Green infrastructure: Guidance and recommendations for overcoming the implementation gap

CONNECTIVE CITIES

Network Nature

Partners of Connective Cities

Deutscher Städtetag

ENGAGEMENT GLOBAL
Service für Entwicklungsinitiativen

with its SERVICE AGENCY
COMMUNITIES IN ONE WORLD

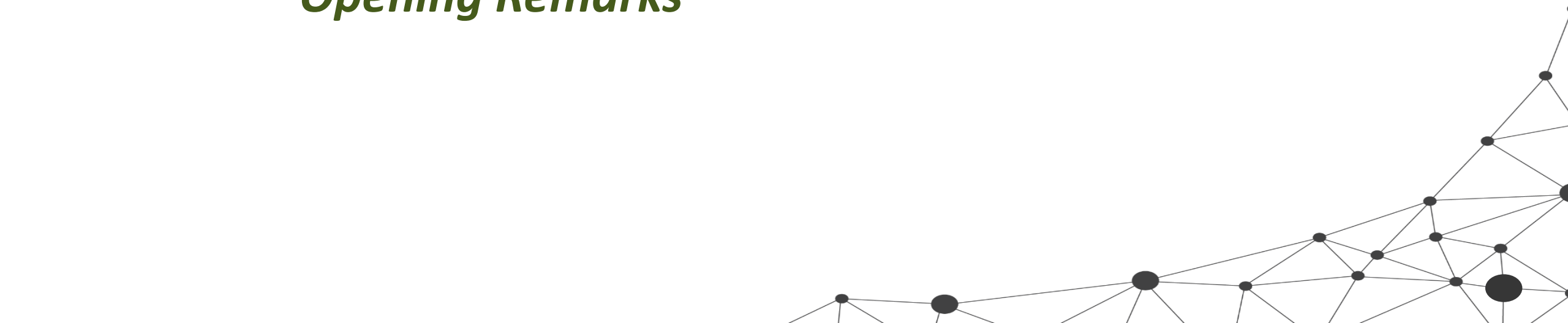
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Commissioned by

Federal Ministry for Economic Cooperation and Development

Daphne Gross Jansen - Federal Ministry for Economic Cooperation and Development (BMZ), Germany

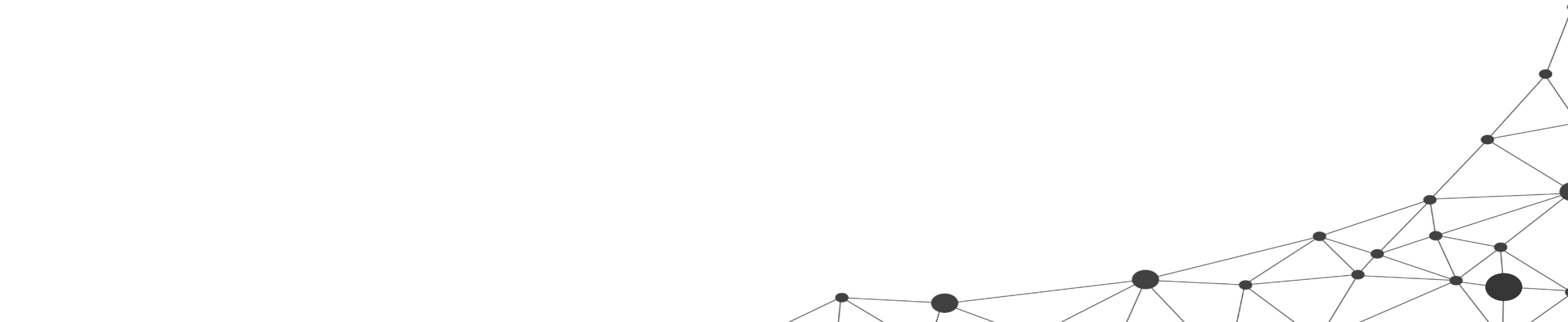
Opening Remarks



Time (CEST)	topic	speaker
PART 1: Experiences and good practices for design, implementation, planning and governance of UGI in cities		
14:15-14:25	Key (institutional) barriers for implementing Urban Green Infrastructure in cities & peri-urban areas	**Bettina Wilk, ICLEI**
City experiences in overcoming barriers to design, implementation, governance of UGI		
14:25-14:30	Green corridor in Campinas-Brazil	**Gabriel Dias Mangolini Neves, Campinas-Brazil**
14:30-14:35	Water Security: through the lens of multi-stakeholder collaboration	**Eddy Chikuta, Lusaka Water Security Initiative**
14:35-15:00	Moderated conversation	**Connective Cities-GIZ**

Bettina Wilk, ICLEI Europe

Key barriers for implementing Urban Green Infrastructure in cities & peri-urban areas



Network Nature

Key barriers for implementing Urban Green Infrastructure in cities & peri-urban areas

Bettina Wilk, ICLEI Europe

Context

To systematically bring nature back to cities, the EU Biodiversity Strategy calls upon cities with over 20,000 inhabitants to develop ***Urban Greening Plans*** by the end of 2021.

Urban Greening Plans as ***opportunity for institutionalizing Urban Green Infrastructure*** in nature-inclusive urban planning, other related policy areas and integrated approaches

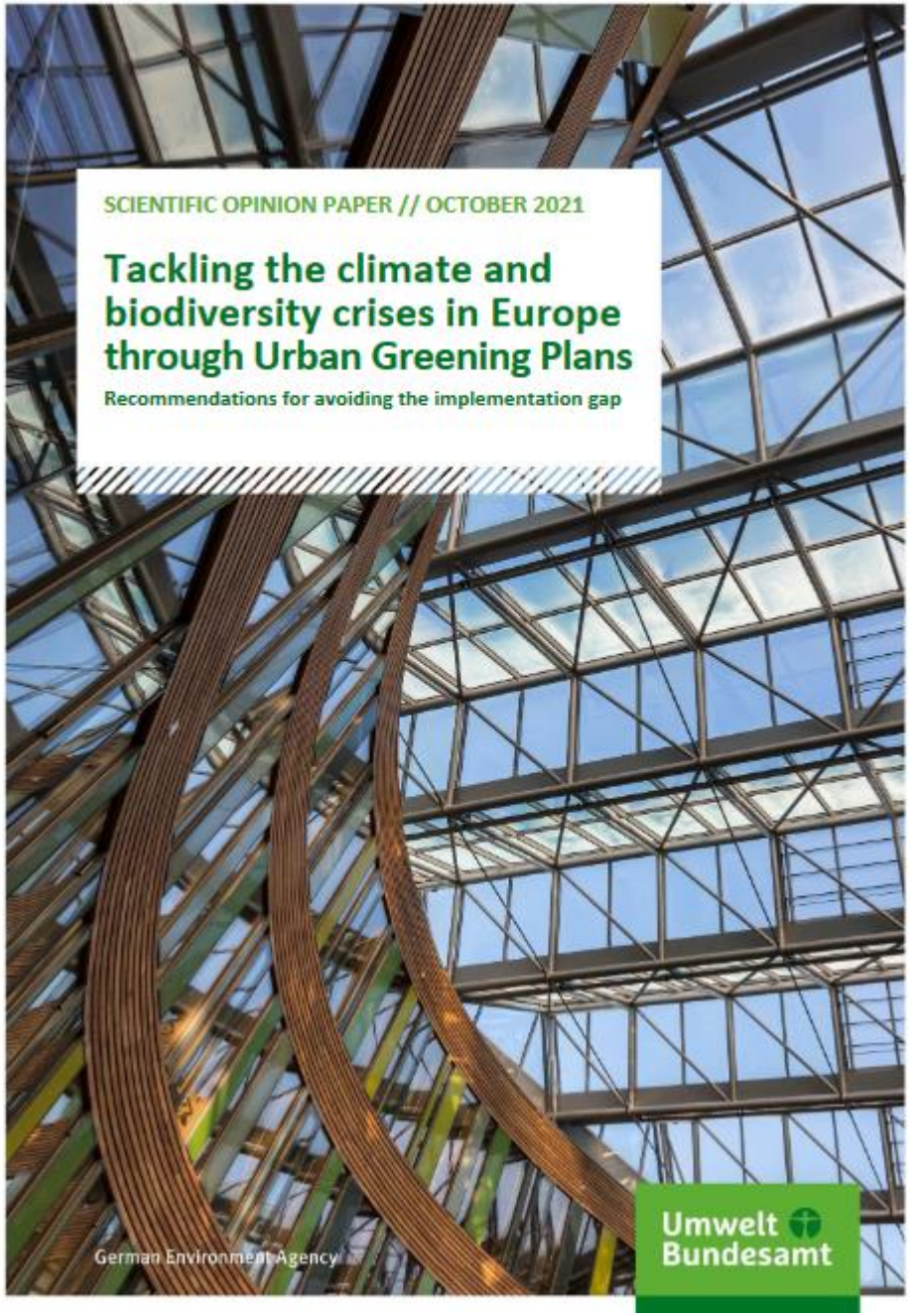
"*A **strategically planned network of natural and semi-natural areas designed and managed to deliver a wide range of ecosystem services** such as water purification, climate mitigation and adaptation*" (European Commission, 2016)

Combine green-grey / **multi-functional use** of space

Ensure **connectivity** of blue-green spaces

Imitate/restore structural and ecological **diversity**

Implementation gap prevents swift up- and outscaling of Green Infrastructure



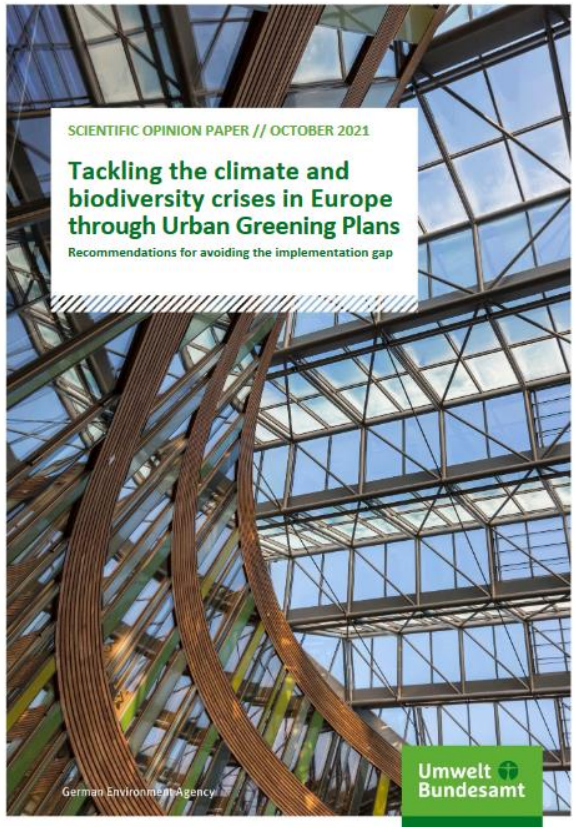
This work has been funded by the German Environment Agency (UBA) in the context of the Klimaresilienz in Europa project (FKZ 3719 48 104 0)

Main barriers to implementation of integrated urban greening strategies

Type of barrier	Barriers mentioned
Political factors (i.e. political commitment, policy consistency, public awareness, political priorities etc.)	**No prioritisation of NbS in land use decisions** as a result of competing interests and high competition over space in urban areas (housing and infrastructure development) **Lack of involvement of citizens in decision making processes and co-design of NbS**
Organisational & institutional factors (i.e. expanded mandates/statutes, institutional routines, cooperation/coordination among departments, across policy levels with private actors)	**Lack of binding long-term regulatory frameworks and legislation** which require compliance across all government levels; **Absence of a governance framework with clear responsibilities and mandates** across levels to engender accountability, and with it, consistent execution of measures and transparency; **Responsibilities** for nature conservation, urban (green space) planning, public health, etc. **are divided up** and have their own structures, goals, logics of acting; environmental departments often lack financial and human resources; **Lack of coordinated decision-making** at city level and collaboration across governance levels to co-develop mutually reinforcing objectives across scales (no landscape planning approach) **Cost-effectiveness analysis** does often not feature all positive effects of urban green, i.e. on public health, ecosystems, quality of life; this results in decisions favouring other land

Main barriers to implementation of integrated urban greening strategies

Type of barrier	Barriers mentioned
Cognitive factors (i.e. such as perceived sense of urgency, problem awareness)	**Perception of higher costs and lower effectiveness associated with NbS** by city planners and decision makers which favours conventional grey infrastructure **Need for citizen-inclusive narratives** for the future reflecting values that implicitly integrate the biodiversity and climate agenda
Resources (i.e. knowledge & expertise, financial and human resources)	**Lack of large scale, blended financing solutions for NbS** with private sector involvement **Need for tools** assessing and illustrating NbS benefits, and guidance for UGP.



5 Recommendations for Urban Greening Plans

1. should ***develop as part of an integrated, overarching city strategy*** issued at high level; be ***action-oriented*** and perform as a comprehensive implementation plan with clear targets, timelines, and responsibilities;

2. include a ***participation strategy for all relevant actors*** and should be accompanied by a communication- /narrative guideline to raise awareness about ecological and social benefits of NbS;

3. ***prioritise nature and biodiversity over competing land use*** and single-sector objectives;

4. should include measurable targets and require regular reporting against ***SMART indicators***, consistent with related international, European, and national targets;

5. should be ***linked to existing funding options*** (i.e. streamlined with other sector programmes at EU/national level), co-investment models and co-financing mechanisms that recognize the ***potential of co-benefits and revenue generation*** of urban greening actions.

Mapping of NbS Knowledge & Implementation Gaps

Desk Study

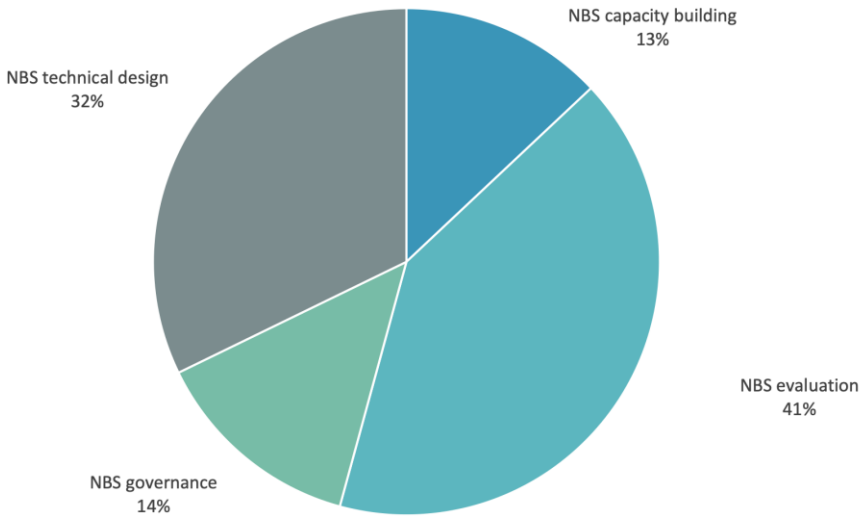
→ **19 Publications** analysed : grey literature and scientific papers

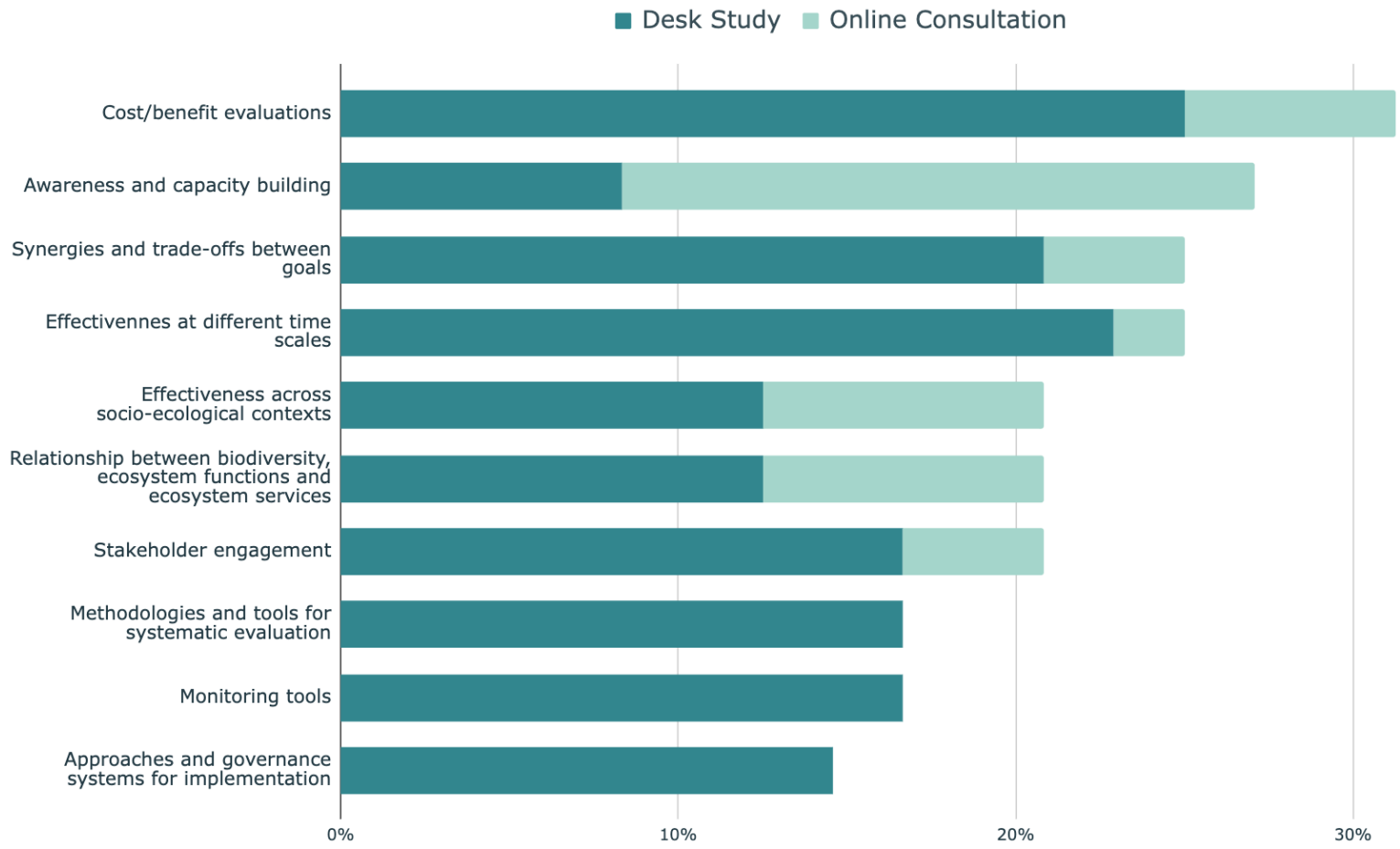
→ **142 gaps categorized into 27 broad gaps identified**

Online Survey

→**45 respondents :** ½ academics and 1/3 stakeholders (national policy makers, NGOs and SMEs)
→Identified **29 unique knowledge and implementation gaps** relevant to NBS

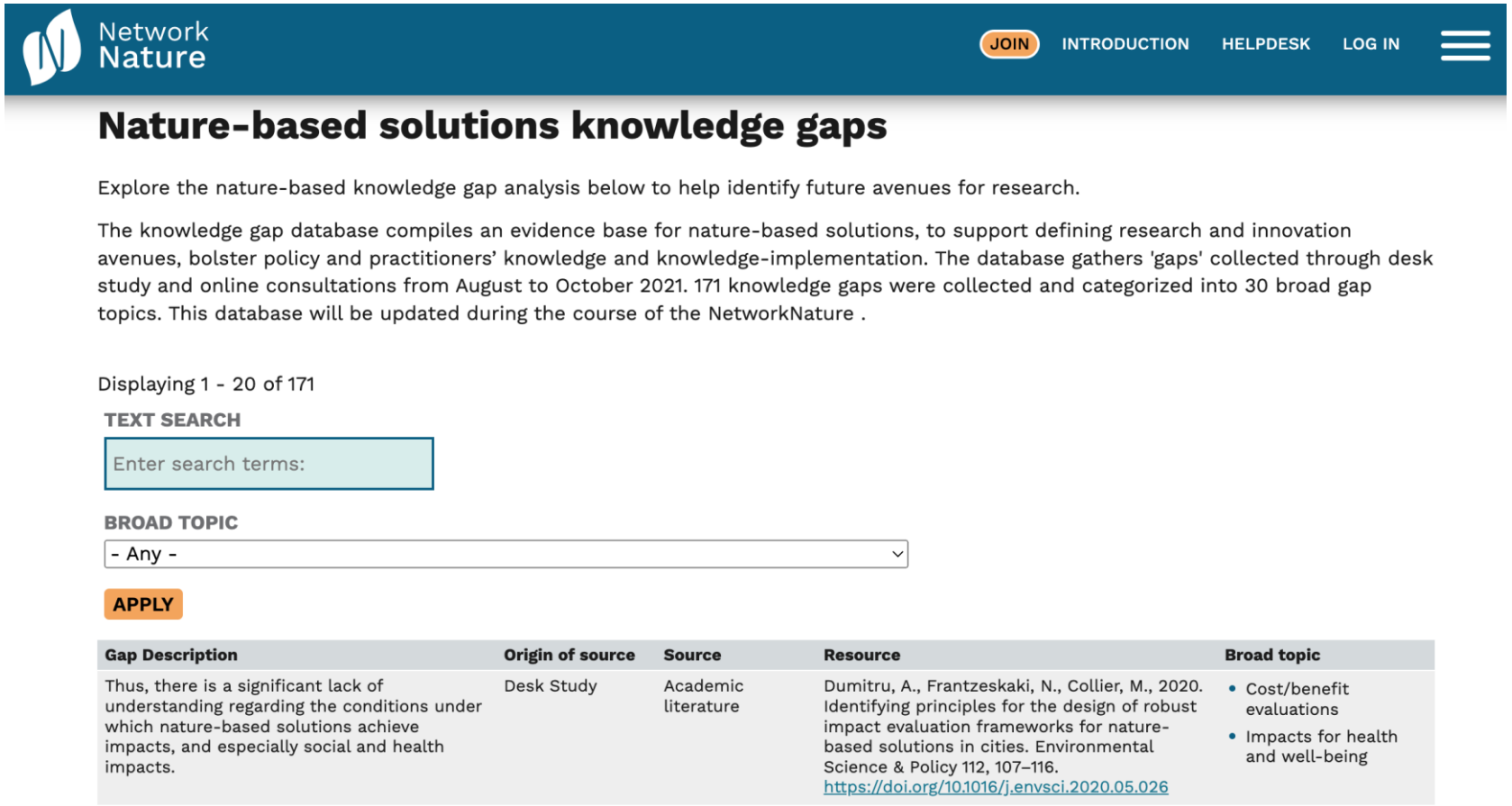
Knowledge gaps results profile





Knowledge gaps database

Network Nature



Networknature.eu

hello@networknature.eu

NetworkNatureEU

NetworkNature

NetworkNature

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 887396.

Gabriel Dias Mangolini Neves, Environmental Licensing Support Coordination of the Secretariat for Green, Environment and Sustainable Development of Campinas- Brazil

Green corridor in Campinas-Brazil

Eddy Chikuta, Lusaka Water Security Initiative

Water Security: through the lens of multi-stakeholder collaboration

Water Security: through the lens of multi-stakeholder collaboration

Eddy Chikuta
Coordinator - LuWSI

The Lusaka Water Security Initiative

NatuReS
NATURAL RESOURCES STEWARDSHIP PROGRAMME
Joint solutions for resilient economic growth

https://www.luwsi.org/

- **Currently has 33 partners**
- **Partnership Activities are coordinated by**: Lusaka Water Security Initiative (LuWSI) Secretariat and lead project partners
- **Lead project partners:** Lusaka City Council (LCC) and Lusaka Water Supply and Sanitation Company (LWSC), Zambia Chamber of Commerce and Industry (ZACCI), WWF Zambia, WaterAid.

Programmes

Water Stewardship

Green Cities Adaptation Programme

GSPP Green Schools Partnership Program

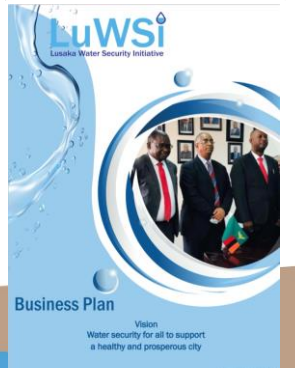
Community Empowerment & Engagement

LuWSI's Value proposition

- **Entrench a collective understanding of water security**
- Provide partners an **opportunity to leverage the strength of multi-stakeholder collaboration**
- Provide a platform for partners to **discuss, harmonise and synchronise** their work
- **Help different actors realise synergies**: resource pooling
- **Act as a container** to incubate ideas and projects
- **Mobilise new forces** to accelerate the delivery of more tangible and sustainable results
- **Overall monitoring, evaluation and learning**

Results

- Strengthened partnerships in the water sector – 33 partners
- Leveraged more than 750,000 Euros in partner support (2021) towards activities and partner strengthening
- Embedding of water security in annual budgets, strategies and work plans of partners – deliberative action
- Water security learning labs & policy brief – ICLEI SA
- Enhanced private sector engagement – Industrial wastewater management RWSII
- Supported the development of 5 COVID-19 response plans & trained 50 people in citizen journalism
- Improved WASH services in over 100 schools, reaching over 150 000 pupils and 3500 teaching staff, especially in the most vulnerable communities (SB2S Campaign)
- Trained 20 women in fabricating handwash facilities – skills development
- Rehabilitation of 11 boreholes, servicing over 400.000 people in marginalized communities
- Developed the LuWSI Strategy and Business Plan 2021 -2023
- Water stewardship activities for private sector, Commercial utilities and communities – 11 CUs officially committed to WS in corporate strategies



NatuReS
NATURAL RESOURCES STEWARDSHIP PROGRAMME
Joint solutions for resilient economic growth

Visit our websites:

https://nature-stewardship.org/

https://www.luwsi.org/

Subscribe to our newsletter:

https://nature-stewardship.org/#newsletter

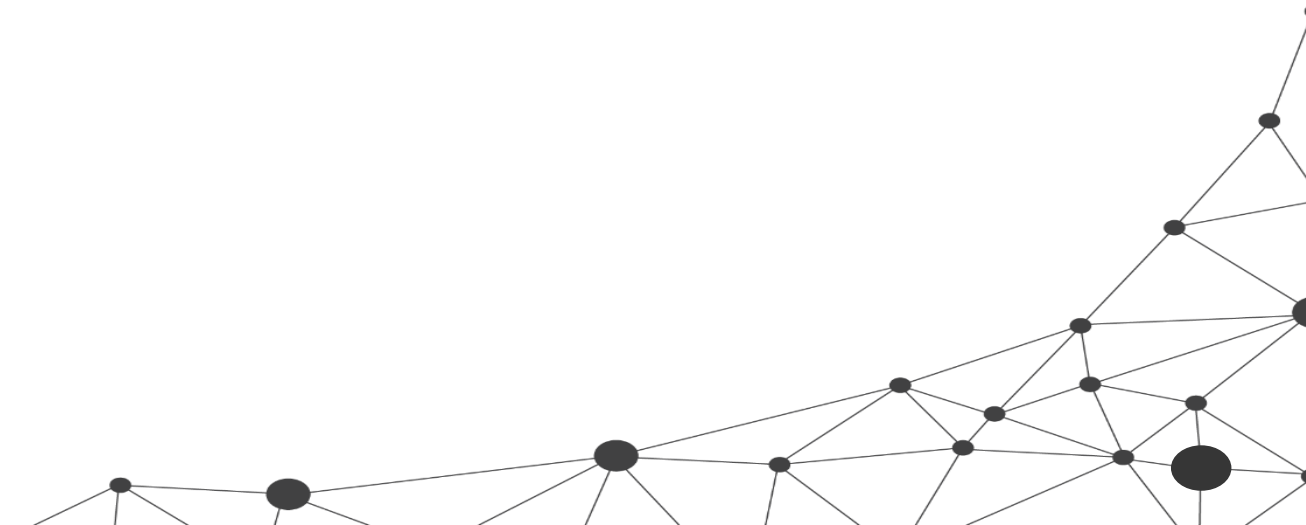
Follow us on Twitter:

@NatuReS_global

Network Nature

CONNECTIVE CITIES

Moderated conversation



Part 2: Training part		
15:00-15:05	Introduction	**Bettina Wilk, ICLEI**
15:05-15:30	**Meeting the financial challenges facing China's Sponge City Program (SCP)** (interactive session)	**Monica A. Altamirano, NOW Partners; Faith Ka Shun Chan, University of Nottingham Ningbo, China**
15:30-15:55	**NBS indicator handbook – NBS monitoring and impact evaluation in cities** (interactive session)	**Laura Wendling, Nature-based Solutions Research Team Leader at the VTT Technical Research Centre of Finland**
15:55-16:00	Closing & Opportunities to stay informed – NetworkNature, NatureWithCities, UrbanbyNature Programme	**Bettina Wilk, ICLEI**

University of Nottingham
UK | CHINA | MALAYSIA

Meeting the financial challenges facing China's Sponge City Program (SCP)

Dr Faith Chan[1] & Dr Monica A. Altamirano[2]

1. School of Geographical Sciences, University of Nottingham Ningbo China
2. NOW Partners

8 June 2022

Green infrastructure in cities: Guidance and recommendations for overcoming the implementation gap

University of Nottingham
UK | CHINA | MALAYSIA

Introduction

Sponge City

Introduction – urban floods in Chinese Cities

Ningbo- October 2013(left) & 26 July 2021 (right) after typhoon Fitow and In-Fa

The initiative of Sponge City Program (SCP)

- The SCP concept adopts alternative methods to transform traditional hard-engineering infrastructures into green or blue-green landuse.

- These new generational infrastructures **enable to collect, control and reuse** stormwater in an ecological pathway, and reduce the urban surface runoff (Chan *et al.*, 2018).

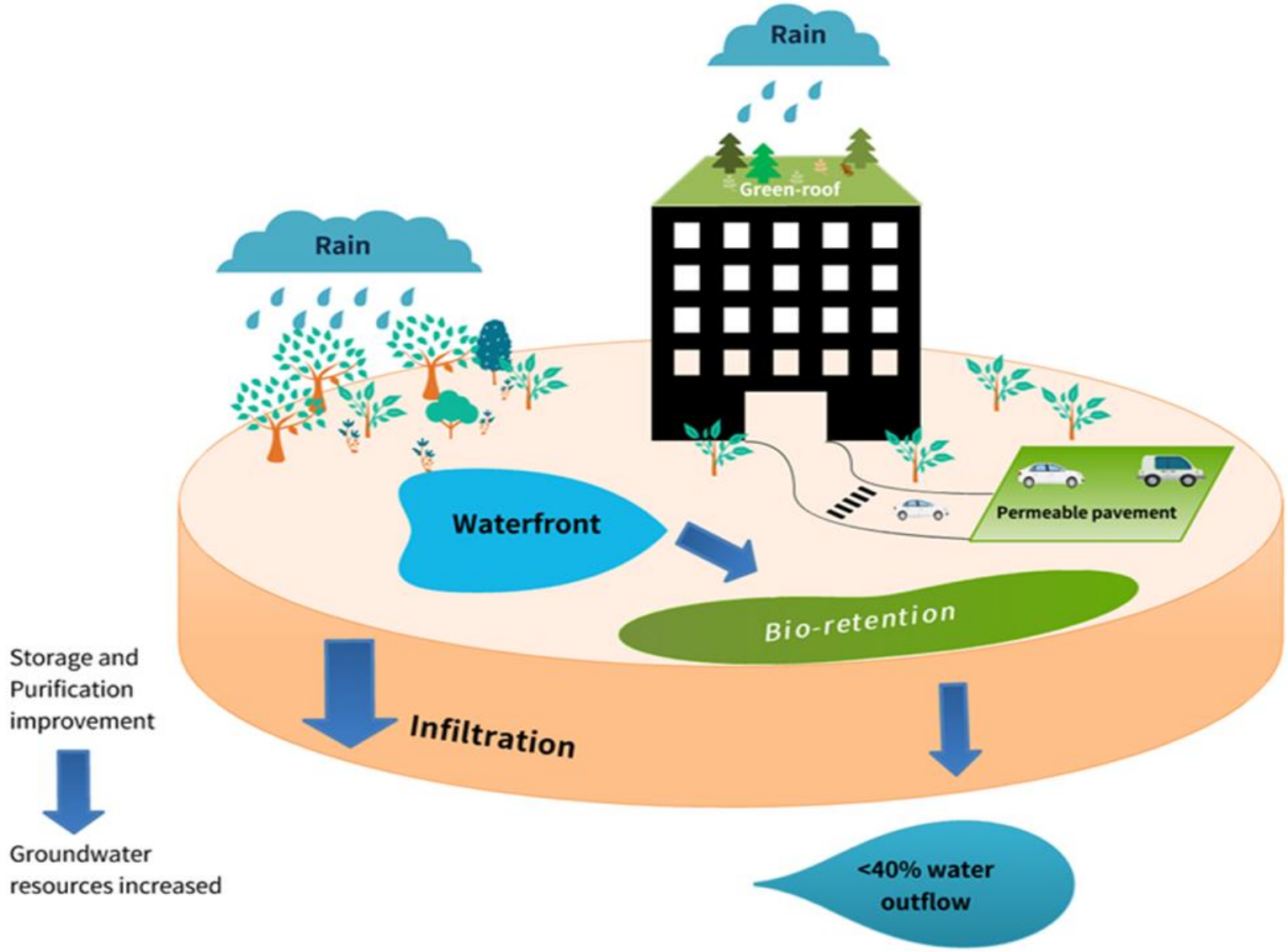
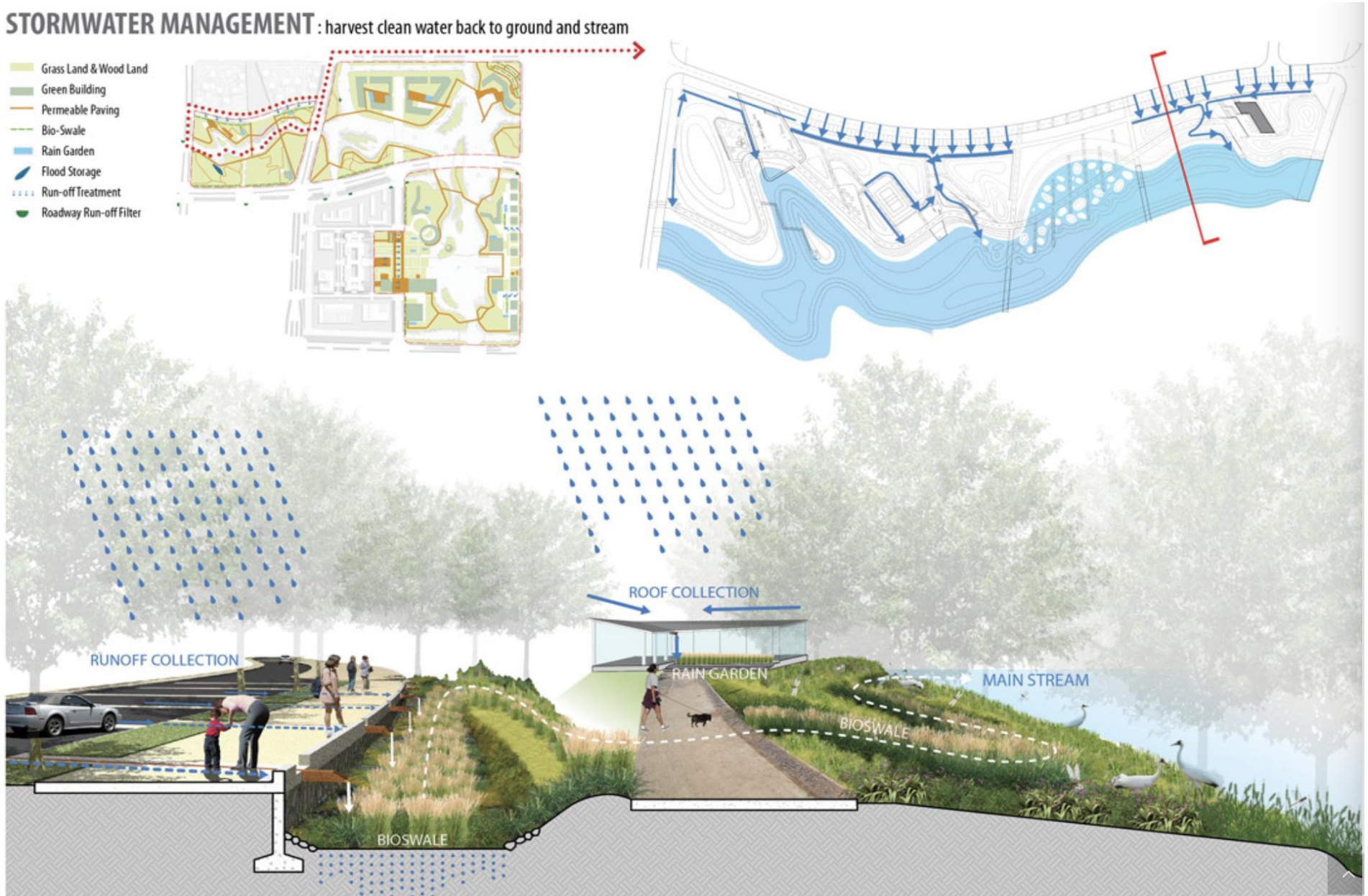


Figure 2 Sponge City concept and idea

The Eco-corridor case – Multiple benefits (Wellbeing)



Multiple design criteria (flood control, water quality and amenity value)

Stormwater run-off is collected and treated before entering the major waterway.

This process is demonstrated and included in the park program and design for educational purposes.

Wildlife Habitat structures like habitat logs and perch trees are planned along the riparian edge.

Integration with the Urban Fabric:
- a symbiotic relationship between the greenway and surrounding landscape.

Sponge City in China – progress

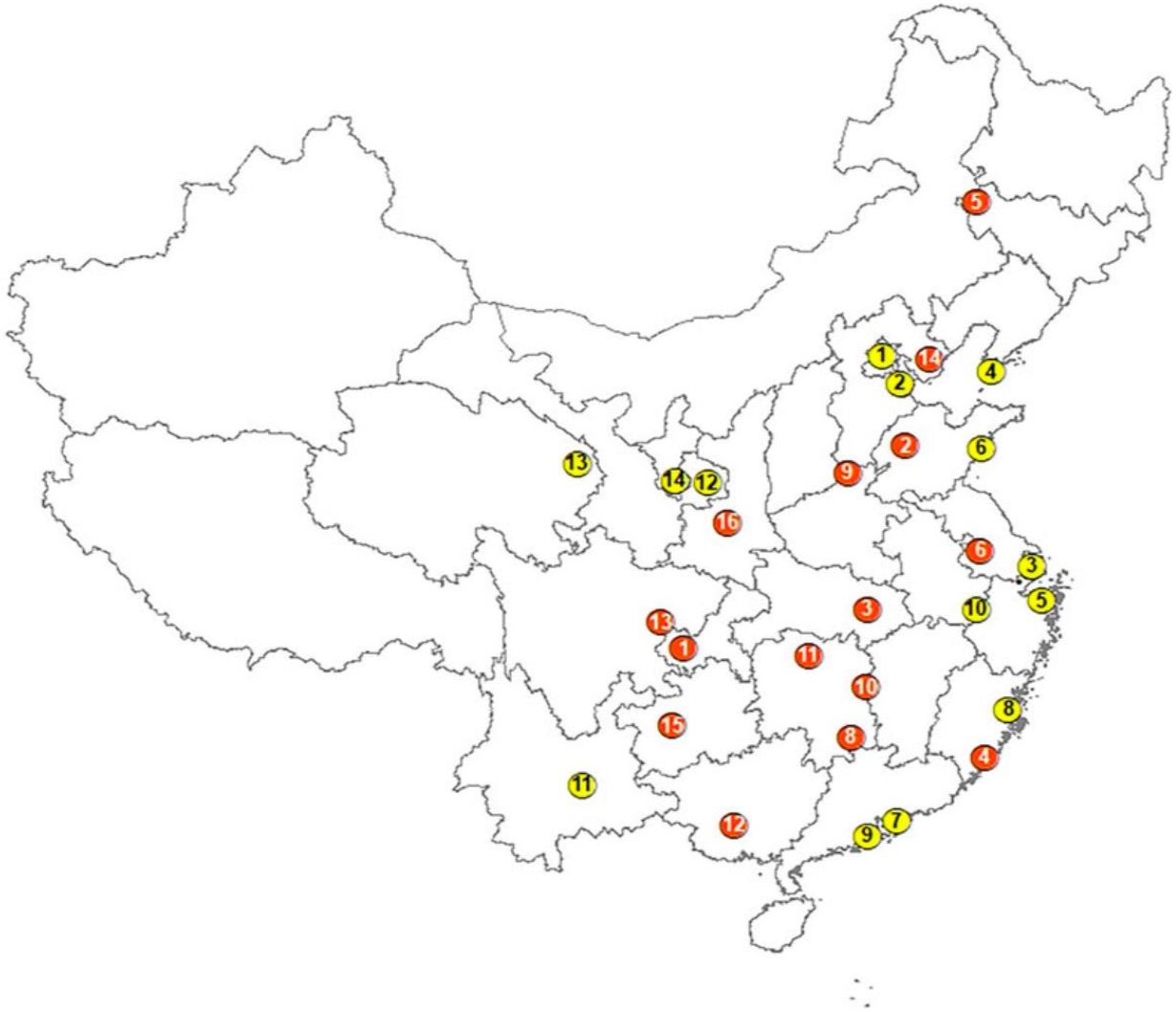


Figure 1. Geographical location of the first (dark circles) and second (light circles) batch of Sponge City pilot cities. (Online version in colour.)

First batch pilot cities: 16 cities
Second batch pilot cities: 14 cities

– Medium term (2018–2020): Establishment of Sponge City standards, management systems, and monitoring and early warning systems by 2020; with greater than 20% of municipal areas able to recycle 70% of incident rainfall.

—— Long term (2020–2030):

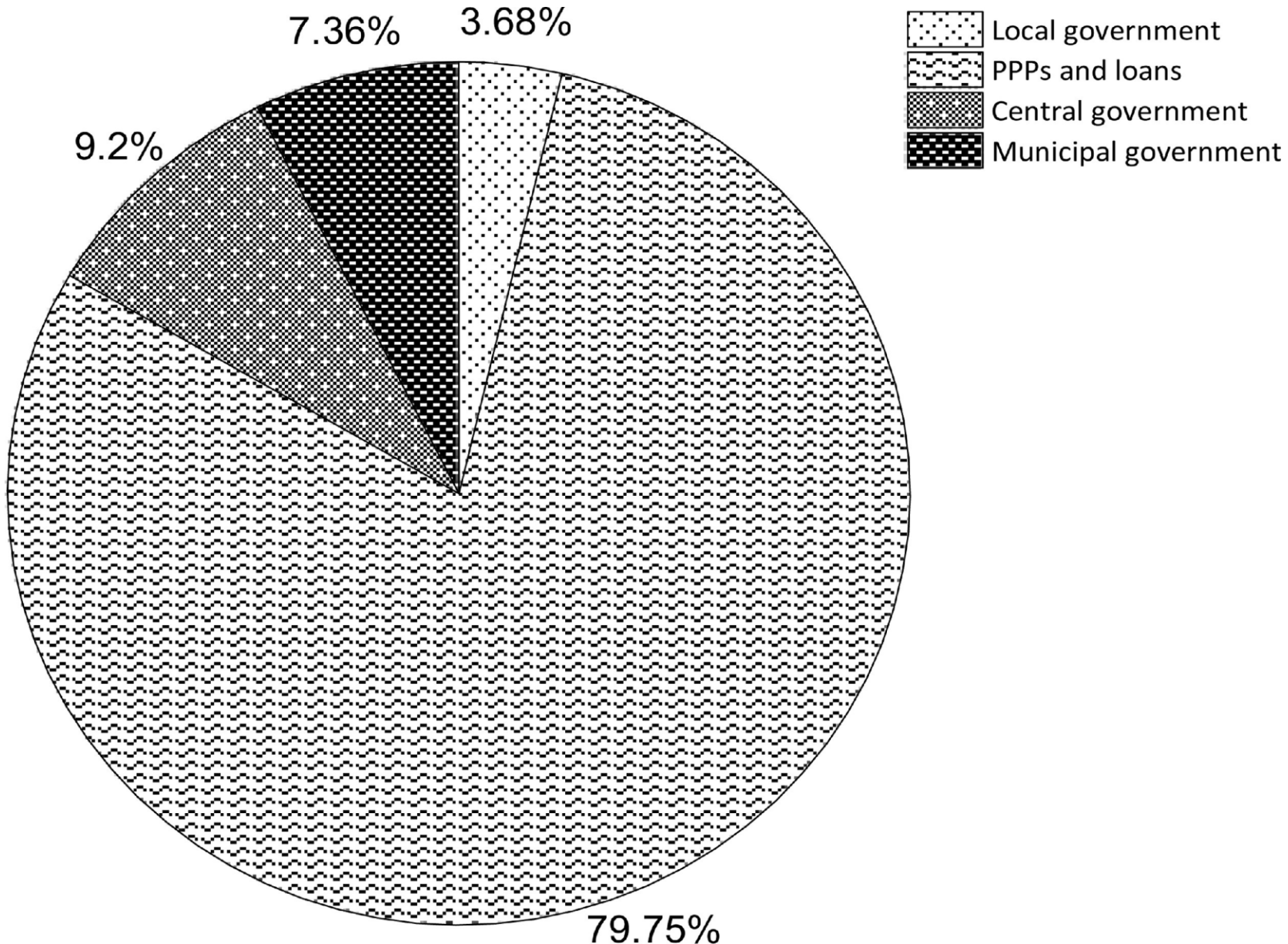
Complete integration of the Sponge City concept in urban development, planning and construction management by 2030;

with greater than 80% of municipal areas able to recycle 70% of incident rainfall.

University of Nottingham
UK | CHINA | MALAYSIA

SCP investment scheme

Source: Chan and Chen et al. 2022



University of Nottingham
UK | CHINA | MALAYSIA

SCP Funding scheme

Funding Scheme	Example	Citations
Direct Investment from Central Govt.	• *Direct investment of 1.2-1.8 billion to each of the 30 pilot cities*	Griffiths et al.; Li et al. , Yang et al. (2020), Chan et al. , Xia et al
Equity/ Environmental stocks	• *Listed corporations in the Hong Kong Stock Exchange market*	Sina Finance, 2015
Public-Private Partnership (PPP)	• Chang'an River project (2017-2020) in Dongguan city, Guangdong province. • Total investment is 739 million RMB; sources of funds include project company financing and municipal government support (BOT), with 15 year contract.	Fu and Guo, 2020
Green Bonds	• On August 5, 2019, Chongqing Nanchuan District Urban Construction Investment (Group) Co. issued a non-public green bond for SCP programs. • The issuance scale is 1.08 billion with 7 year term and 7.80% issuance rate. • In the same year, there existed 1 trillion RMB of green bonds issuance in China.	Deheng News (2019)
Insurance/ Taxes/ General funds	• Changde City Banking Financial Institutions established a sponge city fund with an amount of 1.499 billion RMB	Huang (2017)

Using Hong Kong as the investment fund for SCP

(Chan et al. 2022)

Product	Definition	Key players	Examples
Green Bonds	Financial products to finance or refinance fresh or old eligible green projects	Issuers include commercial banks, corporations, asset-backed security, HKSAR government, policy banks	HKSAR Government Green Bond
Green loans/ Green credits	Loan instruments available to exclusively invest or re-invest in qualified green projects	Banks would provide green loans or credit lines for clients or projects that are making contribution to the overall sustainable development goals of the banks	Alliance for Green Commercial Banks
Green equity investment	Investors use a range of strategies, including positive/negative screening, ESG integration	Investors provide capital for companies that bring positive influence to environment and society. Investors can reduce their environmental risks across their portfolios.	Green Index and Green Derivative
Green funds	These are significantly taking environmental issues into consideration in investment strategies, with ethical avoidance criteria	Fund managers: define a specific theme for the funds and offer to fund eligible companies or projects with strong environmental credentials Green label and certification schemes: indicate the greenness of the funds.	Green Tech fund

University of Nottingham
UK | CHINA | MALAYSIA

EU NBS Green Financing – case and examples

Discussion – Monica

Global Top 100 University

CONCLUSION

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Take-home messages:

- **Sponge City Program at the cross-road on financing**
- **The Central National Govt. halted direct investment since 2018 to the program**
- **Linking the green investment via Hong Kong and taking opportunities on SCP financing**
- **Learning from the EU lessons – Monica**

Thank you!

Please contact me and Monica at faith.chan@Nottingham.edu.cn and monica@now.partners

Refer to:
https://www.sciencedirect.com/science/article/pii/S2772411522000118#bib0036

What is your most important challenge in upscaling UGP?

a. Designing a blended finance arrangement
b. Engaging with the private sector / Public-Private engagement/ Structuring a co-financing arrangements
c. Showing cost-effectiveness of NBS versus traditional infrastructure
d. Drafting a performance-based contracts/ Reliable and professional suppliers
e. Developing the investment case of multifunctional investments
f. Monitoring systems
g. Risk management protocols for construction and maintenance
h. Budget for sustained maintenance

University of Nottingham
UK | CHINA | MALAYSIA

Q&A session

Faith Chan

CLOSING THE IMPLEMENTATION GAP

Handbook for the Implementation of NBS

1

Future proof investments? nature-based solutions and climate change

Risk-based Asset Management

2

Creating demand for investments in nature-based solutions

Governance structures for collective investments

3

Creating markets for implementing nature-based solutions

Market sounding + blueprint for P3

Financing Framework for Water Security

Collaborative modelling protocols to structure bankable propositions

NAIAD

NAIAD project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730497.

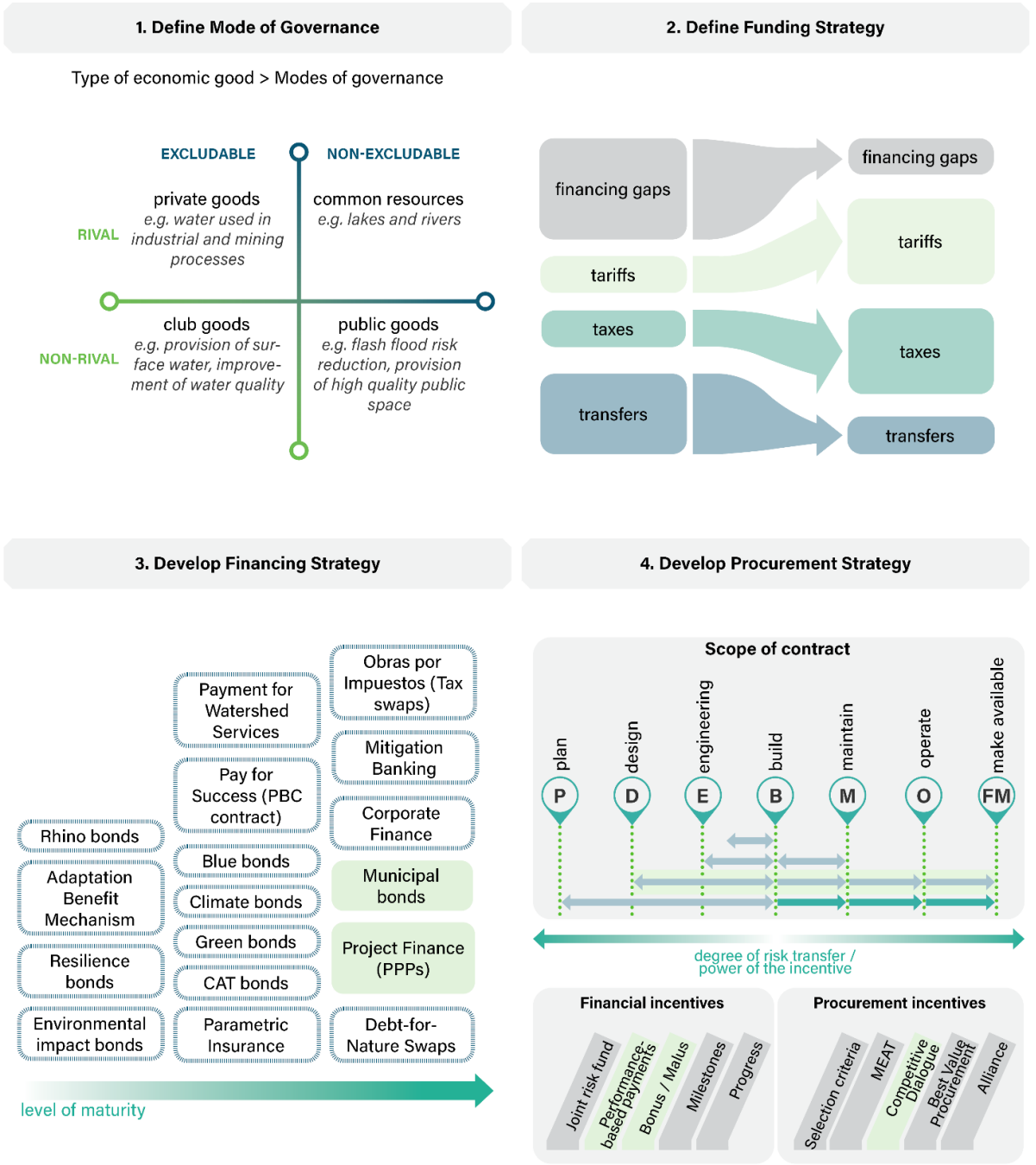
Handbook offers:

- **A step by step guide** for developing NBS business case: how to choose a mode of governance for the project, a funding strategy, a financing strategy and a procurement strategy (Chapter 1)
- **a project preparation facility toolbox**: a toolbox with a compendium of all the analysis grid, checklist, methods to prepare in a collaborative way NBS projects and design a complete project preparation roadmap (chapters 1 to 3 and appendixes); starting with an intake assessment form (Appendix A) and in some cases requiring the development or further detailing of the NBS strategy through a strategic planning process (chapter 2), and including collaborative modelling protocols to guide the design of stakeholder engagement workshops.
- **illustration and inspiration** from three of H2020 NAIAD demo cases in EU and one demo case in Indonesia from the Water as Leverage programme (Chapter 5), as well from pioneering and successful NBS implementation arrangements worldwide (Chapter 6)
- **an analysis of barriers** for public and private investment in NBS, of the specificities of NBS project (as a systemic solutions, as a “new technology” as well as a living solution with its cyclical and long-term ecological processes), and the bankability implications of building with nature: generally higher risk reward ratio, delayed functionality, non-monetarised benefit thus not translated into revenue streams (Chapter 4).
- Sound basis for capacity development in developing an investment plan

Financing Framework Building Blocks

1. Mode of governance
2. Funding Strategy
3. Financing Strategy
4. Procurement Strategy

Download handbook



NAIAD project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730497.

Typology of NBS implementation arrangements

Public project procurement	Public commissioner develops a project and tender it in the market through traditional or PPP/ Performance-based contracts
Water stewardship	Private company invest and commissions a 3rd party to implement watershed conservation measures to reduce their water risks
Collective investment schemes	Entity that pool resources from different beneficiaries and invest them in a variety of NbS and hybrid measures
Environmental markets	An ecosystem service itself is marketed and sold as a commodity to a beneficiary (usually an institution rather than individual) in the context of a dedicated market, usually subject to oversight by a regulatory body

Download handbook

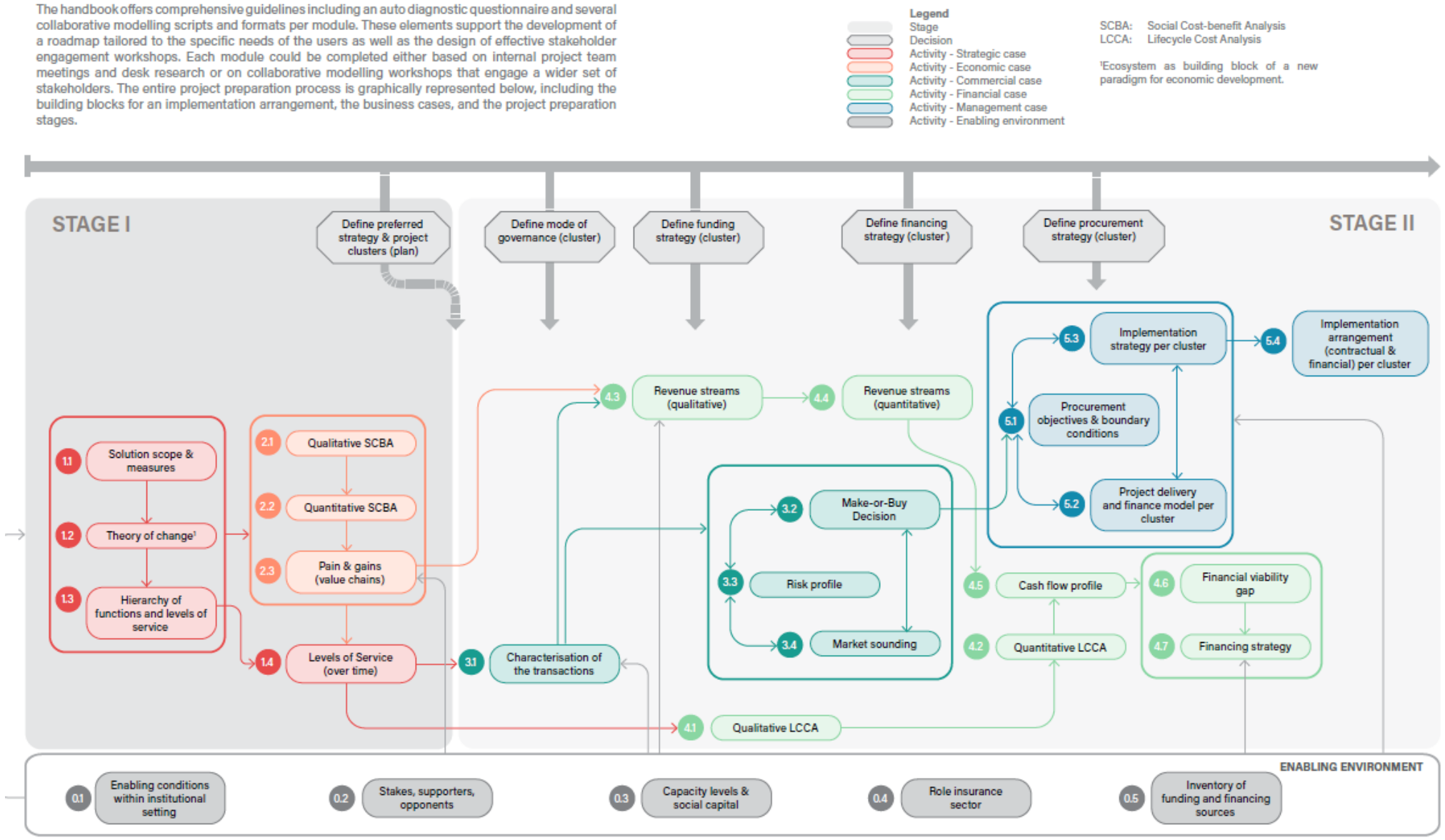
NAIAD project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730497.

Source: Handbook for the Implementation of Nature-based Solutions for Water Security (Altamirano et. Al 2021)

Project preparation roadmap

Roadmap

The handbook offers comprehensive guidelines including an auto diagnostic questionnaire and several collaborative modelling scripts and formats per module. These elements support the development of a roadmap tailored to the specific needs of the users as well as the design of effective stakeholder engagement workshops. Each module could be completed either based on internal project team meetings and desk research or on collaborative modelling workshops that engage a wider set of stakeholders. The entire project preparation process is graphically represented below, including the building blocks for an implementation arrangement, the business cases, and the project preparation stages.



With which of these financing mechanisms do you have experience already? or you know are used in your country/ city?

a. Green bonds
b. Climate Bond
c. Environmental / Ecosystem markets
d. Water Funds
e. Project Finance / PPPs
f. Resilience Bonds
g. Insurance for ecosystems

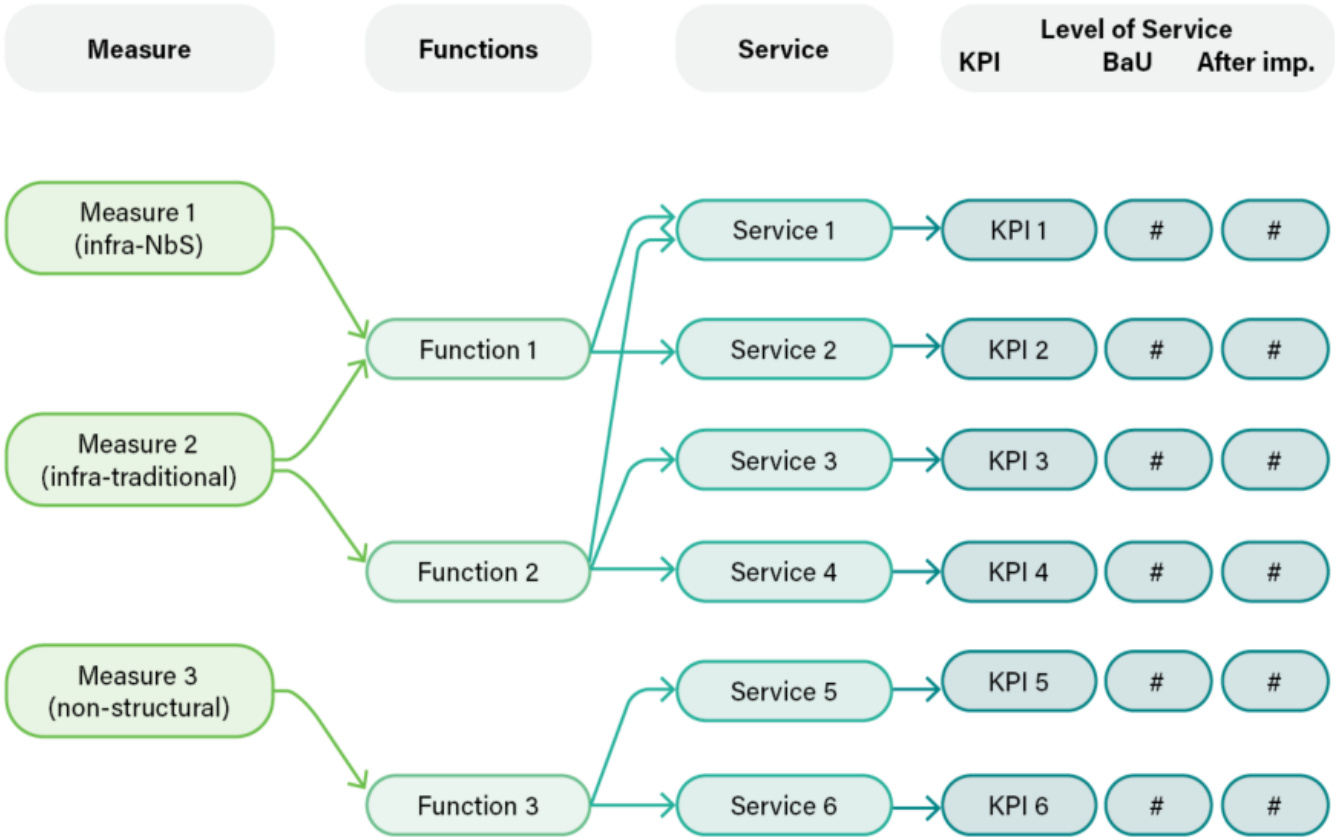
What do you think any suitable/fit for purpose green financing mechanisms that are particularly suitable for NBS/ Urban Green Plans in the Global South?

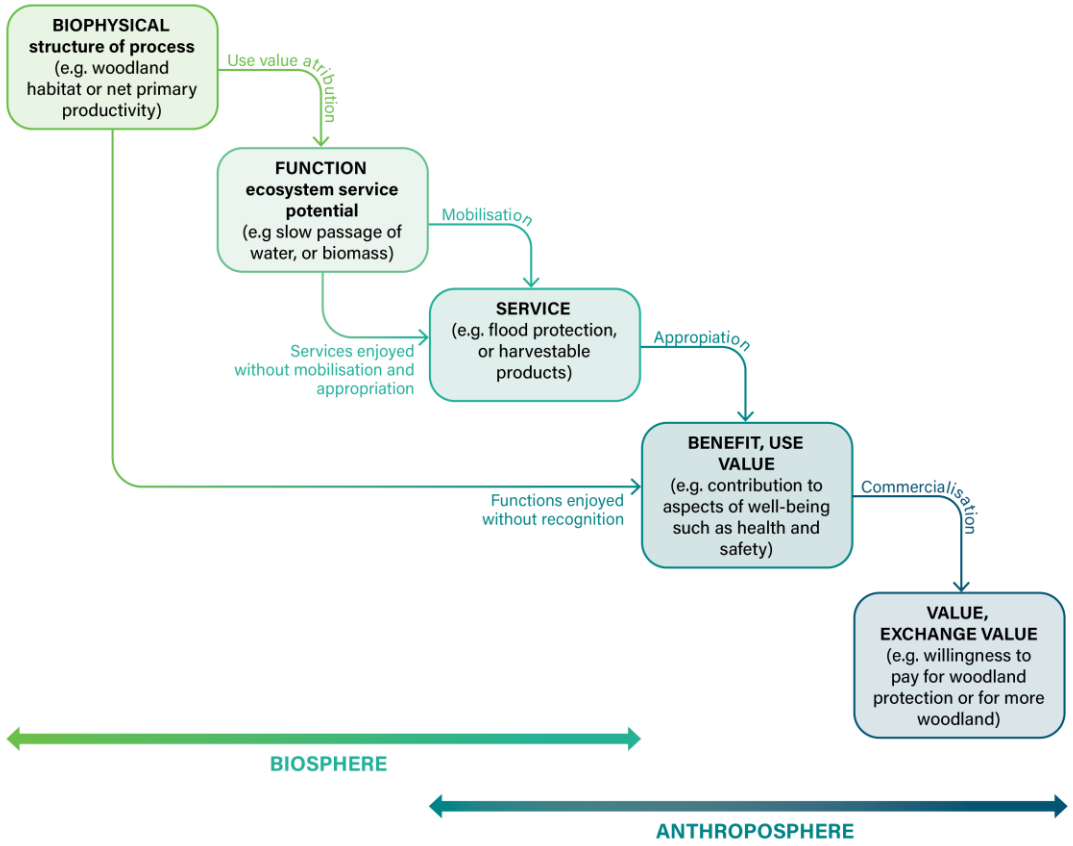
a. Concessional finance: channeled by Multilateral Development Banks– Low interest /special rate loans and grants
b. Public Private Partnerships (Project Finance)
c. Green bonds and securities
d. Green stocks and shares
e. Direct investment by the Government (public budgets)
f. Grants from bilateral donors

Questions?

Mónica A. Altamirano, PhD
Partner, NOW Partners
Email: monica@now.partners
Twitter: @altamiranoCAFF

Phase 2: Commercial, Financial, Management Business Case





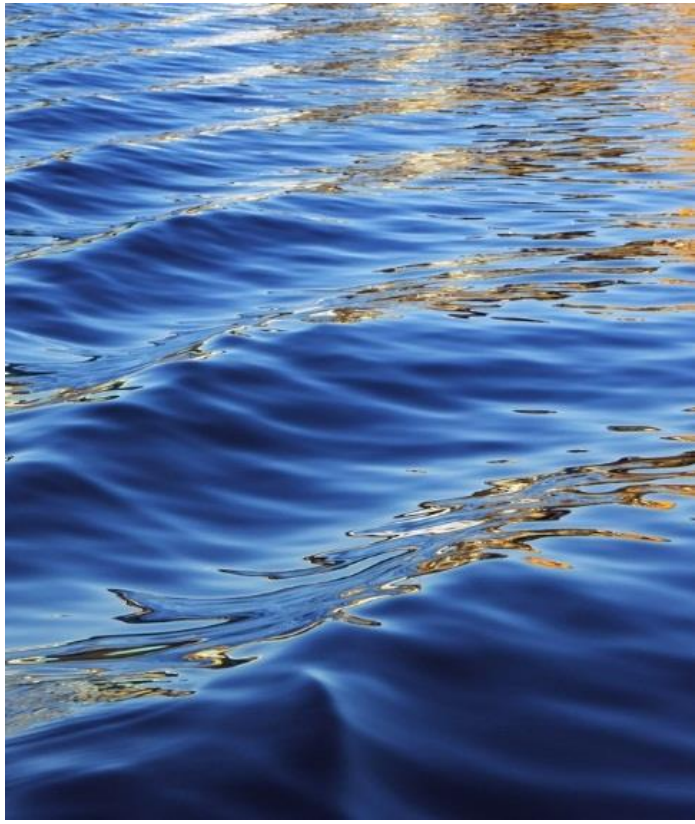
Source: Altamirano, M. A., et al. (Forthcoming). D7.3 *Handbook for the Implementation of Nature-based Solutions for Water Security: guidelines for designing an implementation and financing arrangement*, EU Horizon 2020 NAIAD Project, Grant Agreement N°730497 Dissemination.

Cash profile + Risk profile

These projects have received funding from the European Union's Horizon 2020 research and innovation programme under topic SCC-2-2016-2017: *Smart Cities and Communities Nature based solutions*

Evaluating the Impact of Nature-Based Solutions: A Handbook for Practitioners

Laura Wendling
on behalf of the NBS Impact Assessment Taskforce



Laura.Wendling@vtt.fi
www.unalab.eu
@UNaLab_EU

Why do we need to understand the impacts of NBS?

- NBS can support high-level objectives related to climate change adaptation and mitigation, ecosystem and biodiversity conservation and restoration, sustainable development, etc.

- Widespread adoption of NBS and their incorporation within multi-level policy instruments is hindered by fragmented and largely discipline-specific nature of existing evidence of NBS performance and impact

There is an urgent need to develop an in-depth, common understanding of both the potential benefits of Nature-Based Solutions and any associated trade-offs

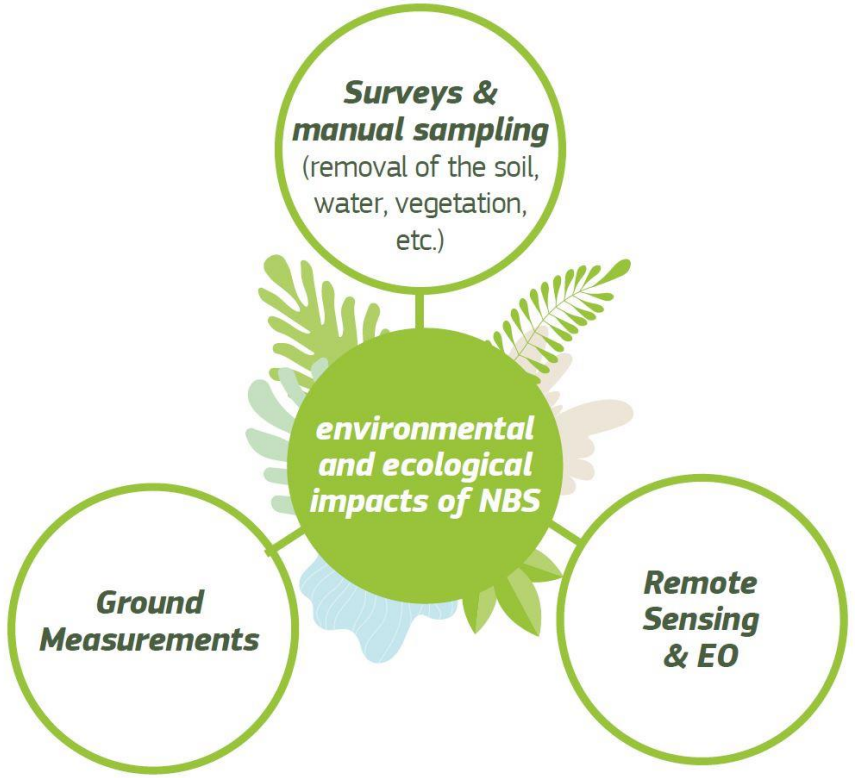


Image source: Leo et al. 2021. *Chapter 7. Data Requirements.* *Evaluating the Impact of Nature-Based Solutions: A Handbook for Practitioners*.

Integrated NBS Impact Assessment Framework

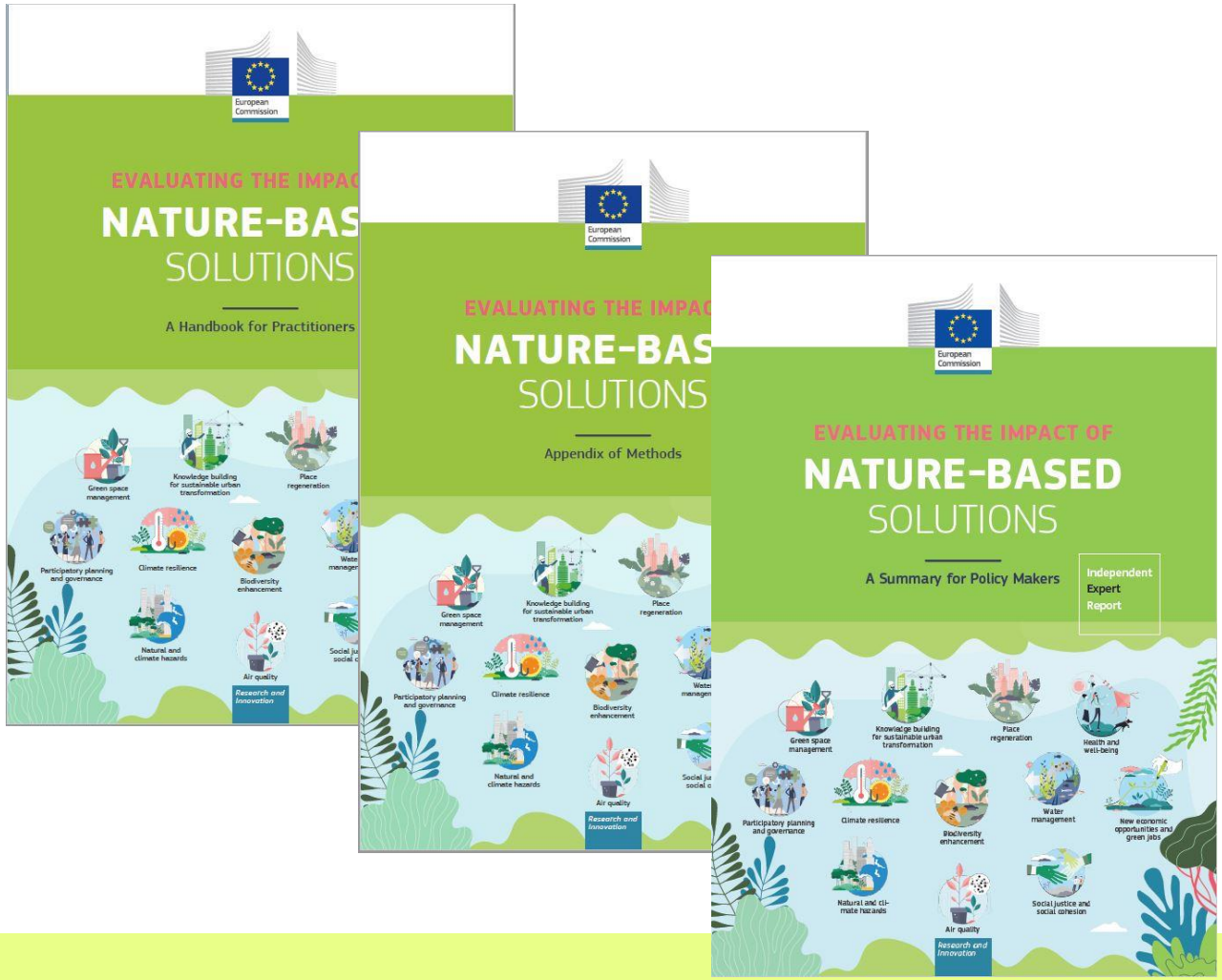
- Collaboration between 17 EU-funded projects and related programmes to develop *Evaluating the Impact of Nature-based Solutions: A Handbook for Practitioners* & *Appendix of Methods*, + *Summary for Policymakers*

The *Handbook* serves as a guide to development and implementation of scientifically-valid monitoring and evaluation plans for the evaluation of NBS impacts

The *Appendix of Methods* provides a brief description of each method, along with guidance about the appropriateness, advantages and drawbacks of each in different contexts

Framework of common indicators and methods for assessing the performance and impact of diverse types of NBS:

- A reference for relevant EU policies and activities
- Orients practitioners in developing robust impact evaluation frameworks for NBS at different scales
- Comprehensive set of indicators and methodologies
- Key points highlighted in *Summary for Policymakers*



Indicators of NBS Performance and Impact

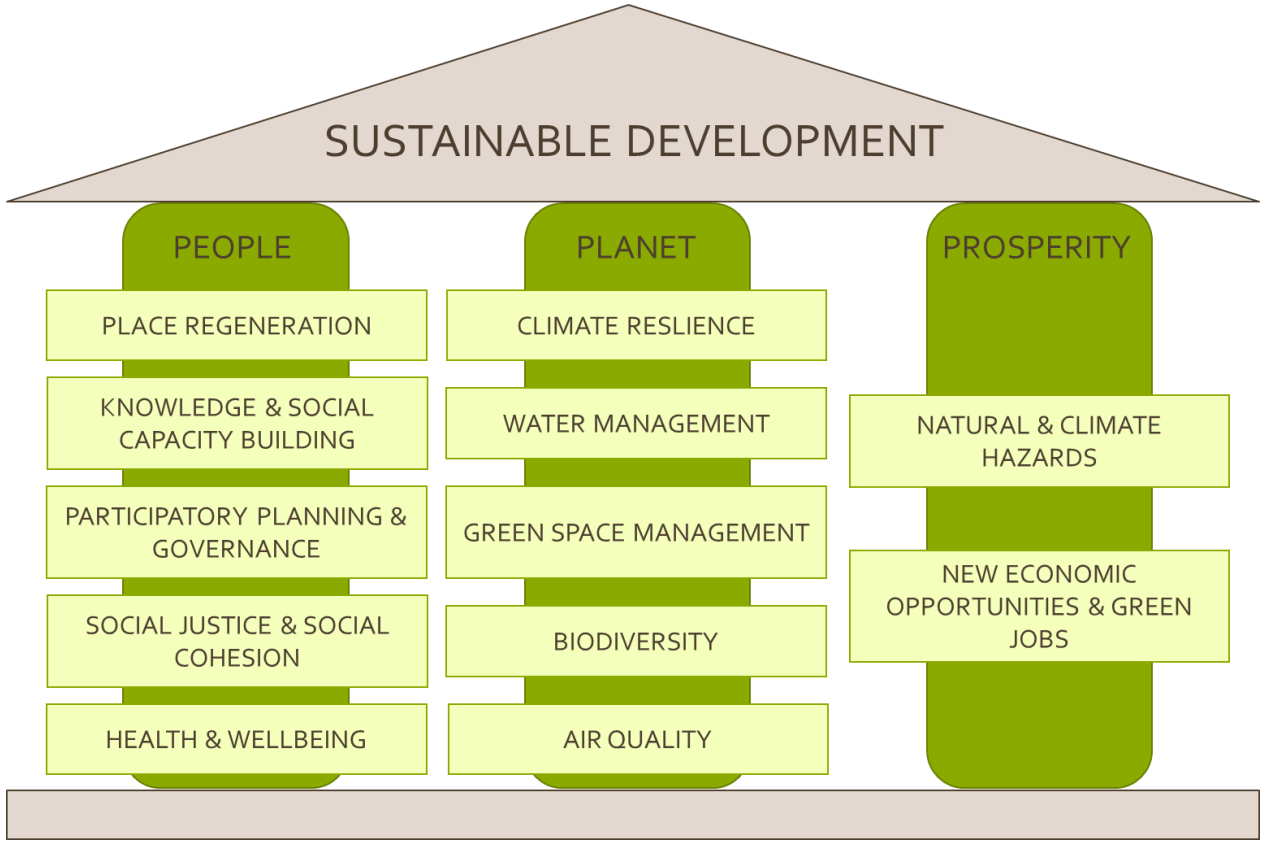


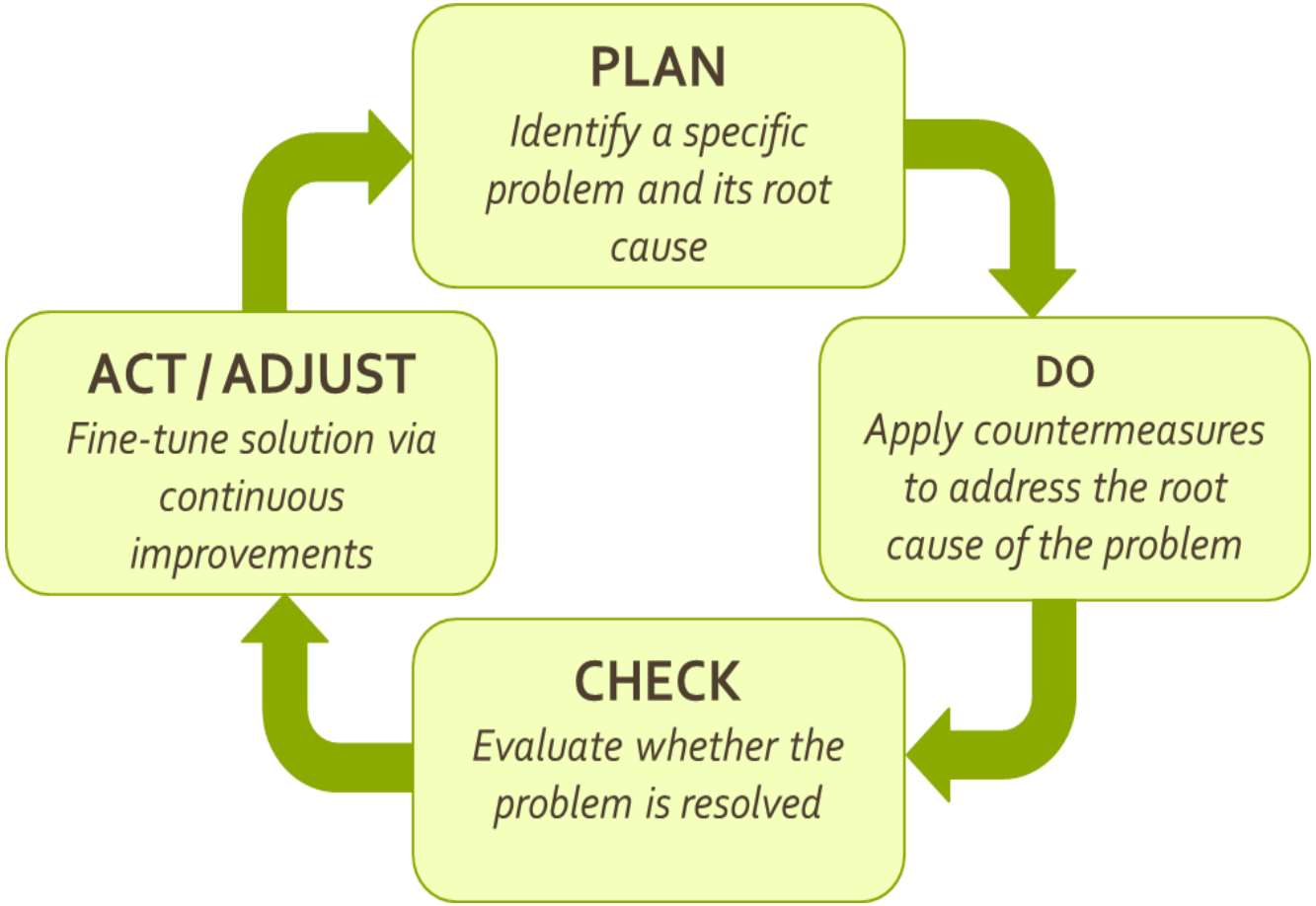
Image source: Wendling et al. 2021. *Chapter 4. Indicators of NBS Performance and Impact.* *Evaluating the Impact of Nature-Based Solutions: A Handbook for Practitioners*.

- Key indicators of performance & impact provide information about NBS effectiveness in comparison with defined objectives
- Handbook presents **446 possible indicators across 12 societal challenge areas**
  - **73 Recommended** indicators that are central to the assessment of main expected outcomes
  - **373 Additional** useful indicators that may be necessary to evaluate specific targets, or desirable when additional resources are available for monitoring and evaluation

Please click on the link provided in the chat!

At what point during the adaptive management cycle common to NBS projects should indicators of NBS performance and impact be selected?

- During planning phase (”plan”)
- During implementation (”do”)
- During evaluation (”check”)
- When making changes (”act/adjust”)



Indicators of NBS Performance and Impact

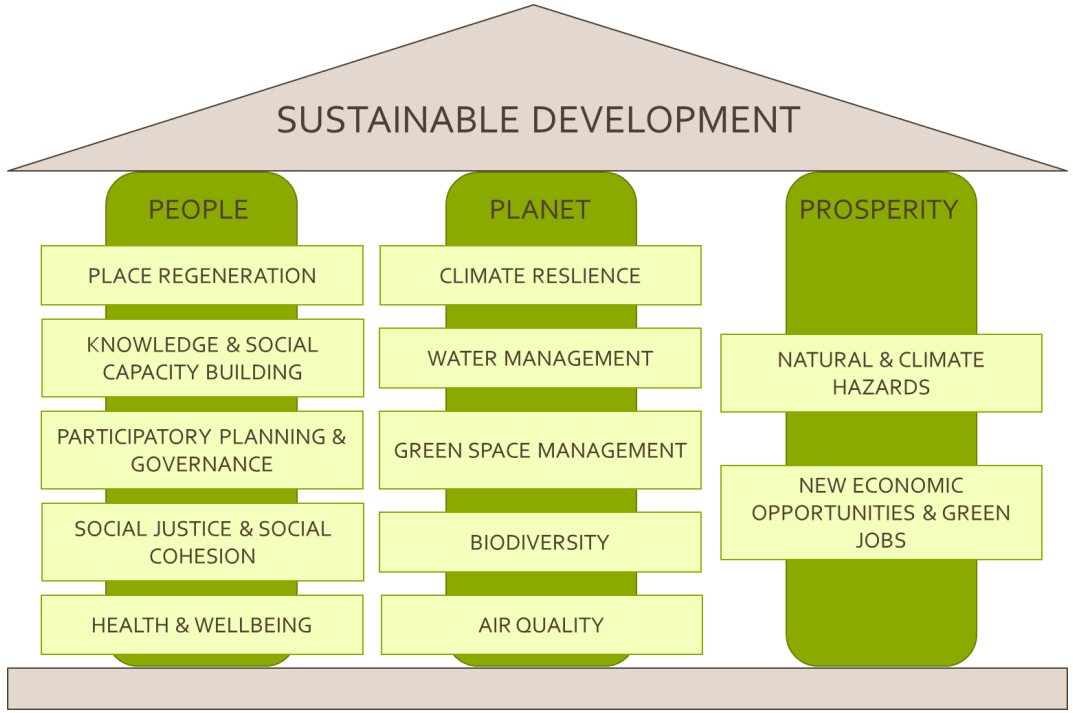


Image source: Wendling et al. 2021. *Chapter 4. Indicators of NBS Performance and Impact.* *Evaluating the Impact of Nature-Based Solutions: A Handbook for Practitioners*.

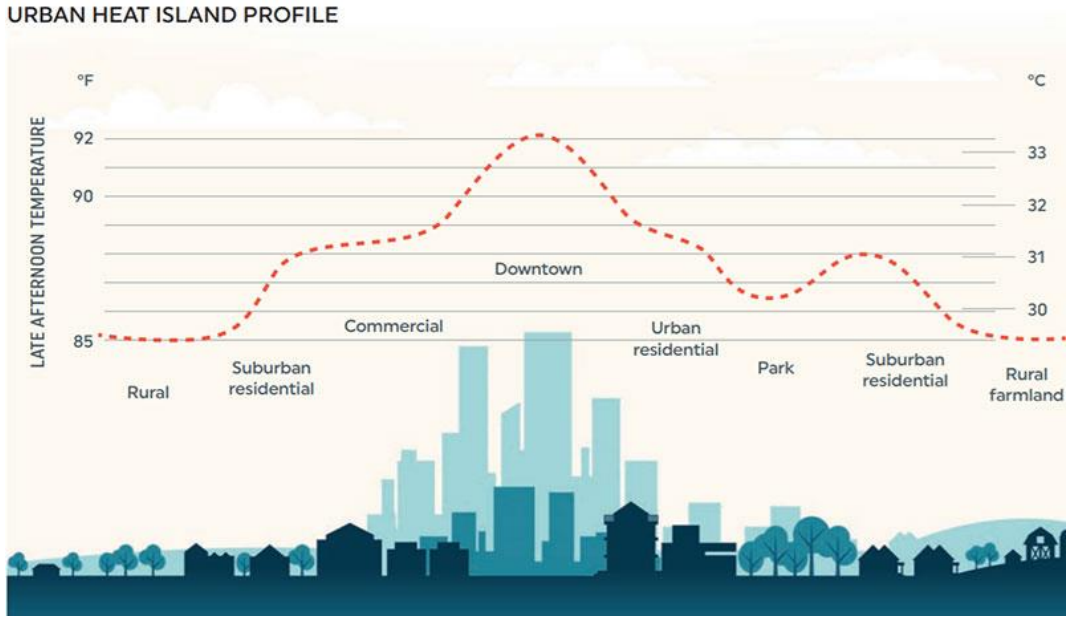
- Key indicators of performance & impact provide information about NBS effectiveness in comparison with defined objectives
- Handbook presents **446 possible indicators across 12 societal challenge areas**
  - **73 Recommended** indicators that are central to the assessment of main expected outcomes
  - **373 Additional** useful indicators that may be necessary to evaluate specific targets, or desirable when additional resources are available for monitoring and evaluation

Selection of indicators can occur at any time during the cycle of adaptive management of NBS

- Initial monitoring and assessment plan identifies "must have" outcomes that can be linked to specific indicators
- Review of planned NBS impact indicators during co-creation process can help to identify potential additional benefits and inform NBS design
- Indicators can be added or replaced at any time in response to observed changes or new challenges (adaptive monitoring)

Challenge → Objective → Target

- Citizens of Summer City have noted that some parts of the city are excessively warm
  - Data show an increase in heat-related illness & mortality
  - Long-term, regional temperature measurements show that the city centre is up to 5˚C warmer than the surrounding countryside on hot days
  - Citizens also noted a lack of outdoor recreational areas in many parts of the city, or "unequal distribution" of public parks
- Co-innovation with stakeholders identified NBS as a preferred option to address urban heating.
- Proposed action: depaving of several areas within the city centre & creation of public green spaces with trees & biodiverse greenery; implemention of green roofs & facades on buildings surrounding new public green spaces



- **Challenge or problem:** Excessive heat in city centre during warm months
- **Objective of NBS action:** Reduce urban heating & increase resilience to future climate warming
- **Target:** Reduce air temperature in city centre by at least 2˚C on hot days

Objective: Cooling the hot city centre

Challenge Categories

1. Climate Resilience
2. Water Management
3. Natural and Climate Hazards
4. Green Space Management
5. Biodiversity Enhancement
6. Air Quality
7. Place Regeneration
8. Knowledge and Social Capacity Building for Sustainable Urban Transformation
9. Participatory Planning and Governance
10. Social Justice and Social Cohesion
11. Health and Wellbeing
12. New Economic Opportunities and Green Jobs

No.	Indicator	Units	Class	Applicability to NBS†		
				Type 1	Type 2	Type 3
RECOMMENDED						
1.1	Total carbon removed or stored in vegetation and soil per unit area per unit time	kg/ha/y	O	●	●	●
1.2	Avoided greenhouse gas emissions from reduced building energy consumption	t CO_2e/y	O		●	●
1.3	Monthly mean value of daily maximum temperature (TX_x)	°C	O	●		●
1.4	Monthly mean value of daily minimum temperature (TN_n)	°C	O	●		●
1.5	Heatwave incidence: Days with temperature >90th percentile, TX90p	No./y	O	●		●
ADDITIONAL						
2.10.1	Urban Heat Island (incidence)	°C	O	●		●
2.10.1	Mean or peak daytime temperature	°C	O	●		●

Mean of daily maximum temperature (TX)	Climate Resilience
Description and justification	Mean of the daily maximum temperatures observed during specific time period, either for a specific year or over a specific period of years[1]. Proposed to detect Tº increment
Definition[2]	Let TX_{ij} be the maximum temperature at day i of period j. Then mean values in period j are given by: $TX_j = \sum_{i=1}^{I} TX_{ij} / I$
Strengths and weaknesses	It is a good indicator together with the mean of daily minimum temperature that can gives an idea of the high temperature effects in urban comfort and human health.
Measurement procedure and tool	Sensors: measuring instruments (measurement stations or manual instruments e.g., TESTO multi-function); thermography camera (e.g., FLIR). The average of the summer period or a hot summer day can be considered from one specific year or range or years Summer is the most common season in which it is assessed (spring and autumn are considered in relatively fewer studies: e.g., Yan H., Wang X., et al. 2012; Shashua-Bar L., Tsiros I.X., Hoffman M.E. 2010) The maximum is the category most employed in the literature, but the average also is relevant and used. For this indicator the average is proposed.
Scale of measurement	It depends on the sensors network coverage; it can be a point or in case there are several localizations it ca be transformed to a grid (through interpolation)

Data source	
Required data	A time series of air Tº data (measured in ºC)
Data input type	Quantitative
Data collection frequency	The sensors can collect the data every 10 minutes. In case the effectiveness of a NBS is analysed this should be measured at least hourly. At midday, the cooling effect reaches its maximum so, for example, the heat effect on health can be analysed; at night, the effectiveness is less, but the effect of the night temperature on sleep disturbance can be analysed. Regardless of the adaptation aim, the best time to measure the higher effect on heat reduction is midday, as this is the hottest time of the day where the cooling effect reaches the maximum (Georgi and Dimitriou, 2010; Shashua-Bar et al., 2012; Tan et al., 2016).
Level of expertise required	The sensors must be calibrated and located in the same place during all the measurement period. Not any sensor is valid
Synergies with other indicators	Synergies with the mean of daily minimum temperature.
Connection with SDGs	SDG 3 Good health and well-being, SDG 11 Sustainable cities and communities, SDG 13 Climate action
Opportunities for participatory data collection	Participatory data collection is feasible with supervision
Additional information	
References	[1] http://glossary.ametsoc.org/wiki/Mean_daily_maximum_temperature_for_a_month [2] https://eca.knmi.nl/indicesextremes/indicesdictionary.php#8

This sounds like a good way to measure longer-term trends, but what if we want to know more specifically about hot days (rather than a monthly average)?

Urban Heat Island (UHI) effect	Climate Resilience Natural and Climate Hazards
Description and justification	The UHI effect is caused by the absorption of sunlight by (stony) materials, reduced evaporation and the emission of heat caused by human activities. The UHI effect is greatest after sunset and reported to reach up to 9°C in some cities, e.g., Rotterdam (Van Hove et al., 2015). Because of the UHI effect, citizens living in urban areas experience more heat stress than those living in the countryside.
Definition	Urban Heat Island (UHI) effect denotes an urban area that is significantly warmer than its rural or undeveloped surrounding areas. Expressed and evaluated as temperature (°C).
Strengths and weaknesses	+ Fairly easy and straightforward assessment of temperature differences - Requires a rather large amount of temperature measurement stations to holistically identify the effect within the urban area - May require modelling expertise
Measurement procedure and tool	1. Identify or install one or more meteorological (temperature) measurement stations within the built environment, and one measurement station outside the city that functions as a reference station. Alternatively, models can be used. 2. Compare the hourly average air temperature measurements of the urban measurement station(s) with the station outside the city (the reference station). 3. Look for the largest temperature difference (hourly average) between urban and countryside areas during the summer months. This temperature difference is an absolute measure of the UHI effect.
Scale of measurement	City to regional scale

Data source	
Required data	Hourly temperature measurements
Data input type	Quantitative
Data collection frequency	Annually; at minimum before and after NBS implementation
Level of expertise required	Low
Synergies with other indicators	Assessed from *Mean or peak daytime temperature* indicator and connected with *Heatwave Risk* indicator
Connection with SDGs	SDG 3 Good health and well-being, SDG 11 Sustainable cities and communities, SDG 13 Climate action
Opportunities for participatory data collection	Participatory data collection is feasible through geographically referenced direct temperature measurements if these are not automated.
Additional information	
References	Van Hove, L.W.A., Jacobs, C.M.J., Heusinkveld, B.G., Elbers, J.A., van Driel, B.L., & Holtslag, A.A.M. (2015). Temporal and spatial variability of urban heat island and thermal comfort within the Rotterdam agglomeration. Building and Environment, 83, 91-103. United States Environmental Protection Agency. (2006). Excessive Heat Events Guidebook. Retrieved from https://www.epa.gov/sites/production/files/2016-03/documents/eheguide_final.pdf

This sounds like it will tell us whether we achieve the target, but does this mean that we also have to measure another indicator?

Mean or peak daytime temperature – Direct measurements	Climate Resilience

Description and justification	Green urban infrastructure can significantly affect climate change adaptation by reducing air and surface temperatures with the help of shading and through increased evapotranspiration. Conversely, green urban infrastructure can also provide insulation from cold and/or shelter from wind, thereby reducing heating requirements (Cheng, Cheung, & Chu, 2010). By moderating the urban microclimate, green infrastructure can support a reduction in energy use and improved thermal comfort (Demuzere et al., 2014). The cooling effect of green space results in lower temperatures in the surrounding built environment. A simulation of the surrounding buildings showed the potential for a 10% decrease in the cooling load due to the presence of the green area in the vicinity (Yu & Hien, 2006).
Definition	Mean or peak daytime local temperature by direct measurement (°C)
Strengths and weaknesses	+ Straightforward assessment of ambient air temperature + Reliable in the long run - Requires a rather large amount of monitoring stations to be installed to monitor various NBS intervention areas
Measurement procedure and tool	Ambient air temperature can be assessed through continuous monitoring of temperature, near the NBS intervention area, and calculation of mean and peak daytime temperature before and after NBS implementation.
Scale of measurement	Plot to district scale

Data source	
Required data	Automated continuous monitoring of ambient air temperature
Data input type	Quantitative
Data collection frequency	Annually; at minimum, before and after NBS implementation
Level of expertise required	Low
Synergies with other indicators	A prerequisite for *Heatwave Risk* and *Urban Heat Island* indicators, and a requirement for *Depth to groundwater* indicator
Connection with SDGs	SDG 3 Good health and well-being, SDG 11 Sustainable cities and communities, SDG 13 Climate action
Opportunities for participatory data collection	Participatory data collection is feasible through direct temperature measurements if these are not automated
Additional information	
References	Cheng, C.Y., Cheung, K.K.S., & Chu, L.M. (2010). Thermal performance of a vegetated cladding system on facade walls. Building and Environment, 45(8), 1779-1787. Demuzere, M., Orru, K., Heidrich, O., Olazabal, E., Geneletti, D., Orru, H., Faehnle, M. (2014). Mitigating and adapting to climate change: Multi-functional and multi-scale assessment of green urban infrastructure. Journal of Environmental Management, 146, 107-115. Yu, C., & Hien, W.N. (2006). Thermal benefits of city parks. Energy and Buildings, 38, 105-120.

Does this measurement tell us whether we have achieved the target?
Do we have the resources and expertise to collect these data?

Measuring the Cooling Effect of NBS

An NBS action was proposed including depaving of several areas within the city centre & creation of public green spaces with trees & biodiverse greenery; implemention of green roofs & facades on buildings surrounding new public green spaces

- Temperature data from measurement stations able to collect data every 10 minutes will provide the information we need for all 3 indicators
- To assess effect of NBS on city temperature we need measurements:
  - In the hot city centre, in close proximity to NBS
  - In the hot city centre, in an area without NBS
- To quantify UHI effect
  - Also need one or more measurement stations in the surrounding countryside

- What do we need to measure?
- What data or data sources are already available?
- How do we get the data (what equipment do we need)?
- Where do we need to take measurements?
- How frequently do we need to take measurements?
- How are the data handled? By whom?
- Do we have the expertise needed to acquire and manage the data?
- Do we have the resources to purchase and maintain necessary equipment?

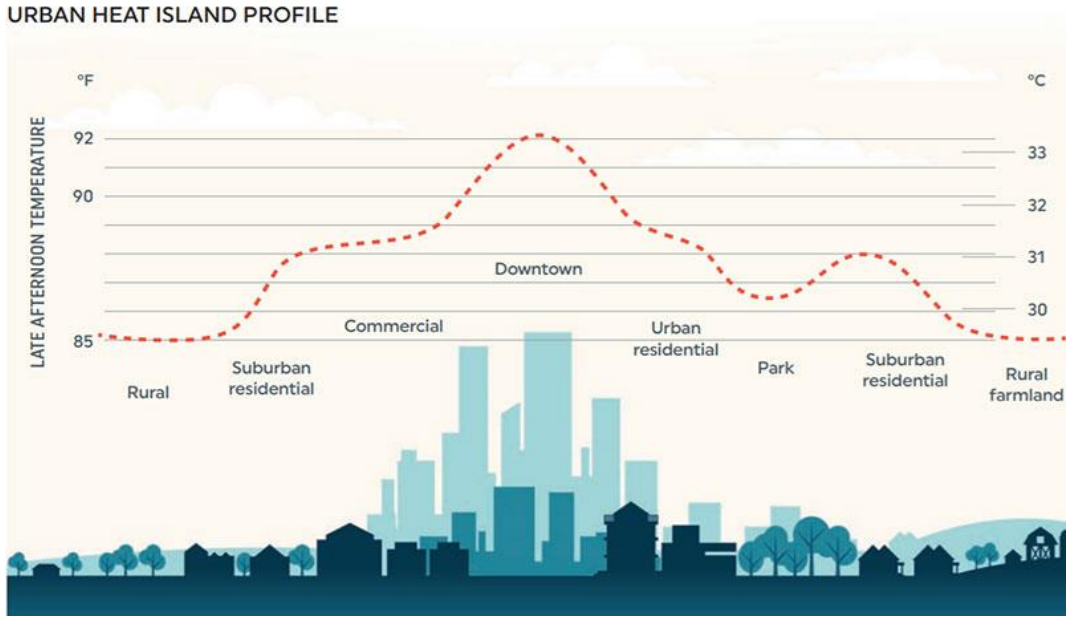
Generate a Tailored Portfolio of Indicators

- The impacts of NBS actions have very broad impacts - consult with experts from a range of different disciplines
- First, consider the main objective(s) of the action
  - What are we targeting?
  - What do we need to measure to know if the objectives have been achieved?
- Next, brainstorm possible additional benefits (co-benefits)
  - What other positive outcomes might we obtain?
  - How can we measure these other benefits?

Consider additional benefits related to climate resilience, water mangement, air quality, green space management, health and well-being, biodiversity, place regeneration

Challenge → Objective → Target

- Citizens of Summer City have noted that some parts of the city are excessively warm
  - Data show an increase in heat-related illness & mortality
  - Long-term, regional temperature measurements show that the city centre is up to 5˚C warmer than the surrounding countryside on hot days
  - Citizens also noted a lack of outdoor recreational areas in many parts of the city, or "unequal distribution" of public parks
- Co-innovation with stakeholders identified NBS as a preferred option to address urban heating.
- Proposed action: depaving of several areas within the city centre & creation of public green spaces with trees & biodiverse greenery; implemention of green roofs & facades on buildings surrounding new public green spaces



- **Challenge or problem:** Unequal distribution of public green space within the city
- **Objective of NBS action:** Improve availability and distribution of public green space
- **Target:** Equal access of all urban citizens to high-quality public green space by 2030

Objective: Improve availability & distribution of green space

Challenge Categories

1. Climate Resilience
2. Water Management
3. Natural and Climate Hazards
4. Green Space Management
5. Biodiversity Enhancement
6. Air Quality
7. Place Regeneration
8. Knowledge and Social Capacity Building for Sustainable Urban Transformation
9. Participatory Planning and Governance
10. Social Justice and Social Cohesion
11. Health and Wellbeing
12. New Economic Opportunities and Green Jobs

No.	Indicator	Units	Class	Applicability to NBS†		
				Type 1	Type 2	Type 3
RECOMMENDED						
7.1	Green space accessibility	%	O	●		●
7.2	Share of green urban areas	Number (0-1)	O	●		●
7.3	Soil organic matter content	%				
7.3.1	Soil organic matter index	Number (0-1)				

No.	Indicator	Units	Class	Applicability to NBS†		
				Type 1	Type 2	Type 3
RECOMMENDED						
19.1.1	Bridging– quality of interactions within and between social groups		O	●	●	●
19.1.2	Bonding – quality of interactions within and between social groups		O	●	●	●
19.2	Inclusion of different social groups in NBS co-co-co processes	Number (0-5)	P	●	●	●
19.3	Trust within the community		O	●	●	●
19.4	Solidarity among neighbours		O	●	●	●
19.5	Tolerance and respect		O	●	●	●
19.6	Availability and equitable distribution of blue-green space	map	O	●	●	●

Availability and equitable distribution of blue-green space	Social Justice and Social Cohesion
Description and justification	It is widely accepted that access to urban green space improves the quality of life for urban residents, facilitating social cohesion, democracy, and equity whilst enhancing physical and psychological health and well-being. Urban green spaces also contribute to the economic vitality of urban neighbourhoods by increasing property values and encouraging tourism (Ibes, 2015). A number of recent studies have highlighted inequitable access to green space in cities around the world. Spatial analysis of metropolitan areas can reveal the relationship between green space access and socio-economic status.
Definition	The availability and distribution of blue-green space with respect to specific individual or household socioeconomic profiles and landscape design
Strengths and weaknesses	+ Provides useful data for urban city planning - Needs expert users and a lot of input data
Measurement procedure and tool	The overall methodology involves selecting relevant characteristics and datasets, then overlaying these dataset using a geographic information system (GIS). Statistical analyses of spatially-explicit variables are then used to explore the relationship between urban green space availability and selected socio-economic characteristics. Additional factors, such as size or type of green space, biodiversity value, etc. can also be evaluated. Steps of the process are given below: Step 1: Separate the metropolitan area of interest into its respective spatial/administrative units which provide clearly defined areas with readily available data regarding population density, demographics, median household income, level of home ownership, etc. Additional information regarding dominant building type (single family and multi-family residences, buildings for retail or commercial/industrial use, mean or maximum building height etc.) can be obtained from municipality records for each spatial/administrative unit. Step 2: Using GIS, overlay the spatial units with available urban landscape data. For example, Cohen et al. (2012) obtained high resolution urban landscape data (1 m) from the Paris Urban Planning Agency that described the spatial distribution of: vegetation patches per strata (i.e., <1 m, 1–10 m, >10 m); (2) water bodies, bare soil and asphalt; and, built up areas based on the median height of buildings and the period of construction. This layer was intersected with the census block group data to view distribution patterns of urban landscapes. Step 3: Statistically analyse spatially-explicit data to evaluate green space availability (and green space type and size and/or biodiversity value, if desired) as a function of socio-economic factors in order to determine equity of green space distribution). A number of different statistical methods may be employed to evaluate the equity of public green space distribution. For example, Cohen et al. (2012) used available botanical information for each of the census block groups, calculating the mean household income per botanical and landscape class cluster. They also assessed the correlation between mean revenue, floral richness, the ecological diversity index and building density.
Scale of measurement	Metropolitan scale
Data source	
Required data	Spatial/administrative data regarding population density, demographics, median household income, level of ownership, etc. Also urban landscape data with green spaces and green space characteristics.
Data input type	Qualitative and quantitative
Data collection frequency	Before and after NBS implementation
Level of expertise required	Moderate to high
Synergies with other indicators	Synergies with *Distribution of public green space* and *Accessibility of urban green spaces*
Connection with SDGs	SDG 15 Life on land
Opportunities for participatory data collection	No opportunities identified

Principles that guide indicator selection

Comparability and standardisation

Evaluate the multiple benefits of NBS

Indicators to quantify both positive and negative outcomes

Allow multiscale and, where appropriate, long-term evaluation

Seeking a holistic picture, including trade-offs

Scientifically robust design of evaluation

Indicators using a range of different quantitative, qualitative and modelled data

Differentiating processes and outcomes

Impacts on different social groups

Please click on the link provided in the chat!

Rank each of the following considerations for NBS impact indicator selection from 1 (least important) to 5 (most important):

- **Methods are scientifically sound** - an appropriate methodology is selected that is capable of assessing the indicator
- **Selected indicators are practical and straight-forward** – indicators are aligned to the scope of expected impacts, specific site(s) or target group(s), and the plan for data collection is both reliable and feasible
- **Reference conditions are established and baseline assessment undertaken** to ensure a clear link between the challenges addressed and the indicators monitored
- **Indicators align with policy principles and reporting obligations**
- **Evaluation of NBS, and indicator selection, is based on a transdisciplinary approach**, combining knowledge from societal actors with knowledge and methods from different disciplines
- **Indicators provide information on both positive and negative outcomes** – potential benefits and trade-offs are equally evaluated

Assessment to Establish Common Understanding

- Addressing major societal challenges requires collaboration among all members of society
- Participatory processes throughout the NbS lifecycle help to build both community and ecosystem resilience and sustainability
- Collaborative, inclusive processes underpinning NBS actions build trust and commitment
  - Increase knowledge & understanding
  - Catalyse enduring networks
  - Enhance social briging & bonding, sense of place
  - Novel procurement practices & certification schemes
  - New decision-making & financing approaches

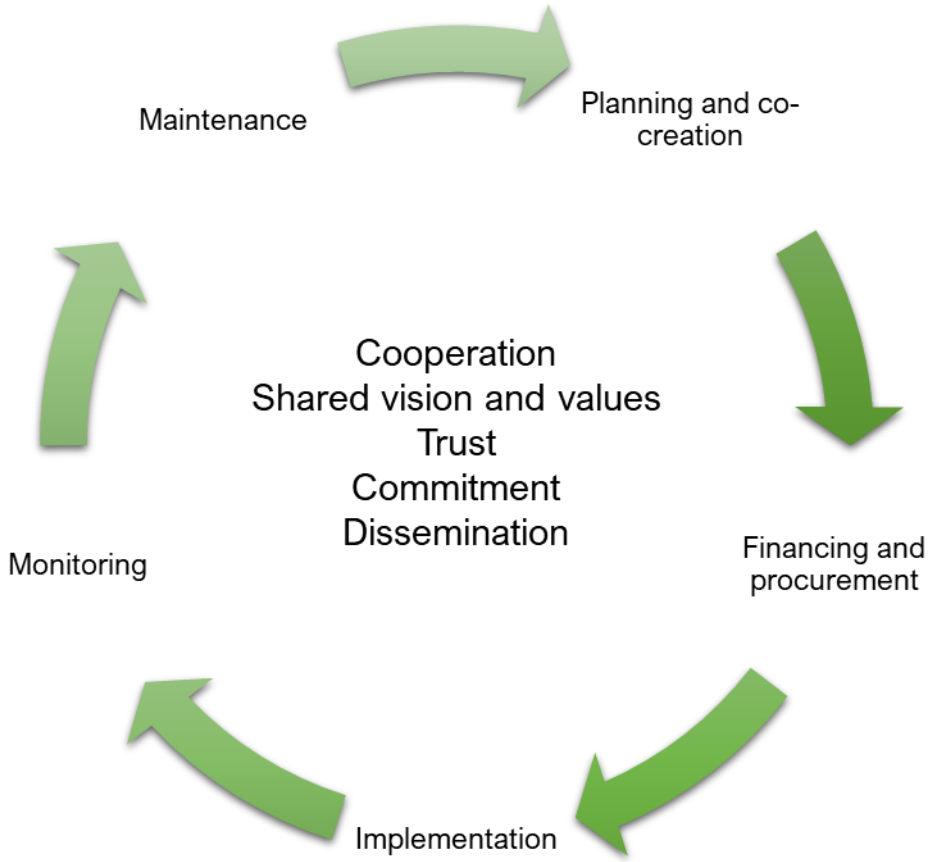
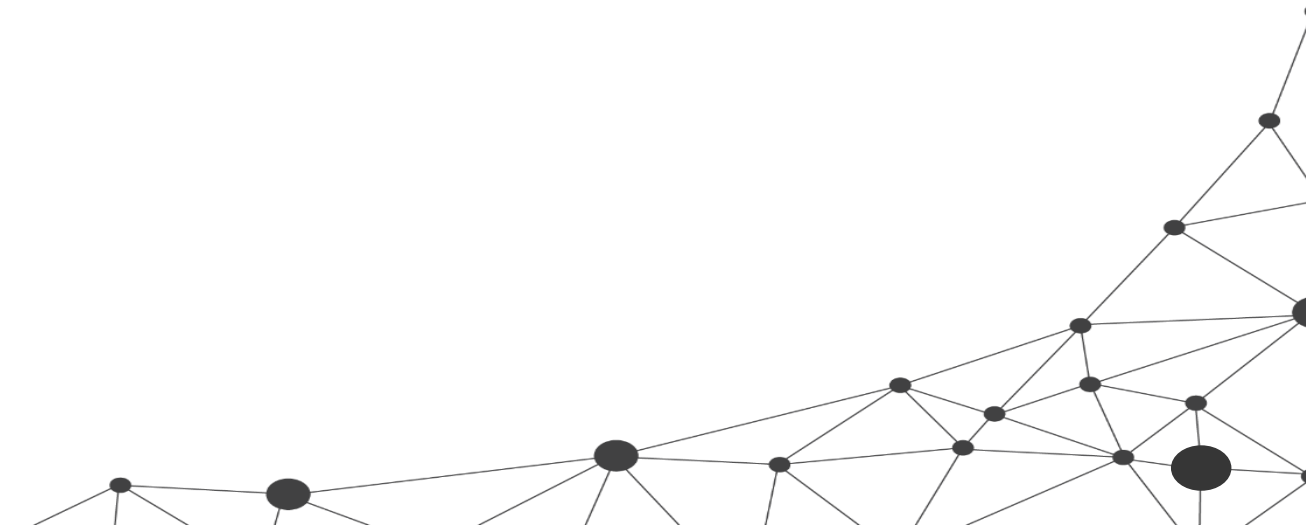


Image source: Laikari et al. 2021. *NBS Demonstration Site Start-Up Report (UNaLab D5.4)*.

Acknowledgements

Opportunities to stay informed – NetworkNature, NatureWithCities, UrbanbyNature Programme



Network Nature

Gathers resources, projects, best practices and tools in one place to support the nature-based solutions community

networknature.eu

Consolidate, support and expand a community of practice

Upscale the use of NbS across science, business, policy and practice

Raise awareness

= Maximise impact and spread of NbS

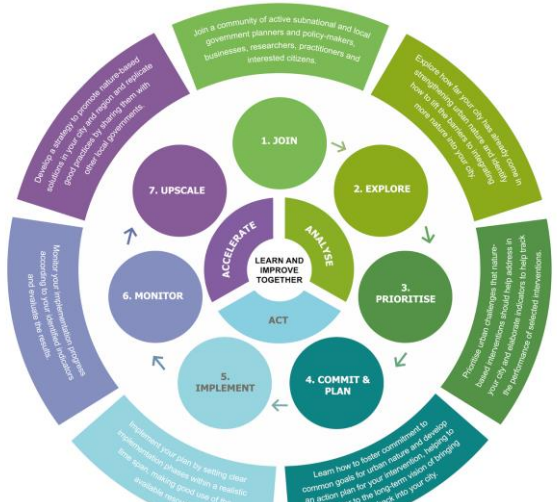
ICLEI Local Governments for Sustainability EUROPE | oppla | IUCN | biodiversa | STEINBEIS 2i

UrbanByNature Programme

UrbanByNature

Knowledge-Sharing and Capacity-Building on Nature-based Solutions

- **Facilitated capacity-building and expertise-sharing** programme
- **only programme worldwide for local governments** adopting a **step-by-step** plan for nature-based solutions in cities, aligned with an **integrated planning process (ISO 37101)**
- **flexible and adaptable** to questions and expertise of participants



1000+ registrants from +100 countries including **local governments** from all over the world

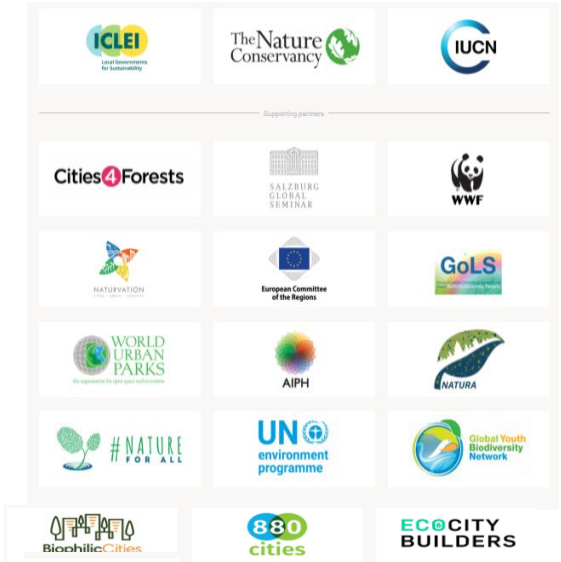
+70 published videos

hosted by and backed up by CitiesWithNature with its 215+ signatory cities (officially recognised city registry by SCBD)

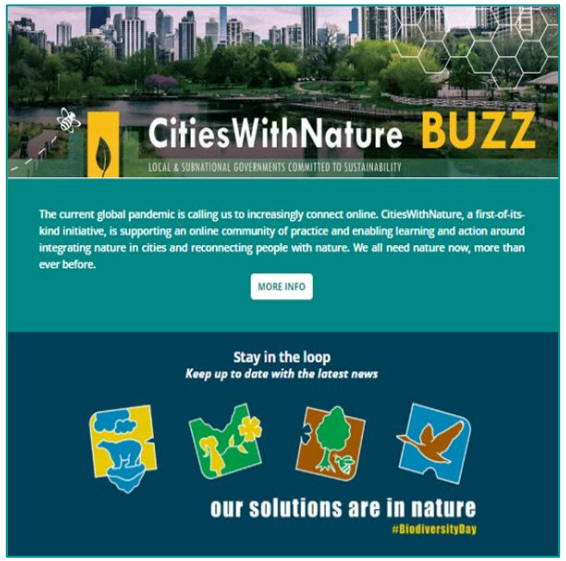
www.urbanbynature.eu

CitiesWithNature: Connecting cities with research/policy/community and peers

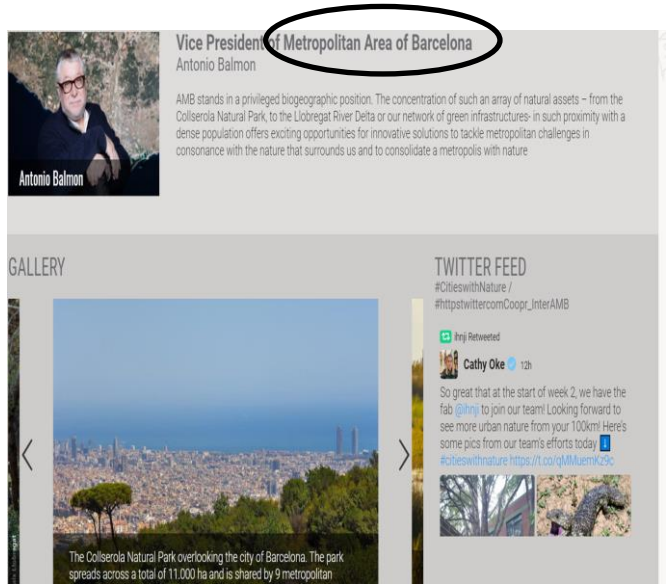
A growing network of cities



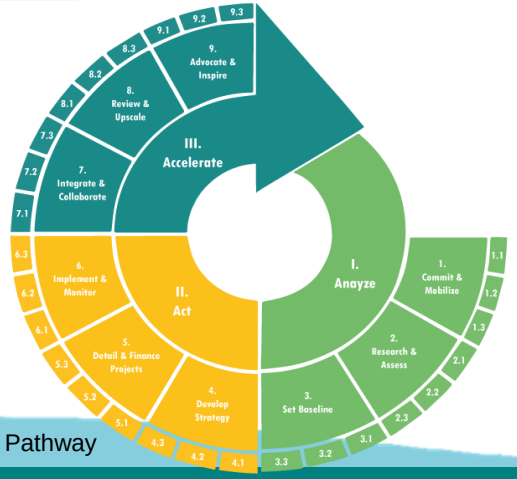
Access to partners & their tools and resources



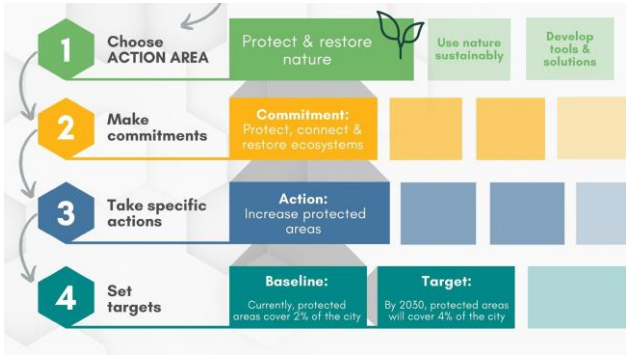
Monthly newsletter that profiles work of cities, news and events.



Sharing City profiles and advocating/promoting urban nature in cities as best practices



Nature Pathway



Action Platform – SCBD endorsed!

Newly launched RegionsWithNature: Website coming soon!