When selecting water management solutions, consider using a mix of grey and green infrastructure
  - o Green technologies complement grey infrastructure

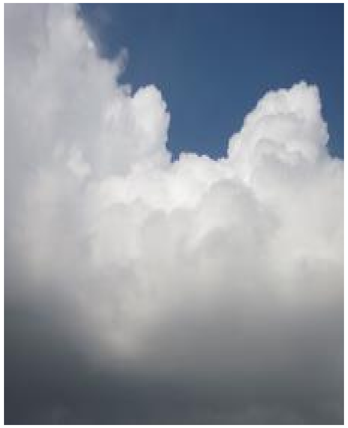
APPLICATION FOR THE LOCAL CONTEXT

Designing to suit local conditions

Treatment to meet local objectives / needs / priorities

+

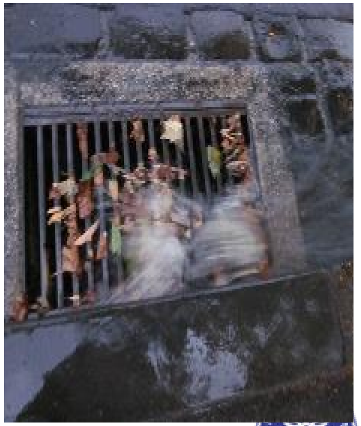
Local climate



Local plants

Local sources of media

Local pollutant characteristics



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Key characteristics of Bogor affecting design and/or operation

- Greater generation of runoff
- Greater erosive capacity
- Greater sediment production
- Greater solid transport capacity
- Favourable conditions for proliferation of mosquitos, etc
- Higher runoff volume and peak flow
- More contaminated runoff (due to washoff from litter disposed on roads, ingress of wastewater into drainage systems)
- More variable influent over the year

Design considerations

- Pre-treatment
  - Solid waste management
    - Litter disposal programs
    - Community education
  - Installation of pre-treatment device upstream of treatment measure, e.g. sedimentation basins, gross pollutant traps, different screens

Gross solids removal

- Various designs of screens, Gross Pollutant Traps, nets to capture gross solids (litter) and large sediment particles within channels or rivers
- Use physical process to remove
- Require ongoing maintenance to periodically clean and removal accumulated litter



System sizing

System size is vital for treatment capacity

- Undersized – system will be overwhelmed and clog earlier, flows will bypass untreated
- Oversized – system may be too dry to support plants

Sizing influenced by multiple design parameters (media infiltration rate, area, ponding depth)

Depends upon local climate

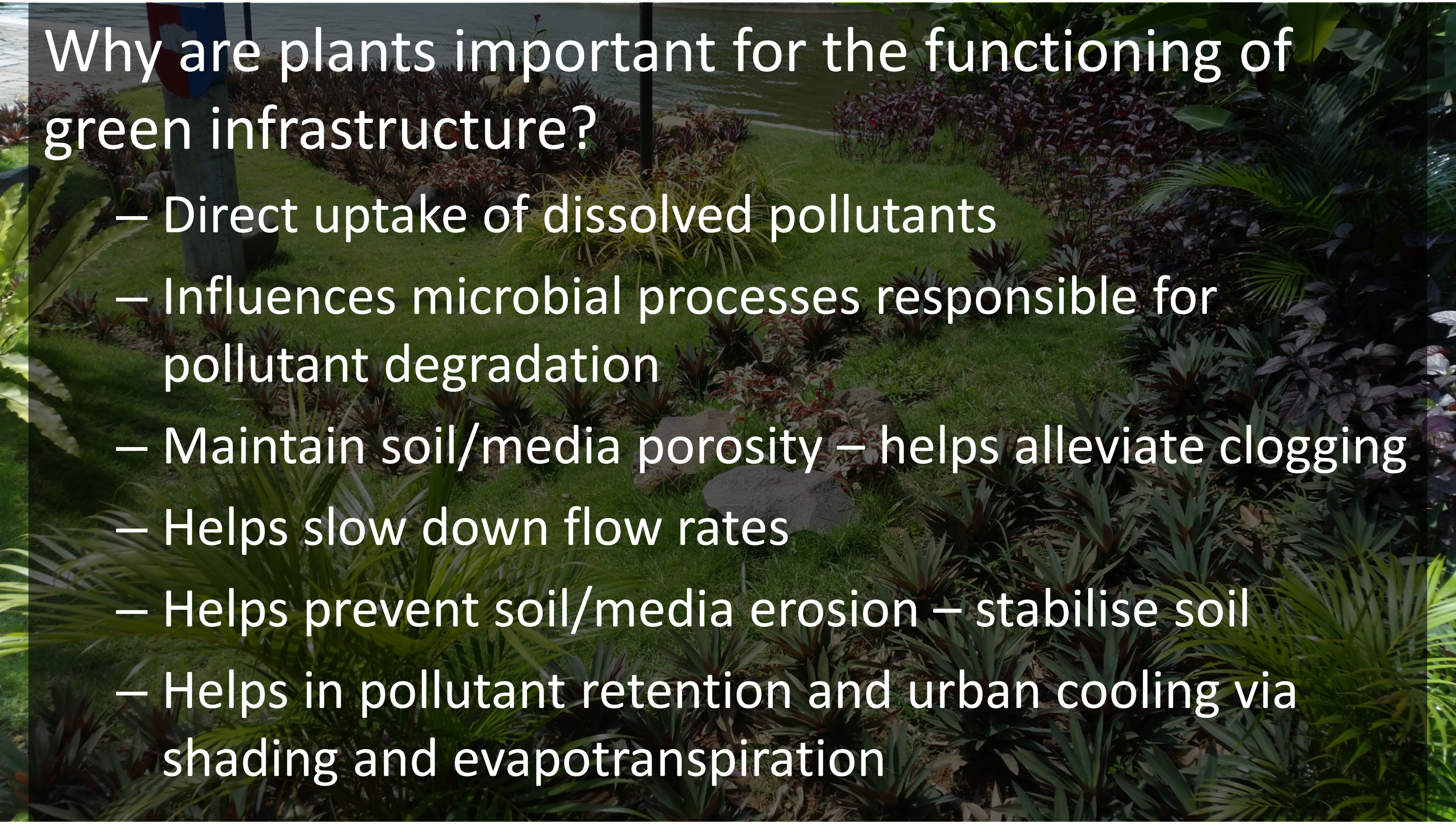
System sizing

- System sizing is key if the system is being designed to manage stormwater flows.
- Stormwater systems in Bogor will be larger than those implemented in temperate climates for the same contributing catchment
- Considerations
  - Consider use of a combination of measures to achieve design objectives
  - Consider use of a number of distributed (and connected) systems
- For greywater system, correct system sizing will avoid premature system failure due to clogging

Filter media

- Low in nutrient and organic content – to prevent leaching
- Must have enough fines to support plant
- Adequate hydraulic conductivity – to ensure satisfactory infiltration otherwise will result in high flow bypass

Vegetation selection

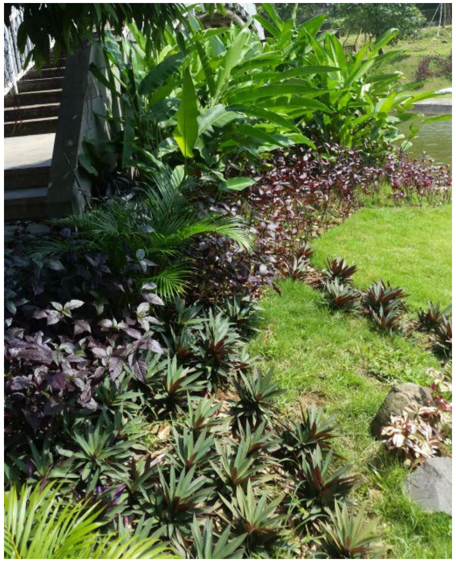


Why are plants important for the functioning of green infrastructure?

- Direct uptake of dissolved pollutants
- Influences microbial processes responsible for pollutant degradation
- Maintain soil/media porosity – helps alleviate clogging
- Helps slow down flow rates
- Helps prevent soil/media erosion – stabilise soil
- Helps in pollutant retention and urban cooling via shading and evapotranspiration

Suitable plant species

- Adapted to local climate
- Species morphological traits – good correlation with nutrient removal
  - Extensive and fine roots
  - Moderate to high growth rate
  - High total plant mass
- Plants displaying 'luxury' nutrient uptake
- Plant with a mixture of species
- Relative dense planting



Economic/business opportunities arising from green infrastructure implementation

Fish farming

Urban farming

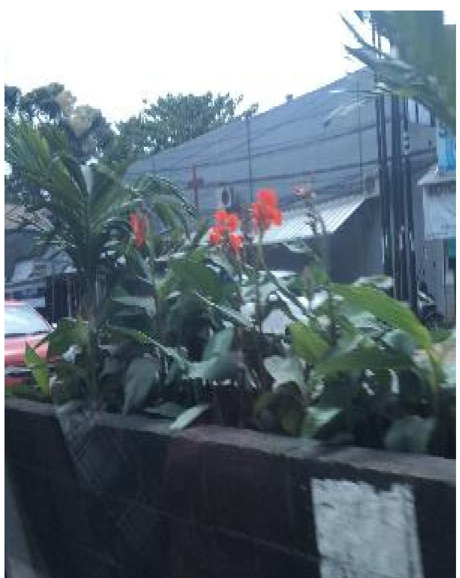
Presence of blue-green spaces can help boost local tourist industry

Urban farming

- Potential to water using stormwater runoff – passively watered systems to reduce potable water demand and provide some flood mitigation
- Provides economic, nutritional, greenery and amenity benefits to communities
- Systems can be vertical in dense environments

Urban greening or farming in Bogor

- Much greenery in Bogor, important to the community
- Includes streetscape greenery, public and private gardens
- Some examples of urban farming, e.g. Prof Hadi’s work in Pulo Geulis
- Plant availability and landscape design skills high – many street nurseries



E.g.s of solutions

- Prof Hadi experimental trial – use of biofilters to treat greywater from households for use for hydroponics – floriculture
- Storage of rainwater during wet seasons for use for irrigation of food crops during dry season
- Ponds/lakes for storage of water for emergency – more water security - case of Sentul City
- Provide city with at least two viable water sources to reduce dependence on freshwater/potable water

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The way forward

- Policy implementations (WQ targets and limits)
- Testing of technological solutions using pilot studies and use this knowledge to facilitate wider adoption and for model calibrations
- Community education around the purpose, operation and maintenance of these systems – community engagement
- Staff training


Terima Kasih
Thank you for
your time

DISCUSSION

DISKUSI

- Identifying opportunities – what are some of the key lessons learnt from existing green technologies in Kota Bogor?

- What do we want to achieve through Green Infrastructure implementation? What are the key objectives? For example, boost local productivity, flood mitigation, alternative water sources…

- Potential for green technology adoption in Bogor
  - Which technologies appear to be most promising?
  - Are there any apparent hurdles to adoption of technologies? Can you suggest ways to enable use of these technologies?
  - Any issues likely to arise for operation or maintenance?

- How contaminated is roof runoff in Bogor? Is there potential for the widespread use of rainwater tanks?

- Any suggestions/comments in regards to Green tech report structure
  - Is the information to be provided adequate?
  - Are there any chapters that need elaboration?
  - Do you have any information relevant to the report?

Informal settlements – potential technology solutions

Potential solution	**Recommend**
Green rooves	✗ (high cost, structural support required)
Green walls treating greywater	✗ (as above)
Rainwater tanks collecting roof runoff for suitable household or outdoor uses	✓ (some present, enhance supply security, but consider pollutants & appropriate reuse**)**
Biofiltration of stormwater runoff and greywater	✓ (build upon Prof Hadi's pilot project. Provide water treatment, flow retention & amenity)
Biofiltration with climbing plants or constructed treatment wetlands possibly located around island perimeter	✓ (Provide water treatment, flow retention & amenity)
Urban farming	✓ (provide nutrition, economic benefits, greenery. Water using rainwater)

Middle class high density – potential technology solutions

Potential solution	Recommend
Biofiltration systems treating stormwater & greywater	✓ (water treatment, flood mitigation, amenity)
Constructed treatment wetlands treating lake inflows, floating treatment wetlands in channels & lakes, restore riparian vegetation	✓ (protect situ ecosystem, building upon work of LIPI)
Promote infiltration (infiltration trenches, porous pavement (carparks, pathways), unlined biofiltration (street trees, streetscape, backyard raingardens, larger systems in reserves), swales, passively watered garden beds)	✓ (flood mitigation and reduced pollutant transport**)**
Promote water storage & flow attenuation (retention ponds, retarding basins, biofiltration & passively watered garden beds, rainwater tanks)	✓ (flood mitigation and reduced pollutant transport)
Rainwater tanks	✓ (Enhance water supply security, flood mitigation)
Green rooves or green walls (watered by stormwater or greywater) on public or commercial buildings	✓ (flood mitigation, amenity)

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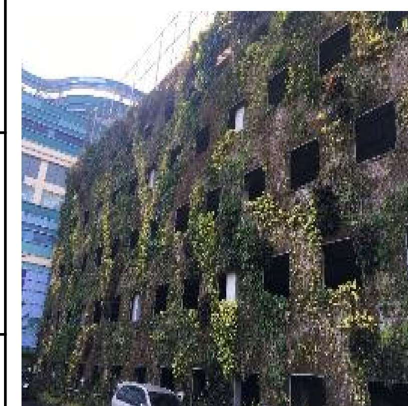
Greenfield – potential technology solutions

Potential solution	**Recommend**
Backyard raingardens (household scale) treating runoff from roof & paved areas	✓ (flood mitigation, water treatment & amenity)
Rainwater collection & harvesting	✓ (enhance water supply security)
Enhance retentive & infiltration capacity of Ciliwung street vegetated drain – similar to a swale, with porous underlying media (lined due to unstable soil), heavily vegetated.	✓ (flood mitigation and reduced pollutant transport**)**
Locate biofiltration systems & constructed wetlands along Ciliwung St, and other public open space parks	✓ (flood mitigation and reduced pollutant transport)
Restore & protect local streams – restore riparian vegetation, natural channel structure & in-stream habitat	✓ (Flood mitigation, amenity, protect water quality)
Green roofs treating stormwater and green walls treating stormwater or greywater on public or commercial buildings	✓ (build upon existing, but not using potable water supply. Provide flood mitigation, amenity)
Infiltration systems – instead line systems	✗ (unstable underlying soils)



Subdivision standard – potential technology solutions

Potential solution	Recommend
Rainwater tanks to diversity water sources – build resilience to possible future changes in springwater	✓ (flood mitigation, water treatment & amenity)
Use constructed wetland to treat springwater close to source, upstream of community extraction points. Treat downstream as well.	✓ (enhance water supply security)
Vegetate the existing fish pond, washing pond & channels to enhance water quality. May include a floating treatment wetland (e.g. LIPI work).	✓ (flood mitigation and reduced pollutant transport)
Urban farming using rainwater to water	✓ (build upon existing activities for nutrition, economic benefit)
Biofiltration (raingardens) in backyards and communal area treating stormwater & greywater	✓ (Flood mitigation, amenity, water treatment)
Green rooves and green walls	× (high cost, structural support required)

Photos: Raul

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