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Ecosystem-based Adaptation for Urban Climate Resilience

Nature Based Solutions

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Training objectives

- Introducing the concept of Nature Based Solutions
- Understanding how NBS can contribute to urban resilience
- Understanding the concept of Ecosystem Services
- Getting to know urban ecosystem-based adaptation measures and how they work
- Understanding considerations for optimal EbA planning, design and implementation

https://commons.wikimedia.org/wiki/File:Nur-Sultan_(8239492922).jpg

Nature Based Solutions – Training 2

- 1. Nature Based Solutions
- 2. How NBS contribute to urban resilience
- 3. How to make optimal use of Ecosystem functions and Services
- 4. Urban Ecosystem-based Adaptation measures
- 5. Planning, design and implementation of EbA measures
- 6. Training assignments

European Space Agency, 2017

1. Nature Based Solutions

1. Nature Based Solutions

- What are Nature Based Solutions
- What are the various terms used in literature/practice?
- What are the underlying principles of NBS?
- What are the main different types of NBS?

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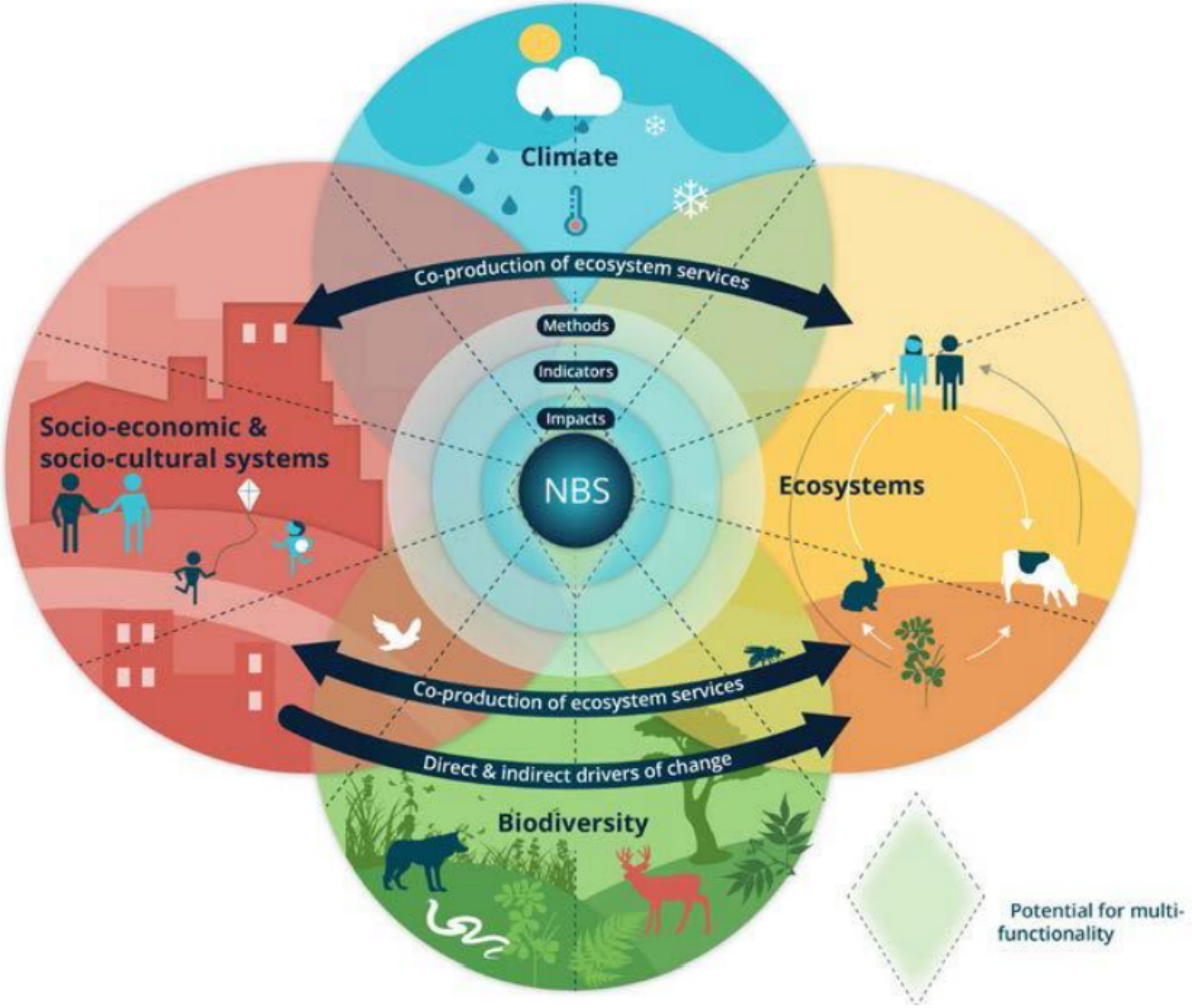
Nature Based Solutions

NBS relationship-framework by EKLIPS (2017)

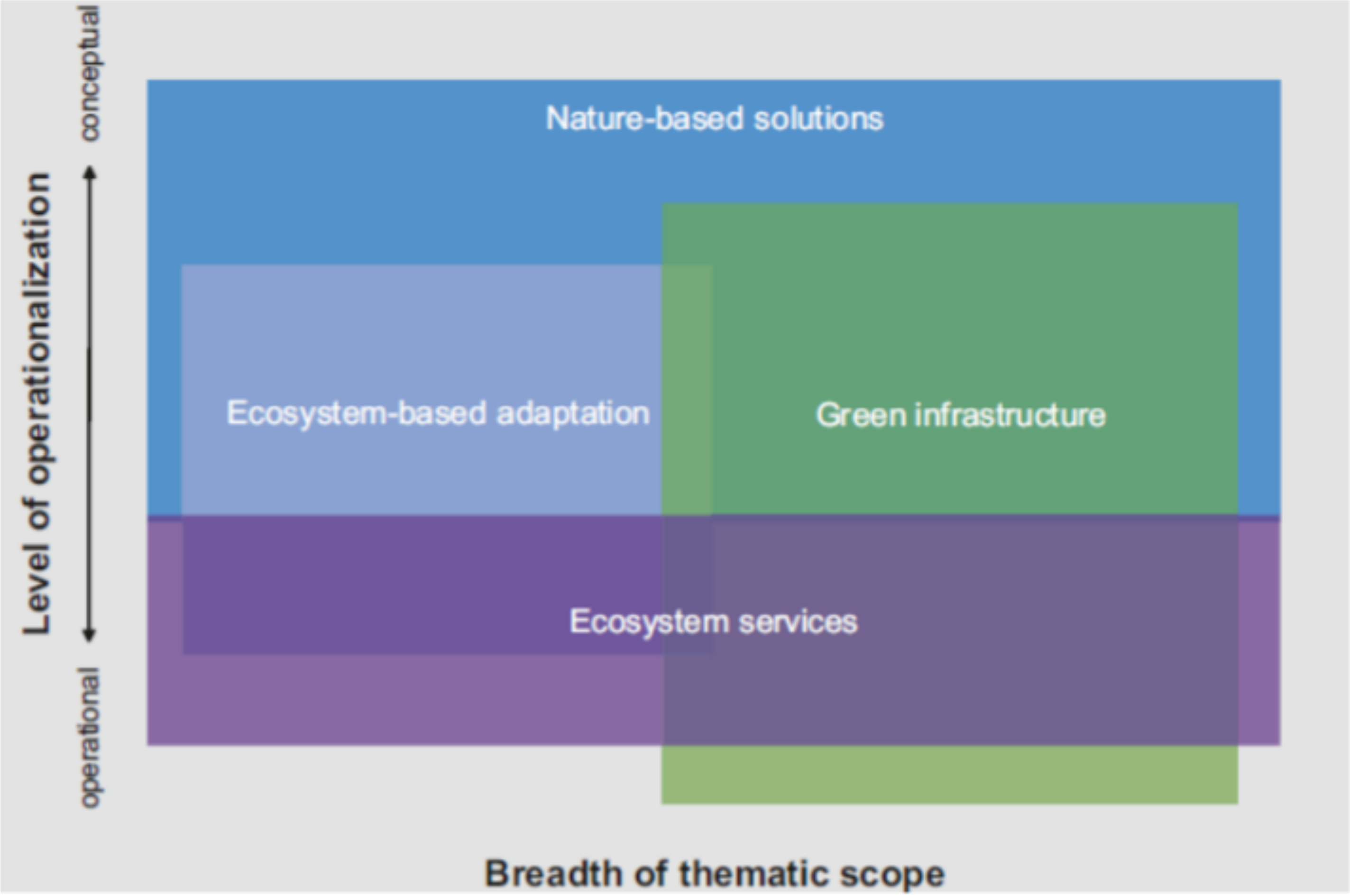
- IUCN: '.. Actions to protect, sustainably manage and restore natural or modified ecosystems, which address societal challenges (e.g., climate change, food and water security or natural disasters) effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits' (Cohen-Shacham et al. 2016).
- EC: '…nature based solutions to societal challenges are solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions (EC 2016)



Nature Based Solutions

- Different terms used:
  - Green infrastructure
  - Ecosystem-based Adaptation (EbA)
  - Building with Nature
  - Working with Nature
  - Blue-Green Infrastructure
  - Nature based features
  - **Sponge Cities**

Level of operationalization and scope of different terminologies relating to Nature Based Solutions (from Kabisch et al. 2017).



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Urban Nature Based Solutions

- We will use this brief definition:
- Urban Nature-based solutions (NBS) refer to the sustainable management and use of nature (e.g. (Blue-)Green Infrastructure) for tackling societal challenges.

Ecosystem based solutions

Hybrid solutions

SOFT ENGINEERING

HARD ENGINEERING

Hybrid solutions: Blue + Green + Grey

Nature-based Solutions (NBS)

Existing natural areas

Designed & constructed NBS

Hybrid NBS

Ecosystem-based NBS

Why hybrid solutions?

- The dichotomy of employing either engineered (grey) or blue-green solutions may not be useful or effective
- Increasingly, research focuses on how NBS can <u>complement</u> technological solutions
- Hybrid approaches combine engineering and ecosystem functions
- Intermediate ‘hybrid’ approaches, combining both blue-green and grey approaches, may be the most effective strategy for reducing risk from environmental hazards, especially when
  - NBS approaches may be insufficient to meet the rising impacts of climate change,
  - in case of space or time limitations, or
  - when resource limitations require cost-effectiveness in the context of both climatic and economic uncertainty.

(Kabich et al. 2017)

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Hybrid versus nature-based Blue-Green solutions





2. How NBS contribute to Urban Resilience – Ecosystem-based Adaptation

Ecosystem-based adaptation to climate change

Harnessing ecosystem services and functions in infrastructure and planning in order to:

- Minimize climate related hazards:
- Flooding
- Heat stress
- Drought

- Maximize resilience:
- Livability / urban regeneration
- Health potential
- Sustainable economic development

Basic principles of Ecosystem-based Adaptation

- Water as local resource: Water harvesting
- Reduce water pollution, keep clean, treat
- Tackle soil & groundwater pollution
- Use water surface to live & work on/in/above
- Water and green for biodiversity
- Water and green for recreation
- Water for urban food production
- Water and green for cooling and/or sheltering the city
- Water as collector of solar thermal energy

Water as local resource: Water harvesting

Not only RAINwater harvesting. Also stormwater and surface water harvesting.

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Prevent water pollution

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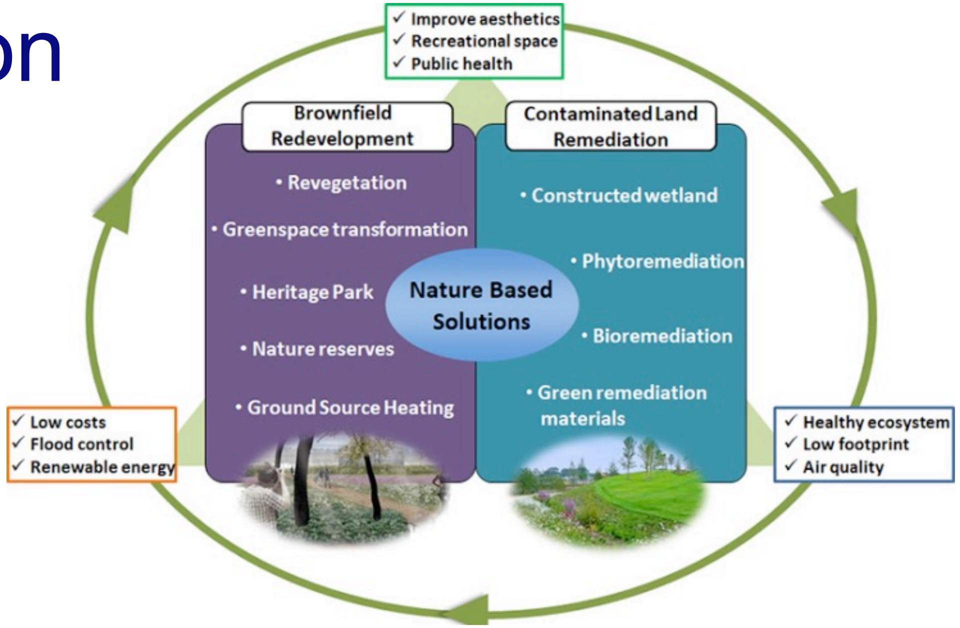
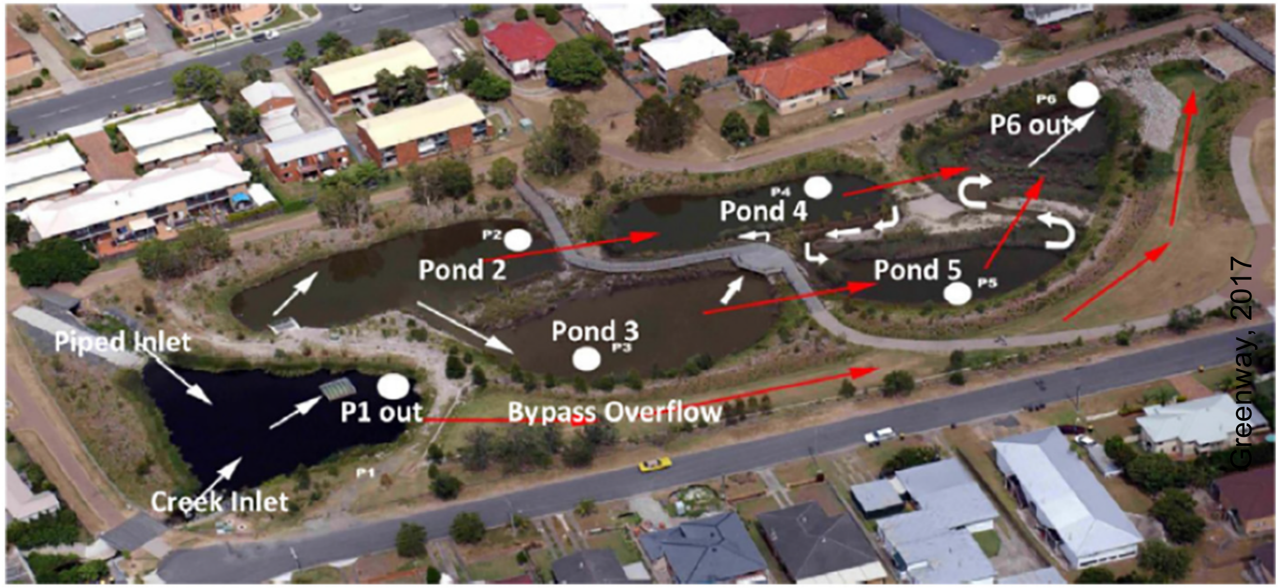
Tackle soil & groundwater pollution





Greenway, 2017

Use water surface to live & work on/in/above

Water and green for biodiversity

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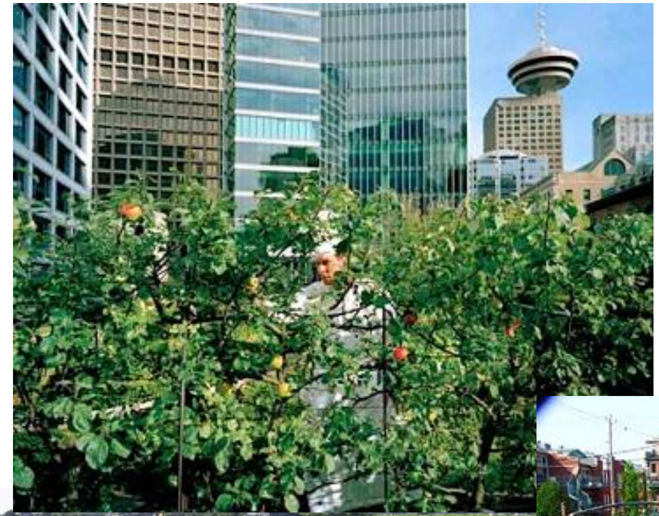
Water and green for recreation

Water for urban food production



Water and green for cooling or sheltering the city

https://www.theguardian.com/cities/2017/oct/18/astana-plan-warm-winter-ring-one-million-trees

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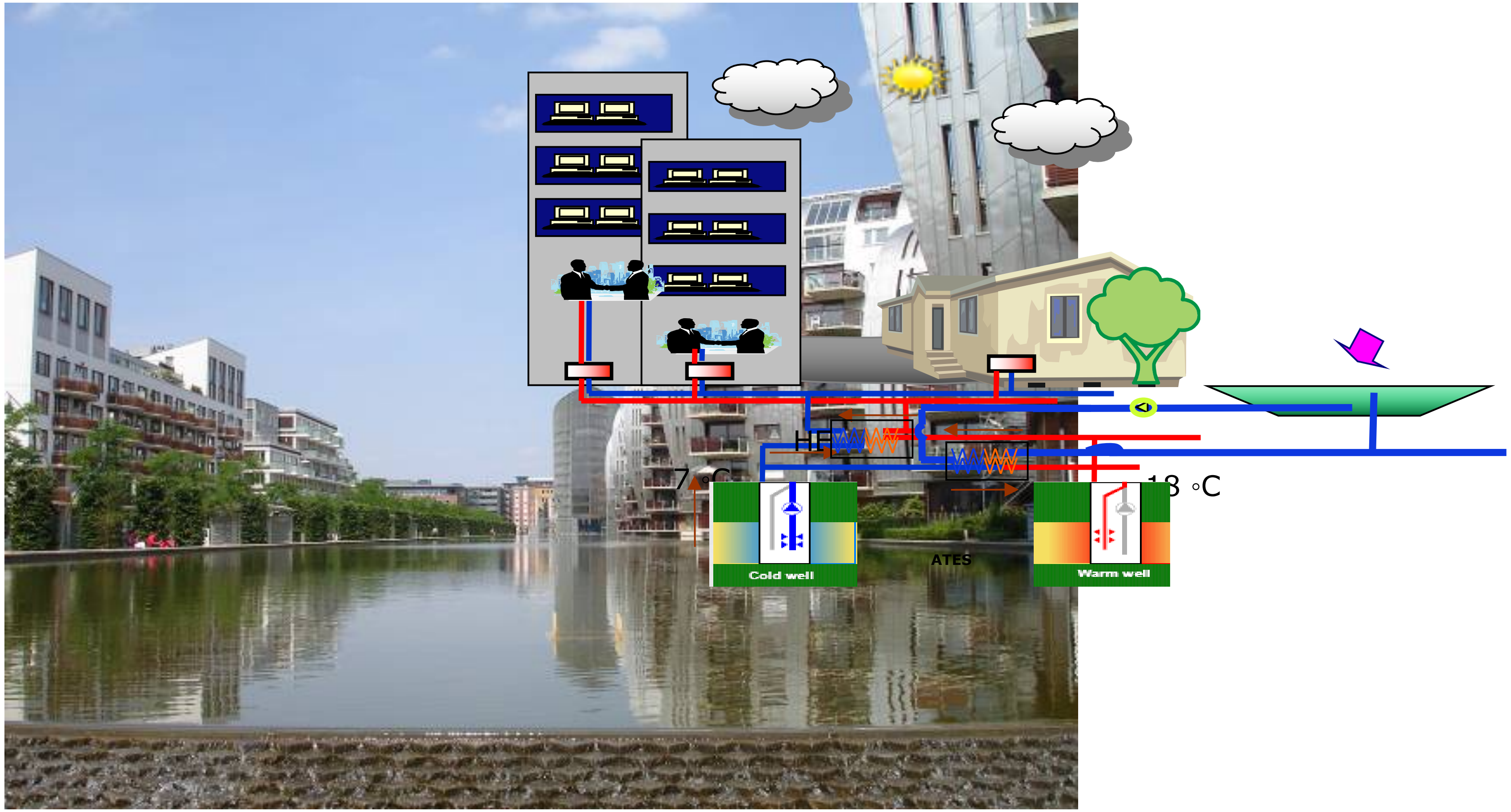
Water as collector of solar thermal energy



E. Aparicio (2008) Using surface water for energy supply and cooling, Delft University of Technology

Types of NBS for climate resilience – Key principles

- Water storage, instead of drainage (flood and drought prevention)
- Infiltration, instead of drainage (flood and drought prevention)
- Handling stormwater locally instead of draining
- Vegetation Evapotranspiration (heat-stress reduction)

How NBS contributes to urban resilience

- How Nur Sultan can benefit from NBS to enhance urban resilience?
- Defensive vs. Opportunistic approach?
- How to learn from limitations of traditional grey infrastructure?
- How to make optimal use of ecosystem services and functions?

https://www.needpix.com/photo/828486/astana-kazakhstan-quay-nikon-summer-capital-yesil-river-yesil-catamaran

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How can Nur Sultan benefit from NBS to enhance urban resilience?

- Creating a healthier, more attractive city

- Increase urban resilience by creating additional
  - water storage (flood prevention)
  - Water availability
  - cool areas

- Overcome limitations to traditional, hard, grey infrastructure

- Create opportunities by developing green or hybrid/integrated (grey/green) solutions
  - Spatial, governance and environmental (connectivity, visibility, legibility)

- Making optimal use of ecosystem functions and services: cost-effective

How can Nur Sultan benefit from NBS to enhance urban resilience?

- NBS can make a significant contrubtion to the effective implementation of all policies where some or all of the desired objectives can be achieved in whole or in part through nature-based solutions

- There is usually a high return on investments

- Overall reviews of restoration projects typically show cost-benefit ratios in the range of 3 to 75.

- Well planned and designed NBS, including water and soil, can contribute to climate adaptation and at the same time promote and support healthy urban living.

Defensive vs. opportunistic approach?

- Create climate resilience
  - Flooding
  - Drought
  - Heat
  - Land subsidence

DEEFENSIVE

- Seize multi-functional opportunities
  - Ecosystem services
  - Social services
  - Economic services

OPPORTUNISTIC

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Limitations of traditional grey infrastructure

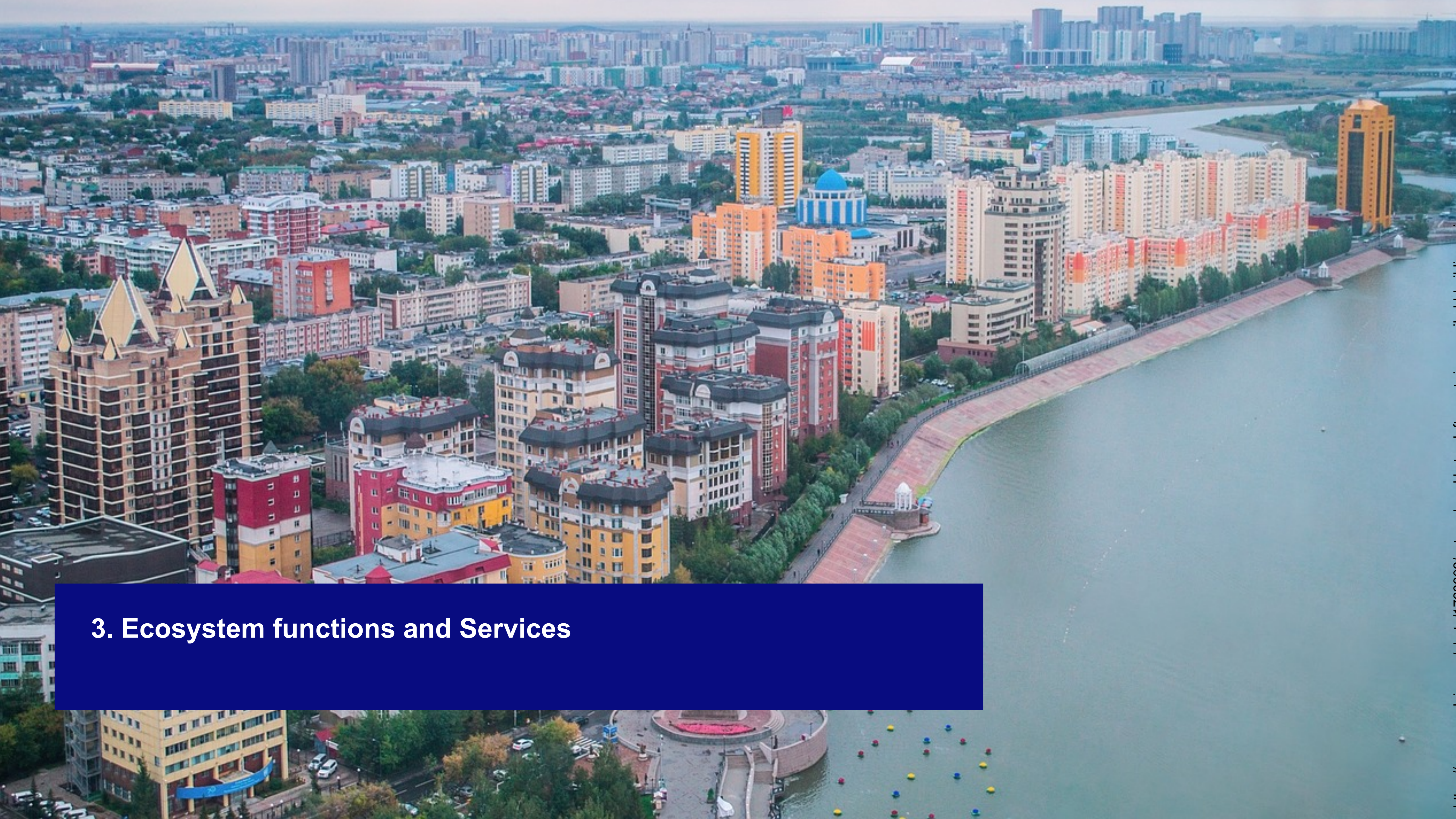
- While hard, grey infrastructure solutions can be effective in providing an immediate, visible solution to a problem, they have limitations:
  - Limited functions, single focus: only draining water, or only for water supply
  - The grey solution can lead to ecosystem disruption or degradation
  - ..reducing the natural dynamics of the system, whereby reducing adaptive capacity

Making optimal use of ecosystem services

- Before making use of ecosystem services in urban development, it is important to understand
  - What are ecosystem services?
  - What is their value or benefit?
  - How can we quantify?
  - How can we incorporate these services and functions in our urban designs?

Next section!

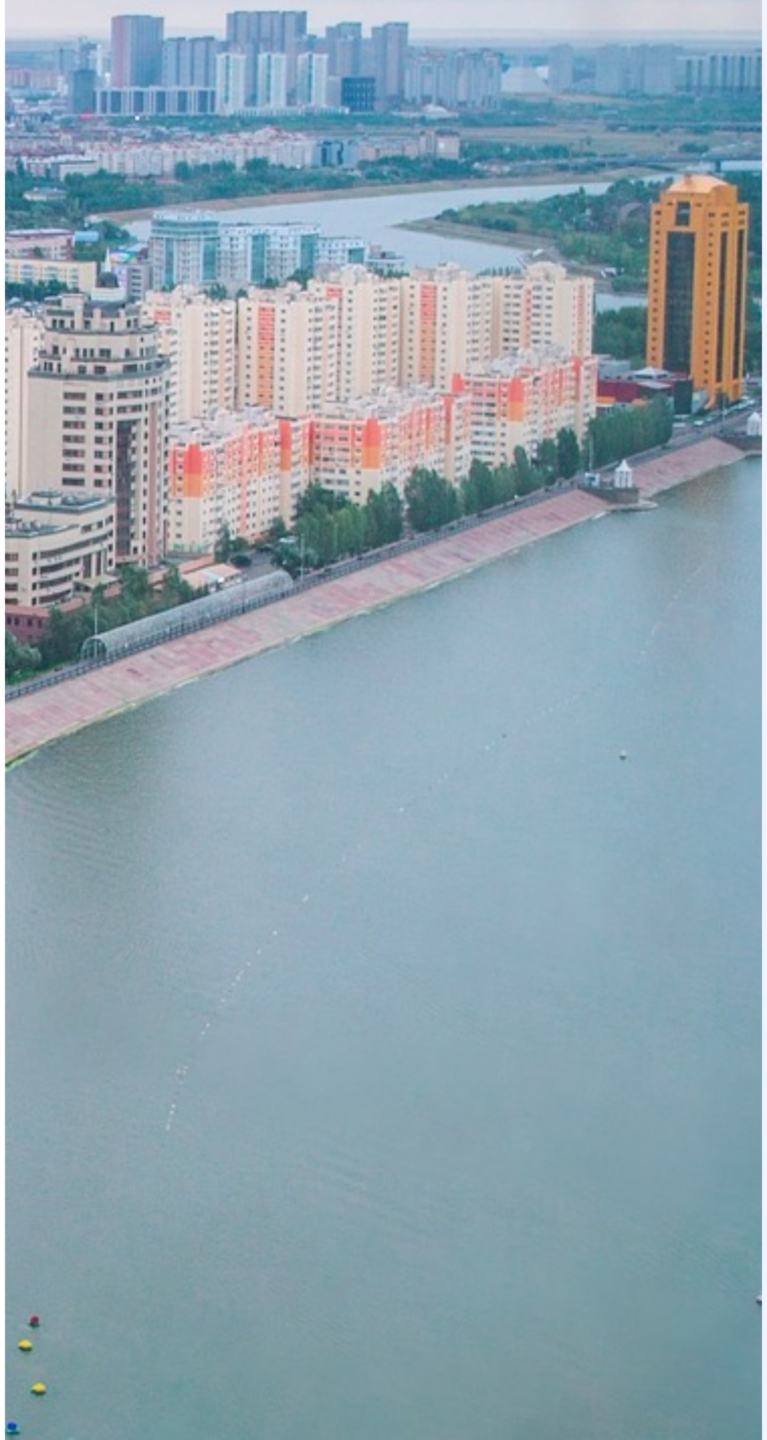
https://pixabay.com/photos/building-city-park-garden-flowers-5461484/



3. Ecosystem functions and Services

3. Ecosystem services

- What are ecosystem services?
- How to harness Natural Capital?
- Optimizing co-benefits
- What does this look like for Nur Sultan?

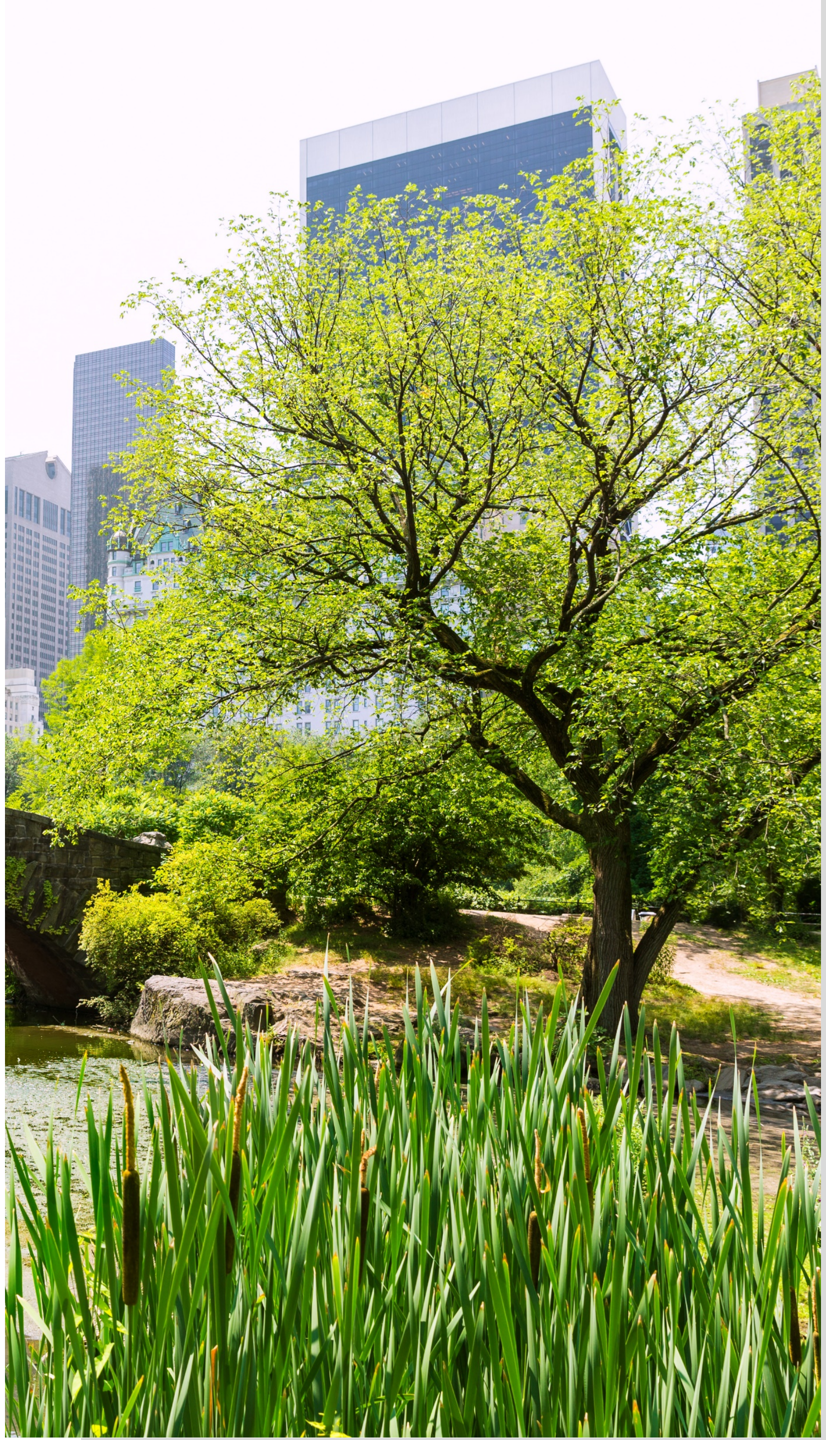


What are ecosystem services?

- Ecosystem services are the benefits that people get from nature.
  - Goods - provisioning services
  - Services - regulating services, cultural services and supporting services.
  - “Ecosystem services are defined as benefits that humans obtain from ecosystem functions or as direct and indirect contributions from ecosystems to human well-being” – IUCN 2013
- Examples of ecosystem services:

Nutrient removal, temperature regulation, carbon sequestration, habitat, flood protection, food and goods, biomass for renewable energy, water supply, recreation, power generation, transportation, fish production, aesthetic, fiber and fuel, hydrological flows (groundwater recharge), pollution control, educational services, soil formation, pollination, nutrient cycling and biodiversity, etc etc.

- Making use of ESS
- Optimizing co-benefits



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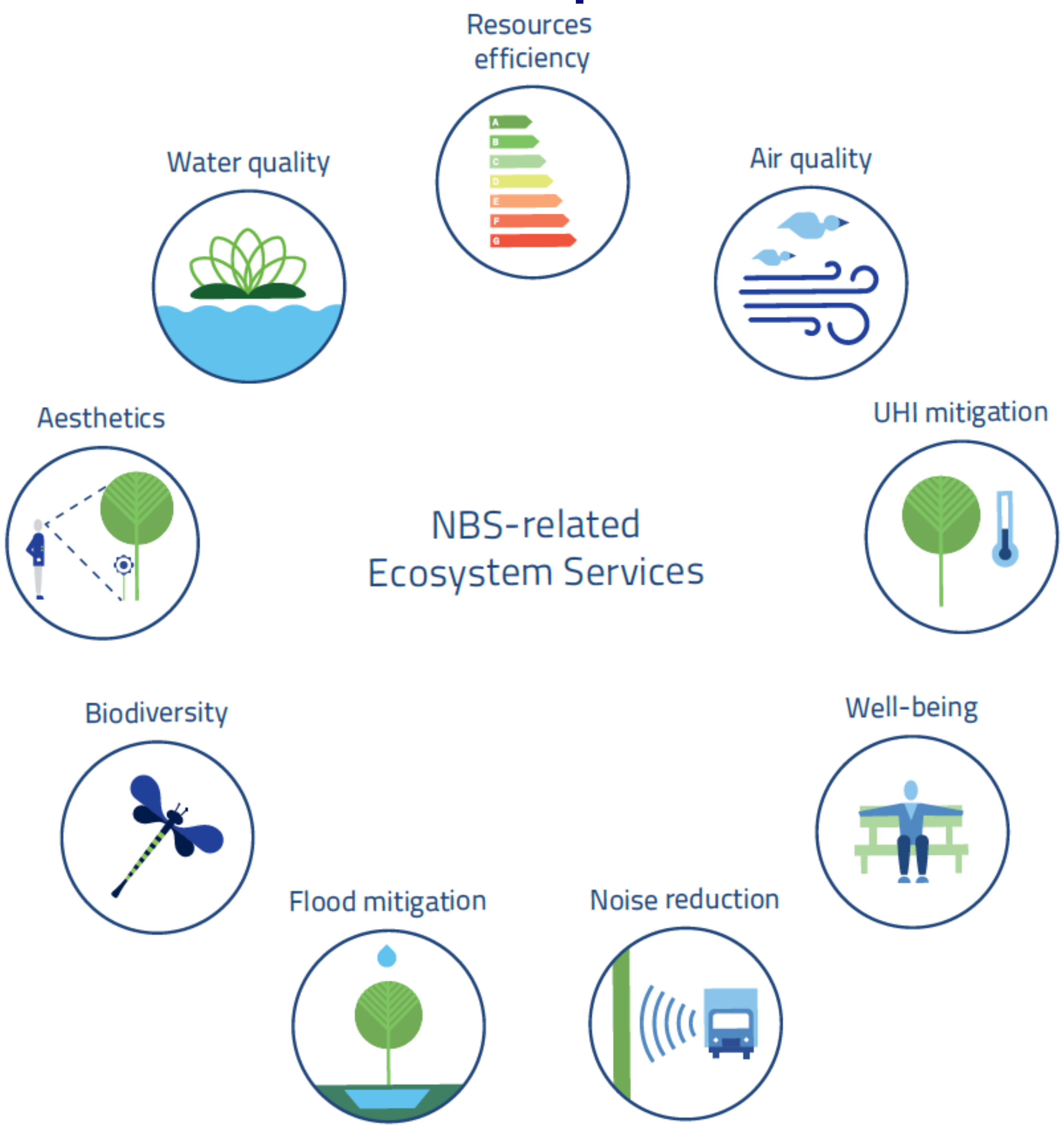
NBS can have different functions and can provide various co-benefits

Urban context:

- The provision of ecosystem services in cities depends on the quality and quantity of urban green infrastructure. Green infrastructure includes parks, gardens, urban allotments, urban forests, wetlands, lakes and ponds in cities, but also the natural areas – such as forests, mountains and wetlands – surrounding urban spaces.



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For example: a tree can provide various benefits

TREE FUNCTIONS

RESULTING SYNERGY BENEFITS

Urban heat island effect reduced	Building envelope cheaper	Reduced noise and air pollution
Outdoor air evaporative cooling	Surface flood risk reduction	Better conditions for pedestrians
Buildings more comfortable	Higher property value	Socialising more intensive
Buildings using less energy	Humans healthier	Water management more effective

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The value of ecosystem services

- For the functions they deliver to people, ecosystem services are considered to have “values”. These values can be of different nature and can be translated into monetary and non-monetary terms.

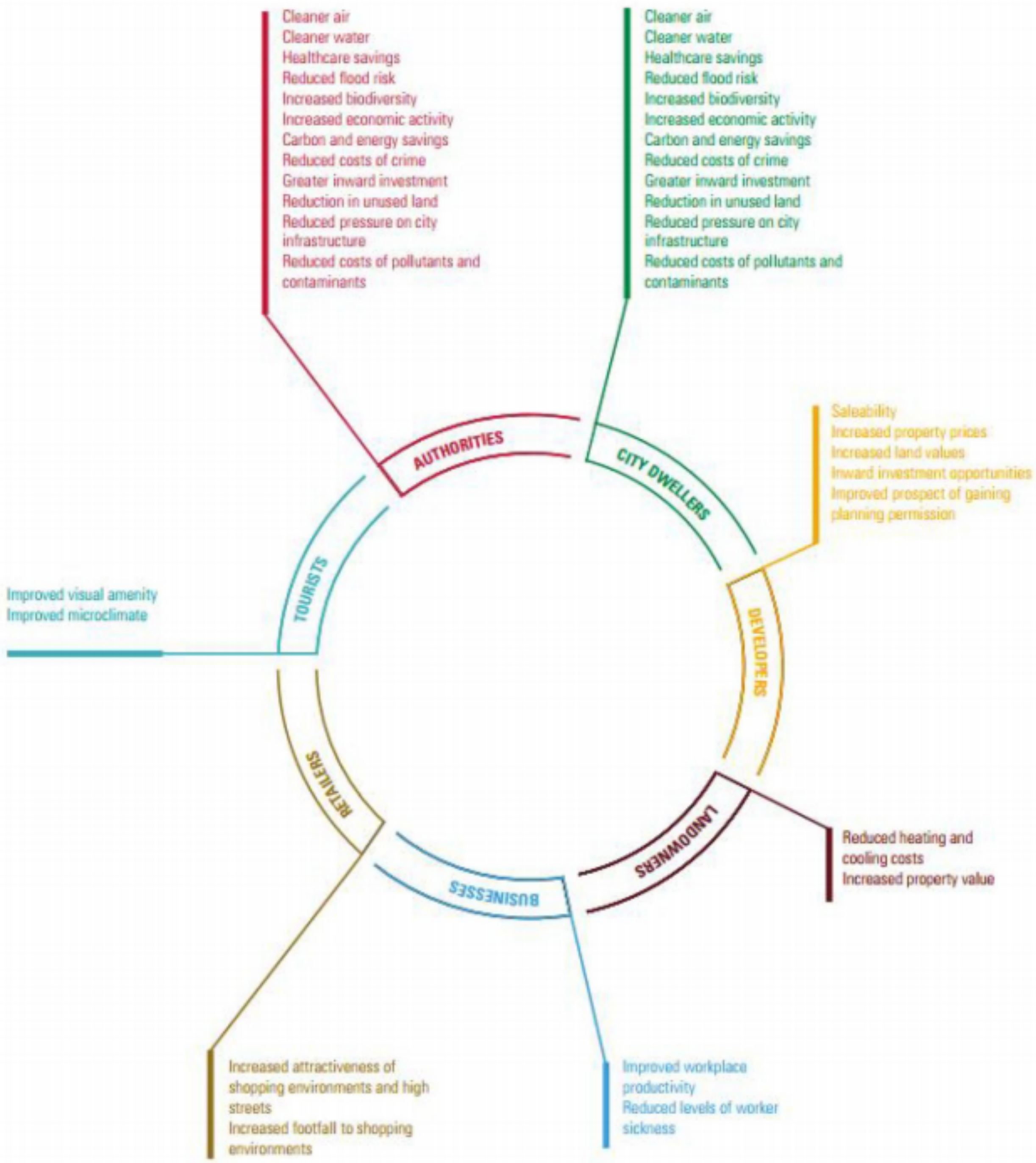
Economic values	Direct or indirect monetary values provided by urban ecosystems, e.g. avoided costs for air pollution reduction by technical solutions or property damage by natural barriers to environmental extremes.
Ecological values	Environmental outputs, which have value for humans, e.g. air purification, carbon storage and sequestration, water filtration, genetic diversity.
Socio-cultural values	Moral, spiritual, aesthetic, ethic, and values associated to urban biodiversity and ecosystem services, including emotional, affective and symbolic views attached to urban nature, as well as local ecological knowledge.
Health values	Health benefits obtained from urban green spaces, consisting of reduction of air pollution, as well as improved water quality, and mental health.
Insurance values	The contribution of green infrastructure and ecosystem services to increased resilience and reduced vulnerability to shocks, such as flooding and landslides.

IUCN 2013 https://www.iucn.org/sites/dev/files/import/downloads/urbes_factsheet_03_web_23_05_2013.pdf

Benefits of NBS

- Benefits can be different for different stakeholders
  - Authorities
  - City dwellers
  - Developers
  - Landowners
  - Businesses
  - Retailers
  - Tourists

(ARUP, 2014)



Benefits of NBS

Examples of indicators to assess co-benefits of NBS (from Raymond et al., 2017).

- Benefits can be measured and assessed
  - **Monetary**: e.g. reduced property damages from extreme climate events
  - **Non-monetary**: cultural, community cohesion, inspiration
- Either **direct benefits**, or **avoided costs** (such as for higher energy demand for heating and cooling due to loss of urban vegetation, or health care expenses related to respiratory diseases e.g.)

Challenge area	Example of indicators	Type of indicator	Unit of measurement
	Net carbon sequestration by urban forests (including GHG emissions from maintenance activities)	Environmental (chemical)	t C per ha/year
	Economic benefit of reduction of stormwater to be treated in public sewerage system	Economic (monetary)	Cost of sewerage treatment by volume (€/m^3)
	Area remaining for erosion protection	Environmental (physical)	km^2 or m^2
	Species richness of indigenous vegetation	Environmental (physical)	A count, magnitude or intensity score of indigenous species per unit area
	Annual amount of pollutants captured by vegetation	Environmental (chemical)	t pollutant per ha /year
	Index of ecological connectivity (integral index of connectivity	Environmental (physical)	Probability that two dispersers randomly located in a landscape can reach each other
	Quality of the participatory or governance processes	Social (process)	Perceived level of trust, legitimacy, transparency and accountability of process
	Accessibility to public green space	Social (justice)	% of people living within a given distance from accessible, public green space
	Level of involvement in frequent physical activity in urban green spaces	Social (physiological)	Number and % of people being physically active (min. 30 min 3 times per week) in urban green spaces
	Net additional jobs in the green sector enabled by NBS projects	Economic (productivity)	New jobs/specific green sector/year

What does this look like for Nur Sultan?

- Nature based solutions harness ecosystem functions and services, to enhance urban resilience
- Nur Sultan has ambitions to enhance urban resilience to climate change
- NBS can play an important and cost-effective role in this: Ecosystem-based Adaptation
- In the next chapter: Urban Ecosystem-Based Adaptation measures

4. Urban Ecosystem-based Adaptation measures

4. Urban Ecosystem-based Adaptation measures

- Overview of different EbA measures
- What are examples of best practices?
- What are EbA costs and benefits?
- How to optimize benefits?

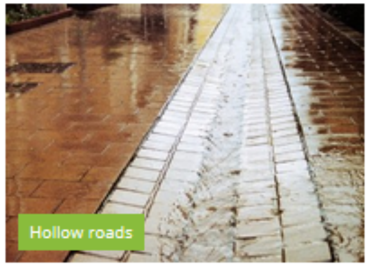
Urban EbA measures


Fluted gutters


Prefab fluted gutter


Open gutters


Covered gutters


Hollow roads


Ditches


Open water channels


Use of groundcover and shrubbery


Porous paving materials


Ground infiltration


Infiltration meadows and infiltration strips with above-ground storage


Rainwater ponds for buffering and purification of moderately polluted water


Rainwater ponds for buffering and purifying extremely polluted water


Nature-friendly bioswales


Gravel layers/trenches/reverse drainage

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Lots of measures can be taken; a selection & planning process is needed

http://www.urbangreenbluegrids.com/design-tool/

Best practices

- A number of best practices is shared to give examples of implementation of EbA measures in practice:

- Raingarden / infiltration strips (Portland)
- Water retention in parks (Singapore)
- Water square (Rotterdam)
- Green roof
- Urban canopies / forest

Water square

- This type of square can combine water storage with the improvement of the quality of urban public space.
- The water square can be understood as a twofold strategy:
  - It makes money invested in water storage facilities visible and enjoyable.
  - It generates opportunities to create environmental quality and identity to central spaces in neighbourhoods.
- Most of the time the square can be used as a recreational space. When heavy rains occur, rainwater that is collected from the neighbourhood will flow into the water square for a short times pan.
- After it has been in use as buffering space, the filtered water is returned to the water system.
- The square can also be a measure to improve the quality of the open water in urban environments.

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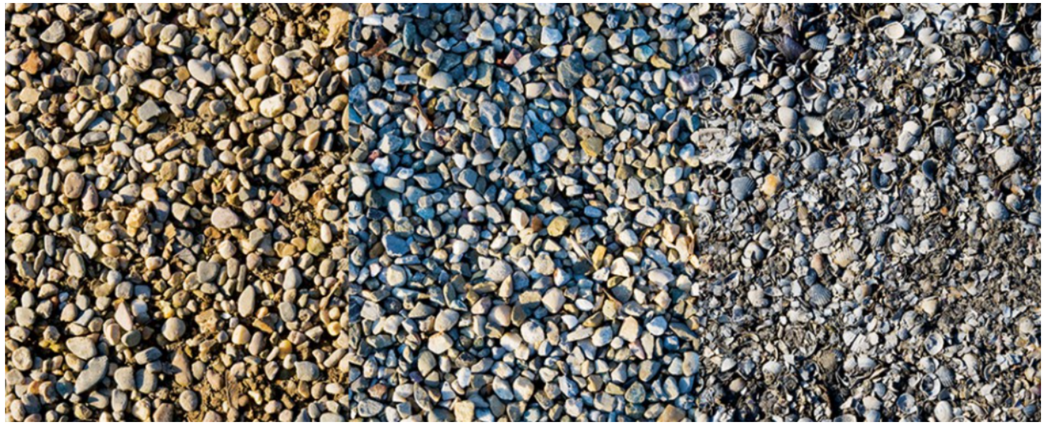
Permeable pavement

- Permeable pavements consist of porous material that absorbs rainfall.
- Water can be stored either in the top layer (e.g. very open asphalt concrete) or in below the top layer in the foundation.
- Besides reducing runoff, permeable pavements can trap suspended solids and filter pollutants from the water.



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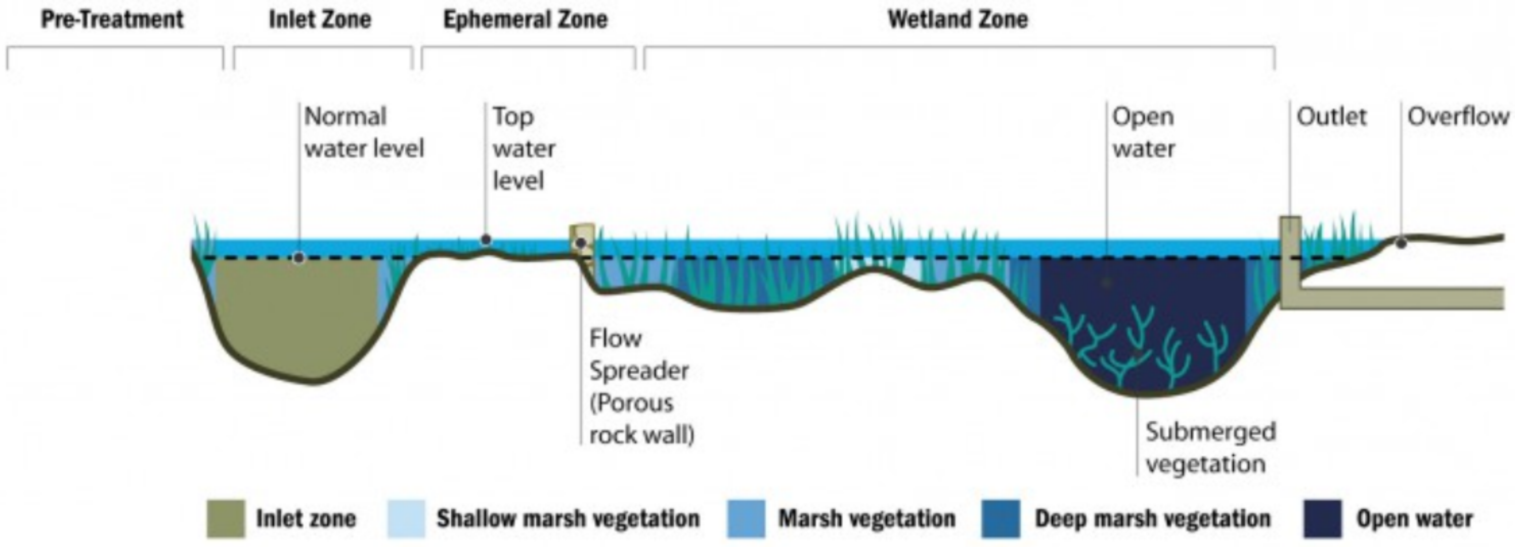
Urban artificial wetland

- Natural wetlands function as water retention basins, sediment traps and wastewater treatment areas by filtration and the immobilizing harmful microorganisms.
- The wetlands can be implemented with or without additions which improve the treatment capacity. Aeration, alteration soil composition or the introduction of a particular plant species in the area can all improve the treatment capacity.

Co-benefits

- Depending on the design, the implementation of such artificial wetlands improves the liveability of the city, downstream flood reduction and of water availability during periods of drought.



Wetland principle © Melbourne Water

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Urban wetlands

- Helophyte filters are artificially created zones of reeds (or other water based plants), which purify surface water in a natural way.
- Thanks to its extensive network of roots and large quantity of biomass, reed has a large living surface for bacteria and other micro-organisms.
- These are responsible for a sizeable part of the purification effect.
- Especially the concentration of nutrients is reduced in helophyte filters

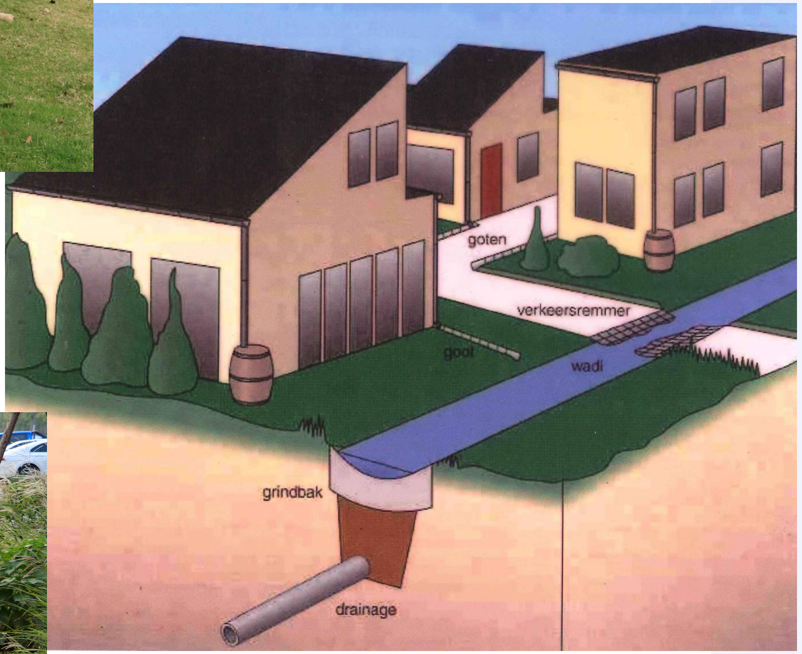
Singapore artificial wetland park with incorporated helophyte filter

Bishan-Ang Mo Kio park

Under the Active, Beautiful and Clean Waters (ABC) Programme, the old concrete canal has been de-concretised and naturalised into a 3 km meandering river with lush banks of wildflowers.

Bioswale

- A bioswale is a naturally designed buffer and infiltration filter, can be a shallow ditch or depression in the field
- The bioswale detaches rainwater runoff from streets and rooftops from the traditional sewer system.
- For the larger part of the year, the bioswale remains dry. Only during heavier rain events it will be filled with water.
- This way clean water is infiltrated into the soil it can be used during drier periods.
- In addition, the overflow risk of the sewage system is limited as rainwater is separated from the sewer system. In turn this leads to a higher water quality of the surface waters.



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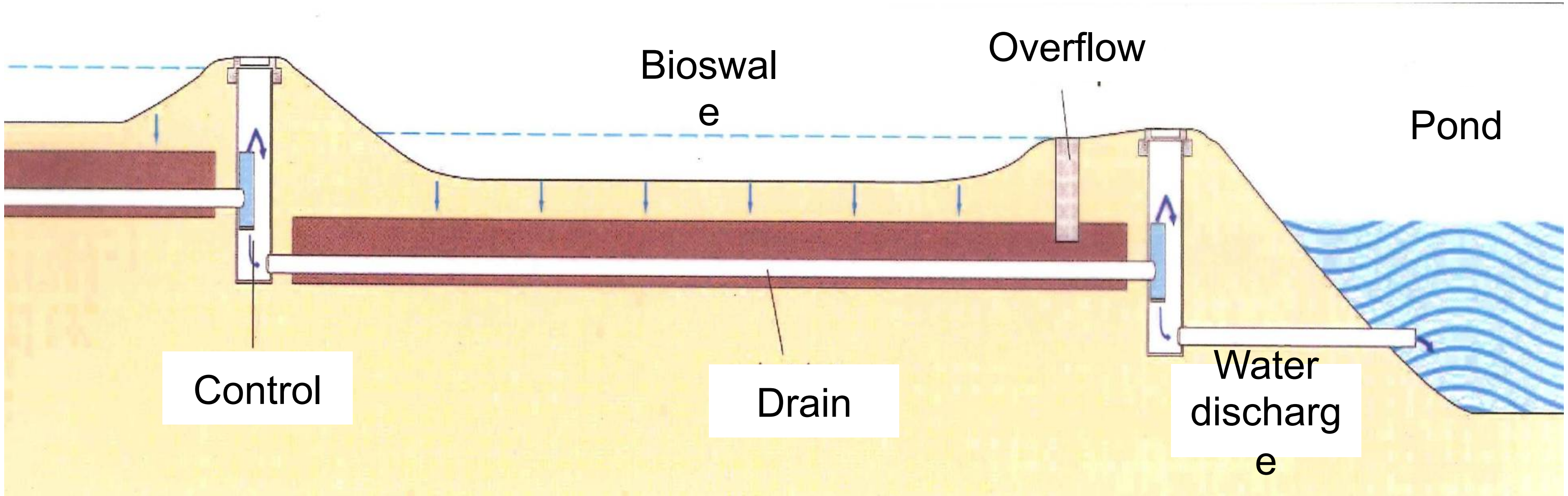
Bioswale conceptual design



Green roof

- A green roof or living roof is a roof of a building that is **partially or completely covered with vegetation** and a growing medium, planted over a **waterproofing membrane**.
- It may also include **additional layers** such as a root barrier and drainage and irrigation systems.
- Green roofs help to **lower urban air temperatures**, mitigate the **heat island effect** and **store rain water**.
- The intensive roofs are thicker and can support a wider variety of plants but are heavier and require more maintenance than extensive roofs.
- Green roofs serve several purposes such a providing insulation, creating a habitat for wildlife, and to improve air quality.

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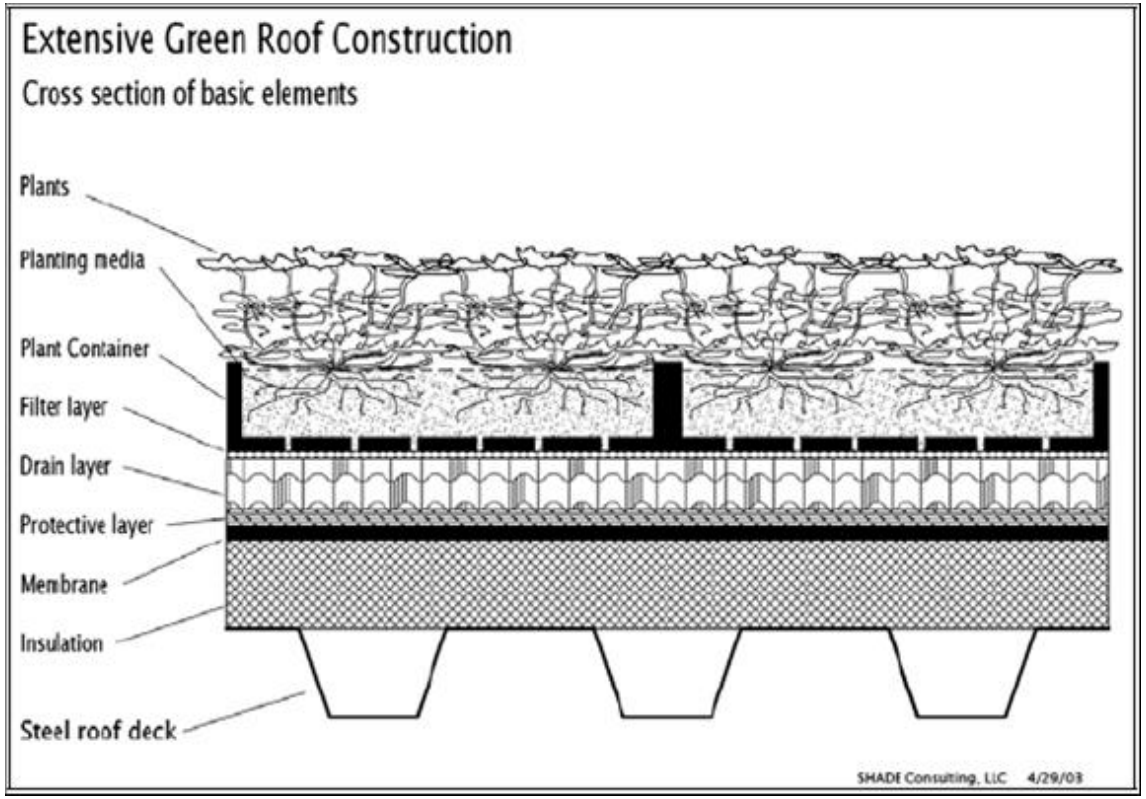
Green roof

Source: Christopher and Wendy, 2003.



Urban EbA measures: Costs

- Costs of
  - planning,
  - preparing for,
  - facilitating, and
  - implementing adaptation measures,
  - including transition costs

  - **Maintenance**

- Costs can differ for different stakeholders

- Costs can be required for different elements: for example, maintenance can fall under a different department than for traditional grey infrastructure

Urban EbA measures – optimizing benefits

- Optimizing benefits:

  - Understanding urban systems context
  - Understanding ecosystem functioning
  - Clear objectives
  - Design principles

5. Planning, design and implementation of EbA

5. Planning, design and implementation of urban EbA measures

- Barriers in implementation of EbA
- EbA principles to design measures
- Considerations for optimal implementation
- Nur Sultan stakeholder context

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Barriers in implementation of EbA

- EbA much less well known than traditional solutions
- More uncertainty about quantitative effect of EbA; harder to predict
- EbA has a different planning horizon – natural systems take time to develop
- Many different stakeholders involved, while municipalities are often siloed organizations
- Costs for implementation and maintenance may shift between departments
- Cost and benefits of EbA at different stakeholders
- Implementation cost may be higher, while operational costs can be lower

EbA principles to design initiatives

- **Principle 1: system-scale perspective** (time, space)
  - Addressing nature-based solutions should start with a system-wide analysis of the local socio-economic, environmental and institutional conditions
- **Principle 2: Risk and benefit assessment of full range of solutions**
  - A thorough assessment of risks and benefits of the full range of possible measures should be conducted, covering risk reduction benefits as well as social and environmental
- **Principle 3: Standardized performance evaluation**
  - Nature-based solutions (especially for flood risk management) need to be tested, designed and evaluated using quantitative criteria.
- **Principle 4: Integration with ecosystem conservation and restoration**
  - NBS should make use of existing ecosystems, native species, and comply with basic principles of ecological restoration and conservation.
- **Principle 5: Adaptive management**
  - NBS needs adaptive management based on long-term monitoring; this ensures sustainable performance.

From Van Wesenbeeck et al. 2018

https://pixabay.com/photos/astana-kazakhstan-flowers-summer-3917295/

Considerations for optimal planning and design

Possibilities for inclusion of EbA measures depends on:

- Study area, problem, key stakeholders and beneficiaries
- Context: on-going initiatives, policy, governance, developments
- Project scope, boundaries, requirements
- Project objectives, targets
- Phase in the project (developments already ongoing?)
- Scale of development
- Local ecosystem, connectivity
- Local capacity in multiple disciplines

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Considerations for optimal implementation

Financing strategy: Evaluate financing options for the proposed measures and secure green finance opportunities, if possible identify funding sources

- Assess project timeline, risk and feasibility in light of financing
- Check for (adverse) incentives
- Innovative Financing Mechanisms?

Engineering

1. Shortlist technically feasible and socially accepted interventions
2. No-regret, low cost strategies first
3. Draft engineering design study to encompass both ecosystem and engineering aspects in hybrid interventions

Monitoring

1. Design a robust monitoring system, starting with baseline monitoring

Draft maintenance plan (next slide)

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Maintenance of EbA

- The **type of maintenance** depends on the selected measures in Nur Sultan; as they differ for
  - Surface water, retention ponds,
  - Surface infiltration measures, bio swales
  - Sub-surface infiltration measures
  - Porous pavements

- **Cost of maintenance**
  - As the EbA measures often require different types of maintenance, different expertise is required
  - Involvement from different departments can be required
  - Funding agencies need to be convinced of or at least informed on the corresponding maintenance cost

Which departments would be responsible in Nur Sultan?

6. Training assignment

https://pixabay.com/photos/astana-kazakhstan-nur-sultan-4977786/

Training assignment

- How to implement NBS in Nur Sultan?
- Selecting NBS for Nur Sultan

https://pixabay.com/photos/astana-kazakhstan-nur-sultan-4977786/

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Nature Based Solutions for Nur Sultan

Which 3 Nature Based Solutions/Adaptation Measures from the handout would you suggest for Nur Sultan?

What would be the main benefits?

Are there local examples of Nature Based Solutions?

Nature Based Solutions for Nur Sultan

- Can these Nature Based Solutions be implemented?
- What would be the main challenge/barrier to implement these Nature Based Solutions?
- What should be done to overcome this challenge/barrier?

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