CONEXUS

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ASSESSMENT FRAMEWORK, INDICATORS AND PARTICIPATORY MONITORING PROCESS

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List of abbreviations

The following provides an overview of abbreviations repeatedly used in this report and their meanings.

Abbreviation	Meaning
BA	Buenos Aires
BCN	Barcelona
BOG	Bogotá
CELAC	Community of Latin American and Caribbean States
EU	European Union
LIS	Lisbon
NBS	nature-based solution(s)
SAO	São Paulo
SDG	Sustainable Development Goal
STGO	Santiago
TF2	Task Force 2
TRN	Turin
UN	United Nations
WP	work package

Executive Summary

1. This report presents the CONEXUS participatory assessment framework to maximize co-benefits and ensure local impact of urban nature-based solutions (NBS). The CONEXUS participatory assessment framework consists of: 1) A portfolio of indicators on NBS performance; 2) A comprehensive yet simple set of indicators for NBS governance; and 3) Guidance on participatory indicator selection and assessment.

2. The development of the assessment framework was guided by six key principles: 1) Different Life-Labs may adopt different assessment approaches with a common thread of indicators relevant to the CONEXUS aims; 2) A transdisciplinary and participatory approach to indicator selection; 3) Indicators are explicitly linked to the UN Sustainable Development Goals; 4) Indicators are relevant for the local urban context; 5) Macro-, meso- and micro- scale indicators are provided; and 6) To achieve impact and success, indicators on NBS performance are complemented by indicators on NBS governance.

3. The CONEXUS assessment framework acts as the basis for developing Information Systems for NBS monitoring in each of the seven Life-Labs – Barcelona, Bogotá, Buenos Aires, Lisbon, Santiago, São Paulo and Turin. The term **'Life-Lab Information System'** is used throughout this report in relation to the indicator system adopted by each of the Life-Labs for monitoring NBS pilots and the broader uptake of NBS in the city, along with the protocol for assessment (see Section 1.4 for a more detailed description).

4. Based on semi-structured interviews with experts on city-specific data and monitoring, we observe that none of the Life-Lab cities are currently using a scientific assessment framework for NBS monitoring. However, some cities have developed their own assessment frameworks based on a strategic selection of indicators in line with sustainability action planning. This includes indicators on NBS governance in some cases.

5. The Horizon 2020 Task Force 2 (TF2) handbook for NBS assessment meets all selection criteria, derived from the CONEXUS key principles for assessment, and is therefore used as a basis for developing the portfolio of indicators on NBS performance.

6. A scoping review is carried out to develop a comprehensive yet simple set of indicators for NBS governance, including e.g. research on the concepts of mosaic governance and nature-based thinking. These provide an alternative to the Participatory Planning and Governance indicators used in the TF2

handbook for NBS assessment and related frameworks, which are focused on a narrow range of interactions, mainly around traditional modes of citizen engagement for sustainability action. We identify the following dimensions: *agency*; *governance structure*; *legislation, regulations & policies*; *collaborative arrangements*; *active community engagement*; *monitoring and assessment*; *knowledge acquisition and sharing*; *financing mechanisms*; and *valuing diversity, equity and inclusion*.

7. A second scoping review is carried out in relation to the literature on participatory monitoring and assessment to conceptualize this and help inform the development of guidance on participatory indicator selection and assessment. This resulted in a number of principles for participatory assessment, which are used to establish selection criteria at the level of individual indicators and at the level of the entire indicator system used by each Life-Lab. The interviews suggest that relevance and feasibility are particularly important selection criteria, while there is also a need to coordinate assessment efforts with societal stakeholders.

8. The Life-Lab Information Systems for NBS monitoring are developed based on a step-wise process, starting with a researcher-led pre-selection of indicators based on criteria such as feasibility and opportunity for participation. In the next step, Life-Lab workshops are organized in order to agree on understandings of success and the indicators most suited to assess this. The guidance on participatory indicator selection and assessment provides a detailed account of how to prepare for and conduct the Life-Lab workshops, and how the outcomes of these can be processed into an Information System for NBS monitoring for each Life-Lab. In choosing appropriate indicators, stakeholders can seek the context-specific optimum on a "continuum of evidence" of indicators, ranging from resource-intensive scientific enquiry to a resource-light and flexible approach to assessment.

9. More comprehensive monitoring and assessment of governance is likely to lead to stronger impact of participatory assessment on NBS uptake, whilst improved assessment signals better NBS governance practices. Assessment and governance are therefore potentially mutually beneficial forces and joining these together represents a potential key impact of the CONEXUS participatory assessment framework.

1 Introduction

Nature-based solutions (NBS) are multifunctional interventions that utilize nature as a key design component for meeting a variety of environmental, economic and social sustainability goals (European Commission, 2015; IUCN, 2020). NBS have particularly strong potential in cities given strong urbanization trends across the globe (Seto et al., 2017), combined with the potential of NBS to tackle associated challenges such as climate resilience, water sanitation, physical and mental health and well-being, and environmental justice (van der Jagt et al., 2021). A broad variety of NBS can be identified, varying from green roofs to communal gardens, and from sustainable urban drainage systems (SuDS) to green infrastructure networks (for comprehensive NBS typologies, see Almassy et al., 2018; Pauleit et al., 2019). Indeed, the nature in NBS can manifest in various forms, scales and extents with 'multifunctionality' and 'holistic and integrative governance' qualifying as key defining features for NBS (Dorst et al., 2019; Pauleit et al., 2017).

Improved data and assessment of co-benefits across different domains (Raymond, Frantzeskaki, et al., 2017), along with advanced metrics, are key stepping stones toward the mainstreaming of NBS in cities (Xie et al., 2020). Evidence on the performance of NBS is needed to demonstrate their contribution to addressing different sustainability challenges simultaneously, while it can also help to make the business case for market development. In addition, a well-structured monitoring and assessment approach contributes to inventory-building, improved management of NBS and improved environmental awareness, especially if non-governmental stakeholders are engaged in monitoring activities through e.g. citizen science (e.g., van der Jagt & Lawrence, 2019).

By adopting a transdisciplinary approach and combining this with NBS experiments in seven Life-Labs[1], the CONEXUS project aims to improve understanding of how NBS contribute to sustainable development (***CONEXUS Document of Work Impact I3 – increased evidence about benefits from restored urban ecosystems***). At the same time, it seeks to enhance understandings of *how* assessment, and approaches toward mainstreaming NBS more generally, can be made more context-sensitive (***CONEXUS Document of Work Impact I2 - Guidance on locally context-sensitive approaches, by carefully and responsibly abstracting principles, approaches and information proven to be transferable and replicable***). For this reason, we develop a participatory – and therefore context-sensitive – approach to assessment. This approach will be applied to monitor new and existing NBS projects, while also enabling an improved understanding of drivers

[1] The seven CONEXUS Life-Labs are: Barcelona (Spain), Bogotá (Colombia), Buenos Aires (Argentina), Lisbon (Portugal), Santiago (Chile), São Paulo (Brazil) and Turin (Italy).

and barriers in NBS governance. The latter is crucial to better understand the potential for improved steering by the city administration in order to improve NBS uptake.

The research presented in this report was carried out as part of Task 4.1 in Work Package 4. The aim of this task is to develop the CONEXUS participatory assessment framework to maximize co-benefits and ensure local impact of urban NBS. To ensure that the assessment approach meets the goals of WP4, and the CONEXUS project more broadly, the starting point of framework conceptualization was the development of a set of shared guiding principles based on the project consortium agreement and in consultation with colleagues in WPs 3 and 4. This resulted in the formulation of six key principles, collectively comprising the 'rule-set' for the assessment approach (Section 1.1). Based on this, we argue, there is a need for the CONEXUS framework to go beyond conventional assessment approaches – it needs to be more than a set of thematically organized indicators for NBS performance. Therefore, the CONEXUS participatory assessment framework has three main components: 1) a portfolio of indicators on NBS performance, 2) a comprehensive yet simple set of indicators for NBS governance and 3) guidance on participatory indicator selection and assessment (Section 1.2). To aid the selection of indicators from the broad set of indicators available, we propose a stepwise process, starting with researcher-led pre-selection of indicators and ending with Life-Lab stakeholder discussing indicators and prioritizing these (Section 1.3). We end this introductory Chapter by outlining the role of the CONEXUS participatory assessment framework in informing the NBS monitoring efforts in each of the Life-Labs (Section 1.4), before providing an overview of the remaining chapters in this report (Section 1.5).

1.1 Guiding principles for the CONEXUS participatory assessment framework

The following principles were defined at the start of the process in order to help guide the search for relevant indicator frameworks acting as source material for the indicator portfolio on NBS performance:

1. **Different Life-Labs adopt different assessment approaches with a common thread to assess multifunctionality.** NBS are defined by the European Commission as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience" (Wild et al., 2020, p.5). Given the NBS core principle of *multifunctionality*, the selected group of indicators used by the Life-Labs need to cover multiple Challenge Areas. At a minimum, this includes those Challenge Areas that are core to the CONEXUS project: biodiversity (SDG 14/15), climate action (SDG 11/13) and environmental justice (SDG 1/5/10). Preferably, Life-Labs also touch upon other areas identified as relevant within their city. For example, urban water & river corridors (SDG 6) and urban food & amenity (SDG 2), see Table 1 for an overview. Consequently, each

Life-Lab will develop their own unique Information System [2] with contextualized (i.e. place-specific) indicators. This will, however, have a foundation of indicators to enable reporting on the CONEXUS core Challenge Areas, creating a common thread across all Life-Labs.

2. **A transdisciplinary and participatory approach to indicator selection.** To ensure the incorporation of credible indicators, the indicators incorporated into the CONEXUS indicator portfolio are drawn from existing NBS assessment frameworks developed by scientists or from research in the CONEXUS project. However, the ultimate goal of the CONEXUS assessment framework is to make an impact on the systemic integration of NBS into the urban fabric, *not* to develop the most scientifically rigorous assessment approach. Therefore, we will liaise with Life-Lab stakeholders from various backgrounds on which indicators are most feasible, relevant, etc. to incorporate in the Life-Lab Information System used for monitoring NBS. This potentially includes co-created indicators on the basis of local expertise. Where possible, the CONEXUS assessment framework also supports participation in data collection and analysis.

3. **Indicators are explicitly linked to the Sustainable Development Goals (SDGs).** One of the ambitions of the CONEXUS assessment framework is to evidence contributions of NBS to the UN Sustainable Development Goals (United Nations, 2015). For that reason, we draw the CONEXUS portfolio of indicators from established assessment frameworks such as EKLIPSE – an impact evaluation framework for NBS prepared by an expert working group on behalf of the European Commission in which indicators are organized according to societal Challenge Areas that are explicitly linked to the SDGs (Raymond, Pam, et al., 2017).

4. **Indicators are relevant for the urban context.** The CONEXUS assessment framework needs to include a portfolio of indicators that will be applied in the seven Life-Lab cities. Therefore, these are drawn from assessment frameworks with indicators that have demonstrated value in urban contexts. They also should be sensitive to various NBS management approaches in cities – varying from intense to more laissez-faire options (e.g. see the CONEXUS tripartite protocol).

5. **Macro-, meso- and micro- scale indicators are provided.** We select a mix of indicators at the micro-scale of individual experimental sites, the meso-scale of the neighbourhood, impacted area or community, and

[2] While the term 'assessment framework' is used for the broad set of indicators and indicator selection guidance presented in this report, the term 'Life-Lab Information System' is applied in relation to indicator system adopted by each of the Life-Labs for monitoring NBS pilots and the broader uptake of NBS in the city, along with the protocol for assessment (see Section 1.5 for a more detailed explanation).

the macro-scale of the city (region). There is no requirement for multi-scale assessment at the level of individual indicators - some benefits will be assessed at the micro-level, whereas others are at the meso- or macro-level. At a minimum, however, we meet the requirements as set out in Table 1 below.

6. **To achieve impact and success, indicators on NBS performance are complemented by indicators on NBS governance.** There is a need to understand – and therefore monitor – governance processes as underlying mechanisms unlocking NBS mainstreaming. Governance is central to unlocking pathways for a transformation towards more nature-based cities. Therefore, we develop process-related indicators based on the latest insights in urban NBS governance, including relevant literature on the concepts of Nature-Based Thinking and Mosaic Governance.

Table 1. Challenge areas identified as important to the Life-Lab cities, split by the preferred scale of analysis (source: CONEXUS work plan).

CONEXUS challenge areas, scales, cases & Life-Labs	**Urban food & amenity**	**Urban water & river corridors**	**Urban heat & air quality**	**Biodiversity**	**Environmental justice**
Micro-scale	Barcelona, Turin	São Paulo, Buenos Aires	Buenos Aires, Lisbon	All cities	All cities
Meso-scale	Bogotá, Lisbon	São Paulo, Santiago	Santiago, Bogotá	All cities	All cities
Macro-scale	Barcelona, Lisbon	Bogotá, Lisbon	Turin, São Paulo	All cities	All cities

1.2 The main components of the CONEXUS assessment framework

Assessment frameworks for NBS are typically based on criteria for assessing the performance of NBS (e.g., Raymond, Pam, et al., 2017). These criteria are translated into indicators, and they serve to assess particular impacts of NBS – i.e. benefits *or* costs – based on one or more possible methods. Indicators can vary from very specific to broad (i.e. assessing multiple impacts simultaneously). To accommodate the principles for assessment, e.g., the need for *participatory* assessment, the CONEXUS participatory assessment framework has a broader scope than previous frameworks for NBS assessment. Indicators for assessing impact make up only one part of it. We discern the following three main components, which together make up the CONEXUS-assessment framework (Figure 1):

1. **A portfolio of indicators on NBS performance.** These are the science-driven indicators and associated methods, with information on e.g. relationship with Challenge Areas (and SDGs), scale of application, level of expertise required and scope for participation in assessment.
2. **A comprehensive yet simple set of indicators for NBS governance.** These are indicators relevant to understanding and monitoring the mechanisms by which NBS come to be conventional urban amenities that are part and parcel of the urban fabric.
3. **Guidance on participatory indicator selection and assessment.** This provides a stepwise approach guiding Life-Labs in the participatory and inclusive development of an Information System for NBS monitoring, including a set of context-sensitive indicators with high potential impact.

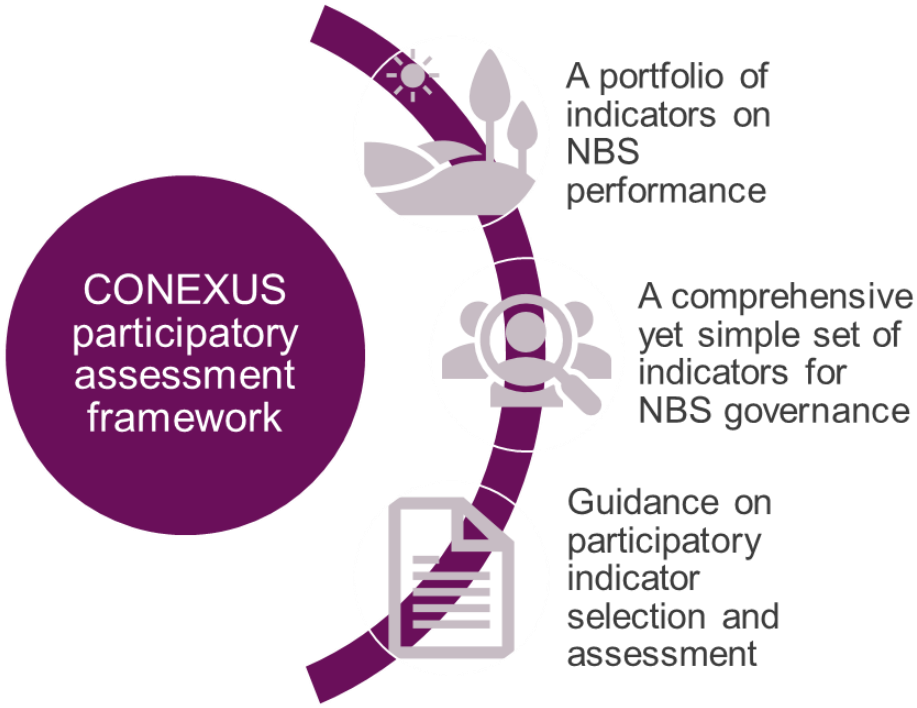

Figure 1. The CONEXUS participatory assessment framework and its three main components.

1.3 The stepwise process of indicator selection

The next step in the process of developing the participatory assessment framework was to design a process for developing each of the components shown in Figure 1. The result is a stepwise approach, shown in Figure 2, in which three filters applied to (pre)select indicators. In the first stage we apply the framework guiding principles described in Section 1.2 to available NBS assessment frameworks (Filter 1 in Figure 2). This process is described in Chapter 2. Next, we assemble Filter 2 in order to narrow down the number of NBS performance indicators, i.e. pre-selecting a manageable number of recommended indicators to present to and discuss with

the Life-Labs. The process of establishing these criteria for indicator selection is described in Chapter 3. The researched-led application of these criteria (Filter 2 in Figure 2) to derive the recommended set of indicators is covered in Chapter 4. On the basis of this as well as other criteria, such as the place-specific high-priority challenge areas, Life-Lab facilitators can select a manageable set of indicators to share with stakeholders in the Life-Labs during a workshop. This workshop organized in each of the Life-Labs will serve to get a local perspective on the indicators, resulting in a ranking of these in order of suitability according to stakeholders. In addition, new indicators might be added that are pre-existing within the Life-Lab context or that are co-produced between researchers and stakeholders. Exactly which criteria Life-Lab stakeholders will use to derive this ranking is not predefined as illustrated with the question mark in Filter 3 (Figure 2). The process of preparing for and organizing this workshop on indicator selection is described in Chapter 6. In addition, this chapter also introduces workshop follow-up activities in collaboration with Tasks 3.3 and 4.2 to develop the assessment approaches in each of the Life-Labs, i.e. the Life-Lab Information Systems.

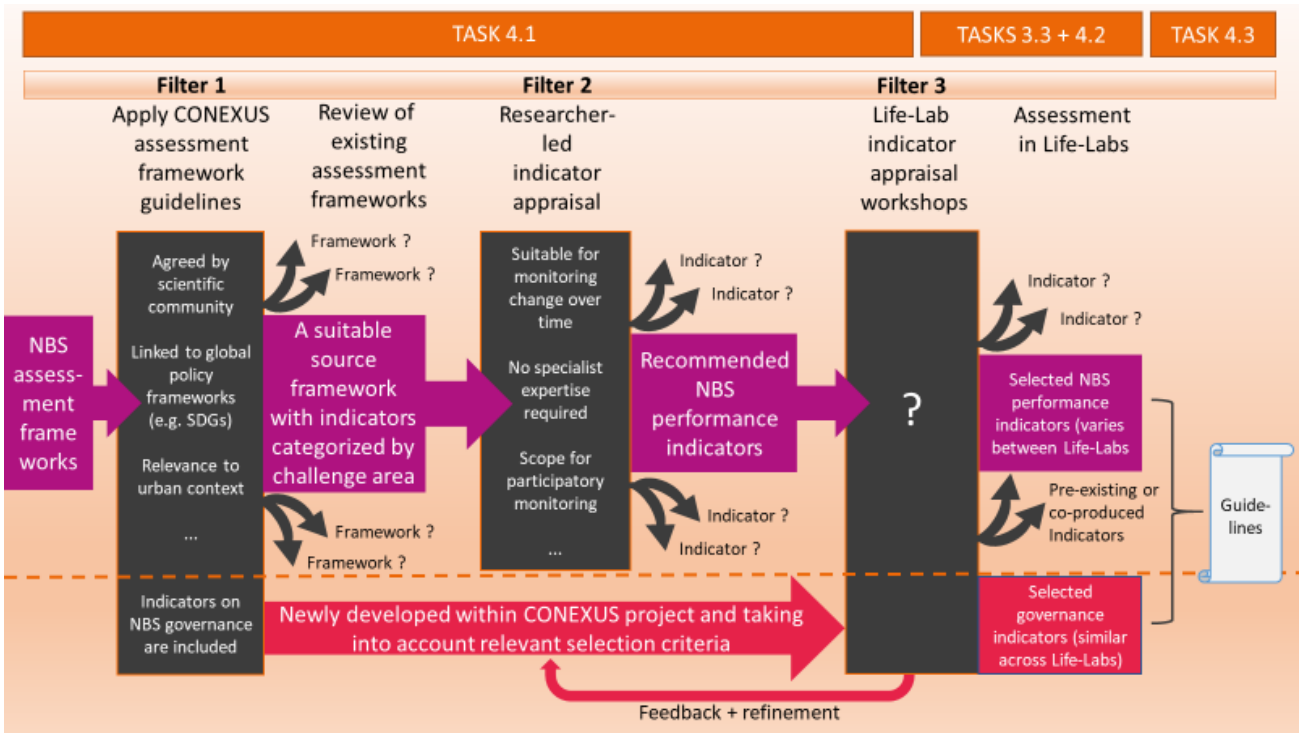

Figure 2. The stepwise process of selecting indicators to be used in each Life-Lab in Task 4.1 of the CONEXUS project. The black bars represent filters with particular criteria that are applied at various stages and with various levels of stakeholder involvement to the selection of (frameworks including) indicators. The selection of NBS performance indicators is done in a different way than that of the NBS governance indicators, which are newly developed within the project. Tasks 3.3 and 4.2 are responsible for the assessment protocols in each of the Life-Labs, whereas Task 4.3 synthesizes lessons from the monitoring process into guidelines.

In addition to indicators on NBS performance and guidance on participatory indicator selection and assessment, the assessment framework also encompasses a novel set of indicators on NBS governance (Figure 1). These are newly developed within the CONEXUS project in line with the framework guiding principles and indicator selection criteria, where possible. Chapter 5 describes the process of establishing these. Since the governance indicators are all equally important and represent dimensions mutually supportive of each other, these are not subject to the same selection process as the performance indicators. The workshops will, however, provide an opportunity for gaining feedback on the governance indicators, as shown in the bottom part of Figure 2.

1.4 The participatory assessment framework is only the start of a longer process

The CONEXUS participatory assessment framework provides the foundation for measurement and monitoring in the Life-Labs, and is therefore carried forward by other Tasks within the CONEXUS project. As shown in Figure 3, the working relationship between Task 4.1 and the Life-Labs in WP3 is mutual and very close. Task 3.3 is responsible for implementing and refining the assessment protocol in each of the Life-Labs. Together with Task 4.1, they are responsible for the establishment of indicators in each of the Life-Labs. Task 4.2 is formally responsible for supporting the analysis of indicators in the Life-Labs as well as monitoring of the participatory process in e.g. co-creating indicators. Task 4.3 synthesizes lessons from the knowledge and experiences generated in CONEXUS, including the participatory process. A transition period is planned between Month 12 and 18 where Life-Labs will be invited to participate in workshops on indicator selection, jointly organized by Tasks 4.1, 4.2 and 3.3, and decisions are made about how to structure the assessment approach in each of these (see Chapter 6). The CONEXUS portfolio of indicators remains flexible, at least throughout the first half of the project, to the inclusion of complimentary indicators developed or suggested by other WPs.

By the very nature of Task 4.1's high interconnectivity with planned activities in other ongoing research tasks, the participatory assessment framework presented in this report should not be confused with the final data monitoring approach to be used by the Life-Labs – it represents the building blocks for how to set this up. To support this 'transition' process, Task 4.1, together with related tasks, is planning Life-Lab workshops on indicator appraisal over the next half year. For this reason, it is important to distinguish between the framework for participatory assessment presented in this report and what we have termed the Life-Lab Information Systems, with different contents for each Life-Lab, which will be developed during the transition period between Task 4.1 and Tasks 4.2 and 3.3. The term 'Life-Lab Information System' is derived from that of 'Environmental Information System'. This can be defined as "an integrated set (or system) of components like

people, data records and activities for collecting, storing, processing and presenting environmental information" (Yousefi-Sahzabi et al., 2014, p.5). Unlike an Environmental Information System, the Life-Lab Information System can also include economic, social, and even process-related data relevant to NBS governance. For each Life-Lab it includes a selection of indicators used in that context along with information on the protocol for assessment and analysis, who is responsible, etc. (see Section 6.3).

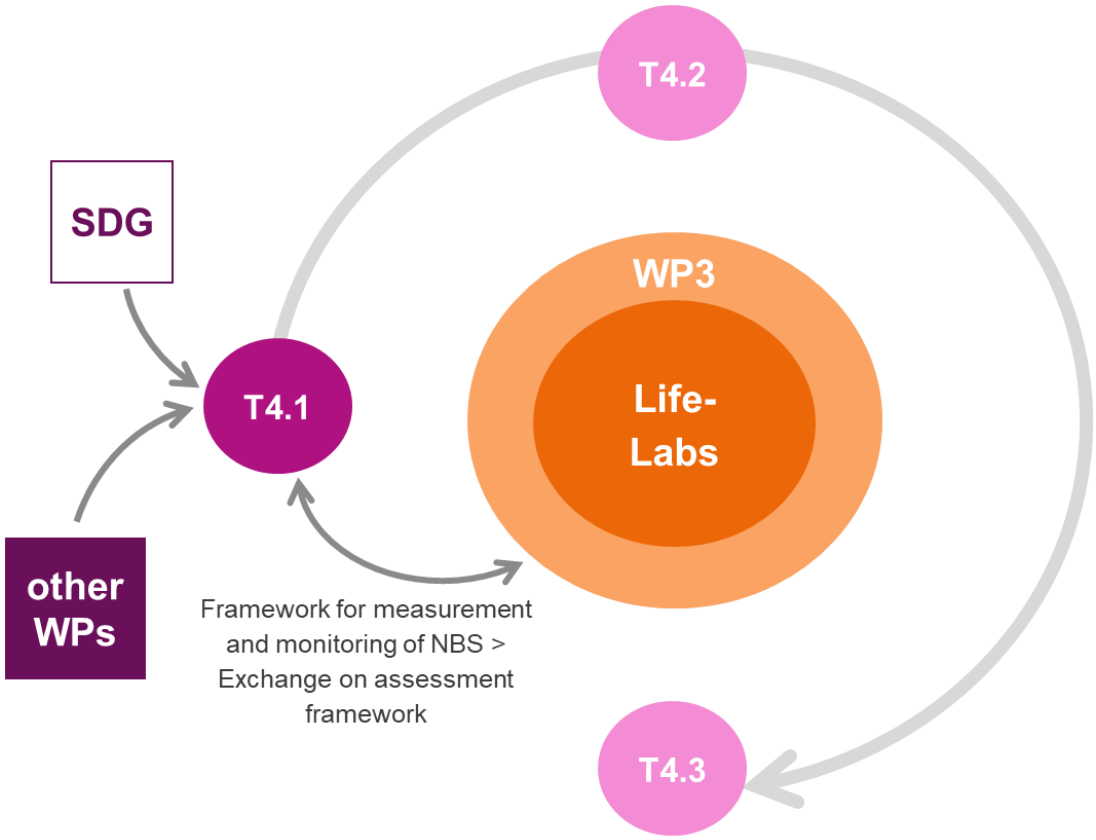

Figure 3. Visualization of the relationships between CONEXUS Task 4.1 and other Tasks and WPs directly involved in the Life-Lab assessment process, including the synthesis of lessons from this (image courtesy: Martina van Lierop).

1.5 Scope of the report and an overview of the methodological approach

Given the multifaceted nature of the participatory assessment framework, which is a portfolio of existing indicators, a comprehensive set of new (governance) indicators and a Life-Lab guideline on selecting indicators all in one, this report draws on a range of different data collection methods. These methods do not neatly map onto the chapter structure of this report. For that reason, these will be briefly described below, and in more detail in Appendix A.

Chapter 2 introduces an inventory of existing assessment frameworks for NBS in order to help build a portfolio of relevant indicators across different Challenge Areas. These were selected based on pre-set criteria derived from the guiding principles presented in Section 1.1. A desk study was undertaken to identify relevant frameworks and associated contact persons. Once the frameworks had been obtained, these were analyzed on the extent they met the CONEXUS framework guiding principles agreed within the team of WP4 researchers. Based on this, one of the frameworks is chosen as the key source for indicators to use within the project. *Chapter 2* also draws on primary research data on the current uptake of assessment frameworks based on interviews with relevant environmental professionals in each of the Life-Lab cities. We interviewed 13 experts (1-3 in each of the Life-Lab cities), who were identified by project partners as knowledgeable on the topics of NBS governance and assessment. Most of these worked for the municipality, but we also interviewed a number of actors managing city-specific programmes at regional government, national government or public institutions, as well as one academic.

In *Chapter 3*, we present an evidence-informed case for participatory assessment as well as an overview of relevant criteria commonly applied in processes of indicator selection to inform an assessment approach. These criteria are derived from the literature on participatory assessment. Some of these were identified based on the expertise of the authors of this report, but we also conducted a scoping review on participatory assessment in relation to NBS, green infrastructure and/or ecosystem services. In line with the previous chapter, the Life-Lab interview data is used to contextualize the findings from the review by conveying how Life-Lab cities typically apply these criteria in the selection of indicators for assessing NBS.

Chapter 4 builds upon the previous chapter by introducing a stepwise approach to indicator selection. This starts with a researcher-led approach to indicator selection and appraisal based on the criteria for indicator selection established in Chapter 3. Based on this, the indicators within the portfolio were classified as unfit, fair or fit for use by the Life-Labs.

Chapter 5 describes the process of developing a comprehensive set of governance indicators, which is the second key component of the participatory assessment framework. To this end, we conducted a scoping review of the literature on governance factors driving or enabling the uptake of NBS in cities. A total of 56 peer-reviewed articles were included in the review. These articles were analyzed for relevant findings on governance drivers. Excerpts were coded using a combination of inductive and deductive reasoning. The groupings of coded text were iteratively refined by two governance experts with a view on simplifying the framework with a more manageable number of indicators. To enable indicator assessment on the basis of the review findings, a survey and associated scoring rubric were developed (see Appendix B). The chapter also

draws upon the interview data to show the perceived role of governance in the uptake of urban NBS within the CONEXUS Life-Lab cities, and how these maps onto the categories of governance drivers conducive to NBS uptake based on the review.

The participatory appraisal of indicators involving the Life-Lab participants is a final and crucial step in the process of constructing the Life-Lab Information Systems. This corresponds with the third dimension of the participatory assessment framework shown in Figure 1. *Chapter 6* provides guidance for how Life-Labs can approach this task. At the core of this is a workshop aimed at ranking a subset of indicators, which have been preselected by the Life-Lab facilitator based on the Life-Lab's key prioritized societal Challenge Areas. On the basis of indicator rankings provided during the workshop and a dialogue with CONEXUS researchers, Life-Labs then make a decision about which indicators to adopt and agree a protocol for assessment.

2 Inventory of existing assessment frameworks for nature-based solutions

The present chapter introduces the inventory of assessment frameworks for NBS that we considered as the source material for the NBS performance indicators used in CONEXUS. We start with a brief overview outlining the important role of NBS assessment in previous Horizon 2020 research projects, while arguing for the need to build on these materials as much as possible. This is followed by an overview of assessment frameworks developed in these projects. We also scrutinize the use of assessment frameworks in the seven Life-Lab cities. Subsequently, we mobilize the framework guiding principles introduced in Chapter 1 to help determine which of these assessment frameworks represent the most suitable sources for indicators. This shows that there is only one framework – the TF2 handbook for NBS assessment – that adheres to all of the principles. This framework will therefore be used as the basis for assessment in the CONEXUS project.

In the process of developing Life-Lab Information Systems, there are different moments where NBS performance indicators are selected for use in the Life-Labs (see Figure 2). We identified three filters. The present chapter represents Filter 1 (in bold):

- ***Filter 1: Selection of scientifically grounded and policy-relevant indicators*. By selecting the TF2 handbook for NBS assessment as the source for indicators, we made sure to include indicators that are agreed by the scientific community, are linked to global policy frameworks and bear relevance to the urban context.**
- *Filter 2: Selection of indicators recommended for use by the Life-Labs.* The suitability of the broad set of indicators from the TF2 handbook for use in the Life-Labs was evaluated by independent reviewers, who evaluated all indicators on a set of criteria derived from the literature on participatory monitoring and ecosystem services assessment (see *Chapter 4*).
- *Filter 3: Place-based appraisal and ranking of pre-selected indicators:* Workshops will be held in each of the Life-Labs in Month 10-14 to help make decisions about which indicators to use as part of the Life-Lab Information System in each of the cities. There is also scope to suggest and discuss alternative indicators that are not part of the recommended list of indicators shown below (see *Chapter 6*).

2.1 The role of assessment in Horizon 2020 projects on urban nature

Prompted by the desire to build on previous experience in the assessment of NBS and for indicators to have a scientific basis, the starting point for developing the Life-Lab Information Systems was to create an inventory of the state-of-the-art in available assessment approaches. To this end, we scrutinized the portfolio of NBS research and innovation projects funded through the European Commission's Horizon 2020 programme. We

took a specific focus on the Horizon 2020 programme since in recent years it has funded an array of projects on the topic of NBS that needed to contribute to the goal of demonstrating their cost-effectiveness (Wild et al., 2020). An overview of relevant projects on NBS is provided in Figure 4.

CALL TOPIC SCC-02-2016-2017
Demonstrating innovative nature-based solutions in cities

PROJECT NAME 2020-2024	EU CONTRIBUTION (in EUR)
Connecting Nature	11 394 282
GrowGreen	11 224 058
UNaLab	12 768 932
URBAN GreenUP	13 970 642
2018-2023	
CLEVER Cities	14 214 661
EdiCitNet	11 254 913
proGIreg	10 432 512
URBiNAT	13 019 300
Total	**98 279 300**

CALL TOPIC SCC-03-2016
New governance, business, financing models and economic impact assessment tools for sustainable cities with nature-based solutions (urban re-naturing)

PROJECT NAME 2020-2024	EU CONTRIBUTION (in EUR)
NATURVATION	7 797 878
Nature4Cities	7 499 981
Total	**15 297 859**

CALL TOPIC SC5-09-2016
Operationalising insurance value of ecosystems

PROJECT NAME 2016-2020	EU CONTRIBUTION (in EUR)
NAIAD	4 994 370

CALL TOPIC SC5-08-2017
Large-scale demonstrators on nature-based solutions for hydro-meteorological risk reduction

PROJECT NAME 2018-2023	EU CONTRIBUTION (in EUR)
PHUSICOS	9 472 200
RECONECT	13 520 690
OPERANDUM	12 257 343
Total	**35 250 233**

CALL TOPIC SC5-13-2018-2019
International cooperation on sustainable urbanisation: NBS for restoration and rehabilitation of urban ecosystems

EU- CHINA RROJECT NAME 2019-2023	EU CONTRIBUTION (in EUR)
REGREEN	4 996 172
CLEARING HOUSE	4 986 464
EU- CELAC 2020-2024	
CONEXUS	4 999 940
INTERLACE	5 476 165
Total	**20 458 741**

CALL TOPIC LC-CLA-11-2020
Innovative NBS for carbon neutral cities and improved air quality

PROJECT NAME 2021-...	EU CONTRIBUTION (in EUR)
Project A	~ 10 000 000
Project B	~ 10 000 000
Project C	~ 10 000 000
Total	**30 000 000**

CALL TOPIC SC5-27-2020
Enhanced NBSfor water security and ecological quality in cities

PROJECT NAME 2021-...	EU CONTRIBUTION (in EUR)
Project A	~ 5 000 000
Project B	~ 5 000 000
Total	**10 000 000**

Figure 4. Funded projects on nature-based solutions and associated call topics in the Horizon 2020 programme (source: Wild et al. 2020).

We added to this overview a small number of projects based on their described relevance to the CONEXUS work programme: The EKLIPSE science-policy framework, the OpenNESS assessment framework and the POCIA framework for integrated sustainability assessment. EKLIPSE was also funded by Horizon 2020 but under a different call, while OpenNESS was funded through the European Commission's FP7 programme. Furthermore, we engaged with the Horizon 2020 Task Force 2 (TF2) on impact assessment. Task Forces are platforms for representatives of EU-funded projects to work together on cross-cutting issues.

Another relevant framework to mention here is the IUCN Global Standard for Nature-based Solutions (IUCN, 2020). This is a framework presenting principles for the design of NBS to effectively address societal challenges. As such, its intended use is *not* to assess the benefits provided by NBS, which is why it is not part of the inventory of assessment frameworks. The framework, however, outlines several process-related criteria that are relevant to the development of governance indicators and the participatory assessment approach, such as the need for inclusive governance, adaptive management and addressing systemic constraints.

2.2 Procedure for inventory-building

After identifying the relevant sources for available assessment frameworks, we searched for reports and other documentation outlining the assessment approach. This was done by identifying the Work Package on assessment and checking for available documentation. In addition, we ran search queries on the CORDIS research archive[3] of the European Commission. We only included documents aimed at assessing NBS benefits. For a number of ongoing projects, no documents could be identified, which implies that some frameworks are still under development or review. The Horizon TF2 provided us with access to a new draft handbook for NBS assessment, which was also included in the review. The period of data collection was between September and October 2020. Table 2 provides an overview of identified assessment frameworks.

Next, we studied the identified reports and reviewed these on a small number of criteria to determine whether these would match the scope of the CONEXUS project. On the basis of this, we prepared a ranking of the best-matching frameworks. We applied the following criteria, which are derived from the principles for assessment previously discussed in Chapter 1:

- scientific basis;
- specific focus on NBS assessment;
- covers multiple sustainability challenges;
- NBS benefits are explicitly linked to SDGs;
- relevant to the urban context;
- distinguishes indicators for micro, meso and macro scales;
- includes process or governance indicators; and
- describes scope for participatory assessment.

[3] https://cordis.europa.eu/projects/en

Table 2. Overview of assessment frameworks included in the inventory, along with information on aims, document title and used sources.

Framework	Aims	Document title	Indicator source(s)	Reference
CLEVER Cities Impact Assessment Framework	To assess NBS impact by means of a flexible co-monitoring framework	D4.3 Monitoring strategy in the FR interventions	Thematic experts suggesting KPIs on the basis of existing frameworks, including EKLIPSE, NATURE4CITIES and the ThinkNature TaskForce	(Zorita et al., 2019)
Connecting Nature - NBS evaluation indicators	To provide an overview of relevant environmental indicators for NBS	Nature-based solution evaluation indicators: Environmental Indicators Review	A review of environmental indicators (remote sensing and applied indicators) suggested in existing assessment frameworks (data sources are not further specified)	(Connop et al., 2020)
EKLIPSE impact evaluation framework for nature-based solutions	To support the generation of common evidence and a knowledge base for NBS, specifically for assessing climate resilience benefits at different geographic scales	An impact evaluation framework to support planning and evaluation of nature-based solutions projects - An EKLIPSE Expert Working Group report	Scientific literature on NBS assessment Grey literature Expert consultation on key papers	(Raymond, Pam, et al., 2017)
Horizon 2020 Taskforce 2 (TF2) handbook for NBS assessment[4]	To develop a common framework for integrated NBS assessment for all H2020 NBS projects, which can be used as a reference for common indicators by NBS projects and EU policy	Evaluating the Impact of Nature-Based Solutions – A Handbook for Practitioners Appendix of Methods	Assessment metrics used in over 20 H2020 projects on NBS	(Dumitru & Wendling, 2021a, 2021b)
NATURE4CITIES Urban Performance	To quantify the contribution of NBS to addressing urban challenges	D2.1 - System of integrated multi-scale and multi-thematic performance	Expert groups on different themes carried out in-depth	(NATURE4CITIES, 2018)

[4] This is also known as 'The European Commission Handbook for NBS Assessment'

Indicators for the assessment of NBS		indicators for the assessment of urban challenges and NBS	literature reviews within their areas of expertise	
NATURVATION Urban Nature Navigator	To help stakeholders understand their sustainability priorities and evaluate the potential of different types of urban NBS in meeting these priorities	Working paper: Set up, applicability and use of the NATURVATION Index	Scientific literature on broad range of ecosystem services and assessment methods Dialogue with urban nature stakeholders and international experts	(Dammers et al., 2019)
OpenNESS Integrated assessment and valuation of ecosystem services	To provide an overview of biophysical, socio-cultural and monetary approaches to ecosystem service appraisal along with guidance for informed decision-making about which method to adopt under which circumstances	Integrated assessment and valuation of ecosystem services: Guidelines and experiences	Survey of methods used in 27 case studies implemented to operationalize the ecosystem services concept across different management contexts	(Barton & Harrison, 2017)
OPERANDUM indicator framework for assessing the efficacy of NBS	To assess the environmental and socio-economic impacts of NBS on hydro-meteorological risks	Report on monitoring criteria of OALs for effective reduction and prevention of risks related to natural hazards (D3.4)	Indicators were sourced from experts in ten Open Air Laboratories (OALs)	(Rutzinger et al., 2019)
POCIA (Principles, Objectives, Criteria, Indicators and Attributes) framework	To operationalize the sustainable development concept for practitioners	"Measuring" sustainable living agendas Integrated modelling for Sustainability Appraisal for Urban River Corridor (re)-development	Different research teams within the URSULA (Urban River corridors and Sustainable Living Agendas) project contributed indicators within their own area of expertise	(Ashley et al., 2008; Hurley et al., 2010; Kumar et al., 2012)
proGIreg monitoring and assessment plan	To monitor and assess NBS implemented for post-industrial urban regeneration	Monitoring and Assessment Plan Protocols of Measurement	A review of existing assessment frameworks and the scientific literature was conducted (data sources are not further specified)	(Baldacchini et al., 2020b, 2020a)

RECONECT assessment framework for hydro-meteorological benefits of NBS	To develop a framework which quantifies the benefits and co-benefits of implemented NBS	A framework for assessing benefits of implemented nature-based solutions	Based on available assessment frameworks (data sources are not further specified)	(Watkin et al., 2019)
REGREEN indicator framework for multiple ecosystem services	To develop a lean indicator framework for mapping (based on remote sensing) multiple ecosystem services associated with NBS based on readily available spatial data	Synthesis report on current datasets and their applicability of ecosystem services mapping and modelling	EKLIPSE indicator framework Nature4Cities indicator framework	(Banzhaf et al., 2020)
UnaLab NBS performance and impact monitoring protocols	To provide practitioners with metrics for assessing NBS benefits along with guidance for monitoring these	Performance and Impact Monitoring of Nature-Based Solutions – D3.1 Deliverable	EKLIPSE indicator framework MAES indicator framework CITYkeys assessment framework UN SDG 11 indicator framework OECD environmental indicators Several NBS assessment frameworks described in scientific literature	(Wendling et al., 2019)
URBAN GreenUP Technical KPIs	To define a set of KPIs (Key Performance Indicators) for NBS based on the challenges in the Eklipse framework	D5.1 - Technical KPIs Definition & D5.3 - City Diagnosis and Monitoring Procedures	EKLIPSE indicator framework	(Ortuño & Fermoso, 2017, 2018)

2.3 Analysis of the use of assessment frameworks in the Life-Lab cities

To explore if the seven CONEXUS Life-Lab cities – Barcelona (BCN), Bogotá (BOG), Buenos Aires (BA), Lisbon (LIS), Santiago (STGO), São Paulo (SAO) and Turin (TRN) – adopted assessment approaches for NBS that we had not been aware of, we included two questions in the interviews with relevant Life-Lab stakeholders (see Appendix A for the Methods):

- In what ways are you assessing the governance of urban nature and the impacts of urban nature? Which are the assessment framework(s) and/or indicators that you are using? Where and at which scale(s) do you measure?
- Are you familiar with other types of assessment frameworks or indicators for the assessment of urban nature?

The analysis of the interviews showed that Life-Lab cities have not adopted any of the assessment frameworks described in Table 2 above. They were also not described as frameworks that interviewed stakeholders were familiar with. The interviewed NBS experts were generally also not familiar with existing scientific assessment frameworks for urban NBS beyond the list provided in Table 2. Only one Santiago-based city representative indicated to be familiar with one such framework, which was developed by the University of the Bío-Bío for the secretariat of Santiago's VII Region. However, the framework was developed for sustainability assessment of projects rather than monitoring NBS performance specifically. Moreover, it had not been replicated beyond this single region due to variation in climatic and social conditions between urban regions, which limited transferability.

> *"I don't know if we are going to take [up] another source of indicators [from CONEXUS]. There are thousands of initiatives that are working on adaptation indicators, everyone is working on adaptation indicators, but the reality is that, at least in our experience, when it comes to managing [adaptation], we generate our own indicators [...]."* (BA).

2.3.1 City-specific observations

These findings should not be interpreted to imply that cities do not engage in any assessment of urban NBS. Each of the studied cities had adopted several indicators for this purpose, as shown in the overview below, which is prepared on the basis of interviews with urban greenspace experts.

- **Barcelona (BCN):** The city has not adopted framework of specific urban NBS evaluation indicators, but as part of the Green Infrastructure and Biodiversity Plan 2020 (Ajuntament de Barcelona, 2013), the city uses individual indicators to assess if projects are adequately implemented – e.g. area of greenspace built in squared meters. This plan also guides the systemic monitoring of green infrastructure at the city level. For example, the Normalized Difference Vegetation Index (NDVI) is used to map the amount of vegetation in the city. At the same time, there is regular monitoring of biodiversity in e.g. the city's bird and butterfly populations. The Programme for Promoting Urban Green Infrastructure (Ajuntament de Barcelona, 2017a)

introduced a commitment to create one square meter of green space per inhabitant by 2030, which is actively monitored. As part of the Tree Master Plan (Ajuntament de Barcelona, 2017b), the city aims to increase its proportion of climate resilient trees from 30 to 40% by 2040. An indicator has been introduced to monitor this, while progress has also been made around other tree-related targets such as the planting of vegetation under trees. At the metropolitan level, there are also efforts to measure e.g. biodiversity in parks using the Shannon Index. The metabolism of the parks – energy use, water consumption, waste generation – is assessed regularly. Barcelona reports data on greenspace availability and biodiversity along with other relevant sustainability data in an annual report to communicate on their sustainability performance.

- **Bogotá (BOG):** The city adopted a few, mostly relatively simple indicators that are directly relevant to urban NBS. For example, square meters of greenspace per inhabitant, total number of public trees and square meters of green roofs. The Secretary of Environment has also assessed temperatures in areas with more and less trees. The use of indicators is, however, not structural and strongly influenced by mayoral leadership. The city does not make use of a complete NBS framework, but inspiration was drawn from the UNECLAC (United Nations Economic Commission for Latin America and the Caribbean) methodology for the adoption of environmental and sustainable development indicators that are mostly applied to the macro scale (Quiroga Martínez, 2009). These relate to environmental resources, environmental quality, greenhouse gas emissions, ecosystems and environmental education. An Environmental Observatory was launched to communicate about this (http://oab.ambientebogota.gov.co/). An initiative 'Cómo Vamos' ('How are we doing?') was launched to systemize the reporting of data relevant to quality of life (e.g. water quality), collect information on perceived quality of life by citizens, and compare findings between different urban districts.

- **Buenos Aires (BA):** Measures are conducted related to air quality, noise pollution, water quality and soil quality, the urban heat island effect, the presence of coral reefs or reed beds to mitigate storm impact. These measures are undertaken as part of the Climate Action Plan 2050 (City of Buenos Aires, 2021) for which indicators were developed to measure progress against the 25 actions included in this, of which about a third could be relevant to NBS monitoring and assessment. These overlap with some of the national-level indicators for climate change, but also include indicators that have been developed with relevant municipal secretariats based on the SDGs, IPCC manuals and other relevant frameworks depending on the focus area of the particular secretariat. However, there is no perfect correspondence between adopted indicators and the different components of these frameworks, and different secretariats

adopt different indicators depending on their focus area. The indicators overlapping with those used by the government will be accessible via the government dashboard for reporting climate adaptation data – the CAP (Climate Action Plan) dashboard (City of Buenos Aires, 2021).

- **Lisbon (LIS):** The city has a Climate Change Adaptation Strategy as part of which data on energy and climate mitigation action is monitored e.g. data on air pollution and waste management (Câmara Municipal de Lisboa, 2017). Membership of the C40 network of sustainable cities was an important driver of the monitoring programme and the annual reporting on this. As part of the municipal Master Plan (Câmara Municipal de Lisboa, 2012), the extent of greenspace cover is monitored (e.g. tree planting and loss) as well as a range of biodiversity metrics. Some of the indicators used by the city were adopted as part of the process of applying to the European Green Capital Award, which the city won in 2020. This includes aspects such as green space accessibility (within 300 meter of residents' homes), water quality, eco innovation and greenspace planning, which are directly relevant to NBS. Norms and regulations around water quality, air quality, sustainable forestry and waste, some from the European level, have historically also been important for engaging in environmental improvements and monitoring progress against these.

- **Santiago (STGO):** Environmental indicators are applied as part of the "Quiero Mi Barrio" ("I Love My Neighbourhood") programme – a national-level initiative to socially and environmentally regenerate 200 neighbourhoods, of which 86 are situated in the metropole of Santiago[5]. These include indicators on the quantity, size, endemic origin and species of urban trees, but also on the area of greenspace and its ownership. At the municipal level, there appeared to be very few relevant indicators in use, but the interviewed experts also expressed some uncertainty about the extent to which they were familiar with what other Departments were assessing. One example of an indicator used by the Ministry of Housing and Urban Development is the number of self-management projects, such as community gardens. The Ministry of Social Development is using an indicator to assess the carbon price, which could be relevant for large-scale interventions. No particular evaluation framework for NBS projects is in use, but generally social and environmental cost-benefit analyses are conducted before investing in public assets, which could favour NBS. Some individual and simple indicators used for NBS such as square meters of green space per inhabitant and park quality are part of the census run by INE (National Institute of Statistics). At the regional territory level, there is also the IBT (Territorial Welfare Indicator) relevant to asses habitat quality and human welfare. This information system was developed by the Territorial Intelligence Centre of the

[5] https://participedia.net/case/103

Adolfo Ibáñez University under the auspices of the Chilean Government's regional development programme.

- **São Paulo (SAO):** They use a significant number of indicators (*N*=142 indicators of which 70 are the responsibility of the Environmental Secretariat) linked to the UN Sustainable Development Goals in order to help deliver the 2030 Agenda for Sustainable Development and help deliver the city's Climate Action Plan (Cidade de São Paulo, 2020). Inspiration and guidance (e.g. through seminars) supporting this effort is provided by the C40 network, of which São Paulo is a member city, and the UN Sustainable Cities Programme. Additional indicators have been adopted as part of the national-level Blue Green municipality programme, which asks all municipal signatories for the collation and sharing of environmental datasets [exact examples of indicators not shared]. These are included in an environmental information system under development by the Environmental Secretariat.

- **Turin (TRN):** Indicators relevant to NBS assessment were developed in conjunction with relevant municipal planning documents, such as the Climate Resilience Strategy (Citta'di Torino, 2020a). This was prepared in consultation with a broad range of municipal departments and includes 80 actions to address vulnerabilities, including governance-related actions, with indicators directly corresponding with these. The city did not adopt an international reference framework, but developed its own set of indicators, measured annually, such as on the implementation of sustainable urban drainage systems, percentage of suitable land area that is renaturalized or communications to residents about the climate emergency. As part of the Strategic Green Infrastructure Plan (Citta'di Torino, 2020c) and the Sustainable Forest Management Plan (Citta'di Torino, 2020b), Turin is also actively monitoring green infrastructure projects, such as new urban forests, using pre-post assessments of ecosystem services. To achieve this, they developed a portfolio with indicators mapping on nine ecosystem services, including but not limited to carbon sequestration, soil stabilization, stormwater capture, shading, biodiversity, pollination and agricultural production. These have been partially derived from the FSC (Forest Stewardship Council) framework for certified forest management.

2.3.2 General observations

Many of the indicators used for NBS assessment are sourced from indicator portfolios collated by higher level of government, sustainable city networks - e.g. C40 or prestigious awards (e.g. European Green Capital). These appear to act as important drivers for engaging in assessment of sustainability indicators, including some relevant to urban nature. Historically, the introduction of environmental regulation around e.g. water quality has also been a very important driver of monitoring and assessment.

> *"At the national level we don't have a framework [for NBS assessment] and we're developing one now, so generally we look to the Ministry for that kind of guideline to make sure that we adopt a [indicator] framework that is coherent with the national strategy and that allows comparison across different cities and territories"* (TRN)

Rather than adopting ready-made assessment frameworks, cities opt to pick and mix indicators from various sources in line with actions set in, often, climate or biodiversity related strategies at the municipal level. Administrations mostly apply indicators at the macro-level of the city or at the district/neighbourhood level – we observed few examples of project-level indicators. The city of Turin is, however, an exception to this rule.

> *"There are indicators that are for the city in general, which are city averages, and there are other indicators that apply to each of the localities. And there we have indicators that are very specific. For example, we have an indicator for urban tree planting, so we have complete data for the city, the number of trees planted in the city, and we have it broken down by each of the localities"* (STGO).

Individual municipal staff members tend to lack an overview of all indicators relevant to urban NBS that are applied in the city – the data is collected and analyzed by different city departments, but efforts to integrate this are often lacking. There is a clear emphasis on indicators relevant to climate change and biodiversity – social and cultural values of nature and the governance of NBS are not usually assessed by cities.

2.4 Review of identified assessment frameworks

Table 3 shows the results of the review of assessment frameworks. For each framework, we determined how it scored on each criterion using a three-point scale (2 = fully meets the criterion; 1 = partially meets the criterion; 0 = criterion is not met). By totalling these scores across frameworks, a picture emerges of how well each of the selection criteria is met by the existing portfolio of frameworks (Figure 5). This shows that available frameworks are generally relevant for the assessment of NBS benefits in urban contexts and make use of indicators touching upon social, economic and environmental dimensions of sustainability. However, existing frameworks typically do not specify how indicators could be used to report progress against Sustainable Development Goals (SDGs). Moreover, most frameworks do not, or only to a limited extent, specify if there is scope for participatory assessment related to selected indicators and only half of the frameworks included one or more governance indicator.

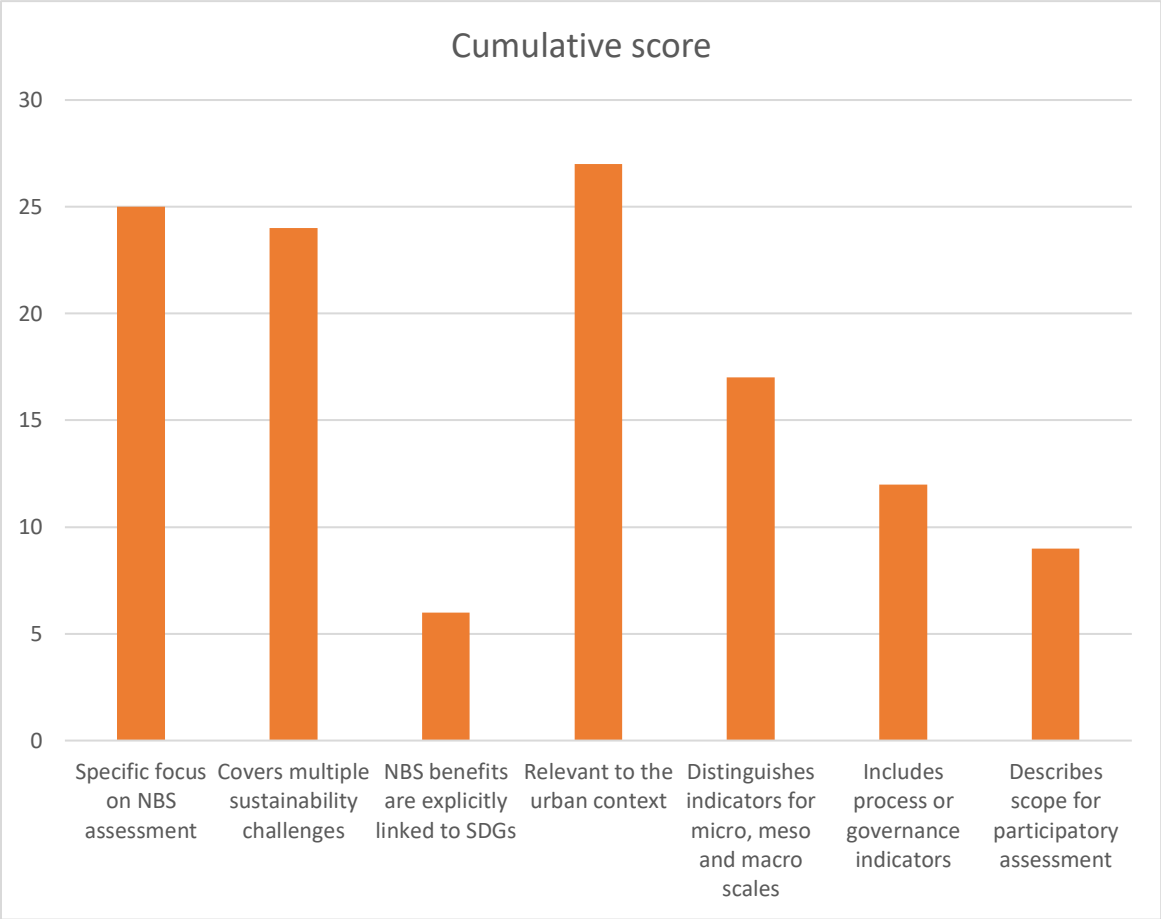

Figure 5. Overview of cumulative scores for the 14 identified assessment frameworks against each of the selection criteria relevant to the CONEXUS participatory framework.

Table 3. EU-level assessment frameworks reviewed using selection criteria derived from the principles relevant to assessment in the CONEXUS project.

Full / Partial / No	Specific focus on NBS assessment	Covers multiple sustainability challenges	NBS benefits are explicitly linked to SDGs	Relevant to the urban context	Distinguishes indicators for micro, meso and macro scales	Includes process or governance indicators	Describes scope for participatory assessment
CLEVER Cities Impact Assessment Framework	Yes	Yes, but only those relevant to 4 categories of social and economic regeneration	No	Yes	No	No	No
Connecting Nature - NBS evaluation indicators	Yes	Yes, but only those on the environmental spectrum of sustainability	No	Yes	Yes, geographical scale is identified for each indicator	No	Yes, detailed description for each indicator
EKLIPSE impact evaluation framework for nature-based solutions	Yes	Yes, indicators grouped into 10 climate resilience challenge areas derived from a review and an expert report on NBS (European Commission, 2015; Kabisch et al., 2016)	No, but see Bulkeley (2017) for an attempt	Yes, specifically developed for use in the urban context	Micro and meso – the meso scale incorporates the urban and the regional levels)	Yes, grouped under the category of 'Participatory planning and governance'	Not explicitly discussed – participatory mapping identified as potential method
Horizon 2020 Taskforce 2 (TF2) handbook for NBS assessment	Yes	Yes, indicators are grouped into 12 challenge areas	Yes, this is described for each indicator	The framework includes indicators relevant to urban, peri-	Yes, described for each indicator	Yes	Yes, scope for participatory data collection is described for each indicator

				urban and rural areas			
NATURE4CITIES Urban Performance Indicators for the assessment of NBS	Yes	Yes, indicators were grouped into 11 categories of urban challenges	No	Yes	Yes	Yes	No
NATURVATION Urban Nature Navigator	Yes	Yes, indicators are grouped into 12 categories of urban sustainability challenges	Yes, clusters of challenges derived based on combining SDGs with potential of NBS as described in EKLIPSE report (Raymond et al., 2017)	Yes, specifically developed for use in the urban context	No	Yes, grouped under the category of 'Inclusive and equitable governance'	It provides generic guidance on participatory and deliberative methods, mainly around understanding stakeholder needs, but not at the level of individual indicators
OpenNESS Integrated assessment and valuation of ecosystem services	No, the focus is on guiding decisions on what assessment methods for ecosystem services to use	Services are broadly grouped in socio-cultural, biophysical and monetary – no more fine-grained classification of benefits provided	No	Not specifically, but methods could also be relevant in an urban context	Yes, relevance to different spatial scales is discussed for methods	No	Yes, potential for stakeholder participation is indicated for each method
OPERANDUM indicator framework for assessing the efficacy of NBS	Yes	Yes, indicators were grouped into 12 clusters relevant to environmental or	No	Yes	No	Not identified as such, but there is some overlap with the	No

		socio-economic performance				'stakeholder engagement' group of indicators	
POCIA (Principles, Objectives, Criteria, Indicators and Attributes) framework	It was applied to a nature-based urban river corridor project that likely qualifies as an NBS	Yes, environmental, economic and social indicators were used	No	Yes	No	No	Stakeholders are engaged to 'score' indicators for different scenarios, but there is no engagement in data collection
proGIreg monitoring and assessment plan	Yes	Yes, the 10 EKLIPSE categories were used, but indicators were not specified for all of these	No	Yes	Three measurement scales are distinguished for framework as a whole, but scale is not specified for individual indicators	No	No
RECONECT assessment framework for hydro-meteorological benefits of NBS	Yes	Yes, the EKLIPSE categories were amalgamated into three overarching clusters	No	The framework includes indicators relevant to urban, hybrid and rural areas	No	No	No
REGREEN indicator framework for	Yes	Yes, but an overview of indicators and challenges is missing	No	Yes	Yes	No	No, the analysis is done on the basis of remote sensing data

multiple ecosystem services							
UnaLab NBS performance and impact monitoring protocols	Yes	Yes, indicators are grouped into 13 categories of urban sustainability challenges with a strong emphasis on climate resilience	Not explicitly, but a subset of indicators have been derived from the indicator framework for SDG 11 on sustainable cities and communities	Yes	Yes, described for each indicator	Yes	No
URBAN GreenUP Technical KPIs	Yes	Yes, EKLIPSE categories were adopted with exception of coastal resilience	No	Yes	Yes	Only a single indicator was used	No

The data in Table 3 can also be used to compare frameworks with each other. This shows that the NBS TF2 handbook for NBS assessment was the only framework that meets all selection criteria. Other frameworks meeting a relatively large number of criteria are the EKLIPSE impact evaluation framework for nature-based solutions, NATURVATION Urban Nature Navigator, NATURE4CITIES Urban Performance Indicators for the assessment of NBS, and UnaLab NBS performance and impact monitoring protocols. Each of these fully met at least five out of seven of the selection criteria. Ranking of frameworks cannot be reliably done given that different selection criteria do not necessarily carry the same weight, whilst it is also not the purpose of the study to do so. However, given that the TF2 handbook for NBS assessment fully met all selection criteria and incorporated most of the other frameworks selected for this review, we confidently selected this framework as the basis for developing the CONEXUS portfolio of indicators presented in Chapter 4 (see Table 5 for an overview of selected indicators).

Despite finding an assessment framework that scores positively against each of the selection criteria that were applied, we identify two key areas where the CONEXUS participatory assessment framework should extend beyond the TF2 handbook for NBS assessment (also see Chapter 1):

- There is a need for adopting a participatory assessment approach that includes participation in indicator selection in addition to participation in data collection;
- There is a need for including state-of-the-art governance indicators that go beyond assessment of governance as NBS benefit (e.g. sense of empowerment or proportion of public participation processes) by also considering it as an essential process in mainstreaming NBS.

3 The approach to participatory monitoring and assessment

For the CONEXUS assessment framework to qualify as 'participatory', it is important to advance participation in the assessment processes to go beyond conventional approaches. This requires an understanding on how participation in assessments has been previously studied and applied by cities around the world. In response to this, we present insights from the literature mixed with observations derived from the Life-Lab interviews on participatory assessment. This serves to address the following questions:

1. What is a participatory assessment approach?
2. What is the added value of participatory over conventional assessment?
3. How to conceptualize participatory monitoring and assessment in the CONEXUS project?

On the basis of a scoping review, this chapter shows that participatory monitoring and assessment has historically been operationalized in different ways, but in its broadest sense can be understood as engagement of relevant stakeholders in all aspects of monitoring and assessment – from collaborative study design and indicator selection to data analysis, and everything in between. Doing so provides important benefits, such as stakeholder empowerment, improved stakeholder buy-in to projects and more relevant data, which underlines the added value of taking a participatory approach.

Based on these insights, and taking into account the busy diaries of stakeholders, we decided on a number of actions to support participatory monitoring and assessment in each of the Life-Labs (Figure 6). This ensures that a minimum level of participation is achieved, while providing scope for Life-Labs to be more ambitious. The final part of this chapter, along with parts of Chapters 4 and 6 outline these steps in more detail. As shown in Figure 6, the participatory formulation of Life-Lab goals has been done previously as part of WP3, a process to be continued in Task 3.3, resulting in the formulation of Life-Lab action plans. In this report, we therefore focus on covering the process of preparing for *participatory indicator selection* and *participatory data collection*. To enable participatory indicator selection, WP4 researchers and the facilitator of each Life-Lab will make a pre-selection of what indicators to share and deliberate with the Life-lab's stakeholders (Filters 1 and 2 in Figure 2). Following this, Life-Lab stakeholders are invited to indicate their preference for each one of the pre-selected indicators, resulting in indicator rankings (Filter 3 in Figure 2).

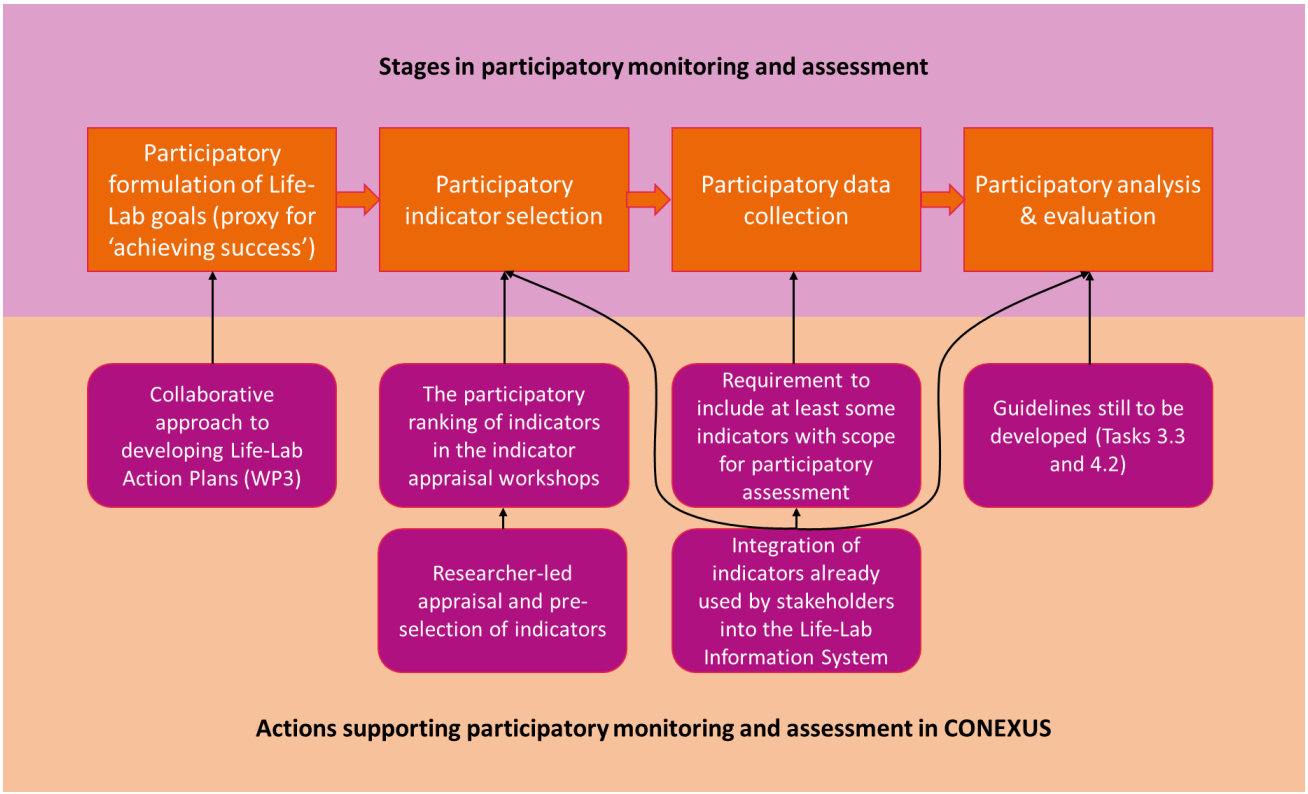

Figure 6. Visualization showing the different stages in participatory monitoring and assessment (top part) and the different actions undertaken in CONEXUS to support opportunities for participation in these (bottom part), which are described in this report.

To encourage participation in data collection, we made it a requirement for the Life-Lab Information Systems to include at least some indicators with scope for participatory monitoring and assessment (Section 3.3.2). Opportunity for participation in data collection, monitoring and evaluation was also an indicator selection criterion during the indicator pre-selection process (e.g. see Section 4.1). However, we do not set a minimum number of indicators to be assessed in a participatory way by each of the Life-Labs – participation processes can be time-demanding and the scope for this is influenced by previous experience and the level of 'participation culture' in the city. Integrating indicators already in use for assessing particular NBS impacts into the Life-Lab Information System, if relevant to the goals of the Life-Lab (Section 3.3.2), represents another way of encouraging stakeholder participation. Not only does this improve adaptation of the assessment framework to local knowledge but it also leverages stakeholder commitment to participate in different stages of monitoring and assessment and improves the likelihood of the assessment framework to be used beyond the duration of the CONEXUS project. Beyond data collection, Life-Labs will also be engaged in the subsequent stages of analysis and evaluation, but the exact process of how this is done will be designed and reported upon by CONEXUS Tasks 3.3 and 4.2.

Given the central role of participation in indicator selection, the final part of this chapter focuses on the identification of a set of principles, i.e. indicator selection criteria, to support this process – both the first stage of researcher-led indicator (pre-)selection (Chapter 4), and the second stage of participatory selection (Chapter 6). We distinguish between criteria relevant at the level of indicators and those relevant at the level of the Life-Lab Information System as a whole. The criteria at the system level are important to ensure that the selected indicators are e.g. sufficiently distinctive from one another and provide sufficient information to monitor progress on the CONEXUS core challenge areas.

3.1 The separation between scientific assessment frameworks and practice

Existing frameworks for urban NBS assessment such as the Eklipse framework (Raymond, Pam, et al., 2017) have greatly advanced understanding of the multiple co-benefits of NBS and available indicators, but generally lack a participatory component (Coletta et al., 2021; Giordano et al., 2020). As a result, usability to stakeholders and influence on decision-making could be compromised (McQuatters-Gollop et al., 2019). Indeed, many indicator frameworks in the field of environmental sustainability have a limited impact on decision-making (Rogers et al., 2020). For example, knowledge derived from ecosystem services assessment only rarely influences decision-making directly (Saarikoski et al., 2018).

This has been explained by a presumption on behalf of many scientists that policy-making operates on the basis of scientific rationality, prompting the use of science-driven indicators without critically understanding how these interact with the worldviews, policy frameworks, working practices and actor network dynamics specific to particular contexts (Rydin et al., 2003). Instead, cities tend to apply green space indicators in a rather pragmatic way, with recommendations made by researchers often dismissed as 'unrealistic' (Carmen et al., 2020). Furthermore, indicators are sometimes used to foment pre-existing viewpoints rather than to build a shared perspective on an issue (Rydin et al., 2003) – i.e. policy-based evidence instead of evidence-based policy (Sharman & Holmes, 2010). Consequently, science-driven assessment frameworks tend to be of limited relevance to policy and practice, which results in stakeholders losing interest (Stevance et al., 2020). Added to this, scientists tend to design frameworks with very detailed or specific indicators, which increases the time burden for analyzing these. This negatively affects momentum and could imply relevant information is not available in time to influence policy agendas (DeMeo et al., 2015).

> *"What is important for both practitioners and academics alike is to understand that indicators function inside the governance process; they are not exogenous factors parachuted in that can act like a magic bullet causing decision making to become instantly objective and scientific. Creating successful indicators relies far more on focusing on how they are integrated into the processes of urban*

governance and far less on devising, designing, and tweaking particular indicator sets" (Rydin et al., 2003, p. 588).

To improve impact of environmental assessment on decision-making, researchers have demonstrated the need for knowledge co-production by a broad range of stakeholders in the research process (Saarikoski et al., 2018). This could make assessment frameworks 'less academic' and more relevant to the decision-making realities of stakeholders (Ashley et al., 2008). Interdisciplinarity and iterative interaction between scientists and stakeholders in the production of information on environmental benefits and ecosystem services are considered crucial ingredients of delivering 'usable science' (Lemos & Morehouse, 2005; Posner et al., 2016; Ruckelshaus et al., 2015). To ensure good uptake of insights based on the assessment of urban NBS pilots in policy and practice, the CONEXUS project adopts a participatory approach to assessment and monitoring.

3.2 What is a participatory monitoring and assessment and why consider it?

Different definitions of participatory monitoring and assessment are provided in the literature. These converge on the idea that stakeholders from multiple levels need to be involved in aspects of data collection and analysis in relation to a management activity that is of relevance to them. The definition by Atkins and Wildau (Atkins & Wildau, 2008), for example, specifies the need to actively engage stakeholders in "the process of data collection, analysis, and communication", with scope for challenging pre-established viewpoints. Stakeholder engagement in monitoring and evaluation similarly plays a central role in the definition by the World Bank (2010). However, a more recent account stresses the need to also include stakeholders in project design activities – "*We define "participatory monitoring" as a system that involves stakeholders from multiple levels in project design and the collection and analysis of data gathered from a given management activity that leads to improved collaborative decision making*" (Evans et al., 2018, p.526).

Regarding the information systems to be developed in the each of the CONEXUS Life-Labs, our stance is that data collection should be participatory where possible to increase public engagement and access to data (e.g., Pocock et al., 2018). However, this is only one of a larger number of indicator selection criteria that need to be considered to ensure local impact (see Section 1.3). We focus here on the need for participation in the process of indicator selection, which is in line with a more comprehensive understandings of participatory monitoring and assessment. Research has shown that considering participation in indicator selection can contribute to exchanging ideas and knowledge, facilitating stakeholder learning and sense of ownership (Bell & Morse, 2004). Importantly, the co-development of indicator sets – along with scoping of the main issues to be assessed – is also an important predictor for indicator uptake by stakeholders beyond a research project (Mickwitz & Melanen, 2009). This is echoed by Morris and Lawrence (2010), who contend that co-developing

indicators with stakeholders contributes to a sense of shared ownership of monitoring and evaluation, increases engagement and the extent to which lessons are applied in practice. Moreover, it leads to the development of indicator frameworks that are well-adapted to the specific socio-cultural, socio-political and socio-environmental context in which the monitoring is taking place (cf. Bautista et al., 2017). On the basis of this understanding, they claim that: *"M&E [Monitoring & Evaluation] research should be participatory and should bring researchers, policy-makers, practitioners and community members together in the collective enterprise of indicator design, data gathering, analysis and interpretation"* (p. 13). In agreement with this, we conceptualize participatory monitoring and assessment comprehensively as the engagement of a broad range of actors in the processes of project and indicator design, as well as the collection, monitoring and evaluation of data. Such an approach ensures that both the identification of issues, as well as the process toward solving these, is done in a collaborative way – creating an opening for new response strategies to emerge (Atkins & Wildau, 2008).

The literature on participatory monitoring and assessment outlines a broad set of benefits associated with participatory assessment. These include:

1. Empowerment of stakeholders individually (e.g. improved knowledge and more adaptive routines & assumptions), collectively (e.g., increased social capital), and politically (e.g., by ability to influence green space management practices) (Bautista et al., 2017; Constantino et al., 2012; Lawrence, 2006);
2. Increased commitment and shared ownership of projects promoting renaturing and sustainability, which contributes to local support for projects and long-term continuity of monitoring and evaluation (DeMeo et al., 2015; Evans & Guariguata, 2016; Viani et al., 2017);
3. Building a shared understanding of concepts and their underlying principles (Rogers et al., 2020);
4. Forging of new partnerships spanning different disciplines, which contributes to improved system understandings of nature benefits, their interactions and interrelationships with culture and traditions, and how these bear relevance to policies and initiatives across different policy domains (Fernandez-Gimenez et al., 2008; Lee & Yan, 2019; Rogers et al., 2020; Sagoe et al., 2021; Tarrasón et al., 2016; Whitfield & Reed, 2012);
5. Improved delivery of cultural ecosystem services, including health and well-being, awareness and learning, community cohesiveness and sense of place (Fernandez-Gimenez et al., 2008; Krasny et al., 2014; Uchiyama & Kohsaka, 2019); and
6. Pragmatic benefits such as data with higher relevance for decision-making, preventing the unduly replication of data collection efforts, improved organizational legitimacy, improved learning capacity of organizations, external validation of results, more effective decision-making and distributing the burden of investment and effort required for data collection and processing (Atkins & Wildau, 2008; Fernandez-Gimenez et al., 2008; M. S. Reed, 2008; Tarrasón et al., 2016).

There are also some challenges or risks associated with adopting a participatory monitoring and assessment approach. One prominent issue is the challenge of equal representation. Stakeholders might have variable viewpoints on a particular issue, and central actors with decision-making power (e.g. about sets of indicators to adopt) are not always open to give equal weight to these different perspectives. For example, there is a risk for data provided by volunteers to be used for purposes diametrically opposite to the very interests that drove a volunteer to get involved – driving disempowerment rather than empowerment (Lawrence & Turnhout, 2010). This is not to say that a participatory process – including those with centralized decision-making power – cannot result both in political and in personal empowerment (Lawrence, 2006). There is also the risk of misinterpreting the decentralization of decision-making processes to the local level as more democratic – the 'local' trap (Purcell, 2006). Consequently, facilitators of participatory processes have a duty of care to engage a representative group of stakeholders *and* provide a mechanism to balance different viewpoints.

3.3 Formulating criteria to support indicator selection and the development of Life-Lab Information Systems

The ambition of the CONEXUS project is to develop a participatory process from scoping the pilots to interpreting the results. Therefore, we mobilize the literature on participatory monitoring and assessment to identify key lessons to help guide the process of indicator selection. Some of these apply to the level of individual indicators and others to the level of the Life-Lab Information System (i.e. the combined set of indicators). In line with the procedure for assembling the Life-Lab Information Systems (see Chapter 6) – where individual indicators are discussed before deliberating how these fit together as a whole – we first present the criteria at indicator level before presenting those at the level of the Information System as a whole.

3.3.1 Indicator level

Several frameworks have been developed to evaluate the use of indicators. The European Commission's handbook for evaluating the impact of NBS projects states that indicators need to meet the criteria of being SMART – Specific, Measurable, Attributable, Realistic and Targeted (Dumitru & Wendling, 2021a). This is a variation on the SMART method popular in management and evaluation studies, where it is operationalized as Specific, Measurable, Achievable (within resource constraints), Relevant and Timely (Bjerke & Renger, 2017). Another variation is the SM(a)RRT – Simple, Measurable, Relevant, Reliable and Timely method (Vallauri et al., 2005).

In the sustainability and ecosystem services literature advances have resulted in criteria for developing and selecting indicators as well. Building on the research by Cash et al. (2003) on bridging sustainability knowledge

and action, van Oudenhoven et al. (2018) introduced a framework with four partially overlapping components: Credibility, Salience, Legitimacy and Feasibility. Each of these criteria can be further broken down into sub-criteria as illustrated in Figure 7:

- *Credibility* refers to the need for indicators and analytical techniques used to have a firm foothold in the scientific literature.
- *Salience* concerns the relevance and applied value of information to potential users and other stakeholders, as well as its understandability to a broad range of stakeholders.
- *Legitimacy* relates to the process of indicator development and selection, which needs to be fair and inclusive.
- Finally, *feasibility* is understood as the availability of time and resources to adequately carry out the assessment and monitoring process.

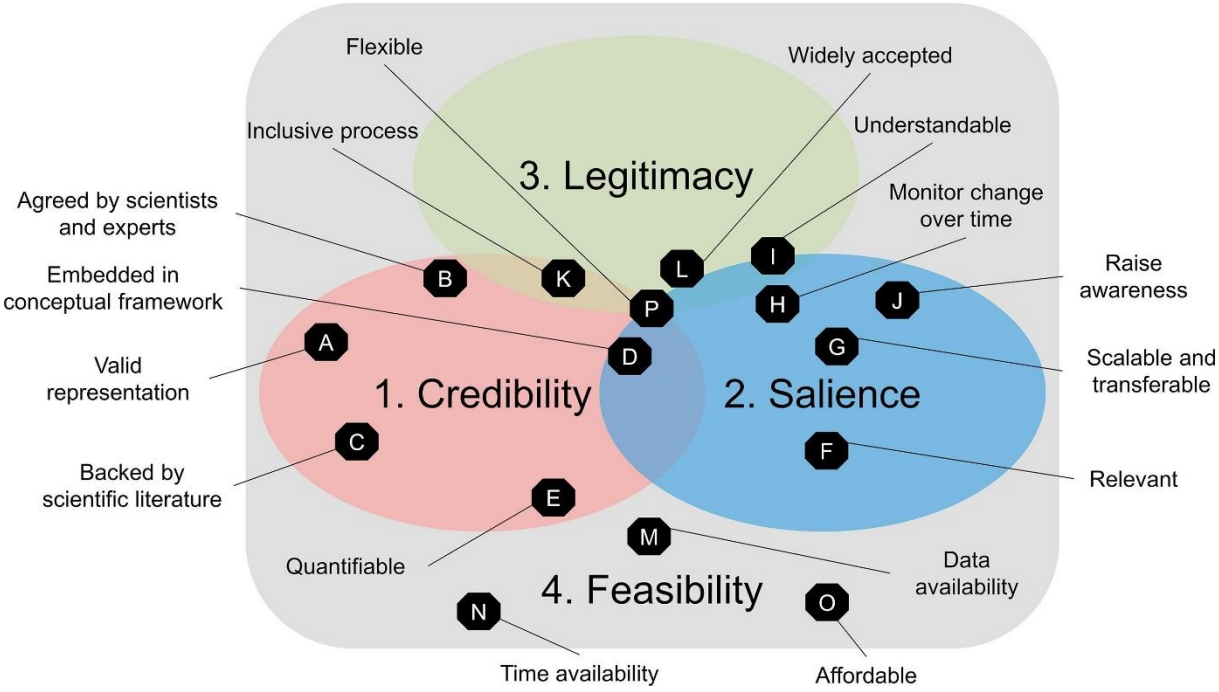

Figure 7. Suggested criteria and sub-criteria for indicator development (source: van Oudenhoven et al. (2018)).

Out of these four, the feasibility criterion, along with relevance, is known to be of particular significance to cities when selecting urban green space indicators (Carmen et al., 2020). The feasibility and relevance (i.e. salience) criteria also incorporate the majority of the elements in the SMART method outlined above, although the timeliness aspect is not clearly covered.

The findings by Carmen et al. (2020) correspond with our findings from the analysis of the interviews held with Life-Lab city representatives (see Appendix A for the Methods), where we asked the following question:

- How important is assessment of urban nature to you? What are the main arguments for doing it (e.g. political influence, justification to co-investors, reporting progress against sustainable development goals)? What are the challenges?

The responses to this question indicated that *Salience* – in particular the sub-dimension of Relevance – and *Feasibility* were the prime considerations for indicator selection. *Credibility* is also scrutinized, but this is done in a heuristic way by relying on established frameworks used by higher-level government and other reputable organizations such as the IPCC– other scientific assessment frameworks were not adopted. Therefore, the dimensions of *Credibility* cannot be clearly distinguished from the (sub-)dimension of Relevance. The role of the fourth dimension *Legitimacy* was considered to become increasingly important in a number of cities – particularly the sharing of data on e.g. air quality with the general public on publicly accessible data portals, but also the incorporation of indicators and data provided by civil society actors into municipal information systems. A text box at the bottom of this section describes the findings from the interviews in a bit more detail, including a number of relevant quotes.

The comprehensive set of criteria forwarded by van Oudenhoven et al. (2018) have now been adopted in numerous projects to ensure a rigorous approach to the development of high-quality indicators. However, we wish to caution against the application of these criteria to potential indicators using a simple checklist approach when adopting a participatory monitoring and assessment approach. First, because the reality of decision-making is rather more pragmatic and less uncanny than most researchers might expect, implying that aspects of feasibility and relevance tend to be weighed more strongly than credibility and legitimacy. Research on the SMART method also stresses the need for delivering results within a defined timeframe (Bjerke & Renger, 2017). Dovetailing assessment outcomes with the timelines of decision-making processes is indeed crucial for the effective uptake of research outcomes (Saarikoski et al., 2018). However, this criterion is not clearly covered in van Oudenhoven's (2018) model. As Carmen et al. (2020) aptly put it: *"While increasing resources and capacities are certainly needed on the municipalities' side, we argue that researchers should avoid compiling idealized, exhaustive and perfect indicator sets, and implying these should be measured for each green space project and repeatedly over time"* (p.6).

Second, the approach by van Oudenhoven et al. (2018) does not 'reward' those indicators with clear scope for participation in assessment or monitoring, which closes the door on an assessment approach contributing to stakeholder empowerment and shared sense of ownership, as outlined in the previous section. For example, if empowerment or long-term continuity of assessment are key interests, indicators with high levels of citizen science potential should perhaps be prioritized over more scientifically rigorous alternatives (Savan et al., 2003).

Third, different stakeholders might disagree on how to score these criteria, especially when adopting a highly inclusive (i.e. legitimate) approach. This could result in tensions or trade-offs between criteria, such as between legitimacy and relevance. It remains unclear how to take this uncertainty into account when taking a checklist approach to indicator selection.

Fourth, there are additional criteria that should be considered at the level of the Life-Lab Information System as a whole, such as flexibility and a well-grounded mix of specific and broad indicators. These concerns are most important when evaluating indicators in isolation from each other. To further elaborate on this point, the next section covers criteria that could be specified at the level of the Life-Lab Information System as a whole. Although some (e.g. flexibility) can also be applied at individual indicator level, our stance is that these are comparatively more important for evaluating the set of indicators as a whole. It should be noted that the criteria specified below have been selected assuming that monitoring and assessments will be done in a participatory way motivated by the ambition of making an impact on policy and practice.

Text Box 1a. Indicator selection criteria for urban NBS: What did the Life-Labs say? (1/2)

The criterion of Relevance – a sub-dimension of **Salience** – is key to indicator selection for urban NBS assessment, which we derive based on the observation that most of the adopted indicators are derived from regulatory or policy frameworks at municipal or higher levels. One of the main reasons for why city administrations are taking such an approach is that it enables the dovetailing of broadly accepted indicators with high **Credibility** across multiple scales, which supports data interpretation.

> *"A very important thing for us is to at least have the same indicators that also exist for [the province of] Catalonia, for Spain and for Europe, so that if you have butterfly or bird populations, all this information also goes into the general database. [...] For example, [if we do this] we can compare the bird populations of Barcelona with those of Catalonia. If the trends are the same, then there are global causes. If they are different, then be careful, which is also very informative" (BCN).*

In terms of decisions on what data to collect, municipal staff also consider the potential impact of data on politicians and key decision-makers. For example, by collecting data to demonstrate how temperatures vary between green and affluent neighbourhoods and deprived areas with relatively less green cover, but also by showing potential cost-savings of NBS related to e.g. flood control (BA,STGO). Therefore, indicators also have to be relevant to locally specific challenges, which likely already differ from region to region within a single country. This limits the scope for copying assessment frameworks from elsewhere without altering these to the local context (STGO). Doing so, assessment can be an effective tool to help decision-makers pay more attention the need for more NBS in the city (BA,LIS).

> *"So saying [to municipalities] that it is going to lower their costs or that it is going to reduce maintenance costs or external costs caused by externalities such as flooding, for example, things of that kind, I think that can be quite attractive to them" (STGO).*

Feasibility is an important consideration to cities as well. One of the interviewees acknowledged that an important criteria for indicator selection is "that it has to be easy to measure" (BA). Other interviewees also stressed the need for taking local capacity into account during the process of indicator selection and associated setting of targets, which was aptly conveyed by the Turin representative:

> *"We wanted to have a practical and realistic approach. We wanted to include actions, objectives and indicators that were within the capacity of the administration to set, implement, achieve and monitor. So we that's why it's very self-reflexive – we didn't expect to have billions of euros to invest in this or that. [...] That's not to say that we were timid, but we wanted to make sure that we didn't set goals and indicators that were sort of just fantasy for us at the time" (TRN).*

Although scientific assessment frameworks were not used by the studied cities, strategic partnerships with universities can be conducive to easing the resource burden of assessment. For example, by supporting the development and analysis of indicators at the city level. They can also help with aggregating and disseminating data in e.g. online knowledge portals (BOG).

Text Box 1b. Indicator selection criteria for urban NBS: What did the Life-Labs say? (2/2)

Collaborating with external actors is not only a way of reducing costs associated with assessment and subsequent analysis, but can also make assessment more participatory and inclusive. **Legitimacy** therefore interlaces with Feasibility. For example, the Bogotá Environmental Secretariat receives data from the Botanical Garden of Bogotá, the Administrative Unit of Public Services and the District Health Secretariat. Moreover, the Bogotá Sewage Company and the Secretariat of Mobility collect data relevant to the Secretariat of Environment. Likewise, the municipality of São Paulo collaborates with the NGO Rede Nossa São Paulo (RNSP) on exploring the potential of assessing some of the city's sustainability goals using the RNSPs structured framework of environmental indicators. This type of collaboration facilitates co-learning processes and results in the uptake of indicators that are broadly perceived to be important within the city context.

Some of the interviews suggested that there is increasing demand from the public for information collected through sustainability indicators (BCN). Cities such as Bogotá and São Paulo are using online platforms (Environmental Observatory & GeoEnvironment, respectively) to make relevant information on water, air quality, fauna and other variables publicly available to citizens, but also to schools, universities and other institutions. This calls for understandable and broadly accepted indicators (BOG,STGO), which highlights another link between Legitimacy and Feasibility.

> *"Basically we have a strong integration with citizens – we generate communications. The website gives them information, there is a bulletin that they receive with the indicator of the week or month – and there people [can] find out what our indicators offer – and we have already put it in [an] open data [format] so that they can use it as they please" (BOG).*

> *"Working with communities and people [on sustainability evaluations] is still a bit far away. So it would be good if these [neighbourhood project] evaluations are not too complex and become 'closer' [with community involvement]" (STGO).*

3.3.2 Information system level

When developing a new monitoring and assessment approach, one of the first steps should be to collectively agree on a set of monitoring goals and objectives for the partnership and individual projects to be developed (DeMeo et al., 2015; Evans & Guariguata, 2016). These would respond to what we want to measure and can be defined by a range of goals, see Text Box 2. This should then be used as the basis for developing indicators, again making sure these are collectively agreed (Neugarten et al., 2018). A mismatch of collected data with the project's objectives (Fernandez-Gimenez et al., 2008), or with the partnership's broader goals (DeMeo et al., 2015), provides a clear barrier to policy impact. For the implementation of indicators, it is also important to consider what type of data is required. This can vary between quantitative and qualitative, monetary and non-monetary, and spatial and non-spatial (Neugarten et al., 2018). Unlike popular belief, practitioners do not

always prefer monetary over non-monetary data (Saarikoski et al., 2018). We concur with van Oudenhoven et al. (2018) that scalability and transferability are important considerations for assessment (cf. Neugarten et al., 2018), but do not necessarily agree with applying this criterion at the level of the individual indicator. That is, it should not be an issue if individual indicators cannot be applied across different scales and contexts, given that the information system[6] provides some options for using alternative indicators.

Text Box 2. Examples of possible participatory monitoring goals

- Promoting general education and awareness
- Building capacity
- Developing a baseline
- Investigating a potential problem
- Addressing public uncertainties
- Addressing public perceptions
- Establishing a technical basis for compliance
- Evaluating the effectiveness of improvements.

derived from Atkins & Wildau (2008)

Research on adaptive management of complex systems highlights a need to regularly reflect on project goals, and where necessary to adapt these to changing circumstances or new insights (Huitema et al., 2009; Pahl-Wostl, 2017). We argue that this should also be reflected in the use of indicators for assessing progress against project goals, which would allow for flexibility in response to local demand for information (Evans & Guariguata, 2016; J. Reed et al., 2016). A good example for this approach on the development of indicators is the Woods In and Around Towns (WIAT) programme in Scotland, which was aimed at leveraging investment for urban forests. The indicators were used to evaluate progress of funded projects against policy objectives and to facilitate operational learning. They were established by first drafting a set of indicators through workshops with stakeholders, then testing these at a number of sites and subsequently improving these if necessary. When using this process, different sites and contexts ended up with different combinations of indicators (Morris & Lawrence, 2010). Like for the criterion of scalability and transferability discussed above, we assert that flexibility is mainly important to be considered at the information system level rather than for individual indicators – a change in system conditions does not imply that all indicators need instant updating.

[6] The term 'information system' is used throughout this report in relation to the indicator system adopted by each of the Life-Labs for monitoring NBS pilots and the broader uptake of NBS in the city, along with the protocol for assessment (see Section 1.4 for a more detailed description).

Significantly, there is a case to be made for maintaining a modest level of rigidity in Life-Lab Information Systems, given the benefits of using indicators to report against long-term high-level policy goals, such as the Sustainable Development Goals stipulated as part of the 2030 Agenda. Using indicators to report against these and other broadly agreed benchmarks and targets can increase stakeholder interest and impact of collected data (Rogers et al., 2020). **Therefore, we adopt an approach to information system development that seeks to select a small set of indicators relevant to high-level project-level targets that are comparable[7] across Life-Labs, and a larger set of place-specific indicators with scope for temporal and spatial variability related to which Challenge Areas are assessed.** This generates an assessment approach with a fixed core set of similar indicators for all Life-Labs and a flexible shell of place-specific indicators (Figure 8) – a solution also previously sought by other projects seeking to balance national or global level interests with those at the local level (DeMeo et al., 2015; Evans & Guariguata, 2016).

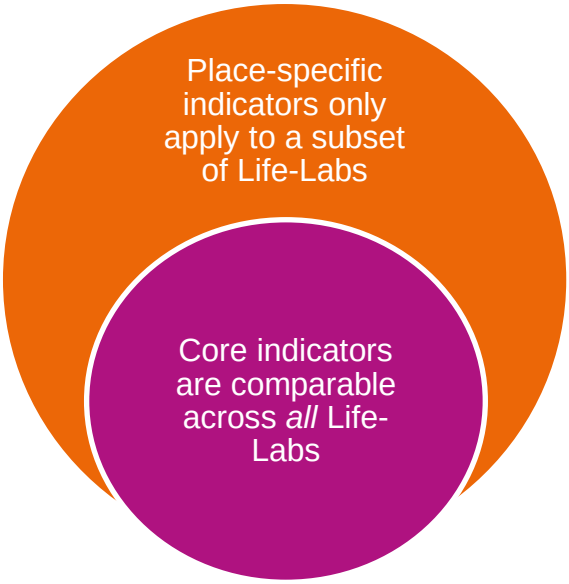

Figure 8. The participatory approach to assessment in CONEXUS requires that each of the Life-Labs generates its own information system on NBS with scope for place-specific indicators based on local demand. In order to enable the reporting of progress against core Challenge Areas (shared by all Life-Labs) in the CONEXUS project, there is also a nucleus of indicators that are comparable across all Life-Labs by virtue of mapping on the same Challenge Areas – biodiversity, climate resilience and environmental justice.

Arguably, there is a need for linking projects to science in order to benefit from the latest insights in relevant concepts, assessment techniques and indicator presentation (Mickwitz & Melanen, 2009). However, it is also important to provide scope for stakeholders to have a voice in decision-making about what indicators to include for reasons – e.g. policy relevance, empowerment, long-term continuity of assessment – outlined in Sections 1.1 and 1.2. DeMeo et al. (2015) present a *continuum of evidence* to illustrate this tension between, on the one hand, a need for broad and generalizable evidence to suit policy actors (cf. van Oudenhoven, Aukes, et al., 2018), and on the other hand, a need for narrow and specific evidence on specific ecosystem categories for purposes of scientific enquiry (Figure 9). They suggest navigating this tension by providing "an evaluation

[7] Comparable, but *not* necessarily identical, given locally variable capacity to collect and analyze data, traditions of using metrics and ways in which e.g. climate effects or biodiversity loss are affecting the city and need to be actioned.

of the level of rigor that is needed to adequately and practically answer each question" (DeMeo et al., 2015, p.6). Consequently, not each and every indicator needs to be narrow and specific, given that the combination of indicators used provides an adequate response to the information requirements of involved stakeholders. This suggests that credibility may be a criterion more important to be evaluated at the level of the information system as a whole rather than for each and every indicator, as suggested by van Oudenhoven et al (2018).

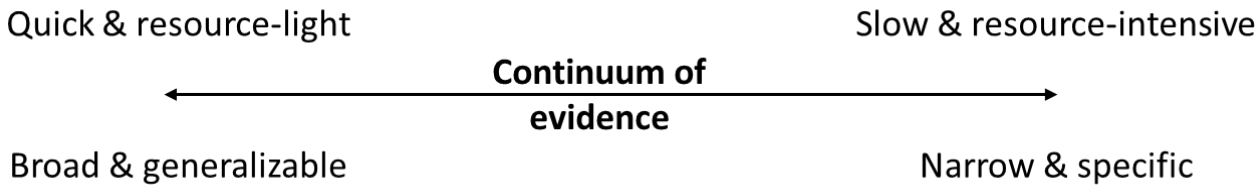

Figure 9. Illustration of the continuum of evidence. For each indicator, an optimum on this continuum needs to be determined.

Finally, there are a number of pragmatic concerns that are best considered at the level of the information system as a whole. Firstly, decision-makers and active citizens often prefer support tools that are simple and low-effort, yet still sufficiently sensitive to demonstrate the relevant effects of interventions (Bayulken et al., 2021; Garibaldi et al., 2017; Lee & Yan, 2019; Ruckelshaus et al., 2015).

"No matter how much interdisciplinary scientists think they are over-simplifying biophysical or socio-economic processes, decision-makers typically ask for simpler, easy-to-use and understandable decision support tools that can be readily incorporated into science-policy processes" (Ruckelshaus et al., 2015, p.17).

Following this, information systems with too many or with resource-intensive indicators tend to be considered too complicated and cost-prohibitive (Evans & Guariguata, 2016; Neugarten et al., 2018; Rogers et al., 2020). It also steepens the learning curve, which negatively affects transferability of the assessment protocol to different stakeholders and contexts (Viani et al., 2017). One way of improving cost-effectiveness and usability of an information system is to provide a proper digital infrastructure supporting the storage and analysis of data (Evans & Guariguata, 2016). In addition, there is a need for a monitoring plan that clearly outlines who is responsible for collecting and analyzing data, what data and at which intervals (Evans & Guariguata, 2016). Finally, there is also a need for providing adequate training and expert support in data monitoring (Fernandez-Gimenez et al., 2008). Feasibility is therefore not only relevant at the level of the indicators but should also be considered at the level of the information system.

Based on the relevant criteria outlined above, a next step was to provide an overview of criteria relevant for evaluating the combined set of indicators as a whole, i.e. the Life-Lab Information Systems (Figure 10). This shows that a substantial number of criteria can be identified as relevant at the information system level. These criteria will not be applied until after the indicator appraisal workshops have been organized (see Section 6.3). Note that although the framework by van Oudenhoven et al. (2018) was used as the basis for outlining relevant criteria at indicator level, some of their sub-criteria have been left out, while others have been combined, revised, or moved to the level of the system.

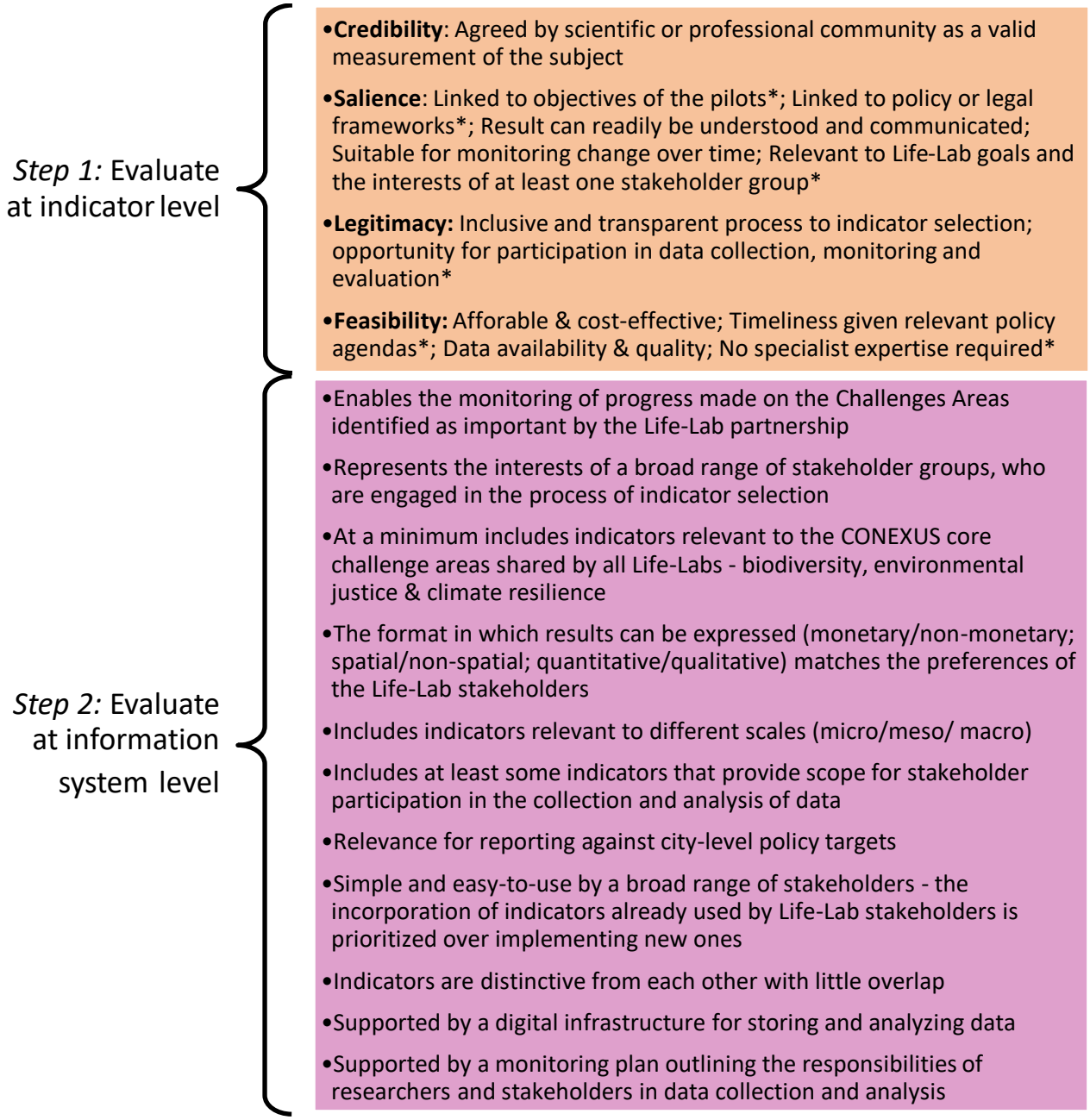

Figure 10. Criteria guiding the selection of individual indicators and the subsequent evaluation of how these combine into Life-Lab Information Systems. An asterisk (*) is used to denote criteria relevant at indicator level that are added to, or substantially revised from, the set of criteria described by van Oudenhoven et al. (2018).

4 Researcher-led appraisal of the indicators on NBS performance

Drawing on the overview from Chapter 3, the present chapter introduces a set of selection criteria applied as part of filter 2 (*Selection of indicators recommended for use by the Life-Labs*) in the development of the Life-Lab Information Systems. A small number of researchers subsequently applied these selection criteria to appraise each of the indicators extracted from the Horizon 2020 Task Force 2 (TF2) handbook for NBS assessment. This resulted in the allocation of indicators to one out of three possible categories: fit, fair or unfit. The indicators considered fit represent the recommended indicators to be used by the Life-Labs.

We would like to remind the reader that the TF2 handbook for NBS assessment was selected as source for NBS performance indicators because it meets all criteria relevant to the CONEXUS project (see Chapter 2). Indicators were grouped into twelve thematic societal challenge areas, which are also applied in the CONEXUS portfolio of indicators. We only selected those indicators – a total of 71 – that were marked as 'recommended' within the TF2 handbook for NBS assessment for the researcher-led appraisal described below. Thus, all NBS performance indicators included in the CONEXUS framework have been successfully applied in previous EU-funded research projects and can be applied to a broad range of nature-based solutions.

Text Box 3. In the process of developing Life-Lab Information Systems, there are different moments where NBS performance indicators are selected for use in the Life-Labs (see Figure 2). We identified three filters. The present chapter represents Filter 2 (in bold):

- *Filter 1: Selection of scientifically grounded and policy-relevant indicators*. By selecting the TF2 handbook for NBS assessment as the source for indicators, we made sure to include indicators that are agreed by the scientific community, are linked to global policy frameworks and bear relevance to the urban context (see *Chapter 2*).

- ***Filter 2: Selection of indicators recommended for use by the Life-Labs.*** **The suitability of the broad set of indicators from the TF2 handbook for use in the Life-Labs was evaluated by independent reviewers, who evaluated all indicators on a set of criteria derived from the literature on participatory monitoring and ecosystem services assessment.**

- *Filter 3: Place-based appraisal and ranking of pre-selected indicators:* Workshops will be held in each of the Life-Labs in Month 10-14 to help make decisions about which indicators to use as part of the Life-Lab Information System in each of the cities. There is also scope to suggest and discuss alternative indicators that are not part of the recommended list of indicators shown below (see *Chapter 6*).

For pragmatic reasons, Life-Labs will also be encouraged to explore other sources for indicators. These could be derived from existing assessment efforts by different municipal departments and NGOs operating in the city (as explained in more detail in Chapter 6). In addition, there should be scope to adopt, and if-needed co-produce new indicators that are not on this list based on local demand for information. We will therefore ask Life-Lab coordinators to remain open to suggestions for indicators made by Life-Lab participants that were not featured on this list.

4.1 The formulation of indicator selection criteria

Given the large volume of recommended indicators included in the TF2 handbook for NBS assessment, we established the need to evaluate and classify indicators. This enables the selection of a smaller, more manageable, set of indicators to be shared and discussed with the Life-Lab stakeholders in each city. Moreover, this process increases the likelihood that the indicators we share with the Life-Labs are genuinely suitable for measuring success within the CONEXUS framework. We present an overview of relevant selection criteria in the bullet-point list below. These were derived from the literature on the (participatory) assessment of nature's benefits and services along with the literature on participatory assessment (see Chapter 3).

Relevant selection criteria:

- **Credibility**: *Agreed by scientific or professional community as a valid measurement of the subject*
- **Salience**: Linked to objectives of the pilots; *Linked to policy or legal frameworks*; Result can readily be understood and communicated; *Suitable for monitoring change over time*; Relevant to Life-Lab goals and the interests of at least one stakeholder group; *Level of scalability*; *Relevant to urban context*
- **Legitimacy:** Inclusive and transparent process to indicator selection; *Opportunity for participation in data collection, monitoring and evaluation*
- **Feasibility:** Affordable & cost-effective; Timeliness given relevant policy agendas; Data availability & quality; *No specialist expertise required*

Table 4. Scoring guide applied for ranking indicators at the second stage of indicator selection for the CONEXUS Life-Lab Information Systems.

Criteria	Unfit (=1)	Fair (=2)	Fit (=3)
Scope for participatory monitoring and assessment	No opportunity	Yes in one aspect of data collection, analysis & reporting	Yes in multiple aspects of data collection, analysis & reporting
No specialist expertise required	High level of specialist expertise required	Some specialist expertise required	No specialist expertise required
Suitable for monitoring change over time	The indicator is not temporally explicit and does not allow for monitoring over time.	This indicator is temporally explicit and allows for monitoring progress over time but does not provide early warning when needed	The indicator is temporally explicit and allows for monitoring over time. It measures progress and provides early warning when needed
Agreed by scientific or professional community as a valid measurement of the subject	No support by experts	Supported by practitioners	Supported by science
Linked to policy or legal frameworks	No clear linkages	Linked to sustainability challenges	Linked to sustainability challenges prioritized in CONEXUS[8]
Level of scalability	Applicable to a single scale (e.g. site-level, district, city (region))	Applicable to two out of three scales	Applicable to all three scales
Relevant to urban context	No	Some urban contexts	All urban contexts

4.2 The portfolio of indicators on NBS performance and their appraisal

To evaluate the suitability of the indicators to monitoring Life-Lab pilots, four WP4 researchers with varying scientific backgrounds and employed by different institutions independently scored the indicators on a subset of these criteria. They only scored indicators on those criteria that could be meaningfully evaluated without stakeholder consultation in the Life-Labs (shown in *italic* font style in the list above). A scale of 1 (unfit) to 3 (fit) for use was applied to score the quality of the indicators on each of the criteria (see Table 4). Reviewers

[8] The five CONEXUS key challenge areas are: ecological restoration: biodiversity and habitat (SDG14/15); increased public health and wellbeing (SDG3/11); potential for citizen involvement in governance and monitoring (SDG11/16); climate change adaptation (SDG11/13); increased social cohesion (SDG5/10); and urban regeneration - green economy, employment and urban liveability (SDG11).

were provided with the following information for each indicator, partially corresponding with how these have been described in the Appendix of Methods of the TF2 handbook for NBS assessment[9]:

- Indicator name
- Societal challenge area (which can be mapped against the Sustainable Development Goals)
- Units of measurement (e.g., €, %, scale)
- Description of indicator
- Measurement procedure
- Required input data
- Level of expertise required (e.g. for data collection or analysis)
- Scale (e.g. plot, district, city, city region)
- Frequency of measurement (e.g., annual, before-after, one-off)
- Link to higher-level (recommended) indicator (this indicates if the indicator be used as input to another indicator)
- Opportunity for participation (e.g. none, self-reported data or participatory methods)
- Indicator source – (i.e. the EU project in which it was applied)
- Authors (i.e. the authors of the Deliverable report in which the indicator was described)

After all the reviewer's scores were obtained, these were compiled, averaged and processed into graphs for each challenge area, see Figure 11 for an example, and Appendix C for the graphs related to all challenge areas.

Based on the averaged reviewer scores (relative to other indicators in the challenge area) and other relevant arguments (see below), the indicators have been allocated to one out of three possible lists:

- **Fit:** Indicators with high scores on the selection criteria (relative to other indicators in the challenge area) and content-wise arguably a good option for Life-Labs to monitor the success of their pilot projects. This category was capped to max. two indicators for each challenge area
- **Fair:** Indicators with medium-high scores on the selection criteria (relative to other indicators in the challenge area) and content-wise arguably an acceptable option for Life-Labs to monitor the success of their pilot projects
- **Unfit:** Indicators with low-medium scores on the selection criteria (relative to other indicators in the challenge area) and content-wise arguably not the best option for Life-Labs to monitor the success of their pilot projects.

[9] The authors can share upon request a spreadsheet with this information for each of the recommended indicators extracted from the TF2 handbook for NBS assessment. It has not been made available as part of this report due to copyright restrictions.

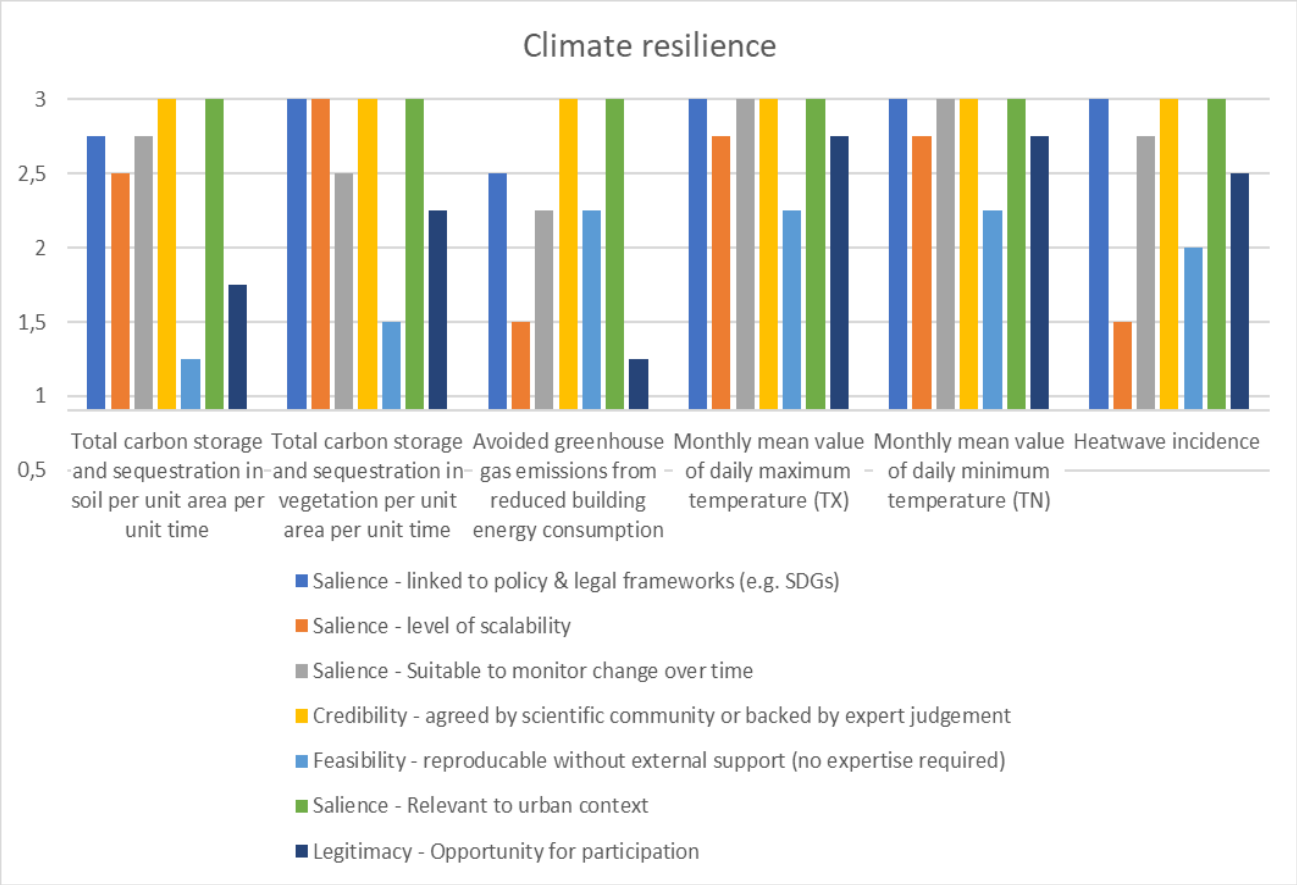

Figure 11. Evaluation of indicators – averages of the scores provided by the four independent reviewers – for the climate resilience challenge area.

The allocation of indicators to each of these three lists is partially informed by researcher interpretation – it was not done exclusively based on quantitative data from the evaluation. This is because: a) there is no reason to assume that all evaluation criteria should be weighted equally (see Section 3.3.1 for detailed argumentation); and b) some relevant considerations have not been 'scored' by the reviewers. For example, it is important to consider whether indicators are sufficiently sensitive to register the effects of NBS pilots within the short timeframe we will be monitoring NBS in the CONEXUS project and at the relatively small scales in which some pilots will be implemented. Other considerations were that some indicators draw on datasets not available within the Latin American contexts or involve complex processes of professional translation into different languages and subsequent validation. We did not include evaluation criteria to obtain quantitative scores related to such considerations, which is why some level of researcher interpretation was applied.

Table 5 provides an overview of the indicator portfolio derived from the TF2 handbook for NBS assessment and their researcher-led appraisal as fit, fair or unfit indicators for the Life-Lab cities. Note, an overview of the methods associated with the (recommended) indicators on NBS performance derived from the TF2 handbook for NBS assessment is not provided in this report due to copyright restrictions and space limitations – we refer

to the source material (Dumitru & Wendling, 2021a, 2021b)**.** A spreadsheet with key information on selected indicators, measurement method, input data, scale of measurement, type of participation and more can be made available upon request by the authors of this report.

We aimed to classify max. two indicators as favoured (i.e. fit) for each sustainability challenge in order to ensure a manageable number of indicators for in-depth discussion in the indicator selection workshops to be held in each of the Life-Labs. The table includes a short justification explaining how the final appraisal was decided. Note, that this table also includes indicators on participatory planning and governance. The options marked as 'fit' for use by the Life-Labs represent output-oriented measures targeted at citizens, which do not clearly overlap with the set of more process-oriented governance indicators targeted at municipalities and institutional actors introduced in Chapter 5.

The indicator appraisals were subsequently discussed and approved – both the selected indicators and their appraisals – in a meeting with all CONEXUS Task Leads engaged in analyzing and guiding the Life-Labs (WP4 – Task 4.1-3) as well as measuring success of the Life-Labs (WP3 – Task 3.3). Concerns were, however, raised regarding the limited inclusion of indicators for liveability, inclusiveness and gender, and Nature-Based Thinking[10]. To some extent, this is being addressed by the governance indicators proposed in Chapter 5, but there is still a need for ongoing dialogue with other WPs and Tasks in the CONEXUS project in order to close any remaining gaps.

[10] Nature-based thinking can be defined as an urban planning logic centred around strengthening the nexus between ecology, economy and community (Randrup et al., 2020).

Table 5. The portfolio of indicators on NBS performance, representing the recommended indicators extracted from the TF2 handbook for NBS assessment, their researcher-led appraisal (fit, fair, unfit), and a justification for how this was decided for each of the indicators. More detailed information for each indicator on e.g. Methods can be found in the Appendix of Methods of the TF2 handbook for NBS assessment (Dumitru & Wendling, 2021b).

No.	Challenge area	NBS indicator	Scale			Appraisal			Justification
			Micro	*Meso*	*Macro*	*Fit*	*Fair*	*Un-fit*	
1	Climate resilience	Total carbon storage and sequestration in soil per unit area per unit time	Plot					■	Relatively high level of expertise required few opportunities for participation and likely to be some issues with scalability
2	Climate resilience	Total carbon storage and sequestration in vegetation per unit area per unit time		District,	urban, region		■		Relatively high level of expertise required and possibly an issue with monitoring change over time. Provides slightly better scalability and opportunities for participation than indicator no. 1
3	Climate resilience	Avoided greenhouse gas emissions from reduced building energy consumption	Build-ing, street	and district				■	Building performance is unlikely to be relevant for the pilot projects; relative low score on scalability, scope for participation and suitability to monitoring change over time
4	Climate resilience	Monthly mean value of daily maximum temperature (TX)	Point or grid			■			Compared with most other indicators for this challenge area, the level of expertise required is relatively low. Good scalability and opportunities for participation available. Could be resource-intensive.
5	Climate resilience	Monthly mean value of daily minimum temperature (TN)	Point or grid			■			Compared with most other indicators for this challenge area, the level of expertise required is relatively low. Good scalability and opportunities for participation available. Could be resource-intensive.
6	Climate resilience	Heatwave incidence	Point or grid				■		Very similar appraisal to indicators 4 and 5, but with much lower scalability and higher resource-intensivity. Could be an interesting measure at higher scales.
7	Water management	Surface runoff in relation to precipitation quantity	Plot	district				■	Run-off is predicted by many factors that are not under control in NBS pilot. Relatively favourable score on scalability but requires high expertise and does not provide a clear opportunity for participation
8	Water management	Water quality: general urban	Site level - applied meth-ods	District - remote sens-ing			■		This indicator covers a broad spectrum of methods, varying from manual sampling, assessment of water organisms to remote sensing. Lack of specificity and potentially high level of expertise required may be challenging to Life-Labs selecting this indicator. Life-Labs may want to consider choosing specific sub-measures from this indicator, but many examples of this are represented by the other indicators within this cluster.

9	Water management	Total Suspended Solids content	Plot	district			■		A large variety of upstream factors can influence the totals of suspended solids in water (e.g. rainfall events), so the effect of NBS may be difficult to detect. No clear opportunity for participation but level of expertise required is relatively low.
10	Water management	Nitrogen and phosphorus concentration or load	Plot	district		■			A very specific and relatively easy to measure indicator. Provides some opportunities to participation. Scalability to higher levels is limited.
11	Water management	Metal concentration or load	Plot	district			■		A very specific and relatively easy to measure indicator. Provides some opportunities to participation. Scalability to higher levels is limited. Not necessarily relevant to all urban contexts.
12	Water management	Total faecal coliform bacteria	Plot					■	Not the most intuitive indicator for NBS impact. Relatively high expertise required, low scalability and no opportunity for participation
13	Natural & Climate Hazards	Disaster resilience			city	■			Measure is only relevant at the city level but includes a number of questions specifically about values of green and blue infrastructure. Evaluations are, however, sensitive to a much broader range of factors. A considerable level of expertise is required, but less complex measure than most other indicators in this cluster. Survey is available in English, Spanish, Portuguese and Italian languages.
14	Natural & Climate Hazards	Disaster-risk informed development		Municipality	Municipality or national level		■		Relatively low level of expertise required compared to other indicators in this cluster, but not the most suitable for monitoring change over time. Scalability is low – only relevant at the city level. No direct effect of NBS pilot to be expected – evaluations are sensitive to a much broader range of factors.
15	Natural & Climate Hazards	Mean annual direct and indirect losses due to natural and climate hazards	Scale is flexible; economic activity in surrounding area is often not taken into account				■		Although a relevant measure for calculating economic losses to assets with comparatively good scalability and credibility, a high level of expertise is required for assessment. It is not very suitable for monitoring change over time.
16	Natural & Climate Hazards	Mean number of people adversely affected by natural disasters each year	Scale is flexible (unlikely a sensible measure at site-level)				■		Although a relevant measure with comparatively good scalability and scope for monitoring change over time, a high level of expertise is required for assessment. It is also not the most credible approach to measure natural & climate hazards through health impacts.
17	Natural & Climate Hazards	Risk to critical urban infrastructure	Storm sewer system or local flood	Catchment scale, storm sewer system				■	A high level of expertise is required for assessment and the connection of this indicator to this SDG is not very clear. Credibility rated lower than for other indicators in this cluster.

			risk area						
18	Natural & Climate Hazards	Multi-hazard early warning		Municipality	Municipality				An NBS is unlikely to influence the implementation of this warning system. Indicator scores poorly on scalability. Relatively low scores on credibility, suitability to monitoring change over time and opportunity for participation.
19	Green Space Management	Green space accessibility		District	city				A simplified measure of accessibility of greenspace that can be used for monitoring social justice component of greenspace management, which is relevant given the CONEXUS aims. Some opportunities for participation are available and the measure has relatively good scalability. The measure might not be able to pick up changes over short period of time and does not take into account all relevant factors influencing accessibility. See indicator 55 for a more complex approach tailored to comparing access to greenspace by different demographic groups.
20	Green Space Management	Total green space within a defined area: Share of green urban areas		District (min. mapping unit is 0.25 ha)	city (min. mapping unit is 0.25 ha)				Relatively simple and therefore attractive measure of green space availability within the city; only relevant at higher scales. Measure is not very sensitive to short-term changes resulting from pilots and does not provide opportunities for participation.
21	Green Space Management	Soil organic carbon	micro						Indicator of carbon captured by organic material in soil, mainly relevant for agricultural land and measured over long time scales. Not scalable and limited opportunity for participation. Requires relatively high level of expertise and does only provide a mediocre measure of green space management in the city.
22	Green Space Management	Soil organic matter index	plot						Indicator of soil quality, mainly important at initial planning stage of NBS and for agricultural uses. A short-term effect of NBS is not necessarily to be expected. Not scalable and no opportunity for participation. Requires relatively high level of expertise and does only provide a mediocre measure of green space management in the city.
23	Biodiversity Enhancement	Structural and functional connectivity of green infrastructure		district	regional				A rather complex measure specifically for assessing the development of green infrastructure, requiring a high level of expertise. Mostly relevant at the macro scale. Limited sensitivity to short-term change.
24	Biodiversity Enhancement	Number of native species	site	district	city				Useful measure if interested in the development of specific or multiple taxa of species. Requires considerable expertise in species identification or the availability of a good dataset but can be made manageable by reducing

						■			number of taxa or species that are monitored. Provides a good measure for participatory monitoring and for monitoring change over time.
25	Biodiversity Enhancement	Number of non-native species introduced	site	district	city		■		Introduction of non-native species is unlikely to be problematic when NBS is implemented with biodiversity in mind. In the unlikely scenario that any adverse effects are expected, it provides a useful measure with opportunities for participation and monitoring change over time. Requires considerable expertise in species identification.
26	Biodiversity Enhancement	Number of invasive alien species	site	district	city		■		Introduction of invasive alien species is unlikely when NBS is implemented with biodiversity in mind. In the unlikely scenario that any such effects are expected, it provides a useful measure with opportunities for participation and monitoring change over time. Requires considerable expertise in species identification.
27	Biodiversity Enhancement	Shannon Diversity Index: Species diversity within defined area	site	district	city		■		Relevant measure for species diversity, rather than supporting particular species, is the main aim of the NBS intervention. Would require considerable expertise and time investment given the need to monitor the community as a whole. Provides good opportunities for participation and monitoring change over time.
28	Biodiversity Enhancement	Shannon Evenness Index: Number of species within defined area	site	district	city		■		Relevant measure if wanting to understand homogeneity of different species in terms of numbers, rather than abundance for particular species, is the main aim of the NBS intervention. Would require considerable expertise and time investment given the need to monitor the community as a whole. Provides good opportunities for participation and monitoring change over time.
29	Air Quality	Number of days during which air quality parameters exceed threshold values		district	region-al	■			Measure of different types of air pollutants drawing on data from a measurement station close to the NBS, which results in relatively good scalability. Medium level of expertise required and no opportunity for participation provided. Suitable for monitoring change over time.
30	Air Quality	Proportion of population exposed to ambient air pollution		district	region-al			■	Measure of different types of air pollutants drawing on data from multiple measurement stations across the city, which limits scalability to smaller levels and sensitivity to effects of site-specific NBS measures. There are likely many background factors influencing the data. High level of expertise required and no opportunity for participation provided. Suitable for monitoring change over time.
31	Air Quality	European Air Quality Index		district	region-al		■		Reports for individual stations across the EEA (European Economic Area), which means it is only relevant for the European Life-Labs. Cannot be scaled

									to the micro level of individual NBS interventions. There are likely many background factors influencing the data. Low level of expertise required and no opportunity for participation provided. Suitable for monitoring change over time.
32	Place Regeneration	Derelict land reclaimed for NBS	street	district	city				Only relevant if NBS are created on open and previously derelict spaces. Offers a more valid measure of place regeneration than indicator 33 below, but still considered less credible than some of the other indicators in this cluster. Opportunities for participation are limited.
33	Place Regeneration	Quantity of blue-green space ratio to built form	street	district	city				This ratio of open space to urban built form is not necessarily a good measure to monitor NBS pilots, as open space does not equal NBS and densification can also provide opportunities for more NBS. The credibility as a measure for regeneration can therefore be questioned. The variable offers limited opportunities for monitoring change over time and participatory monitoring.
34	Place Regeneration	Perceived quality of urban green, blue and blue-green spaces	street	district	city				The most valid measure of place regeneration in this cluster. The indicator is mostly relevant to score quality of a particular NBS, which limits scalability to higher levels. It provides some opportunities for participation, while also allowing for monitoring change over time. The measure is based on a survey, which limits feasibility given the need to get this professionally translated and validated.
35	Place Regeneration	Place attachment (sense of place): place identity	street	district	city				Indicator scores well on scalability and opportunity for participation, while also allowing for monitoring change over time. The measure is based on a survey, which limits feasibility given the need to get this professionally translated and validated. Might not necessarily be a good indicator of improved sustainability.
36	Place Regeneration	Recreational value of public green space	area	district	city				Provides a simple and effective measure of the number of recreational activities in the NBS. Can be easily scaled and used for monitoring change over time. Also offers good opportunities for participation. Might not necessarily be a good indicator of improved sustainability. Recommended to combine this measure with surveys or interviews to understand cultural values and the role of functional features in predicting visitor motivations.
37	Place Regeneration	Incorporation of environmental design in buildings		district	city				This measure for individual buildings measures many sustainability components of buildings beyond the use of NBS, which limits sensitivity. The focus on individual buildings also limits relevance for regeneration of a place as a whole, opportunities for scaling and assessment of changes over time.

									Draws on survey which needs professional translation, which limits feasibility. No opportunities for participation.
38	Place Regeneration	Preservation of cultural heritage		district	region-al				A rather broad measure of cultural heritage that includes the consideration of all heritage places in urban planning. The measure is simple using a single question but because of the focus on planning it cannot be easily scaled to lower levels or used for monitoring short-term change. The measure is not highly relevant for assessing regeneration and does not allow for participation.
39	Knowledge and Social Capacity Building for Sustainable Urban Transformation	Citizen involvement in environmental education activities	site	district	city				Measure making use of a survey to assess global environmental awareness as a proxy for environmental education by citizens but may also incorporate more qualitative methods to study implementation and effects of environmental education efforts in relation to NBS. Provides a relatively direct measure of knowledge and social capacity. Good opportunities for participation. Not easily scalable beyond the micro level. Could be quite resource-intensive, a characteristic applying to all indicators in this cluster. *Sensitivity to NBS pilot interventions is likely limited for this sustainability challenge, which is why there is no favoured indicator.*
40	Knowledge and Social Capacity Building for Sustainable Urban Transformation	Social learning regarding ecosystems and their functions/services	site	district	city				Provides a measure of how decision-makers incorporate knowledge about NBS in their processes, discussions, and documents. Does not rely on structured survey that needs to be translated like indicators 41 & 42, but is quite resource-intensive given the combination of methodologies that is required. Difficult to scale to lower levels and no scope for participation. *Sensitivity to NBS pilot interventions is likely limited for this sustainability challenge, which is why there is no favoured indicator.*
41	Knowledge and Social Capacity Building for Sustainable Urban Transformation	Pro-environmental identity	site	district	city				Provides a more direct measure of connection to nature than indicator 42 below – relevant for nature-based thinking concept. Some overlap with indicator 35 on place identity. Its validity for assessing knowledge and capacity is limited. This indicator is challenging to assess beyond the micro level given reliance on survey methodology. The measure is based on a survey, which limits feasibility given the need to get this professionally translated and validated. Limited opportunity for participation. *Sensitivity to NBS pilot interventions is likely limited for this sustainability challenge, which is why there is no favoured indicator.*
42	Knowledge and Social	Pro-environmental behaviour	site	district	city				NBS may be expected to influence pro-environmental behaviour if resulting in improved connection to nature. However, this is a rather indirect

	Capacity Building for Sustainable Urban Transformation							■	measure of such an effect. Its validity for assessing knowledge and capacity is limited. Opportunities for pursuing environmental goals may be limited in the urban context. Challenging to assess beyond the micro level given reliance on survey methodology. The measure is based on a survey, which limits feasibility given the need to get this professionally translated and validated. Limited opportunity for participation
43	Participatory Planning and Governance	Openness of participatory processes		district	city		■		This indicator provides an indication of the number of participatory activities, the level of engagement and the quality of engagement. The method is not entirely transparent, especially the scoring and weighting of different sub-variables, which reduces feasibility. Scalability and suitability to monitoring change over time are limited. Monitoring of stakeholder meetings is a good idea, but citizen support can also be informal. Therefore, we consider the outcomes of participatory governance (indicators 45 & 48) more relevant than the number of activities or how these are externally evaluated.
44	Participatory Planning and Governance	Openness of participatory processes: proportion of citizens involved		district	city		■		A measure specific on the number of public participation processes. This is a simple and relevant measure if studied in relation to relevant themes such as NBS. However, sensitivity to individual NBS pilots is likely low. Scalability is limited as it is mostly relevant at the city-level. There is no clear scope for participation.
45	Participatory Planning and Governance	Sense of empowerment: perceived control and influence over decision-making	site	district	city	■			Psychological empowerment is a relevant outcome of participatory governance of NBS when citizens are involved. Potentially a high level of expertise is required, but researchers can choose between quantitative and qualitative methods, including e.g. stakeholder analysis. If using a survey, this needs to be translated professionally. Most relevant at micro level, it cannot be easily scaled to higher levels. There is limited scope for participation. *It is a rather indirect measure of governance – alternative governance indicators will be developed by Task 4.1.*
46	Participatory Planning and Governance	Public-private partnerships activated			city			■	Although a relevant governance measure, there are many more ways for different parties to work together than only public-private partnerships. The measure cannot easily be scaled down to lower levels. There is no scope for participation.
47	Participatory Planning and Governance	Policy learning for mainstreaming NBS			city		■		A rather straightforward measure of the number of policies promoting NBS. Cannot be easily scaled down to lower levels, but rather straightforward to measure through document analysis. Monitoring period may be too short

									for finding an effect. Good measure of planning, but rather limited as a measure of governance. Clear overlap with indicator 40.
48	Participatory Planning and Governance	Trust in decision-making procedures and decision makers	Area	district	city				Political trust is an important factor predicting scope for social learning and can be increased through successful partnership working. Potentially a high level of expertise is required, but researchers can choose between quantitative and qualitative methods. If using a survey, this needs to be translated professionally. Scalability to higher levels of limited. There is some scope for participation. *It is a rather indirect measure of governance – alternative governance indicators will be developed by Task 4.1.*
49	Social Justice and Social Cohesion	Bridging social capital - quality of interactions between social groups	site	district	city				Measure of whether interactions mainly take place with others having similar or dissimilar demographic backgrounds, and perceived quality of this. Would be a relevant measure if NBS is expected to contribute to the mixing of different demographic groups. Scalability to higher levels and scope for participation are limited. Complementary with indicator 50.
50	Social Justice and Social Cohesion	Bonding social capital - quality of interactions within social groups	site	district	city				Measure of whether interactions mainly take place with others having similar or dissimilar demographic backgrounds, and perceived quality of this. Would be a relevant measure if NBS is expected to contribute to the mixing of different demographic groups. Scalability to higher levels and scope for participation are limited. Complementary with indicator 49.
51	Social Justice and Social Cohesion	Inclusion of different social groups in NBS projects		district	city				A single survey question to study how NBS contributes to participation of underrepresented groups provides a simplified approach to studying a complex phenomenon. As a result, credibility of this indicator is relatively low. However, the question touches on the core of this challenge area. It could be improved by refining it to individual items for different types of vulnerable groups. The indicator does not provide opportunities for participation and scalability to higher levels is limited.
52	Social Justice and Social Cohesion	Trust within the community	site	district	city				Trust is a component of social cohesion and can be measured using established surveys, along with aspects of solidarity and tolerance (indicators 53 & 54). Scalability to higher levels and scope for participation are limited. The measure is based on a survey, which limits feasibility given the need to get this professionally translated and validated. No clear opportunity for participation.
53	Social Justice and Social Cohesion	Solidarity among neighbours	site	district	city				A measure of social capital indicating preparedness to help others in the community. This is a slightly more indirect measure of social cohesion than some of the other indicators, which is why the link to sustainability challenges is less obvious than for other indicators in this cluster. Scalability

							■		to higher levels and scope for participation are limited. The measure is based on a survey, which limits feasibility given the need to get this professionally translated and validated.
54	Social Justice and Social Cohesion	Tolerance and respect	site	district	city	■			Tolerance and respect for differences between people is a component of social cohesion and can be measured using established surveys, along with aspects of solidarity and tolerance (indicators 52 & 53). Scalability to higher levels and scope for participation are limited. The measure is based on a survey, which limits feasibility given the need to get this professionally translated and validated. No clear opportunity for participation.
55	Social Justice and Social Cohesion	Availability and equitable distribution of blue-green space			city		■		Spatial analysis of green space availability as a function of socio-economic factors provides a credible approach to evaluating environmental justice. There is considerable overlap with indicator 19, which has overall better scalability. Therefore, we recommend using that indicator instead. This indicator is, however, more relevant if there is an interest in comparing access between different types of groups.
56	Health and Wellbeing	Level of outdoor physical activity	site	district	city	■			Relevant straightforward measure to assess effects of NBS on physical activity, which is relatively suitable to monitor change over time and could potentially be scaled. The measure is based on a survey, which limits feasibility given the need to get this professionally translated and validated. No clear opportunity for participation.
57	Health and Wellbeing	Level of chronic stress (Perceived stress)	site	district	city	■			This provides a very relevant measure within this cluster given that the mitigating effects of nature experience on stress levels are well-established. Medium levels of scalability and suitability to monitoring change over time. The measure is based on a survey, which limits feasibility given the need to get this professionally translated and validated. No clear opportunity for participation.
58	Health and Wellbeing	General wellbeing and happiness	site	district	city		■		Life satisfaction, including finding a sense of purpose and mood or affect, is a relevant measure within this cluster. Given the focus on general life satisfaction and finding purpose in life, in addition to affect, the effects of nature might be slower to observe than when only focusing on affect. Medium levels of scalability and suitability to monitoring change over time. The measure is based on a survey, which limits feasibility given the need to get this professionally translated and validated. No clear opportunity for participation. It overlaps with indicator 71, but that indicator lacks a hedonic or experienced component.

59	Health and Wellbeing	Self-reported mental health & well-being	neigh-bour-hood						Positive effects of nature on mental health are to be expected, but it provides a less direct measure of the positive effects of nature than some of the other indicators in this cluster. Would be relevant if improving mental health is a direct objective of a pilot. Relatively low level of scalability and a medium suitability to monitoring change over time. The measure is based on a survey, which limits feasibility given the need to get this professionally translated and validated. No clear opportunity for participation.
60	Health and Wellbeing	Cardiovascular diseases (prevalence, incidence, morbidity & mortality)	neigh-bour-hood		city				This measure requires access to data on cardiovascular disease and the analysis of large datasets. The analysis is therefore likely very complex and requiring a high level of expertise. Likely requires long-term assessment to establish an effect of the NBS. No opportunity for participation.
61	New Economic Opportunities and Green Jobs	Value of NBS calculated using the 'GI-Val' toolkit	plot	district	city				Provides a prediction of potential impact of green infrastructure, without doing any on-site assessments. Therefore it is not suitable to monitoring change over time. It looks at a range of benefits, much broader than only the green economy, which limits credibility. Validity may be lower in non-European context. It cannot be easily scaled beyond the project level. No opportunity for participation.
62	New Economic Opportunities and Green Jobs	Value of NBS calculated using Economic Value of Urban Nature Index	site						The value of one type of urban nature to urban residents relative to another is not the most credible measure for a green economy. The measure cannot be easily scaled to higher levels and not suitable to monitoring change over time. No opportunity for participation.
63	New Economic Opportunities and Green Jobs	Mean land and/or property value in proximity to green space		district	city				A commonly used approach for measuring economic impacts of NBS, but increasing prices of land and property can also be socially exclusive, which means it could undermine the social pillar of the green economy. It might be relevant to use this indicator for monitoring effects on social equity, but care needs to be taken when interpreting findings this way – they need to be compared with developments in the city as a whole. Scalability of this measure is somewhat limited. No opportunity for participation.
64	New Economic Opportunities and Green Jobs	Changes in mean house prices / rental markets		district	city				Very similar to indicator 63, but also looks at rental prices. See indicator 63 for a justification of the appraisal.

65	New Economic Opportunities and Green Jobs	Average land productivity and profitability		aquifer scale	aquifer scale			■	This measure is about economic return of agricultural activity per ha, which is unlikely of interest in an urban context and not the most credible measure for a green economy. The measure is not scalable and provides no opportunity for participation.
66	New Economic Opportunities and Green Jobs	Property betterment and visual amenity enhancement		district	city		■		Similar to indicator 62 and 63, but with valuation weighted for investment made. See indicator 63 for a justification of the appraisal.
67	New Economic Opportunities and Green Jobs	Number of new jobs created	plot	district	city	■			This provides a straightforward measure of how many jobs are created because of the NBS at the municipality and project partners. It provides a credible measure for the green economy, has good scalability, and can be used for monitoring change over time. Relevance is likely limited for informal urban NBS. No high level of expertise required. No clear opportunity for participation.
68	New Economic Opportunities and Green Jobs	Retail and commercial activity in proximity to greenspace		district			■		Retail and commercial activity in proximity of an NBS does not necessarily contribute to sustainability, which harms credibility of this indicator. However, data may be controlled for type of commercial activity. It is suitable to monitoring change over time. Scalability and opportunities for participation are limited.
69	New Economic Opportunities and Green Jobs	Number of new businesses created and gross value added to local economy		district	city			■	Measure of Gross Value Added by businesses created as a result of NBS. Measure does not reflect how sustainable those newly created businesses are, which limits credibility. Most urban NBS likely do not result in the creation of new businesses. Scalability and opportunities for participation are limited.
70	New Economic Opportunities and Green Jobs	Recreational monetary value		district	city			■	This provides an estimate of recreational value based on background information such as population density, street network and NBS attributes. There is direct measurement of willingness to pay and acceptable walking distance. The suitability for monitoring change over time is therefore limited. It requires a high level of expertise to calculate, unlike some of the other measures in this cluster. The measure cannot be easily scaled to higher levels.
71	New Economic Opportunities	Overall economic, social and health wellbeing		district	global		■		This indicator of general well-being shows parallels with indicator 58, which is likely more sensitive to short-term changes in mood/affect. It reflects achievement against key dimensions of human development and/or

	and Green Jobs								development over time on the index of social deprivation. It represents a good measure of the green economy, but clear effects are unlikely to emerge at short time intervals within the timespan of the project. Scalability and opportunities for participation are limited.

5 The development of a comprehensive set of indicators for NBS governance

In Chapter 2, we showed that some of the recent NBS assessment frameworks include governance indicators. Examples of these are proportion of citizens involved in participatory activities, sense of citizen empowerment and number of public-private partnerships activated. We claim that these indicators build upon a rather narrow framing of governance with a specific focus on (preparedness for) citizen participation and therefore non-hierarchical steering. However, in the CONEXUS assessment framework we aim for a broader, more comprehensive understanding of governance as: "the totality of interactions, in which public as well as private actors participate, aimed at solving societal problems or creating societal opportunities" (Kooiman, 2003, p.4). Importantly, this includes not just the interactions with citizens, but also with other actors. Moreover, it also comprises self-steering, and the factors influencing steering, such as institutions, the funding landscape and available expertise (Lawrence et al., 2013). Governance encompasses a range of different potential arrangements between government, market and civil society actors, varying from centralized governance with a strong degree of top-down planning by government to self-governance where space is provided for civil society (or market) -led planning with government in a more supportive or facilitatory role (Ambrose-Oji et al., 2017; Driessen et al., 2012; Wild et al., 2020).

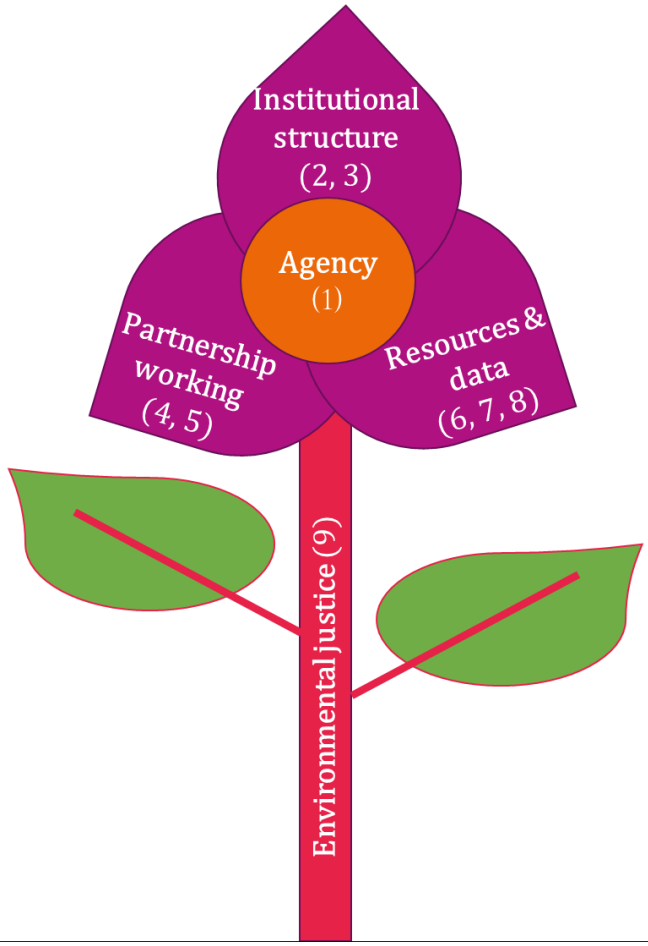

Figure 12. Visualization showing how agency is central to the realization of an improved institutional structure, partnership working and data & monitoring. We call for an approach where valuing diversity, equity and inclusion is at the basis of NBS governance. The digits (between brackets) correspond with the governance indicators in Table 6.

To advance the current use of governance indicators in assessment frameworks for NBS (Chapter 2), we carried out a scoping literature review on the topic of urban NBS governance (see Appendix A for a description of the Methods). Using thematic analysis and a combination of inductive and deductive analysis, we developed a framework with five themes, together encompassing nine governance indicators, of which some can be further broken down into dimensions (Table 6). Figure 12 visualizes how the indicators can be positioned in relation to each other for NBS to 'bloom'. The Nature-Based Innovation Systems framework (van der Jagt, Raven, et al., 2020) and the NATURVATION portfolio of stepping stones for mainstreaming urban NBS (Xie et al., 2020) provided key sources of intellectual influence during framework conceptualization.

Table 6. The thematically grouped governance indicators and corresponding dimensions relevant to the uptake of urban NBS used as a basis for developing higher-level governance indicators.

Number	Themes	Indicators	Dimensions
1	***Agency***	*Agency*	Commitment to NBS by politicians and executive management
			Enabling staff to act as NBS ambassadors
2	***Institutional structure***	*Governance structure*	Combining different modes of governance
			Integrated working
3		*Legislation, regulations & policies*	
4	***Collaboration & partnerships***	*Collaborative arrangements*	
5		*Active community engagement*	
6	***Resources and data***	*Monitoring and assessment*	
7		*Knowledge acquisition and sharing*	Access to relevant expertise
			Environmental education
			Social learning based on a reflexive approach
8		*Financing mechanisms*	
9	***Environmental justice***	*Valuing diversity, equity and inclusion*	Recognizing culturally diverse perspectives
			Fair representation of stakeholders
			Ensuring equitable access to NBS

Once we established a structure for reporting on governance indicators relevant to urban NBS uptake, we applied this structure to coding the interview data for each of the seven Life-Labs (see Appendix A for a detailed description of the Methods). This served to build a structured understanding of the role of governance – both challenges and opportunities – in the Life-Lab cities. The outcomes of the interviews analysis are

presented in text-boxes entitled 'What did the Life-Lab cities say?' presented for each of the governance indicators below.

On the basis of the governance framework, we developed a set of new indicators to be integrated in the CONEXUS participatory assessment framework. There will be an opportunity for the Life-Labs to provide feedback on these (see Chapter 6). The indicators can be assessed using a survey to be distributed to some of the key actors in the city and/or life-labs, including the municipality or city administration. The survey includes four questions for each governance indicator. For each dimension, the first two questions ask about the extent to which a particular governance process is conducive to NBS uptake (e.g. integrated working) can be observed in a particular city, and how this has been achieved. The second set of questions relate to the perceived significance of governance processes. Here, respondents are asked to indicate the extent to which each governance indicator is considered decisive in determining the successful uptake of NBS in a particular city. Respondents are also asked to explain their response. An overview of a survey that could be used for assessing these indicators is provided in Appendix B. An example of a question for the indicator of Agency is provided below. Table 7 provides an overview of evaluative criteria for each of the governance indicators, derived from the more extensive scoring rubric provided in Appendix B.

1. a)	To what extent are nature-based solutions initiatives being championed in your city? *Please rate your personal view between 1 (not at all) and 5 (to a great extent)*	*Not at all*	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	*To a great extent*
b)	If answered 3 or higher, please describe how this has been achieved by referring to particular actions taken: …							
c)	To what extent is the championing of nature-based solutions a decisive factor for the successful uptake of NBS in your city? *Please rate your personal view between 1 (not at all) and 5 (to a great extent).*	*Not at all*	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	*To a great extent*
d)	Please explain your viewpoint, for example by referring to particular characteristics of your city and its people, environment, economy or political situation …							

Note, that unlike the indicators on NBS performance, there is no scope for Life-Labs to pick and choose from these indicators on NBS governance - all dimensions are interrelated as shown in Figure 12. Therefore, the approach to assessing governance using this framework is the same across each of the Life-Labs. The survey has been designed to keep assessment simple yet comprehensive, resulting in higher feasibility.

Table 7. The governance indicators along with key evaluative criteria for measuring these.

Governance indicators	Key evaluative criteria
Agency	- NBS are championed by a range of actors in leadership positions at different institutions relevant to the city - Staff at municipalities and non-governmental organizations are enabled and, where possible, incentivized for their engagement with the topic of NBS
Governance structure	- Strategic collaborative working relationship between different departments, e.g. through a multidisciplinary hub - The development of NBS is supported by multiple plans and policies emanating from different departments
Legislation, regulations & policies	- Housing, infrastructure and/or utility providers are mandated by one or more levels of government to incorporate NBS into planning and design approaches. - There are a number of government action plans or policies directly contributing to more NBS in the city
Collaborative arrangements	- The municipality engages in partnership working with private firms and civil society on NBS - There is an active working relationship between public institutions managing different levels of the (peri-)urban green infrastructure
Active community engagement	- Citizens are engaged in the co-design and -management of NBS projects and plans throughout the city - Citizen initiatives are supported with human and financial capital
Monitoring and assessment	- The municipality applies indicators, combined in an assessment framework, for monitoring NBS along a range of urban challenges - Pooled data is used for decision-making about where to invest in which type of NBS
Knowledge acquisition and sharing	- There is access to expertise required for the development of a broad range of NBS - The development of new knowledge relevant to NBS is encouraged through experimentation, education and social learning opportunities
Financing mechanisms	- NBS development and maintenance is supported with a sustainable and diversified funding structure. - NBS are partially funded through innovative business models involving the private sector, NGOs or other relevant actors
Valuing diversity, equity and inclusion	- Different groups in society are recognized and fairly represented in decision-making processes relevant to NBS development - NBS are distributed equitably across the city, resulting in different societal groups having comparable levels of access to NBS benefits

5.1 Agency

5.1.1 Commitment to NBS by politicians and executive management

The uptake of innovations such as nature-based solutions into urban planning practice is not self-evident. Politicians and executive leadership are therefore key to generating support and guiding the planning and implementation of NBS and related concepts (Dushkova & Haase, 2020; Li et al., 2020; Wamsler et al., 2016; Workalemahu Habtemariam et al., 2019; Zuniga-Teran et al., 2020). They are central to the endeavour of renaturing cities – directly by implementing new NBS and relevant policy and regulation, and indirectly by providing funding and policy support to relevant bottom-up initiatives to legitimize and sustain these. In addition, they can invest in the professional development of their staff; and help to (re)defining internal structures, formal norms and role descriptions, in ways that are supportive of NBS development (Wamsler, 2015; Workalemahu Habtemariam et al., 2019).

5.1.2 Enabling staff to act as NBS ambassadors

In addition, there is a need for committed staff at municipalities and other institutions (e.g., non-profits or universities), who champion NBS through funding applications for new projects, rethinking policy, outreach to the general public, and lobbying powerful actors (e.g. politicians or influential adaptation networks) (Kabisch et al., 2016; Wamsler, 2015; Wamsler et al., 2014, 2020; Workalemahu Habtemariam et al., 2019). A particularly important task is to coordinate social learning processes and integrated planning by interdisciplinary stakeholder groups across different levels (Ibrahim et al., 2020; Larson et al., 2013; O'Donnell et al., 2018). There is a need for such leadership to persist even with unfavourable shifts in the political or policy landscape (Ibrahim et al., 2020; Mell, 2020b; Shih et al., 2020).

Successful championing of NBS relies on the availability of human capital. Perhaps most importantly, NBS champions need to be able to relate to the realities and priorities of different disciplines involved in order to build a shared conceptualization of NBS and their values in a particular context (Sarabi et al., 2019). This requires well-developed networking capacities and expertise regarding the rationales of stakeholders and how this intersects with the broad range of urban sustainability values associated with NBS (Wamsler et al., 2020). Successful leaders also should be open to new ideas and instruments (e.g. to support spatial planning), and actively seek new knowledge in these areas through e.g. partnerships with academia (Campbell et al., 2016; Frantzeskaki, 2019; Wamsler et al., 2014).

Text Box 4a. Agency: What did the Life-Lab cities say? (1/2)

The interviews supported the view from the heads of municipal departments, mayors, elected municipal officials and other senior staff in charge of projects who play a central role in agenda setting, intra-municipal coordination of activities and timelines between departments on key cross-cutting themes. They also influence other aspects of governance, including the availability of relevant knowledge and finance, the working culture and the extent to which data driven decision-making takes place (SAO,BA). Elected officials and senior staff thus play an important role in ensuring that the environmental and sustainability perspectives are taken into account right from the beginning of the urban planning processes, which facilitates the integration of NBS (SAO). Moreover, they have the power to influence public opinion, and even incite social movements, through high-impact initiatives. For example, the former mayor of Bogotá – Enrique Peñaloza – was responsible for a programme resulting in the planting of 100,000 trees in the city.

> *"The São Paulo mayor was an example for us in the way he tried to set up the cycling path network and all the responses [of support] there were [in return]. We went through the same here but São Paulo had a much better organized lobby at the time. In the meantime, I think we've matched that [level of] lobbying and now there really is a support structure, which there wasn't ten years ago. So if someone wants to do harm to the cycling network they're going to have to face a lot of people along the way. The same thing [happens] for tree advocacy" (LIS).*

In this sense, it is a concern that cities such as São Paulo and Bogotá experience political volatility with frequent shifts in political direction and leadership, which can diminish support for NBS and the retention of relevant expertise.

> *"There is a very strong polarisation, and that makes it even more difficult for the civil servants who are in these administrations to maintain a single line of work. Every four years they are changing from one [political] side to the other, and whoever arrives [in the position of power] wants to completely change what the previous one did, to ignore it, and that generates many conflicts and challenges" (BOG).*

Committed staff members can, however, exert a strong influence over the initiation of particular projects conducive to the protection and advancement of NBS, provided that they bring the right people together. Municipal staff in São Paulo were actively attempting to make the management of NBS more resilient to political change by setting up an environmental information system and increasing transparency in departmental responsibilities related to this. This ensures adequate long-term storage of data important to the continuity of monitoring with buy-in from several departments.

Text Box 4b. Agency: What did the Life-Lab cities say? (2/2)

" [If] you are working on a [research] project related to NBS, [then] you need information [...], and you start to look for partners to understand who could effectively collaborate in the project. The same thing applies to us within the public administration. [...] [For example,] I might be clear about the technical or methodological outlook on a certain subject, but to implement the project I [need to] train the team, have hardware, software, [and] field monitoring. In the end, it hinges on the people working there" (SAO).

5.2 Governance structure

5.2.1 Combining different modes of governance

Non-hierarchical governance and network-type of approaches have been associated with a successful NBS uptake (Fink et al. 2019; Ibrahim et al., 2020; Workalemahu Habtemariam et al., 2019). Such arrangements are characterized by high network connectivity and a distribution of decision-making power and resources (Campbell et al., 2016; Schifman et al., 2017). However, leadership and mandatory urban greening measures could also be powerful levers for NBS mainstreaming, as shown in the descriptions for the next two dimensions below. In addition, there is a need for applying checks and balances via top-down steering in order to maintain a sufficient level of democratic control on e.g. NBS design and distribution (Mell, 2020a; Toxopeus et al., 2020). Therefore, opportunities for improved governance of NBS can be identified regardless of the dominant governance structure in a city and/or nation, with the ideal situation a strategic combination of network governance and hierarchical steering.

5.2.2 Integrated working

To generate broad policy support for NBS and related objectives (e.g. biodiversity enhancement and climate action), there is often a need to reconfigure or realign institutional structures within city administrations (Dorst et al., 2019; Pauleit et al., 2019; Randrup et al., 2020; Wamsler, 2015). There are different ways to achieve this. One approach is to reshuffle departments and sections in order to create new coalitions, while another option is to appoint a particular boundary spanning group or individual with the specific task of bridging different municipal departments (e.g. on spatial planning or environmental conservation) relevant to NBS development (Wamsler et al., 2014, 2016, 2020; Zuniga-Teran et al., 2020). An external organization such as a university or an NGO can also take up this role within the context of specific transdisciplinary projects that aim to influence the management of socio-ecological systems (E. Andersson, 2018; Campbell et al., 2016; Workalemahu Habtemariam et al., 2019).

Relevant activities conducive to, and evidencing, boundary spanning include shared meetings, joint field trips, intersectoral project collaborations and consultation of a range of departments on new policies and plans (Wamsler et al., 2020). Success can also be measured through the integration of NBS in environmental and cognate policy frameworks and operations, including those related to water management, nature conservation, horticulture, transport, infrastructure and climate action (Aubrechtová et al., 2020; Dushkova & Haase, 2020; Mguni et al., 2015; Pasimeni et al., 2019; Wamsler, 2015; Wamsler et al., 2016; Wang et al., 2021). In order to achieve this, there is a need to engage with emerging structures and resources developed as part of efforts to upscale low carbon measures and other types of sustainability innovation (Wamsler, 2015; Wamsler et al., 2014).

Text Box 5a. Governance structure: What did the Life-Lab cities say? (1/2)

The issue of coordinating different departments and teams relevant to sustainability and environmental management was most frequently mentioned as a governance challenge in the cities that have been studied (SAO,STGO,BA,TRN). This affects the stages of project design, project planning and project maintenance, but also policy development relevant to sustainability (TRN). The Environmental Policy department (alternatively called: Secretariat of Environment – SAO,BOG) is often perceived as responsible for sustainability policy, even though it is a cross-cutting issue bearing relevance to multiple departments (TRN).

> *"The main challenge is to coordinate the different departments [in order] to understand the 'backbone' of the city's environmental management. This depends on a lot of multidisciplinarity, on the technicians in the other departments or other bodies related to the specific management of some [related urban] themes. [...] And also to align the offices of high administration. Everybody thinks this is only the responsibility of the Secretariat for the Environment, but they don't understand that this is a city[-wide] issue" (SAO).*

> *"Beyond good intentions and having a certain awareness that it is necessary to apply certain sustainability criteria, there is not much [focus] on who takes responsibility, and from that to allocate positions of responsibility" (STGO).*

Text Box 5b. Governance structure: What did the Life-Lab cities say? (2/2)

Different cities mentioned different solutions to this challenge. A solution could be to create environmental nuclei or centres within the different departments, such as was done in São Paulo in i.a. the Secretariat of Education. Alternatively, a new intermediary body, task force or working group could be created to act as a single hub for all relevant departments regarding sustainability planning and policy (TRN,BA). The introduction of the Urban Ecology Directorate in Barcelona is probably the most impactful example of this encountered in the studied cities. This encompasses a single unit responsible for issues around the environment, urban planning, infrastructure and mobility. As a result, formerly complicated relationships between these departments have been strengthened, resulting in less conflicts of interest. The new unit has around 1,200 staff and although working together has not always been easy, a number of successful projects have emanated from the creation of this hub, that would otherwise not have happened or at a much longer time-scale. An example is the urban canopy project in Parque de las Glorias, done collaboratively with various disciplines. The Urban Ecology Directorate also serves as a timely reminder that partnership working culture can improve very rapidly provided that there is sufficient desire and political intention:

> *"Not so long ago, let's say 10 years, the relationship with, for example, urban planning on projects was very weak, practically non-existent, and it was carried out through the managers. This has changed completely. Now, the nature plan is done collectively with all these people, we are assembling the projects to do [together]" (BCN).*

5.3 Legislation, regulations and policies

One of the most effective ways to mainstream NBS is to mandate sustainable urban drainage systems, street trees and other examples of nature-based climate measures as compulsory measures in land use policy and comprehensive planning (Clark et al., 2020; Kordana & Daniel, 2020; Sarabi et al., 2019; Wamsler et al., 2016). NBS also benefit from the legal protection of urban green- and blue spaces on public and private land through, municipal ordinances, byelaws or permit systems and the use of standards around environmental quality and pollution, when these are actively enforced (Clark et al., 2020; Kordana & Daniel, 2020; Zuniga-Teran et al., 2020). Beyond planning frameworks, the public procurement system provides an avenue to mandate urban NBS, for example by including a requirement for pro-environmental measures in the application process (Kordana & Daniel, 2020). Other types of policy instruments used by cities to provide a clear direction for NBS development include no net loss regulation, participatory planning approaches and ecosystem services assessment (BenDor et al., 2018; Dobbs et al., 2019; Wamsler et al., 2020).

Text Box 6a. Legislation, regulations and policies: What did the Life-Lab cities say? (1/2)

The interviews suggested that the public mandate for urban NBS is not very strong yet, with no clear examples of compulsory NBS measures as part of e.g. new urban development projects provided. Urban planning frameworks such as the Master Plan, General Metropolitan Plan or Land Use Plan were described as conducive to maintaining a sense of continuity in urban nature policy, especially in countries with political volatility (BOG). These plans can be very powerful drivers of urban nature development vis-a-vis conflicting land uses on public land, particularly on derelict land (BCN,LIS):

> *"In just over 10 years we implemented a 15% increase in the green structure of the city. That's 250 hectares of new green spaces. Except for one specific case, where a park is being built on an old car junction and it is necessary to remove the asphalt, almost all of it was land that the Master Plan endorsed us to build the green structure [on]. In some cases we had to buy some land, but 80% of the problems were immediately solved by the Municipal Master Plan" (LIS).*

NBS measures were included in some cases in Green Infrastructure, Biodiversity, Urban Trees and/or Climate Action Plans (BCN,TRN). They were also sometimes promoted by policy in domains such as Housing, for example to alleviate the risk of flooding (SAO). None of the interviews mentioned examples of specific NBS policy documents. Policies supporting NBS measures act as important reference works when it comes to interdisciplinary action planning and adopting a structured approach to NBS assessment:

> *"It gives our department a firm reference point for assessing policy implementation with indicators based on specific actions and goals, and the ability to monitor [these]. But it also gives us the opportunity to do that coordination, which I think we've only been able to do very emblematically in the past. In the sense that now we [are able to] have periodic meetings with all of the different departments that are touched by these strategies and confer with them about what they are able to implement in what time frame" (TRN).*

Text Box 6b. Legislation, regulations and policies: What did the Life-Lab cities say? (2/2)

International law and agreements helped to increase institutional preparedness for NBS implementation. The ratification of the Paris Agreement and national-level approval of the UN Agenda 2030, along with membership of sustainable cities networks such as C40, have spurred the studied cities to develop their own climate action commitments (e.g. the Action Plan for Buenos Aires Climate Neutral 2050). This prompted more integrated ways of working within municipalities in order to meet the goals that often transcend disciplinary boundaries. Establishing such cross-departmental connections improved staff members' understanding of the institutional structure and how to navigate this, which fosters future interdisciplinary partnership working (BA,SAO). In Europe, the European Union (EU) also acts as a catalyst for relevant policy development and indicator uptake. For example, the annual prestigious European Green Capital competition incites cities to produce evidence of how they are performing on a variety of sustainability themes (LIS).

Likewise, sustainability policy at regional, state and national scales can provide windows of opportunity for strengthening inter-municipal partnership working *across*. For example, the Green-Blue Municipality Programme, providing a shared environmental agenda for the 645 municipalities in the State of São Paulo, stimulated partnership and the uptake of a structured monitoring system to measure progress against the proposed actions (SAO). Likewise, Buenos Aires is implementing green corridors with active travel opportunities as part of a sustainable cities initiative at the federal level.

5.4 Collaborative arrangements

A vital step in the development of NBS is to forge collaborative ways of working between different types of institutions and organizations, as well as to operate across various scales and jurisdictions. This includes coalition building between governmental and nongovernmental actors (i.e. private firms, academia and civil society), which contributes to pooling funds and expertise (Ahmed et al., 2019; Frantzeskaki, 2019; Larson et al., 2013; Li et al., 2020; Sarabi et al., 2019; Schifman et al., 2017; Wamsler, 2015; Wamsler et al., 2020; Zuniga-Teran et al., 2020).

In the pursuit of partnership working, the engagement of actors with different interests and areas of (critical) expertise provides a fruitful approach to enable the design of multifunctional NBS. Relevant disciplines include urban planning and design, urban governance, water management, forestry, landscape architecture, horticulture, ecology, psychology and engineering (K. Andersson et al., 2013; Larson et al., 2013; Lin et al., 2019; Schifman et al., 2017; Wang et al., 2021). Actors with local knowledge (e.g. regarding traditional land-

based traditions and customs) also should be given a voice (Cousins, 2021; Gulsrud, Hertzog, et al., 2018). Transdisciplinary partnership work contributes to the mainstreaming of NBS beyond isolated interventions through social learning, shared visioning, co-creation of new knowledge and innovative practices, growth of social capital and empowerment (Dushkova & Haase, 2020; Kabisch et al., 2016; O'Donnell et al., 2018; Schifman et al., 2017). This implies the need for sufficient openness and flexibility to inputs by academics, local communities and city officers, among other actors (Fink, 2019; Ibrahim et al., 2020; Workalemahu Habtemariam et al., 2019).

Engaging the private sector can be challenging, so it might be fruitful to connect with Local Enterprise Partnerships, Local Nature Partnerships, Business Improvement Districts or other types of established public-private and public-civic coalitions to connect with potential investors for NBS (Mell, 2020b). Alternatively, hybrid governance arrangements involving public-private partnerships could be actively pursued to create more resilient funding streams for NBS (Mell, 2020a; Toxopeus et al., 2020). However, this should not come at the loss of government control over key urban public assets (Toxopeus et al., 2020).

In addition to partnering among different types of organizations, there is also a need for scale-crossing brokers to improve the alignment between urban and regional green infrastructure management. For example, spatial landscape data can support policy coherence across scales (Andersson et al., 2013; Aubrechtová et al., 2020). A regional planning authority is well-positioned to take up a leadership role in improving the alignment of activities between the local and national levels (Mell, 2020; Workalemahu Habtemariam et al., 2019). There is also a need for policy alignment with the Sustainable Development Goals at the transnational level (Rogers et al., 2020).

In order to build effective partnerships, there is a need for understanding the broader urban system, e.g. relevant sectors, coalitions and policies, in which NBS need to be integrated, as well as the stakeholder landscape associated with this (Larson et al., 2013). To improve the level of participation, it could be beneficial to appoint an chair person with a neutral position in sensitive political debates specific to that location (O'Donnell et al., 2018). The chair also needs to have good people skills and an ability to create rapport between different types of stakeholders (E. Andersson et al., 2014; O'Donnell et al., 2018). It can also be regarded good practice to regularly reflect on the functioning of the partnerships and how satisfied members are with their own role in these (Shih et al., 2020).

Text Box 7. Collaborative arrangements: What did the Life-Lab cities say? (1/2)

Given the importance attributed to collaborative arrangements between a broad range of actors in the scientific literature, it was surprising to find that there were few mentions of productive partnerships between municipalities, academia and NGOs for urban NBS in the studied cities. This is not to say that such collaborative arrangements do not exist at all regarding e.g. sustainability programmes more broadly. Nonetheless, we observed a desire to strengthen relationships with external actors in order to improve the alignment between e.g. research and municipal practice on the topic of NBS. There is particular scope of strengthening mutual relationships with academia.

> *"These external actors, for the time being, participate mostly in a provocative way. [...] I thought there would be a strong debate with the academy, the third sector and NGOs, and actually I felt a little orphaned in the technical debate with these external actors. [...] And perhaps this happened because there is no real rapprochement between what the academia is doing and what [of that knowledge] we actually use [in the municipality]" (SAO).*

A good-practice example can be found in Barcelona, where a broad range of actors contributed technical expertise to the development of the Barcelona Green Infrastructure and Biodiversity Plan, including i.a. The Science Museum, the Zoo, the Serra de Collserola Natural Park Consortium and the Consortium for the Protection of the River Besòs. Direct outreach to stakeholders, having a strong community of experts and developing pilot projects are two of the ways in which a municipality can make itself more attractive to external stakeholders (STGO,LIS).

Ironically, two cities that are well-established in influential international city networks such as C40 – Barcelona and Buenos Aires – experienced difficulties around forging an effective working relationship with neighbouring municipalities and higher levels of government. In Barcelona, the powerful City Hall operates relatively independently from neighbouring municipalities, the Metropolitan Area of Barcelona and the Barcelona Provincial Deputation responsible for planning and managing infrastructure and public services in the metropolitan region and beyond. This also applies to the use of indicators for NBS assessment.

> *"We would have to compare [ourselves] with Madrid, Paris or Lyon, with these types of cities, because in terms of territory we are very far apart [from regional cities]" (BCN).*

Text Box 7b. Collaborative arrangements: What did the Life-Lab cities say? (2/2)

Even within city boundaries, there can be profound challenges around partnership working between different municipalities. For example, in the Santiago metropolitan area there are over 50 different municipalities with different leaders, and a regional government in charge of coordinating inter-communal activities. The governance structure in Santiago provides an advantage for innovative micro-scale projects, but creates a challenge for projects transcending boundaries (BOG,STGO).

Such challenges of intermunicipal partnership working are, however, strongly city-specific. The situation in Santiago can be contrasted with Bogotá, where there is a single mayor and municipality for the entire city area. Amongst solutions to this challenge of partnership working across administrative boundaries are the implementation of ecosystem-level committees and top-down directives (e.g. related to water quality) inciting sustainability action at a catchment level (BA).

5.5 Active community engagement

Beyond working with private and third sector organizations, it is also crucial to invest in community engagement. To develop place-based NBS and build broad support for NBS in cities, community engagement needs to go beyond passive consultation, while at the same time providing space for experimentation by bottom-up initiatives (Buijs et al., 2016). There are many different ways in which this can be approached, e.g. through community management or transfer of NBS, incentivizing bottom-up NBS projects, crowdsourcing, focus groups, scenario building, storytelling and other platforms and methods for dialogue and exchange (e.g., Buijs et al., 2019; Frantzeskaki, 2019; Gulsrud, Raymond, et al., 2018; Toxopeus et al., 2020). These activities are perceived to bring about a broad range of benefits – improved public awareness, accounting for underrepresented views in decision-making, addressing socio-economic inequalities, the consideration of diverse nature values (e.g., cultural or spiritual) in decision-making, social cohesion and improved sense of belonging, the identification of new or alternative solutions to challenges, an improved user experience, increased public support of nature and improved motivation to engage in environmental stewardship on public and private land (E. Andersson, 2018; BenDor et al., 2018; Buijs et al., 2016, 2019; Campbell et al., 2016; Clark et al., 2020; Cousins, 2021; Dushkova & Haase, 2020; Ferreira et al., 2020; Finewood et al., 2019; Gulsrud, Hertzog, et al., 2018; Larson et al., 2013; Mguni et al., 2015, 2016; Nastran & Regina, 2016; Randrup et al., 2020; Shih et al., 2020; Wamsler et al., 2016, 2020).

The most empowering form of community engagement is citizen management or responsibility for NBS. To enable this, it is key for municipalities to provide adequate support on aspects such as fundraising,

management and legal affairs (Mell, 2020a). Some municipalities manage this through a dedicated front office or contact person available for support with practical questions or equipment (Buijs et al., 2019; Wamsler et al., 2020), but availability of long-term funding is also key for some types of initiatives (Dushkova & Haase, 2020). It could also be considered to draw upon the support of NGOs, consultants and other contractors with particular knowledge or skills that are lacking within the municipality (Buijs et al., 2019). In addition, municipalities could take up a coordinating role where they aim to facilitate mutual learning between initiatives, whilst also endeavouring to connect different initiatives with each other to enable social learning (Buijs et al., 2016). As coordinators of this process, municipalities also need to keep an eye on the extent to which community initiatives are inclusive of underrepresented groups in environmental decision-making (e.g. ethnic minorities, children, low-income groups, elderly people), and engage in compensatory measures if necessary (Kabisch et al., 2016; Steen Møller et al., 2019; Toxopeus et al., 2020). Financial incentives such as grants, loans, fiscal measures or donations of plants/trees or materials could be considered to steer citizen initiatives in strategic ways (Buijs et al., 2019; Clark et al., 2020; Schäffler & Swilling, 2013).

Aside from providing hands-on support, more empowering forms of community engagement benefit from the availability of a clear set of rules or guidelines around community management of public assets, which spell out the rights and responsibilities (e.g. around stewardship activities or internal management structure) associated with different forms of land tenure (e.g. use or lease) (E. Andersson, 2018; Buijs et al., 2016, 2019; Langemeyer et al., 2018). For example, there needs to be an adequate level of power sharing between different citizens that are members or partners of the initiative (Campbell et al., 2016; Shih et al., 2020).

Municipalities can also take advantage of smart technologies in supporting citizen engagement, particularly citizen science and crowdsourcing. A range of applications and technologies are available, including volunteered geographic information (VGI), e-tools and the Internet of Things (i.e. the networking of portable devices using the internet) (Campbell et al., 2016; Gulsrud, Raymond, et al., 2018; Steen Møller et al., 2019; Wild et al., 2019; Zevenbergen et al., 2018). Data collected in this way can be used to help understand what types of NBS are (dis)favoured by different demographic groups and what they consider to be missing (e.g. by co-creating maps) (Gulsrud, Raymond, et al., 2018; Sarabi et al., 2019). Smart technologies to support NBS development are most effective if there is scope for co-design by citizens and stakeholders, particularly if taking an inclusive approach where the views of different societal groups are utilized (Gulsrud, Raymond, et al., 2018; Steen Møller et al., 2019).

Text Box 8a. Active community engagement: What did the Life-Lab cities say? (1/2)

Some of the studied cities reported an increase in citizen feedback and activism with the support of (online) social networks, which in some cases resulted in more criticism on environmental planning and management (BOG). Occasions where this happens include, for example, when the most sustainable way of managing an NBS is not the most aesthetically pleasing or constrains the pursuit of particular recreational activities (LIS). It was considered problematic that the timing of the critical feedback provided often did not coincide with the formal consultation processes on environmental plans (BOG). It is, however, difficult to engage the public in such consultation processes, particularly those communities affected by poverty, which limits their interest in engaging with questions around the long-term sustainability of the city (BOG). The challenge is not limited to Latin American cities – promoting and supporting citizen participation on urban NBS was also considered important in Barcelona, partially because requests for NBS co-management are increasing in recent years (BCN). Efforts to address this include offering various ways of providing feedback (both digital platforms and walk-in), networking with communities, information sharing and hands-on projects (BOG,BCN,STGO).

> *"For many people, a well-tended green space is a green area with grass, [which is] mowed, like we see in the magazines. And that has no interest or little interest [to the municipality] [...] because it consumes water, it doesn't bring biodiversity and so we have been trying to change that paradigm. People don't accept it [...], they call the City Hall and send e-mails asking the City Hall to water [the flowers], because maybe someone forgot to water [the vegetation]. People don't understand natural processes" (LIS).*

Beyond the somewhat ineffective consultation processes related to formal plans and large-scale projects, the interviews also did not expose many inspiring examples of active citizen engagement in co-designing or -managing greening projects in the studied cities. Possibly because these were simply not considered important governance challenges or solutions.

> *"I think there is a lack of citizen participation. That would be really important [to do], so [that] all these issues of participation and awareness-raising, more campaigning, more work with neighbours [can be done], so that they understand what this is all about. But what happens is that it is rare, it is complicated" (BA).*

Text Box 8b. Active community engagement: What did the Life-Lab cities say? (2/2)

A notable exception is Santiago, where citizens in a large number of neighbourhoods were involved in co-developing a work plan for public space and environmental regeneration as part of the "I Love my Neighbourhood Programme". In Bogotá the mayor was an important instigator of participation and co-creation processes, but there was no dedicated budget to fund such activities. In the European cities municipal initiatives aimed at citizen engagement appear to be more widespread. For example, Lisbon has been integrating allotments in urban parks, with 800 plots divided over 21 parks created over a decade, while also implementing an orchard and vineyard for community use, the latter producing a wine that is used for city branding. The latest plan is to create a 4 hectare honey park with beehives as a new component within an existing park.

In Lisbon, more activating forms of participation such as co-creation of NBS were perceived to be crucial to success. Not only in creating a higher sense of ownership and satisfaction, but also in generating a higher level of social control to help protect the NBS from abuse by visitors (LIS).

5.6 Monitoring and assessment

NBS in cities benefit from a design sensitive to place-specific geographical conditions (E. Andersson, 2018), but also to societal challenges and user preferences in order to deliver upon their potential as multifunctional sustainability innovations (Pauleit et al., 2019). Therefore, copying best-practice examples from elsewhere without grasping the main local particularities is unlikely to contribute to success (E. Andersson, 2018; Gulsrud, Hertzog, et al., 2018; Larson et al., 2013; Shih et al., 2020). For example, the choice for the 'right' tree species and the design of sustainable drainage systems cannot be made without taking regional climate and biodiversity conditions and dynamics (e.g. rainfall intensities and seasonal droughts) into account (BenDor et al., 2018; Fink, 2019). Likewise, micrometeorological conditions *within* the urban fabric should be considered in order to distinguish the urban heat island 'hotspots' and how can they be addressed in effective ways. This implies that factors such as evapotranspiration, wind circulation, shading and light absorption need to be understood, which are influenced *inter alia* by urban form and density, surface albedo, the proximity to green- and blue spaces and their composition (BenDor et al., 2018).

In addition to acquiring an ecological and (micro)meteorological understanding of a city, neighbourhood or place, decision-makers also should heed the social, economic and cultural particularities of cities, neighbourhoods and communities (Mell, 2020a; Mguni et al., 2016). If NBS are used to create more sustainable cities and communities, it is important to get a sense of how green- and blue spaces might influence power dynamics – help to redress socioeconomic inequality or strengthening processes of green gentrification

(Cousins, 2021; Gulsrud, Hertzog, et al., 2018; Zuniga-Teran et al., 2020). To better grasp these aspects, there is a need for using instruments to map the spatio-temporal dynamics of socioeconomic inequality (Dobbs et al., 2019), while it is also desirable to engage with disenfranchised voices at specific locations where NBS are planned (Gulsrud, Hertzog, et al., 2018).

To build a place-specific understanding of relevant conditions and challenges relevant to NBS, one should have access data, invest in long-term monitoring programmes and gauge user preferences and place-specific attitudes and values using e.g. surveys or more qualitative modes of enquiry (Buijs et al., 2019; Li et al., 2020; Lin et al., 2019). This requires investment in expanding inventories (e.g. on urban trees) and keeping these up to date and, where possible, pooling information from multiple (geo-referenced) databases to build a more comprehensive picture (K. Andersson et al., 2013). For example, spatial data and modelling can be used to understand vulnerabilities to stormwater flooding, which enables a rapid appraisal of locations that might be suitable for NBS targeted at providing particular benefits (Kazak et al., 2018; Kuller et al., 2019).

Expert advice and guidance on how to integrate (particular types of) NBS into the urban fabric, as well as the particular policy instruments that can be used to support this, can help practitioners to design NBS that are well-embedded into their context (Tiwary et al., 2020; Wang et al., 2021). Although expert guidelines based on the state-of-the-art in science are available, these could be made more relevant if translated into different languages and with the contents adapted to specific geographic and socio-political settings (Dobbs et al., 2019). It is also important that cities are presented with examples from places with a similar level of sustainability ambition – cities tend to draw inspiration from places with similar priorities and a comparable political landscapes (Fink, 2019).

Furthermore, NBS are ideally monitored following their implementation to enable learning about what works well and what does not, regarding management approaches. There are a range of off-the-shelf metrics that can be used for this purpose, including i-Tree Eco or the Water Sensitive Cities (Kabisch et al., 2016; Lin et al., 2019; Rogers et al., 2020). Many assessment instruments also provide an economic evaluation, which can help to make the case for more investment in the development and maintenance of NBS (Li et al., 2020; Lin et al., 2019). An additional benefit of post-implementation assessment of NBS might be the identification of place-specific ecosystem disservices, including vector-borne diseases, allergy responses and tree-related nuisance, which could subsequently be addressed by a redesign of the NBS (Dobbs et al., 2019).

Text Box 9a. Monitoring and assessment: What did the Life-Lab cities say? (1/2)

Despite the importance attributed to data management in the review, some of the interviewed city representatives indicated to experience challenges around the limited availability of up-to-date and systematically collected data relevant to planning decisions influencing urban NBS (BA). One way of addressing this is by creating more transparency, not just externally, but also internally within public authorities about available indicators, which data is being collected and who is using this for which purposes. This generates a better sense of what data is available, which organizational unit is responsible, how it should be monitored, processed and communicated (SAO).

> *"We went through a long consultation process with all of the various city departments that will somehow be affected by extreme events, weather, precipitation, the urban heat island effect and so forth. And through that process we developed a framework, strategies and almost 80 specific actions to implement in the next years and then our indicators are directly corresponding to those actions" (TRN).*
> *"There were indicators for a lot of things that we didn't know about until we put a team together" (LIS).*

A complimentary measure would be the development of a single structured data repository including all types of environmental information (and other data relevant to NBS) collected by different municipal departments. This requires careful consideration by interdisciplinary teams of which data is relevant to include in a repository like this (SAO,TRN,LIS). For example, it might be particularly relevant to collect data that is directly relevant for reporting against formally agreed sustainability actions within the municipality because it allows for reporting progress related to local challenges (TRN). Once established, it is important to regularly keep updating the data repository, which requires good coordination with the inspection team and the institutionalisation of an 'information culture (SAO).

> *"The creation of an information culture is difficult, but once [the Environmental Information System is] implemented, it is necessary to update it year by year, reviewing the methodology and updating the data, and the system will not remain static. We will then [need to] organise and figure out the management of this data and the single [shared data] repository, and make it available to all" (SAO).*

Text Box 9b. Monitoring and assessment: What did the Life-Lab cities say? (1/2)

Unlike the reviewed literature, the interviewed staff also touched upon the challenges of monitoring and assessment. Most noteworthy was the lack of uptake of established assessment frameworks. In practice, municipalities developed their own frameworks, comprising a mixture of indicators developed in-house for monitoring projects or activities, *and* individual indicators extracted from existing frameworks. Crucially, none of these were frameworks specific to NBS assessment. These findings are discussed in more detail in Chapter 3 'Developing a shared understanding of participatory assessment'. More information on what indicators are used by cities has been provided previously in Chapter 2 'Inventory of existing assessment frameworks for nature-based solutions'.

5.7 Financing mechanisms

Municipal funding such as direct investment or subsidies for sustainability measures are a key enabler of NBS and other innovations. However, direct funding is often perceived to be insufficient in supply. This demonstrates the need to improve integration of ecosystem services into asset management, which could unveil the large opportunity cost of investing in grey instead of green infrastructure – especially if taking into account its capacity for asset appreciation rather than depreciation over time (Schäffler & Swilling, 2013).

In parallel with this, municipalities could explore opportunities to develop NBS through co-funding mechanisms, including examples such as park trusts, in-kind contributions by civil society, public-private partnerships, and compensatory measures by the real estate sector (Kordana & Daniel, 2020; Li et al., 2020; Mell, 2020a; Mguni et al., 2015; Zuniga-Teran et al., 2020). An indirect way of inviting private co-funding of NBS is by integrating the use of nature in certification systems for sustainable housing (e.g. BREEAM) along with more technological sustainability measures (Zuniga-Teran et al., 2020). Demand for NBS could also be stimulated by efforts to make NBS part of dominant, or 'sanctioned' discourses in urban regimes, which are strongly influenced by the agendas of powerful actors. Whereas this might be relatively straightforward if the sanctioned discourse is about sustainable living (Herslund & Mguni, 2019), there are also opportunities to integrate NBS into seemingly less sustainable storylines, such as infrastructure upgrading (Mguni et al., 2015). There are often also opportunities to charge for the use of nature products and services, such as charging money for timber, food products, parking spaces near nature or the use of a park as an event location. Municipalities, in collaboration with higher levels of government and other key actors, could also consider introducing fiscal instruments or making use of grant programmes to incentivize urban greening (Sarabi et al., 2019).

Text Box 10. Financing mechanisms: What did the Life-Lab cities say?

In agreement with the findings of the review, insufficient financial resources is considered a bottleneck to the development, but also the execution of plans made for new NBS in the city (BOG). For example, funding limitations can limit the scope for in-depth engagement by experts from multiple disciplines in an NBS project, which is often important to a successful NBS design (BCN). Funding the maintenance of NBS (along other types of public spaces) is a clear challenge, particularly in Latin American cities, and is sometimes also used as an argument against the development of new NBS (STGO). A particular concern in the Latin American cities is also the protection of existing NBS in peripheral areas from illegal settlements, which can add considerably to the cost of maintenance for green spaces (BOG).

> *"Environmental literacy, recycling, etc., are luxuries. [...] The maintenance of public space projects [in a way] that is sensitive to the introduction of certain species, or the management of vulnerable areas, is very expensive. It is very far away" (STGO).*

There might be a danger in communicating NBS as cost-effective solutions as it could lead to even less money invested, while expecting more quality (BCN).

> *"We are asking more and more of this nature, this green we have in the city or the urban gardens, we are demanding more and more, but if it is with the same resources, then we are deceiving ourselves" (BCN).*

Unlike the findings of the review, the interviews did not unveil any clear examples of specific instruments to help address the financing challenge.

5.8 Knowledge acquisition and sharing

5.8.1 Access to relevant expertise

Although information and expertise on NBS development can be obtained from external sources, city administrations should also focus on training and education of their own staff and other relevant NBS stakeholders. First of all, it is important for decision-makers to have a basic awareness of available policies and funding options for NBS development (Shih et al., 2020). In addition, there is a need for expertise in designing and engineering, as well as performance monitoring, of particular NBS such as sustainable urban drainage systems (Kordana & Daniel, 2020; Mguni et al., 2016; Sarabi et al., 2019; Wang et al., 2021; Workalemahu Habtemariam et al., 2019). Furthermore, for many cities there is untapped potential in the use of technological innovation in supporting NBS development and maintenance. For example, cities in China are exploring the

potential of tree-climbing robots to provide regular maintenance – a technology that could also have potential elsewhere to reduce maintenance costs (Gulsrud, Raymond, et al., 2018).

NBS advocates also benefit from training in soft skills or tacit knowledge, such as on group facilitation, community outreach and team working in order to communicate effectively with a range of different audiences internal and external to the administration (K. Andersson et al., 2013; Buijs et al., 2019; Shih et al., 2020). To establish urban NBS, managers are required to navigate a complex array of institutional structures and actors, which requires an ability to build mutual trust, be inclusive in the co-creative processes and be open to processes of social learning (Wamsler et al., 2020). NBS practitioners should be open to feedback, respond in constructive ways to scepticism, and consider each NBS (and policy to support this) as an experiment from which to learn new skills and expertise for improving designs into the future (i.e. learning-by-doing) (Frantzeskaki, 2019; Sarabi et al., 2019; Wamsler et al., 2014).

Relevant knowledge, where possible, needs to be captured and shared within knowledge platforms. Relevant sources for expertise are knowledge platforms highlighting examples of NBS across different contexts, including Oppla and ThinkNature (Kabisch et al., 2016; Sarabi et al., 2019). However, city administrations also need an effective data management system internally to conserve knowledge in times of high staff turnover (Sarabi et al., 2019; Wamsler et al., 2020).

5.8.2 Environmental education

We have previously touched upon activities such as social learning, staff training and learning-by-doing, which illustrates the central role of experimentation and knowledge acquisition. It is important to make the insights gained through these activities broadly available – in accessible formats – to stakeholders and to the general public. Demonstration projects provide an excellent way to showcase emerging knowledge on the state-of-the-art in nature-based urban innovation, while also potentially contributing to gaining public acceptance of e.g. nature-based stormwater management (Mguni et al., 2015). City administrations could also invest in events and activities on urban nature aimed at environmental education and citizen engagement (e.g. food growing festivals and fairs) (Dushkova & Haase, 2020). Education about NBS and improved connectedness to nature can also happen through the direct participation of citizens in stewardship activities such as ecosystem monitoring or by providing knowledge exchange opportunities to bottom-up greenspace initiatives (Ahmed et al., 2019; E. Andersson et al., 2014; Buijs et al., 2019; Frantzeskaki, 2019; Mguni et al., 2015; Wamsler et al., 2020; Zuniga-Teran et al., 2020). Moreover, environmental education can be received in more passive ways through opening up more greenspaces to the public and/or improving accessibility for pedestrians and cyclists (Nastran & Regina, 2016). There is a need for providing nature that allows the public to connect with nature in multiple ways, including on physical, emotional and spiritual levels, that go beyond the cognitive or rational

component. This calls for diversity in urban nature provision with scope for spontaneous nature and wilderness experiences inspiring feelings of awe, in addition to more intensively managed places (Randrup et al., 2020).

5.8.3 Social learning based on a reflexive approach

NBS benefit from processes of experimentation and social learning, e.g. between practitioners and researchers as part of so-called Learning and Action Alliances, Living Labs or Life Labs (O'Donnell et al., 2018). Seeking learning opportunities of this type allows the co-definition of research goals, questions and assessment approaches, which enhances the applied value of scientific research. A shared understanding of challenges can be built through joint participation in meetings, field trips and symposia. Moreover, research findings can be continually shared and discussed, which enables scientific knowledge to influence decision-making on urban NBS as soon as it becomes available (Campbell et al., 2016). A particular example of an activity that benefits from the collaboration of researchers and practitioners is the development of urban NBS assessment approaches, which have to be designed including the needs of policymakers (Lin et al., 2019). Therefore, the views of stakeholders should be included when deciding about criteria used for indicator selection (Kuller et al., 2019).

Whereas researchers can learn from practitioners and policymakers, there is also a need for city administrators to learn from researchers and, beyond this, all (potential) managers of urban NBS. This calls for a non-linear approach to governance in which there is scope for mutual learning around which approaches to management (from the perspective of the NBS steward) and steering (from the perspective of the city administration – e.g. which incentives and regulations to use?) are most constructive (E. Andersson et al., 2014; Kabisch et al., 2016; Mguni et al., 2016). This requires a mosaic governance approach where a style of steering is adopted that flexibly responds to the needs of urban communities managing NBS (Buijs et al., 2016, 2019; Gulsrud, Hertzog, et al., 2018). In other words, there is a need for a place-based approach to urban NBS governance tailored to community identities and practices, which takes into account the presence of actor-networks, availability of resources, power imbalances and the local geography (Buijs et al., 2016; Pauleit et al., 2019; Zuniga-Teran et al., 2020).

To align governance approaches to particular contexts, there is a requirement for local administrators to be reflexive. That is, they need to be prepared to adapt the policy framework and support structures (e.g. funding landscape, available human capital) in order to better assist successful NBS initiatives (Buijs et al., 2019; Dorst et al., 2019; Gulsrud, Hertzog, et al., 2018). To provide space for the expression of spirituality, culture and political activism in relation to nature – experiences potentially enticing environmental stewardship –a level

of flexibility needs to be allowed to citizen initiatives by employing a variety of management styles to NBS such as urban gardens (Langemeyer et al., 2018).

A reflexive approach is likely to be conducive to leveraging the commitment of other types of non-governmental stakeholders to NBS. That is, there is not a single most effective strategy to increase NBS uptake. Mainstreaming NBS calls for mixing different approaches for supporting the uptake of NBS, monitoring the effects of these, and using observations to fine-tune strategies and instruments (Wamsler, 2015; Wamsler et al., 2014; Zevenbergen et al., 2018). Developing a system understanding is needed to grasp the key local issues and structures (Mell, 2020a). For example, informal and decentralized planning systems in the Global South enable and constrain particular types of measures and strategies when compared to more centralized and formal systems, typical of many cities from the Global North (Herslund & Mguni, 2019; Mguni et al., 2016). System understanding also needs to be adapted over time as e.g. organizations might enter and leave the stakeholder arena based on factors such as temporal fluctuations in funding availability (Schifman et al., 2017). Planning, designing and implementing urban NBS therefore should evolve over time – a process informed by different cycles or iterations of dialogue and deliberation (Randrup et al., 2020).

Text Box 11. Knowledge acquisition and sharing: What did the Life-Lab cities say?

Some city administrations indicated a lack of sufficient expertise in some areas relevant to sustainability and NBS management (BOG,SAO), especially outside the Environment Department (LIS). For example, civil engineering expertise might be dominant amongst civil servants responsible for managing public spaces and infrastructure (SAO). Also the operational staff responsible for implementation and maintenance often do not incorporate NBS into their working practice (STGO). In general, there is limited understanding of the concept of 'nature-based solutions' amongst civil servants, although it is used increasingly often (STGO). More established related concepts include 'environmental sustainability', 'resilience' and 'quality of life' (STGO).

Engagement in urban sustainability issues by the scientific community is not uncommon and often leads to a promotion of NBS and an improvement of the environment (BOG,SAO). Despite this, there is a need for science to produce knowledge that is more directly relevant to decision-making, and that is better responding to the specific knowledge demands of the city (BOG,SAO). For example, many cities are struggling with the coupled issues of how to integrate NBS in densely built-up neighbourhoods where climate vulnerabilities are often highest (BCN,BA,TRN) while decision-makers still systematically favour housing and grey infrastructure over NBS (BA). Green space managers are also dealing with more pragmatic questions around how to advance the sustainable management of urban NBS (BCN). The availability of locally relevant information is particularly important in order to convince colleagues in other departments and senior management to buy into NBS projects based on e.g. urban resilience considerations (SAO).

In at least one city, municipalities and other public bodies were perceived to insufficiently emphasize environmental education, with few opportunities for nature experience offered to some parts of the urban population (BA). This might be one of the factors contributing to limited environmental awareness among the general public (BA,BOG).

> *"Residents often do not see NBS as something that helps them in reducing the temperature in their houses or in reducing flooding risk in their neighbourhoods. Frequently, the residents see it as a nuisance, as something that causes dirt, that causes problems with branches that can fall off when there is a storm" (BA).*

To improve this, Lisbon municipality offers citizens opportunities for hands-on experience with nature in the city near to where people live and visit (see section on 'Active Community Engagement'). The city also produces short educational videos about projects such as the pollinator-friendly 'honey park' in order to help spread the message. Another good example is São Paulo, which launched a municipal Environmental Education Center – part of the Secretariat of Education – a few years ago.

5.9 Valuing diversity, equity and inclusion

Implementing NBS, and transformative changes towards sustainable cities in general can have great impact on the distribution of environmental burdens and benefits in the city. Increasingly, environmental justice and urban green equity are considered key in transitioning towards fair and sustainable cities. Current focus on environmental justice emerged as a response to unequal distribution of the benefits of urban green, while *just* transition approaches emerged from criticism on dominant transformation pathways that reinforce existing power inequalities. Consequently, literature on sustainability transitions has argued for the need for *just* transitions, taking into account the consequences of these transitions for all communities in a city.

To monitor the distribution of the effects of developing and implementing NBS, we seek inspiration from the environmental justice literature. Environmental justice often is conceptualized as consisting of three related elements: recognition justice, procedural justice and distributional justice (Nesbitt et al., 2018; Rutt & Gulsrud, 2016). Recognition justice (sometimes called interaction justice) focuses on acceptance of and respect for identities and cultural differences, and whether these are considered legitimate inputs in decision making (Langemeyer & Connolly, 2020). Procedural justice focuses on the inclusiveness of the planning processes. Distributional justice focuses on equity in the distribution of environmental benefits and burdens across communities. Although these aspects of environmental justice are relevant for all governance indicators developed above, they merit a separate set of indicators because of the fundamental nature of justice in sustainability transitions.

5.9.1 Recognizing diverse perspectives

There is a need for cities to respond to the different needs and preferences that sociocultural groups and communities of place might have for NBS management (Randrup et al., 2020), while at the same time offering opportunities for reimagining the relationship between people and nature by challenging dominant ideas of what e.g. parks should look like (Gabriel, 2016). For example, while in many cities urban NBS are highly managed to conform with an entrepreneurial strategy of maximizing economic value from ecosystem service provision, there are increasingly fewer opportunities to experience urban nature for its intrinsic or biodiversity values (Gabriel, 2016; Randrup et al., 2020). Different cultural groups may prefer different types of NBS, since they often differ in how they use and value urban green and biodiversity (Kloek et al., 2013). Not only cultural background, but also their immigration status, age, and socio-economic status play a role in explaining this (Botzat et al., 2016). Recognition justice starts with looking beyond groups and communities as homogeneous, and recognizing diversity in experiences, interests, aspirations, knowledges, capabilities, intersectionalities and challenges. By responding to diversity, the discourse on NBS can be made more inclusive and directly responsive to urban socioecological challenges (Frantzeskaki, 2019). This is also reflected in the concept of

biocultural diversity, which draws attention to the diversity in knowledge and values between cultural groups, resulting in different ways of relating to biodiversity and nature (Elands et al., 2019). By providing space for different types of interactions, urban nature can be made more diverse with more people being able to connect with it. A first step in recognizing plurality is seeking or organizing spaces for deliberation, exchange of views and preferences (de Oliveira Fontes, 2020). Recognizing diverse perspectives and needs between e.g. age, ethnic, income and gender groups in society is also pivotal for procedural justice – without pursuing recognition justice, the odds of achieving procedural justice are greatly diminished.

5.9.2 Fair representation of stakeholders

To better understand and respond to plurality, municipalities should focus on equal opportunities for all relevant stakeholders in NBS governance and provide opportunities for meaningful involvement for all in policy making, planning, management and decision making (including legal decisions). To enable such opportunities, a diversity of strategies may be applied, all related to the opening up of existing spaces for deliberation. The most common strategy is organizing participation in decision-making processes through formal participation processes (M. S. Reed et al., 2018). Formal participation processes, if organized in an inclusive, transparent and responsive manner, can contribute to adapting top-down strategies and decisions to local needs and preferences in a socially inclusive way (Coenen, 2009; Hansen et al., 2017). Some of the existing NBS assessment frameworks already include indicators for participation in policy making and implementation, e.g. by measuring the proportion of citizens involved in participatory meetings (see Table 5). However, they lack indicators for assessing the participation of the full diversity of stakeholders in the processes, including marginalized groups, such as immigrant, indigenous people or young people.

Following the formal participation processes, inclusiveness of NBS development and implementation also depends on the recognition of, and support for place-based initiatives. Local entrepreneurs, NGOs and active citizens often develop community-based NBS as solutions for socioenvironmental problems (Ambrose-Oji et al., 2017). Urban agriculture initiatives is one of the most common examples (van der Jagt et al., 2017). Although these initiatives often emerge from local challenges, collaborations across sectors and scales, including municipality, greatly contributes to the success and impact of these initiatives (de Wilde et al., 2014). Because such initiatives are community-driven and tend to engage a diversity of socio-cultural and -economic groups, inclusiveness of urban NBS can be increased if municipalities and other institutional stakeholders actively support bottom-up community initiatives with knowledge and funds. They should also be open to reconsider their policies and practices in response to lessons around how to support community groups (Buijs et al., 2019; van der Jagt et al., 2021). Amongst other measures, this would benefit from the creation of open forums for civil society dialogue (Schifman et al., 2017).

5.9.3 Ensuring equitable access to NBS

Recognizing diverse perspectives and fair representation of stakeholders can contribute to equitable access to NBS. As such, equitable access can be considered the historical outcome of procedural and recognition injustices on the local, national and global scale (Nesbitt et al., 2018; Rutt & Gulsrud, 2016). In many places, social groups with higher socio-economic status have more access to urban green space, and often also to higher quality green spaces (de Vries et al., 2020). Meanwhile, greening disadvantaged communities may also contribute to gentrification of these communities, e.g. through rising housing prices (Gould & Lewis, 2017). Quantitative measures for equitable access commonly include tree cover data and green space proximity metrics, although also questionnaires have been used to measure use and access to NBS in the city (de Vries et al., 2020; Nielsen et al., 2017). To recognize the diversity of nature values between groups, the co-creation of assessment approaches with stakeholders is crucial (Rutt & Gulsrud, 2016). Following the equal benefits of NBS for all socio-economic groups, distributional justice also relates to different groups carrying a proportionate share of the environmental burden in a city. NBS can be used to mitigate disproportionate environmental challenges, such as flooding or heat island effects. Some scholars argue the need for restorative justice, i.e. compensating for the legacy of environmental burdens (Hazrati & Heffron, 2021), which would imply investing more in NBS across areas with historically disadvantaged communities than elsewhere in the city.

Text Box 12. Valuing diversity, equity and inclusion: What did the Life-Lab cities say?

The issue of vulnerable communities and their disadvantaged access to urban NBS was brought up several times, despite this not being one of the topics specifically addressed in the interviews. For example, the Buenos Aires Secretary of Environment conducted air temperature measures in vulnerable communities to demonstrate the effects of lower tree cover. The disadvantaged access to the benefits of nature is often matched with lower resilience of these neighbourhoods to climate-related extreme weather events and higher air pollution, creating another incentive for urban NBS to target these areas in particular.

> *"Latin America is one of the locations on the planet where informal settlements are very significant, and Bogotá is no exception to that. A very significant part, around 20-30% of the population, is [living] in informal settlements and/or is in built-up neighbourhoods that have been legalised, but they are still in very vulnerable conditions when faced with [climate-related] phenomena, particularly landslides and floods. This vulnerability also points to the [issue of] degradation of certain ecosystems that are key to regulating these types of phenomena, such as wetlands, [in the city]" (BOG).*

It was also expressed that engaging vulnerable communities in co-design, -planning or -management of NBS was much more challenging when compared to more wealthy communities (SAO,STGO). This can be explained in part by the dense living conditions and overall lack of space (SAO), but also education (STGO). This raises clear issues concerning procedural justice – the ability of different communities to participate in decision-making.

> *"We work with communities whose vulnerabilities are so structural that sustainability often seems distant or almost a luxury. I am thinking about maintaining certain parts of public spaces or even the construction of a home garden. [...] These [actions] often feel more like a luxury, rather than an access point to change or improve the living conditions or quality of life of communities" (STGO).*

As a result of the most vulnerable communities having more basic, urgent needs than the protection of urban nature and improving sustainability, recognizing their needs in decision-making on urban NBS is not straightforward. For example, biodiversity is simply not understood or considered important by large parts of the population (BOG). At the minimum, however, there needs to be an endeavour to ensure that the benefits of nature to quality of life (e.g. air purification or stormwater attenuation) are distributed in more equitable ways across the city, e.g. using spatial mapping (BOG,BCN).

> *"What we want is more green, that the green is [put] in the areas most in need and that therefore the green is distributed [more] equitably" (BCN).*

6 The participatory stage of indicator appraisal

An important ambition in the CONEXUS project is to consider different stakeholders' perspectives in a balanced way to help inform the participatory process of indicator selection. To achieve this, workshops will be organized in each of the Life-Labs to deliberate and rank the indicator portfolio described in Chapter 4 in Month 10-14. They also provide an opportunity to gain feedback on the newly developed set of NBS governance indicators described in Chapter 5. In this chapter, we sketch out a structured approach for organizing these workshops. It starts with a preparatory period where researchers reach out to Life-Lab facilitators to help them develop and share e.g. targets indicating success and an overview of pre-existing indicators already used for NBS assessment in their city. Next, we provide a structure for the workshop itself, of which the sharing, deliberating and ranking indicators provide three key components. Third and finally, we describe follow-up activities in order to convert the indicator ranking into a preliminary Life-Lab Information System for NBS monitoring, which is relevant, realistic and participatory. The outlined approach with the three steps described above is visualized in Figure 13.

Text Box 13. In the process of developing Life-Lab Information Systems, there are different moments where NBS performance indicators are selected for use in the Life-Labs (see Figure 2). We identified three filters. The actions described in the present chapter represent Filter 3 (in bold):

- *Filter 1: Selection of scientifically grounded and policy-relevant indicators*. By selecting the TF2 handbook for NBS assessment as the source for indicators, we made sure to include indicators that are agreed by the scientific community, are linked to global policy frameworks and bear relevance to the urban context (see *Chapter 2*).

- *Filter 2: Selection of indicators recommended for use by the Life-Labs.* The suitability of the broad set of indicators from the TF2 handbook for use in the Life-Labs was evaluated by independent reviewers, who evaluated all indicators on a set of criteria derived from the literature on participatory monitoring and ecosystem services assessment (see *Chapter 4*).

- ***Filter 3: Place-based appraisal and ranking of pre-selected indicators:* Workshops will be held in each of the Life-Labs in Month 10-14 to help make decisions about which indicators to use as part of the Life-Lab Information System in each of the cities. There is also scope to suggest and discuss alternative indicators that are not part of the recommended list of indicators shown below.**

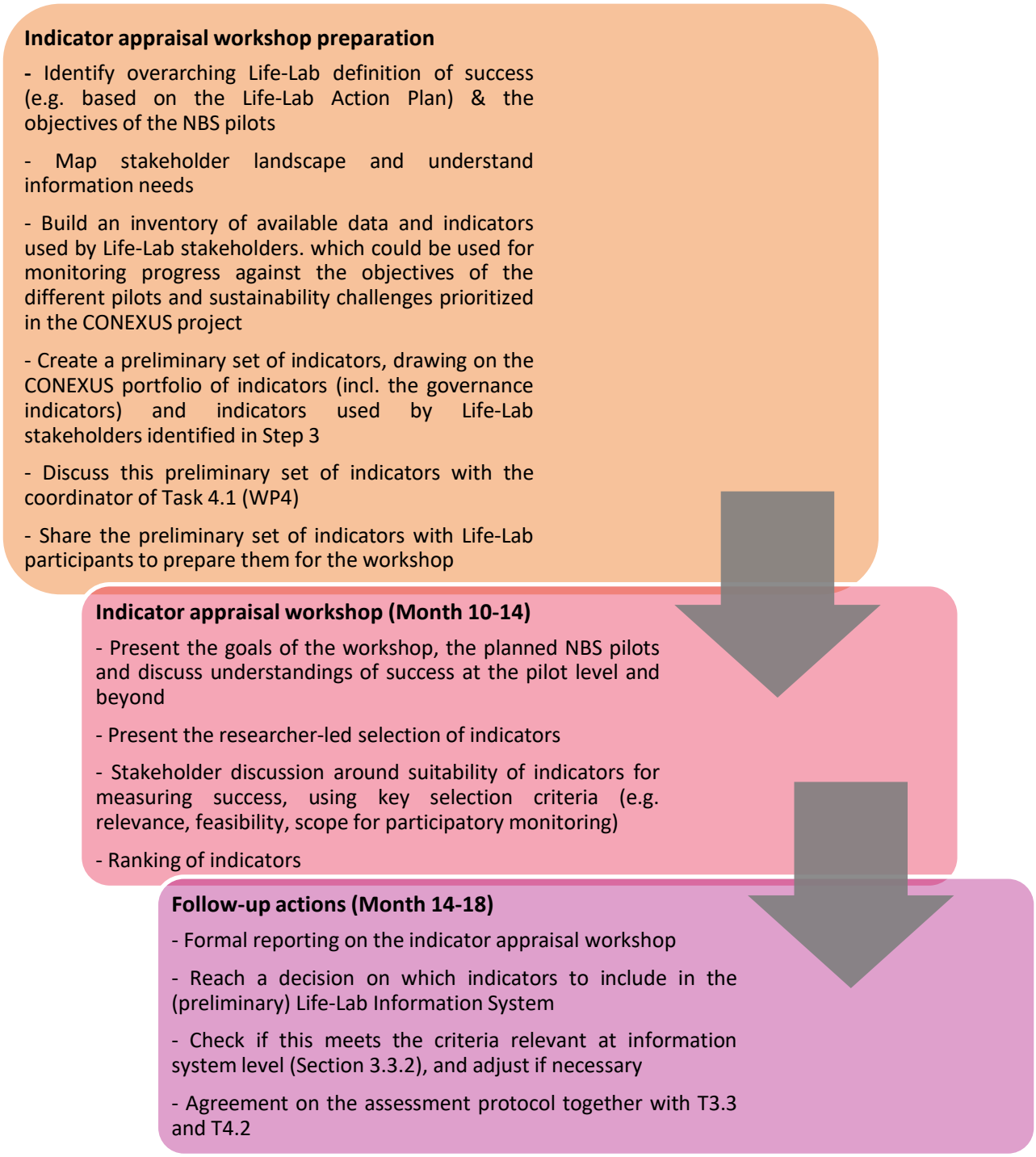

Figure 13. Overview of the participatory approach to indicator selection in the Life-Labs, and the preparation and follow-up actions required for this by each of the Life-Lab facilitators, with support of WPs 3 and 4.

6.1 Indicator appraisal workshop preparation

Given the Covid-19 pandemic, the workshops planned in Month 10-14 to deliberate and rank potential indicators for use in the Life-Lab Information Systems most likely will take place in a virtual environment. As this limits the attention span of participants, we advise a workshop of max. 2-3 hours, therefore preparation becomes key. Below, we outline the different steps within the preparatory stage of workshop organization, which are the responsibility of the Life-Lab facilitator.

1. Developing a shared understanding of success – in relation to both the NBS pilot projects and the broader ambitions of the Life-Labs around e.g. a shift in routine working practices or more citizen participation. This is a crucial first step towards the participatory selection of indicators, as the collected data is ideally used to monitor if the expected success is achieved. In the case of the CONEXUS project, the WP3 Life-Lab Action Plans provide the instrument to report on these. We encourage Life-Lab facilitators to link these Life-Lab ambitions and objectives to the Challenge Areas used to group the CONEXUS indicator portfolio (Chapter 4) to make potential matches with indicators. On the basis of this, a ranking can be made of the Challenge Areas most relevant to the Life-Lab (e.g. a top 3 or top 5). Facilitators should also be reminded that the indicators in their Life-Lab Information Systems will need to match the challenge areas prioritized in the CONEXUS project – biodiversity, environmental justice & climate resilience.

2. We recommend Life-Labs to engage in stakeholder mapping (e.g. Mind Maps & Stakeholder Salience Analysis (van der Jagt et al., 2019)) once NBS pilots and associated objectives have been defined. This will help to inform which stakeholders are relevant to invite for the indicator ranking workshop. Depending on who has been consulted during the drafting of the Life-Lab Action Plans, it may be necessary to initiate complementary interviews, document analysis or focus groups with particular stakeholder groups (e.g. local people) whose interests are insufficiently represented in the Life-Lab (cf. Lee & Yan, 2019). We suggest a mixture of stakeholders from public institutions, academia, the private sector and civil society. Care needs to be taken to invite stakeholders representing the interests of marginalized groups and communities that have a say in NBS development in the city. It could be helpful to brainstorm about potential situations in which the collected data could be used ahead of the workshop, e.g. the use of biodiversity data to help inform choice of tree species in a park. This will help in developing an understanding of the different interests of the involved stakeholders and what type of data (e.g. monetary or non-monetary) is needed at which moment(s) in time (Mickwitz & Melanen, 2009).

3. In parallel, the Life-Lab facilitator invites relevant stakeholders to share available indicators and data that could be integrated in the Life-Lab Information System. Previous research and the CONEXUS interviews

conducted with data experts in each of the Life-Labs showed that stakeholders already collect relevant data that can be used for monitoring progress against urban sustainability targets. The WP3 Life-Lab Action Plans might also act as a reference to potential indicators. Pooling and incorporating these established indicators into the Life-Lab Information System offers the potential to considerably reduce the time and financial investment associated with implementing new indicators (Rogers et al., 2020). Moreover, it paves the way for developing an information system that serves to brings different actors together, resulting in social learning and potentially commitment to continue urban NBS assessment beyond the CONEXUS project.

4. The overview of established indicators from Step 3 above, along with the CONEXUS portfolio of indicators on NBS performance outlined in Chapter 4, is then mapped onto the prioritized Challenge Areas identified in Step 1. This results in a confined range of potentially relevant indicators. In addition, the researcher-led ranking of indicators (Section 4.2) can be used to further narrow down the selection of indicators. By doing so, the preselection of a smaller and more manageable set of indicators ready for deliberation and ranking during the Life-Lab workshop is made. Note, the comprehensive set of indicators on NBS governance does **not** have to be ranked during the workshop.

5. The preliminary set of indicators to be used in the workshop is shared with the Task 4.1 (WP4) coordinator for reporting purposes and as a way of externally validating the selection made. This serves to ensure that the indicator portfolio meets the criteria for assessment agreed within the CONEXUS project. At this and earlier stages, an agenda and format for the workshop can also be discussed.

6. The set of indicators emanating from Step 5, along with information on the measurement method, is shared with the Life-Lab stakeholders who are participating in the indicator ranking workshop. They are urged to study the indicators as well as the associated Challenge Areas before the workshop. This enables stakeholders to prepare themselves for the workshop, which frees up more time for deliberation during the event. We encourage the Life-Lab coordinators to also share the indicators for NBS governance (Chapter 5) during the workshop, in order to gain feedback on these. The Task 4.1 interviews highlighted NBS governance challenges in each of the Life-Labs, whilst these indicators are also crucial for monitoring the uptake of the key CONEXUS approaches of mosaic governance and nature-based thinking in the Life-Labs. Note, this specific set of indicators is not part of the ranking exercise during the workshop, but can be discussed in a separate session.

6.2 The indicator appraisal workshop

The CONEXUS indicator ranking workshops are planned between Months 10 and 14. They serve to narrow down the number of indicators that could be potentially used for monitoring by the Life-Labs (see Figure 14). They are organized by the Life-Lab facilitator with support from the T4.1 coordination team. We propose the following structure:

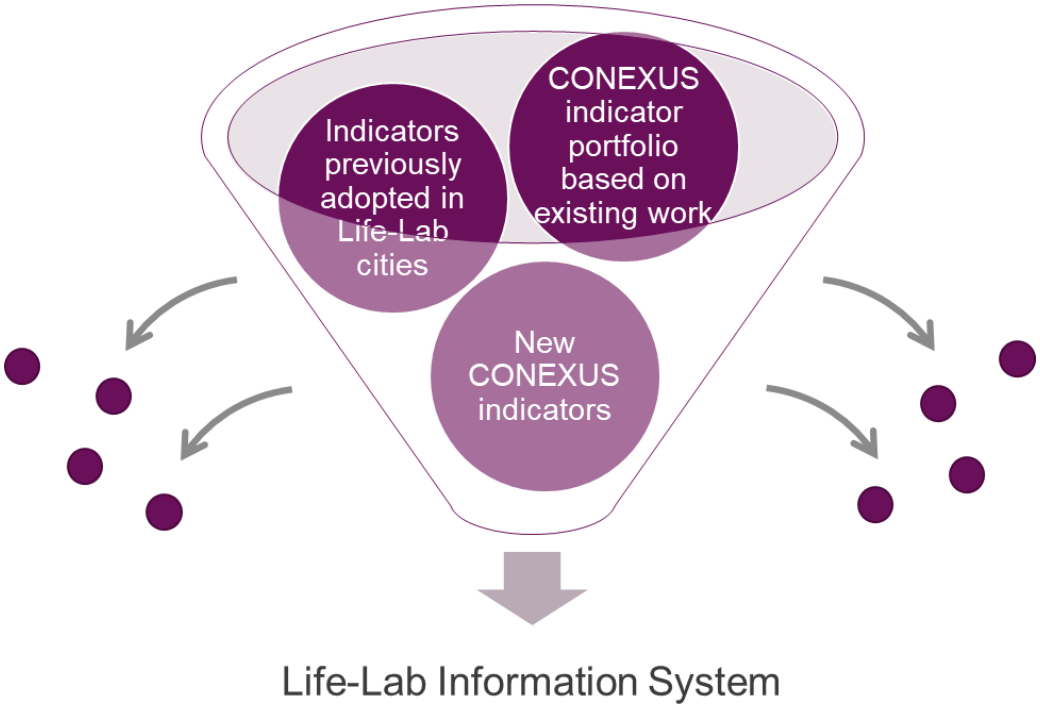

Figure 14. Illustration showing the different sources of indicators potentially to be included in the Life-Lab Information Systems. The goal of the workshop is to appraise indicators and filter out any that are not suitable for inclusion in the information systems.

1. The workshop starts with an introduction explaining the goal of the workshop, the participatory approach in CONEXUS, the planned NBS pilots in the Life-Lab city and view on what success entails (see Step 1 in Section 6.1). This is followed by a Q&A session to address any questions and concerns.

2. Next, the facilitator briefly presents ideas on how the achievement of success could be monitored with data and indicators already used in the city (see Step 3 in Section 6.1). Any knowledge gaps are identified and suggestions for new indicators are made, drawing upon the CONEXUS portfolio of indicators (see Step 4 in Section 6.1).

3. Following this, the interactive part of the workshop begins with participants deliberating the suitability of the proposed indicators to assess progress against objectives. Depending on the number of participants, break-out groups of c. five participants are created with participants clustered based on interest and expertise to discuss indicators for different Challenge Areas. To structure and broaden the discussion, the facilitator can introduce a number of key selection criteria (e.g. Feasibility, Relevance or Legitimacy – see Section 3.3.1). In the second part of the session, discussants are expected to agree on a ranking of indicators. To balance different voices and perspectives, it is advisable if rankings are first provided individually and pitched to the group before the rankings are discussed by the (break-out) group as a whole. Each of the (break-out) groups requires a facilitator and a note taker. The role of the note taker is to register the arguments used in favour and against particular indicators, which are an important part of the reporting (see Step 1 in Section 6.3).

4. The break-out groups (if any) reconvene and present their top 5 indicators in the plenary, where others have an opportunity to provide feedback on the selection made. There should also be scope to discuss any remaining knowledge gaps for which no suitable indicator was provided or for participants to suggest existing indicators that had not been included in the Life-Lab portfolio. Participants are explained about next steps and thanked for their participation.

6.3 Follow-up activities: Towards a preliminary Life-Lab Information System

The results of the workshop will be used as the basis of decision-making about which indicators to use in each of the Life-Labs as part of their information system. Therefore, the follow-up reporting and subsequent dialogue with Tasks 3.3 and 4.2 in the period up to Month 18 is key to the initiation of the assessment efforts in each of the Life-Labs. We recommend the following actions:

1. Following the workshop, the Life-Lab facilitator prepares a formal report showing the agreed ranking of indicators for each of the relevant Challenge Areas. The report also includes a section describing the main arguments used by participants in favour and against the ranked indicators. A final section of the report describes any identified knowledge gaps for which additional indicators might need to be identified and any specific indicators suggested by the workshop participants.

2. Based on this ranking, and with support of Tasks 3.3 and 4.2, the Life-Lab facilitator proposes an information system on NBS for their Life-Lab. There is no minimum or maximum number of indicators as this depends on the number of indicators already applied in the city, the complexity of indicators, etc. At a minimum, however, indicators for each of the CONEXUS core challenge areas – biodiversity,

environmental justice & climate resilience – should be included in order to assess of NBS are providing multifunctional benefits (also see Step 3 below).

3. Next, the Life-Lab facilitator is prompted to compare their preliminary information system on NBS to the system-level criteria (see Section 3.3.2), and makes changes if necessary. As a result, the facilitator is prompted to ask critical questions about issues such as whether adopting the set of indicators as a whole is manageable given time and resource availability, if it provides sufficient substance to monitor progress against the Life-Lab partnership's overarching goals and if it provides the minimum required evidence to report against the challenge areas prioritized in CONEXUS. Moments of reflection on the functioning of individual indicators and the Life-Lab Information System as a whole should be maintained over time at regular intervals during the monitoring process. There might be a need for revising the indicators or associated methods in response to new insights or understandings emerging over time (Huitema et al., 2009; Pahl-Wostl, 2017).

4. The preliminary set of indicators for each of the Life-Labs are discussed with Task 3.3 (responsible for indicator selection and support with data collection), and Task 4.2 (responsible for monitoring the learning process and support with data analysis). Together, they discuss the feasibility of the preliminary Life-Lab Information System, touching upon questions such as at which intervals data will be collected and reported, at which scales, using which methods, and who is responsible? In addition, it is also checked if the core indicators mapping onto the CONEXUS core Challenge Areas are sufficiently comparable across the Life-Labs (i.e. do they form a common thread across the Life-Labs?). The set of indicators is revised, if necessary, and the Life-Lab Information System is further expanded with a protocol for data collection and analysis along with ideas for an information infrastructure to support data storage and exchange. **We recommend the comprehensive set of NBS governance indicators to be applied in each of the Life-Labs on an annual basis by Tasks 4.2 and 4.3 through the learning log and cycle.**

7 Conclusion

Nature-based solutions are interventions that seek to harness the power of nature in addressing sustainability challenges such as climate change, biodiversity loss and socio-spatial injustices. Assessment and monitoring are widely regarded as crucial components in strategies for mainstreaming multifunctional NBS in cities across the world. Not only does it play an important role in making the case for investment in NBS, but it also contributes to the development of contextualized knowledge about NBS performance and processes underlying this. For this reason, the development of an assessment framework to support the co-creation of NBS together with relevant stakeholders in the Life-Labs is a crucial step towards generating impact within the CONEXUS project.

7.1 Overview of the key contributions of this research

Scientific research has developed several assessment frameworks for urban NBS in recent years, providing comprehensive overviews of indicators organized by different societal Challenge Areas. Seeking to build upon this wealth of knowledge related to different benefits (and costs) of NBS, this research also aimed to go beyond conventional NBS assessment approaches in two main ways. First, we conceptualized a *participatory* approach to assessment. This was done based on the assumption that knowledge, including the assessment approaches, needs to be co-produced with stakeholders for generating impact on decision-making in complex urban systems. We undertook a scoping review that showed how participation can be realized at different stages during the process of NBS assessment and monitoring, starting with indicator selection and ending with their evaluation. Given the particular scope of this report, we discuss participation mainly in relation to the stage of indicator selection. At a minimum, Life-Labs engage in the co-selection of indicators for their NBS pilots. If feasible, we also engage Life-Lab stakeholders, and the broader population of stakeholders and citizens of each Life-Lab city, in processes of participatory data collection, monitoring and assessment. Scope for participation was therefore an important selection criterion for indicators in the CONEXUS portfolio.

Second, we developed a novel set of governance indicators and use these as complementary measures to the NBS performance indicators. Governance is concerned with understanding the structures and processes that facilitate the uptake of NBS, and sustainability more broadly. A robust assessment is unlikely to generate much of an impact on NBS uptake without good governance, and vice versa. Governance of NBS is difficult to improve without understanding and analyzing its different components and strategically intervening in these where possible (see Figure 15). Despite this, existing assessment frameworks do not include indicators that provide a comprehensive assessment of governance. Featured indicators are typically simplistic and mainly focused on the participation of certain groups in projects or events, rather than on the totality of actions

relevant to addressing sustainability problems through NBS. We therefore reviewed the recent literature on drivers for successful NBS governance to identify relevant underlying dimensions. These were used as the basis for developing a novel set of indicators, which are comprehensive, yet simple enough to be applied at regular intervals without requiring too much time investment.

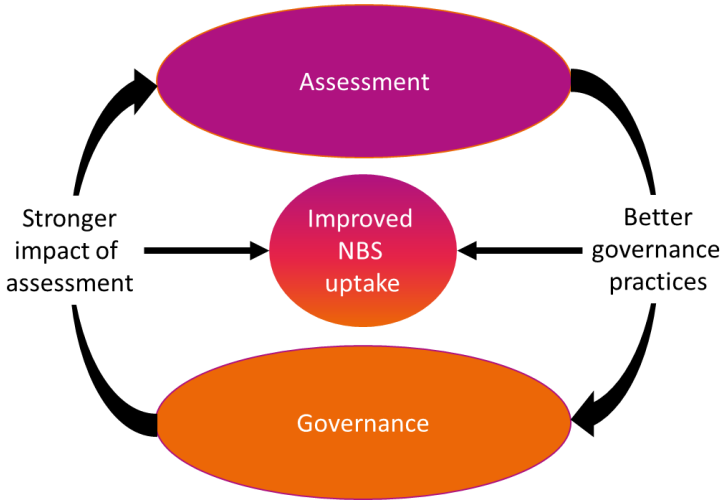

Figure 15. Visualization of the mutually reinforcing relationship between assessment and governance, with both factors leading to improved NBS uptake.

The structure of the CONEXUS participatory assessment framework reflects the considerations described above – it includes not only a portfolio of indicators on NBS performance, but also guidance on participatory indicator selection and assessment and indicators on NBS governance. The portfolio of indicators on NBS performance was derived from the TF2 handbook for NBS assessment. We selected this framework as the key source for indicators on NBS performance by virtue of its alignment with a number of key guiding principles for assessment in the CONEXUS project, including the need for indicators to be categorized by challenge areas that are mapped onto the SDGs, their relevance to the urban context, their relevance to multiple urban scales and scope for participation in data collection and assessment. This handbook includes a substantial number of indicators – too many for Life-Lab stakeholders to deliberate within the limited time available. Hence, the report also described a stepwise approach for narrowing down the number of indicators, employing selection criteria to ensure that only the most credible, feasible, salient and legitimate indicators are included. The first step is led by researchers engaging in a pre-selection of indicators. This is followed by a participatory process of deliberating indicators with Life-Lab stakeholders, which serves to further refine the selection of indicators.

7.2 Outlook: from theory to practice

Whereas the CONEXUS participatory assessment framework is a project output on its own, it provides only the beginning of the project's engagement with co-developing a place-based approach to assessment in each

of the seven CONEXUS Life-Labs. The next step is to organize indicator appraisal workshops for each of the Life-Labs. These effectively provide the anticipated participatory element in indicator selection described above. We provided a detailed structure for these workshops, starting with a preparatory stage where the Life-Lab facilitator is responsible for activities such as stakeholder mapping, building an inventory of relevant indicators previously adopted in the city and developing an understanding of what it means for the Life-Lab to be successful. This is followed by the workshop itself, organized by each of the Life-Labs in the autumn of 2021, during which Life-Lab stakeholders will provide their appraisal, and subsequent ranking, of indicators across those challenge areas closely linked to the key aspects defining success in the Life-Lab. This process ends with a number of follow-up activities for the Life-Lab facilitator, in collaboration with researchers in WPs 3 and 4, to report on the workshop and develop a Life-Lab Information System used for monitoring NBS on the basis of the indicator rankings. It is important that this meets basic criteria around e.g. the inclusion of indicators relevant to each of the CONEXUS core challenge areas and indicators with scope for participatory monitoring. The information systems will likely look different for each of the Life-Labs as these are specified based on place-specific needs and interests. However, our ambition is for there to be a common thread running through all of these – all Life-Labs will at the very least include indicators for the following three core challenge areas: biodiversity, climate resilience and environmental justice in order to assess if NBS deliver upon their promise of multifunctionality. Moreover, all Life-Labs will complete all items in the survey on NBS governance developed as part of the CONEXUS project (Appendix B) at regular intervals. An opportunity to provide feedback on the governance indicators will be provided when sharing these for the first time with Life-Lab representatives as part of the CONEXUS learning cycle.

The upcoming period within the CONEXUS project will mark a moment of transition where some of the theoretically derived principles for participatory monitoring and assessment will be applied and tested in practice. Decisions about which indicators to adopt for use in each of the Life-Labs should be made soon after the workshops are organized, and a protocol for assessment answering questions around who is doing what at which intervals needs to be finalized before the end of winter. After this, Life-Labs move from constructing their monitoring and assessment approach to data collection and analysis. However, this does not mark the end of the period of collaborative learning and participation. The indicators and methods collectively part of the Life-Lab Information Systems will remain subject to critical scrutiny at regular intervals. Selection and refinement of indicators is an ongoing process that will be supported and monitored over time. This also applies to the methods for employed for data collection – some approaches might generate useful data

whereas others do not. Often multiple methods are available for the same indicator, which provides options to experiment with different ways of employing these[11].

We also look forward to learning more about experiences with applying the comprehensive set of governance indicators in each of the Life-Labs. The introduction of these indicators is a key contribution in helping the CONEXUS project meet its ambitious goals around developing place-based approaches to NBS development through the use of mosaic governance and nature-based thinking, and monitoring the success in achieving this. The process of applying the framework is likely to reveal new insights about current enabling and constraining conditions for successful NBS governance within the context of Latin American and Southern European cities. We also expect it to uncover particular pathways to improved governance that have not been previously reported in the literature on NBS, which has a strong bias to countries in the Global North.

The period ahead provides a time for ongoing learning about approaches to set up a fruitful participatory monitoring and assessment process for urban NBS across a range of different contexts, while also providing an exciting opportunity to better understand ways to enable successful NBS governance across a range of different contexts. Aside from these research-oriented benefits, the CONEXUS participatory assessment framework also provides an opening for research to meaningfully contribute to improved uptake and impact of urban NBS in some of the world's largest metropoles – an opportunity which we hope to seize with both hands.

7.3 Critical reflection

This report provides a detailed overview of the planned assessment approach in CONEXUS, including an NBS performance and an NBS governance component. The approach is ambitious and its application in practice will be subject to a learning process on which we will regularly report as part of the learning cycle in Task 4.2. Whereas we cannot foresee the full range of challenges ahead, a number of these have been anticipated. First, it is likely going to be a challenge for the Life-Labs to meet in-person as a result of the Covid-19 pandemic. This limits the available time to deliberate the indicators with a broad and representative group of stakeholders. Moreover, the workshops will be delivered by local facilitators, who are not fully informed about the assessment framework. Doing so will be a challenging endeavor given the complexity and scale of the assessment framework in front of you. Hence, a condensed version of this document needs to be prepared ready for sharing with Life-Lab representatives over the next few months. Furthermore, virtual

[11] Methods have not been described as part of this report beyond those for the novel set of governance indicators (Appendix B). The reason is that these have been covered comprehensively in the Appendix of Methods developed together with TF2 handbook for NBS assessment (Dumitru & Wendling, 2021b).

meetings will be organized with the Life-Lab coordinators in order to prepare them for delivering the workshops along a pre-set format.

Second, we expect challenges related to the ability of Life-Lab Information Systems to iteratively respond to new inputs and insights. For example, whereas the initial selection of indicators will be based on the objectives as stated in the Life-Lab Action Plans, these represent a snapshot of interests at a particular time. These could change over time as a result of e.g. a new political regime, observations made in the pilots or new Life-Lab stakeholders. We also expect the introduction of new research-driven indicators over the course of the project, e.g. around measuring the monetary and non-monetary value of NBS (WP5). However, these will still be under development at the time of the indicator appraisal workshops, preventing their inclusion in the planned indicator appraisal workshops. There is also the risk that, once these become available, these might not be of genuine interest to stakeholders. The extent to which the Life-Lab Information Systems can iteratively respond to new suggestions and inputs over time remains unclear. Task 4.2 is therefore advised to design Life-Lab learning cycles in such a way to provide opportunities for deliberating on the right balance between consistency and flexibility.

Third, we anticipate challenges around stakeholders showing particular interest for indicators for which we will have insufficient expertise, tools or capacity to implement and/or analyze. The extent to which such support is available is difficult to gauge as it depends on aspects such as pandemic-related travel restrictions, the time demands of all indicators combined, in-house capacity at the city administrations, and scale and frequency of measurement. Consequently, there is a risk for Life-Labs being forced to make concessions to the information systems that they will co-develop with researchers. This could reduce stakeholder interest and the impact of assessment on policy and practice.

Fourth, a potential issue with the newly developed governance indicators is that these have been based on the current state-of-the-art in the literature, which is largely based on experiences and perspectives in the Global North. Compared to the EU, perspectives from CELAC (Community of Latin American and Caribbean States) countries and cities are underrepresented in the literature (Breen et al., 2020). This poses the risk that the indicators and their descriptions might not map well onto the underlying dimensions that matter most in the CELAC context. The survey format suggested to assess these indicators might therefore not the most suitable – it does not allow for building a shared understanding between researcher and local expert about what different governance dimensions entail and about any dimension(s) that are missing. A semi-structured interview could therefore represent a more suitable format, provided sufficient capacity is available within the project to carry this out. Another benefit of undertaking interviews might be that it allows for exploring

the underlying conditions explaining the current governance situation, and therefore enables a more context-specific understanding on how to potentially address the reported governance challenges.

Fifth and finally, we wish to draw attention to the challenge of empowering stakeholders to participate in stages beyond indicator selection. This requires the selection of indicators that provide opportunities for participatory data collection, analysis and evaluation (Figure 6), and a motivation by researchers and Life-Lab stakeholders to develop a citizen science approach to NBS assessment. It is crucial to the success of the participatory assessment framework for these considerations to be carried forward to the period following indicator selection. This requires continuous championing and commitment to participation on behalf of leading researchers in CONEXUS, particularly those responsible for assessment in the Life-Labs. We also call for the fair participation in various aspects of collecting and analyzing data to be regularly evaluated as part of the learning cycles in the CONEXUS project.

References

Ahmed, S., Meenar, M., & Alam, A. (2019). Designing a Blue-Green Infrastructure (BGI) Network: Toward Water-Sensitive Urban Growth Planning in Dhaka, Bangladesh. *Land*, *8*(138).

Ajuntament de Barcelona. (2013). *Barcelona green infrastructure and biodiversity plan 2020*. Ajuntament de Barcelona.

Ajuntament de Barcelona. (2017a). *Medida de Gobierno: Programma de Impulso de la Infraestructura Verde Urbana*. Ajuntament de Barcelona.

Ajuntament de Barcelona. (2017b). *Trees for Life: Master Plan for Barcelona's Trees 2017-2037*. Ajuntament de Barcelona.

Almassy, D., Pinter, L., Rocha, S., Naumann, S., Davis, M., Abhold, K., & Bulkeley, H. (2018). *Urban Nature Atlas: A Database of Nature-Based Solutions Across 100 European Cities*. NATURVATION.

Ambrose-Oji, B., Buijs, A., Gerőházi, E., Mattijssen, T., Száraz, L., Van der Jagt, A., Hansen, R., Rall, E., Andersson, E., Kronenberg, J., & Rolf, W. (2017). *Innovative governance for urban green infrastructure: A guide for practitioners*. GREEN SURGE Deliverable 6.3.

Andersson, E. (2018). Functional landscapes in cities: A systems approach. *Landscape and Ecological Engineering*, *14*, 193–199. https://doi.org/10.1007/s11355-017-0346-6

Andersson, E., Barthel, S., Borgström, S., Colding, J., Elmqvist, T., Folke, C., & Gren, Å. (2014). Reconnecting cities to the biosphere: Stewardship of green infrastructure and urban ecosystem services. *Ambio*, *43*(4), 445–453. https://doi.org/10.1007/s13280-014-0506-y

Andersson, K., Angelstam, P., Elbakidze, M., Axelsson, R., & Degerman, E. (2013). Green infrastructures and intensive forestry: Need and opportunity for spatial planning in a Swedish rural–urban gradient. *Scandinavian Journal of Forest Research*, *28*(2), 143–165. https://doi.org/10.1080/02827581.2012.723740

Ashley, R. M., Moug, P., Wild, T., Hurley, A. L., & Molyneux-Hodgson, S. (2008). Assessing Sustainability for Urban Regeneration in a River Corridor—Accounting for Climate Change. *International Low Impact*

Development Conference 2008: Low Impact Development for Urban Ecosystem and Habitat Protection, 1–10. https://doi.org/10.1061/41009(333)72

Atkins, D., & Wildau, S. (2008). *Participatory Water Monitoring: A Guide for Preventing and Managing Conflict*. The Office of the Compliance Advisor/Ombudsman.

Aubrechtová, T., Semančíková, E., & Raška, P. (2020). Formulation matters! The failure of integrating landscape fragmentation policy. *Sustainability*, *12*, 3962. https://doi.org/10.3390/SU12103962

Baldacchini, C., Calfapietra, C., Guidolotti, G., Sanesi, G., Spano, G., DeBellis, Y., Dadvand, P., de Keijzer, C., Gil-Roldán, E., Larcher, F., Paradiso, F., Ferracini, C., Bonelli, S., Xu, Y., & Ruan, T. (2020a). *Monitoring and Assessment Plan*. proGIreg Project Deliverable 4.1, Amendment 02.

Baldacchini, C., Calfapietra, C., Guidolotti, G., Sanesi, G., Spano, G., DeBellis, Y., Dadvand, P., de Keijzer, C., Gil-Roldán, E., Larcher, F., Paradiso, F., Ferracini, C., Bonelli, S., Xu, Y., & Ruan, T. (2020b). *Protocols of Measurements*. proGIreg Project Deliverable 4.3, Amendment 02.

Banzhaf, E., Bird, D. N., Blanco, E., Fletcher, D., Jones, L., Knopp, J., Luo, X., Wu, W., & Yang, J. (2020). *Synthesis report on current datasets and their applicability of ecosystem services mapping and modelling*. REGREEN Project Deliverable 3.1.

Barton, D. N., & Harrison, P. A. (2017). *Integrated assessment and valuation of ecosystem services: Guidelines and experiences.* OpenNESS Deliverable 33-44.

Bautista, S., Llovet, J., Ocampo-Melgar, A., Vilagrosa, A., Mayor, Á. G., Murias, C., Vallejo, V. R., & Orr, B. J. (2017). Integrating knowledge exchange and the assessment of dryland management alternatives – A learning-centered participatory approach. *Journal of Environmental Management*, *195*, 35–45. https://doi.org/10.1016/j.jenvman.2016.11.050

Bayulken, B., Huisingh, D., & Fisher, P. M. J. (2021). How are nature based solutions helping in the greening of cities in the context of crises such as climate change and pandemics? A comprehensive review. *Journal of Cleaner Production*, *288*, 125569. https://doi.org/10.1016/j.jclepro.2020.125569

Bell, S., & Morse, S. (2004). Experiences with sustainability indicators and stakeholder participation: A case study relating to a “blue plan” project in Malta. *Sustainable Development*, *12*(1), 1–14. https://doi.org/10.1002/sd.225

BenDor, T. K., Shandas, V., Miles, B., Belt, K., & Olander, L. (2018). Ecosystem services and U.S. stormwater planning: An approach for improving urban stormwater decisions. *Environmental Science and Policy*, *88*, 92–103. https://doi.org/10.1016/j.envsci.2018.06.006

Bjerke, M. B., & Renger, R. (2017). Being smart about writing SMART objectives. *Evaluation and Program Planning*, *61*, 125–127. https://doi.org/10.1016/j.evalprogplan.2016.12.009

Botzat, A., Fischer, L. K., & Kowarik, I. (2016). Unexploited opportunities in understanding liveable and biodiverse cities. A review on urban biodiversity perception and valuation. *Global Environmental Change*, *39*, 220–233. https://doi.org/10.1016/j.gloenvcha.2016.04.008

Breen, A., Giannotti, E., Flores Molina, M., & Vásquez, A. (2020). From “Government to Governance”? A Systematic Literature Review of Research for Urban Green Infrastructure Management in Latin America. *Frontiers in Sustainable Cities*, *2*, 572360. https://doi.org/10.3389/frsc.2020.572360

Bryman, A. (2016). *Social Research Methods*. Oxford University Press.

Buijs, A., Hansen, R., van der Jagt, A. P. N., Ambrose-Oji, B., Elands, B., Lorance Rall, E., Mattijssen, T., Pauleit, S., Runhaar, H., Stahl Olafsson, A., & Steen Møller, M. (2019). Mosaic governance for urban green infrastructure: Upscaling active citizenship from a local government perspective. *Urban Forestry & Urban Greening*, *40*, 53–62. https://doi.org/10.1016/j.ufug.2018.06.011

Buijs, A., Mattijssen, T. J., van der Jagt, A. P. N., Ambrose-Oji, B., Andersson, E., Elands, B. H., & Steen Møller, M. (2016). Active citizenship for urban green infrastructure: Fostering the diversity and dynamics of citizen contributions through mosaic governance. *Current Opinion in Environmental Sustainability*, *22*, 1–6. https://doi.org/10.1016/j.cosust.2017.01.002

Câmara Municipal de Lisboa. (2012). *PDM: Plano Diretor Municipal de Lisboa*. Câmara Municipal de Lisboa.

Câmara Municipal de Lisboa. (2017). *Estratégia Municipal de Adaptação às Alterações Climáticas de Lisboa: EMAAC 2017*. Camara Municipal de Lisboa.

Campbell, L. K., Svendsen, E. S., & Roman, L. A. (2016). Knowledge Co-production at the Research–Practice Interface: Embedded Case Studies from Urban Forestry. *Environmental Management*, *57*, 1262–1280. https://doi.org/10.1007/s00267-016-0680-8

Carmen, R., Jacobs, S., Leone, M., Palliwoda, J., Pinto, L., Misiune, I., Priess, J. A., Pereira, P., Wanner, S., Ferreira, C. S., & Ferreira, A. (2020). Keep it real: Selecting realistic sets of urban green space indicators. *Environmental Research Letters*, *15*(9). https://doi.org/10.1088/1748-9326/ab9465

Cash, D. W., Clark, W. C., Alcock, F., Dickson, N. M., Eckley, N., Guston, D. H., Jäger, J., & Mitchell, R. B. (2003). Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences of the United States of America*, *100*(14), 8086–8091. https://doi.org/10.1073/pnas.1231332100

Cidade de São Paulo. (2020). *PlanClimaSP: Plano de Ação Climática do Município de São Paulo 2020-2050*. Cidade de São Paulo.

Citta'di Torino. (2020a). *Piano di Resilienza Climatica* (p. 185). Citta'di Torino.

Citta'di Torino. (2020b). *Piano Forestale Aziendale 2020*. Citta'di Torino.

Citta'di Torino. (2020c). *Piano Strategico dell'Infrastruttura Verde*. Citta'di Torino.

City of Buenos Aires. (2021). *Climate Action Plan 2050*. The Government of the City of Buenos Aires.

Clark, C., Ordóñez, C., & Livesley, S. J. (2020). Private tree removal, public loss: Valuing and enforcing existing tree protection mechanisms is the key to retaining urban trees on private land. *Landscape and Urban Planning*, *203*, 103899. https://doi.org/10.1016/j.landurbplan.2020.103899

Coenen, F. H. J. M. (2009). *Public participation and better environmental decisions: The promise and limits of participatory processes for the quality of environmentally related decision-making*. Dordrecht: Springer.

Coletta, V. R., Pagano, A., Pluchinotta, I., Fratino, U., Scrieciu, A., Nanu, F., & Giordano, R. (2021). Causal Loop Diagrams for supporting Nature Based Solutions participatory design and performance assessment. *Journal of Environmental Management*, *280*, 111668. https://doi.org/10.1016/j.jenvman.2020.111668

Connop, S., Nash, C., Elliot, J., Haase, D., & Dushkova, D. (2020). *Nature-based solution evaluation indicators: Environmental Indicators Review*. Connecting Nature Project Deliverable.

Constantino, P. de A. L., Carlos, H. S. A., Ramalho, E. E., Rostant, L., Marinelli, C. E., Teles, D., Fonseca-Junior, S. F., Fernandes, R. B., & Valsecchi, J. (2012). Empowering local people through community-based resource monitoring: A comparison of Brazil and Namibia. *Ecology and Society*, *17*(4). https://doi.org/10.5751/ES-05164-170422

Cousins, J. J. (2021). Justice in nature-based solutions: Research and pathways. *Ecological Economics*, *180*, 106874. https://doi.org/10.1016/j.ecolecon.2020.106874

Dammers, E., Veerkamp, C., Ruijs, A., Hedlund, K., Alsterberg, C., Hanson, H., Lundmark, L., Olsson Alkan, J., Pinter, L., Almassy, D., Rocha, S., Werner, A., Bockarjova, M., & Bulkeley, H. (2019). *Working paper: Set up, applicability and use of the Naturvation Index*. NATURVATION Project Deliverable 3.4.

de Oliveira Fontes, L. (2020). From cultural formation to social mobilization: Spaces for formation and mobilization over three generations in the São Paulo outskirts. *Lua Nova: Revista de Cultura e Política*, *109*, 51–101. https://doi.org/10.1590/0102-051101/109

de Vries, S., Buijs, A. E., & Snep, R. P. H. (2020). Environmental Justice in The Netherlands: Presence and Quality of Greenspace Differ by Socioeconomic Status of Neighbourhoods. *Sustainability*, *12*(15), 5889. https://doi.org/10.3390/su12155889

de Wilde, M., Hurenkamp, M., & Tonkens, E. (2014). Flexible relations, frail contacts and failing demands: How community groups and local institutions interact in local governance in the Netherlands. *Urban Studies*, *51*(16), 3365–3382. https://doi.org/10.1177/0042098013519832

DeMeo, T., Markus, A., Borman, B., & Leingang, J. (2015). *The Monitoring Process Used in Collaborative Forest Landscape Restoration Projects in the Pacific Northwest*. *54*, 1–20.

Dobbs, C., Escobedo, F. J., Clerici, N., Barrera, F. D., Eleuterio, A. A., Macgregor-fors, I., Reyes-paecke, S., Vásquez, A., Danilo, J., Camaño, Z., & Hernández, H. J. (2019). Urban ecosystem Services in Latin America: Mismatch between global concepts and regional realities? *Urban Ecosystems*, *22*, 173–187.

Dorst, H., van der Jagt, A. P. N., Raven, R., & Runhaar, H. (2019). Urban greening through Nature-Based Solutions – key characteristics of an emerging concept. *Sustainable Cities and Society*, 101620. https://doi.org/10.1016/j.scs.2019.101620

Driessen, P. P. J., Dieperink, C., van Laerhoven, F., Runhaar, H. A. C., & Vermeulen, W. J. V. (2012). Towards a Conceptual Framework for The Study of Shifts in Modes of Environmental Governance—Experiences From The Netherlands. *Environmental Policy and Governance*, *22*(3), 143–160. https://doi.org/10.1002/eet.1580

Dumitru, A., & Wendling, L. (2021a). *Evaluating the Impact of Nature-Based Solutions: A Handbook for Practitioners*. Luxembourg: Publications Office of the European Union.

Dumitru, A., & Wendling, L. (2021b). *Evaluating the Impact of Nature-based Solutions: Appendix of Methods*. Luxembourg: Publications Office of the European Union.

Dushkova, D., & Haase, D. (2020). Not Simply Green: Nature-Based Solutions as a Concept and Practical Approach for Sustainability Studies and Planning Agendas in Cities. *Land*, *9*, 19.

Elands, B. H. M., Vierikko, K., Andersson, E., Fischer, L. K., Gonçalves, P., Haase, D., Kowarik, I., Luz, A. C., Niemelä, J., Santos-Reis, M., & Wiersum, K. F. (2019). Biocultural diversity: A novel concept to assess human-nature interrelations, nature conservation and stewardship in cities. *Urban Forestry & Urban Greening*, *40*, 29–34. https://doi.org/10.1016/j.ufug.2018.04.006

European Commission. (2015). *Towards an EU Research and Innovation policy agenda for Nature-Based Solutions & Re-Naturing Cities*. Brussels: European Commission.

Evans, K., & Guariguata, M. (2016). *Success from the ground up: Participatory monitoring and forest restoration*. Occasional Paper 159. Bogor, Indonesia: CIFOR.

Evans, K., Guariguata, M. R., & Brancalion, P. H. S. (2018). Participatory monitoring to connect local and global priorities for forest restoration. *Conservation Biology*, *32*(3), 525–534. https://doi.org/10.1111/cobi.13110

Fernandez-Gimenez, M. E., Ballard, H. L., & Sturtevant, V. E. (2008). Adaptive management and social learning in collaborative and community-based monitoring: A study of five community-based

forestry organizations in the western USA. *Ecology and Society*, *13*(2). https://doi.org/10.5751/ES-02400-130204

Ferreira, V., Barreira, A. P., Antunes, D., & Panagopoulos, T. (2020). Stakeholders' Engagement on Nature-Based Solutions: A Systematic Literature Review. *Sustainability*, *12*, 640.

Finewood, M. H., Matsler, A. M., & Zivkovich, J. (2019). Green Infrastructure and the Hidden Politics of Urban Stormwater Governance in a Postindustrial City. *Annals of the American Association of Geographers*, *109*(3), 909–925. https://doi.org/10.1080/24694452.2018.1507813

Fink, J. H. (2019). Contrasting governance learning processes of climate-leading and -lagging cities: Portland, Oregon, and Phoenix, Arizona, USA. *Journal of Environmental Policy & Planning*, *21*(1), 16–29. https://doi.org/10.1080/1523908X.2018.1487280

Frantzeskaki, N. (2019). Seven lessons for planning nature-based solutions in cities. *Environmental Science and Policy*, *93*, 101–111. https://doi.org/10.1016/j.envsci.2018.12.033

Gabriel, N. (2016). "No place for wilderness": Urban parks and the assembling of neoliberal urban environmental governance. *Urban Forestry and Urban Greening*, *19*, 278–284. https://doi.org/10.1016/j.ufug.2016.02.006

Garibaldi, L. A., Gemmill-Herren, B., D'Annolfo, R., Graeub, B. E., Cunningham, S. A., & Breeze, T. D. (2017). Farming Approaches for Greater Biodiversity, Livelihoods, and Food Security. *Trends in Ecology and Evolution*, *32*(1), 68–80. https://doi.org/10.1016/j.tree.2016.10.001

Giordano, R., Pluchinotta, I., Pagano, A., Scrieciu, A., & Nanu, F. (2020). Enhancing nature-based solutions acceptance through stakeholders' engagement in co-benefits identification and trade-offs analysis. *Science of the Total Environment*, *713*, 136552. https://doi.org/10.1016/j.scitotenv.2020.136552

Gould, K. A., & Lewis, T. L. (2017). *Green Gentrification: Urban Sustainability and the Struggle for Environmental Justice*. Routledge.

Gulsrud, N. M., Hertzog, K., & Shears, I. (2018). Innovative urban forestry governance in Melbourne?: Investigating "green placemaking" as a nature-based solution. *Environmental Research*, *161*, 158–167. https://doi.org/10.1016/j.envres.2017.11.005

Gulsrud, N. M., Raymond, C. M., Rutt, R. L., Olafsson, A. S., Plieninger, T., Sandberg, M., Beery, T. H., & Jönsson, K. I. (2018). 'Rage against the machine'? The opportunities and risks concerning the automation of urban green infrastructure. *Landscape and Urban Planning*, *180*, 85–92. https://doi.org/10.1016/j.landurbplan.2018.08.012

Hansen, R., Rall, E., Chapman, E., Rolf, W., & Pauleit, S. (2017). *Urban Green Infrastructure Planning: A Guide for Practitioners*. GREEN SURGE Deliverable 5.3.

Hazrati, M., & Heffron, R. J. (2021). Conceptualising restorative justice in the energy Transition: Changing the perspectives of fossil fuels. *Energy Research & Social Science*, *78*, 102115. https://doi.org/10.1016/j.erss.2021.102115

Herslund, L., & Mguni, P. (2019). Examining urban water management practices – Challenges and possibilities for transitions to sustainable urban water management in Sub-Saharan cities. *Sustainable Cities and Society*, *48*, 101573. https://doi.org/10.1016/j.scs.2019.101573

Huitema, D., Mostert, E., Egas, W., Moellenkamp, S., Pahl-Wostl, C., & Yalcin, R. (2009). Adaptive water governance: Assessing the institutional prescriptions of adaptive (co-)management from a governance perspective and defining a research agenda. *Ecology and Society*, *14*(1), 26.

Hurley, L., Ashley, R., Molyneux-Hodgson, S., Moug, P., & Schiessel, N. (2010). "Measuring" sustainable living agendas. *Management of Environmental Quality: An International Journal*, *21*(1), 45–57. https://doi.org/10.1108/14777831011010856

Ibrahim, A., Bartsch, K., & Shari, E. (2020). Green infrastructure needs green governance: Lessons from Australia's largest integrated stormwater management project, the River Torrens Linear Park. *Journal of Cleaner Production*, *261*, 121202. https://doi.org/10.1016/j.jclepro.2020.121202

IUCN. (2020). *IUCN Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of NbS* (First edit). Gland, Switzerland: IUCN.

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., Haase, D., Knapp, S., Korn, H., Stadler, J., Zaunberger, K., & Bonn, A. (2016). Nature-based solutions to climate change mitigation

and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action. *Ecology and Society*, *21*(2), 39.

Kazak, J. K., Chruściński, J., & Szewrański, S. (2018). The development of a novel decision support system for the location of green infrastructure for stormwater management. *Sustainability*, *10*, 4388. https://doi.org/10.3390/su10124388

Kloek, M. E., Buijs, A. E., Boersema, J. J., & Schouten, M. G. C. (2013). Crossing Borders: Review of Concepts and Approaches in Research on Greenspace, Immigration and Society in Northwest European Countries. *Landscape Research*, *38*(1), 117–140. https://doi.org/10.1080/01426397.2012.690861

Kooiman, J. (2003). *Governing as Governance*. Sage Publications Inc.

Kordana, S., & Daniel, S. (2020). An analysis of important issues impacting the development of stormwater management systems in Poland. *Science of the Total Environment*, *727*, 138711. https://doi.org/10.1016/j.scitotenv.2020.138711

Krasny, M. E., Russ, A., Tidball, K. G., & Elmqvist, T. (2014). Civic ecology practices: Participatory approaches to generating and measuring ecosystem services in cities. *Ecosystem Services*, *7*, 177–186. https://doi.org/10.1016/j.ecoser.2013.11.002

Kuller, M., Bach, P. M., Roberts, S., Browne, D., & Deletic, A. (2019). A planning-support tool for spatial suitability assessment of green urban stormwater infrastructure. *Science of the Total Environment*, *686*, 856–868. https://doi.org/10.1016/j.scitotenv.2019.06.051

Kumar, V., Rouquette, J. R., & Lerner, D. N. (2012). Integrated modelling for Sustainability Appraisal for Urban River Corridor (re)-development. *Procedia Environmental Sciences*, *13*(2011), 687–697. https://doi.org/10.1016/j.proenv.2012.01.062

Langemeyer, J., Camps-Calvet, M., Calvet-Mir, L., Barthel, S., & Gómez-Baggethun, E. (2018). Stewardship of urban ecosystem services: Understanding the value(s) of urban gardens in Barcelona. *Landscape and Urban Planning*, *170*, 79–89. https://doi.org/10.1016/j.landurbplan.2017.09.013

Langemeyer, J., & Connolly, J. J. T. (2020). Weaving notions of justice into urban ecosystem services research and practice. *Environmental Science & Policy*, *109*, 1–14. https://doi.org/10.1016/j.envsci.2020.03.021

Larson, K. L., Wiek, A., & Withycombe, L. (2013). A comprehensive sustainability appraisal of water governance in Phoenix, AZ. *Journal of Environmental Management*, *116*, 58–71. https://doi.org/10.1016/j.jenvman.2012.11.016

Lawrence, A. (2006). 'No personal motive?' Volunteers, biodiversity, and the false dichotomies of participation. *Ethics, Place and Environment*, *9*(3), 279–298. https://doi.org/10.1080/13668790600893319

Lawrence, A., De Vreese, R., Johnston, M., Konijnendijk van den Bosch, C. C., & Sanesi, G. (2013). Urban forest governance: Towards a framework for comparing approaches. *Urban Forestry & Urban Greening*, *12*(4), 464–473. https://doi.org/10.1016/j.ufug.2013.05.002

Lawrence, A., & Turnhout, E. (2010). Personal meaning in the public sphere: The standardisation and rationalisation of biodiversity data in the UK and the Netherlands. *Journal of Rural Studies*, *26*(4), 353–360. https://doi.org/10.1016/j.jrurstud.2010.02.001

Lee, K. C., & Yan, S. Y. (2019). Participatory planning and monitoring of protected landscapes: A case study of an indigenous rice paddy cultural landscape in Taiwan. *Paddy and Water Environment*, *17*(3), 539–548. https://doi.org/10.1007/s10333-019-00750-1

Lemos, M. C., & Morehouse, B. J. (2005). The co-production of science and policy in integrated climate assessments. *Global Environmental Change*, *15*(1), 57–68. https://doi.org/10.1016/j.gloenvcha.2004.09.004

Li, L., Collins, A. M., Cheshmehzangi, A., & Chan, F. K. S. (2020). Identifying enablers and barriers to the implementation of the Green Infrastructure for urban flood management: A comparative analysis of the UK and China. *Urban Forestry and Urban Greening*, *54*, 126770. https://doi.org/10.1016/j.ufug.2020.126770

Lin, B. B., Meyers, J. A., & Barnett, G. B. (2019). Establishing Priorities for Urban Green Infrastructure Research in Australia. *Urban Policy and Research*, *37*(1), 30–44. https://doi.org/10.1080/08111146.2018.1523054

McQuatters-Gollop, A., Mitchell, I., Vina-Herbon, C., Bedford, J., Addison, P. F. E., Lynam, C. P., Geetha, P. N., Vermeulan, E. A., Smit, K., Bayley, D. T. I., Morris-Webb, E., Niner, H. J., & Otto, S. A. (2019). From science to evidence—How biodiversity indicators can be used for effective marine conservation policy and management. *Frontiers in Marine Science*, *6*(MAR), 1–16. https://doi.org/10.3389/fmars.2019.00109

Mell, I. (2020a). The impact of austerity on funding green infrastructure: A DPSIR evaluation of the Liverpool Green & Open Space Review (LG&OSR), UK. *Land Use Policy*, *91*. https://doi.org/10.1016/j.landusepol.2019.104284

Mell, I. (2020b). What Future for Green Infrastructure Planning? Evaluating the Changing Environment for Green Infrastructure Planning Following the Revocation of Regional Planning Policy in England. *Planning Practice & Research*, *35*(1), 18–50. https://doi.org/10.1080/02697459.2020.1714271

Mguni, P., Herslund, L., & Bergen, M. (2016). Sustainable urban drainage systems: Examining the potential for green infrastructure-based stormwater management for Sub-Saharan cities. *Natural Hazards*, *82*(2), 241–257. https://doi.org/10.1007/s11069-016-2309-x

Mguni, P., Herslund, L., & Jensen, M. B. (2015). Green infrastructure for flood-risk management in Dar es Salaam and Copenhagen: Exploring the potential for transitions towards sustainable urban water management. *Water Policy*, *17*(1), 126–142. https://doi.org/10.2166/wp.2014.047

Mickwitz, P., & Melanen, M. (2009). The role of co-operation between academia and policymakers for the development and use of sustainability indicators—A case from the Finnish Kymenlaakso Region. *Journal of Cleaner Production*, *17*(12), 1086–1100. https://doi.org/10.1016/j.jclepro.2008.12.003

Morris, J., & Lawrence, A. (2010). *Learning from Monitoring & Evaluation – a blueprint for an adaptive organisation* (pp. 1–22). Farnham, UK: Forest Research.

Nastran, M., & Regina, H. (2016). Advancing urban ecosystem governance in Ljubljana. *Environmental Science & Policy*, *62*, 123–126. https://doi.org/10.1016/j.envsci.2015.06.003

NATURE4CITIES. (2018). *D2.1—System of integrated multi-scale and multi-thematic performance indicators for the assessment of urban challenges and NBS*. NATURE4CITIES Project Deliverable 2.1.

Nesbitt, L., Meitner, M. J., Sheppard, S. R. J., & Girling, C. (2018). The dimensions of urban green equity: A framework for analysis. *Urban Forestry & Urban Greening*, *34*, 240–248. https://doi.org/10.1016/j.ufug.2018.07.009

Neugarten, R. A., Langhammer, P. F., Osipova, E., Bagstad, K. J., Bhagabati, N., Butchart, S. H. M., Dudley, N., Elliott, V., Gerber, L. R., Gutierrez Arrellano, C., Ivanić, K.-Z., Kettunen, M., Mandle, L., Merriman, J. C., Mulligan, M., Peh, K. S.-H., Raudsepp-Hearne, C., Semmens, D. J., Stolton, S., & Willcock, S. (2018). *Tools for measuring, modelling, and valuing ecosystem services: Guidance for Key Biodiversity Areas, natural World Heritage Sites, and protected areas*.

Nielsen, A. B., Hedblom, M., Olafsson, A. S., & Wiström, B. (2017). Spatial configurations of urban forest in different landscape and socio-political contexts: Identifying patterns for green infrastructure planning. *Urban Ecosystems*, *20*(2), 379–392. https://doi.org/10.1007/s11252-016-0600-y

O'Donnell, E. C., Lamond, J. E., & Thorne, C. R. (2018). Learning and Action Alliance framework to facilitate stakeholder collaboration and social learning in urban flood risk management. *Environmental Science and Policy*, *80*, 1–8. https://doi.org/10.1016/j.envsci.2017.10.013

Ortuño, J., & Fermoso, J. (2017). *D5.1: Technical KPIs Definition*. URBAN GreenUP Project Deliverable 5.1.

Ortuño, J., & Fermoso, J. (2018). *D5.3: City Diagnosis and Monitoring Procedures*. URBAN GreenUP Project Deliverable 5.3.

Pahl-Wostl, C. (2017). An Evolutionary Perspective on Water Governance: From Understanding to Transformation. *Water Resources Management*, *31*(10), 2917–2932. https://doi.org/10.1007/s11269-017-1727-1

Pasimeni, M. R., Valente, D., Zurlini, G., & Petrosillo, I. (2019). The interplay between urban mitigation and adaptation strategies to face climate change in two European countries. *Environmental Science & Policy*, *95*, 20–27. https://doi.org/10.1016/j.envsci.2019.02.002

Pauleit, S., Ambrose-Oji, B., Andersson, E., Anton, B., Buijs, A., Haase, D., Elands, B., Hansen, R., Kowarik, I., Kronenberg, J., Mattijssen, T., Stahl Olafsson, A., Rall, E., van der Jagt, A. P. N., & Konijnendijk van den Bosch, C. (2019). Advancing urban green infrastructure in Europe: Outcomes and reflections from the GREEN SURGE project. *Urban Forestry and Urban Greening*, *40*, 4–16. https://doi.org/10.1016/j.ufug.2018.10.006

Pauleit, S., Zölch, T., Hansen, R., Randrup, T. B., & Konijnendijk van den Bosch, C. C. (2017). Nature-Based Solutions and Climate Change – Four Shades of Green. In N. Kabisch, H. Korn, J. Stadler, & A. Bonn (Eds.), *Nature-Based Solutions to Climate Change Adaptation in Urban Areas* (pp. 29–49). Springer.

Pocock, M. J. O., Chandler, M., Bonney, R., Thornhill, I., Albin, A., August, T., Bachman, S., Brown, P. M. J., Cunha, D. G. F., Grez, A., Jackson, C., Peters, M., Rabarijaon, N. R., Roy, H. E., Zaviezo, T., & Danielsen, F. (2018). A Vision for Global Biodiversity Monitoring With Citizen Science. In *Advances in Ecological Research* (Vol. 59, pp. 169–223). Elsevier. https://doi.org/10.1016/bs.aecr.2018.06.003

Posner, S. M., McKenzie, E., & Ricketts, T. H. (2016). Policy impacts of ecosystem services knowledge. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(7), 1760–1765. https://doi.org/10.1073/pnas.1502452113

Purcell, M. (2006). Urban democracy and the local trap. *Urban Studies*, *43*(11), 1921–1941. https://doi.org/10.1080/00420980600897826

Quiroga Martínez, R. (2009). *Guía metodológica para desarrollar indicadores ambientales y de desarrollo sostenible en países de América Latina y el Caribe*. Naciones Unidas, CEPAL.

Randrup, T. B., Buijs, A., Konijnendijk, C. C., & Wild, T. (2020). Moving beyond the nature-based solutions discourse: Introducing nature-based thinking. *Urban Ecosystems*, *23*, 919–926. https://doi.org/10.1007/s11252-020-00964-w

Raymond, C. M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M. R., Geneletti, D., & Calfapietra, C. (2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environmental Science and Policy*, *77*(July), 15–24. https://doi.org/10.1016/j.envsci.2017.07.008

Raymond, C. M., Pam, B., Breil, M., Nita, M. R., Kabisch, N., de Bel, M., Enzi, V., Frantzeskaki, N., Geneletti, D., Cardinaletti, M., Lovinger, L., Basnou, C., Monteiro, A., Robrecht, H., Sgrigna, G., Munari, L., & Calfapietra, C. (2017). *An Impact Evaluation Framework to Support Planning and Evaluation of Nature-based Solutions Projects—An EKLIPSE Expert Working Group report*. Wallingford (UK): Centre for Ecology & Hydrology.

Reed, J., Van Vianen, J., Deakin, E. L., Barlow, J., & Sunderland, T. (2016). Integrated landscape approaches to managing social and environmental issues in the tropics: Learning from the past to guide the future. *Global Change Biology*, *22*(7), 2540–2554. https://doi.org/10.1111/gcb.13284

Reed, M. S. (2008). Stakeholder participation for environmental management: A literature review. *Biological Conservation*, *141*, 2417–2431. https://doi.org/10.1016/j.biocon.2008.07.014

Reed, M. S., Vella, S., Challies, E., de Vente, J., Frewer, L., Hohenwallner-Ries, D., Huber, T., Neumann, R. K., Oughton, E. A., Sidoli del Ceno, J., & van Delden, H. (2018). A theory of participation: What makes stakeholder and public engagement in environmental management work?: A theory of participation. *Restoration Ecology*, *26*, S7–S17. https://doi.org/10.1111/rec.12541

Rogers, B. C., Dunn, G., Hammer, K., Novalia, W., de Haan, F. J., Brown, L., Brown, R. R., Lloyd, S., Urich, C., Wong, T. H. F., & Chesterfield, C. (2020). Water Sensitive Cities Index: A diagnostic tool to assess water sensitivity and guide management actions. *Water Research*, *186*, 116411. https://doi.org/10.1016/j.watres.2020.116411

Ruckelshaus, M., McKenzie, E., Tallis, H., Guerry, A., Daily, G., Kareiva, P., Polasky, S., Ricketts, T., Bhagabati, N., Wood, S. A., & Bernhardt, J. (2015). Notes from the field: Lessons learned from using ecosystem service approaches to inform real-world decisions. *Ecological Economics*, *115*, 11–21. https://doi.org/10.1016/j.ecolecon.2013.07.009

Rutt, R. L., & Gulsrud, N. M. (2016). Green justice in the city: A new agenda for urban green space research in Europe. *Urban Forestry and Urban Greening*, *19*, 123–127. https://doi.org/10.1016/j.ufug.2016.07.004

Rutzinger, M., Zieher, T., & Polderman, A. (2019). *Report on monitoring criteria of OALs for effective reduction and prevention of risks related to natural hazards*. OPERANDUM Project Deliverable 3.4.

Rydin, Y., Holman, N., & Wolff, E. (2003). Local Sustainability Indicators Local Sustainability Indicators. *Local Environment*, *8*(6), 581–589. https://doi.org/10.1080/1354983032000152707

Saarikoski, H., Primmer, E., Saarela, S. R., Antunes, P., Aszalós, R., Baró, F., Berry, P., Blanko, G. G., Goméz-Baggethun, E., Carvalho, L., Dick, J., Dunford, R., Hanzu, M., Harrison, P. A., Izakovicova, Z., Kertész, M., Kopperoinen, L., Köhler, B., Langemeyer, J., … Young, J. (2018). Institutional challenges in putting ecosystem service knowledge in practice. *Ecosystem Services*, *29*(September 2017), 579–598. https://doi.org/10.1016/j.ecoser.2017.07.019

Sagoe, A. A., Aheto, D. W., Okyere, I., Adade, R., & Odoi, J. (2021). Community participation in assessment of fisheries related ecosystem services towards the establishment of marine protected area in the Greater Cape Three Points area in Ghana. *Marine Policy*, *124*, 104336. https://doi.org/10.1016/j.marpol.2020.104336

Sarabi, S. E., Han, Q., Romme, A. G. L., de Vries, B., & Wendling, L. (2019). Key enablers of and barriers to the uptake and implementation of nature-based solutions in urban settings: A review. *Resources*, *8*, 121. https://doi.org/10.3390/resources8030121

Savan, B., Morgan, A. J., & Gore, C. (2003). Volunteer environmental monitoring and the role of the universities: The case of Citizens' Environment Watch. *Environmental Management*, *31*(5), 561–568. https://doi.org/10.1007/s00267-002-2897-y

Schäffler, A., & Swilling, M. (2013). Valuing green infrastructure in an urban environment under pressure—The Johannesburg case. *Ecological Economics*, *86*, 246–257. https://doi.org/10.1016/j.ecolecon.2012.05.008

Schifman, L. A., Herrmann, D. L., Shuster, W. D., Ossola, A., Garmestani, A., & Hopton, M. E. (2017). Situating Green Infrastructure in Context: A Framework for Adaptive Socio-Hydrology in Cities. *Water Resources Research*, *53*(10), 10139–10154. https://doi.org/10.1002/2017WR020926

Seto, K. C., Golden, J. S., Alberti, M., & Turner, B. L. (2017). Sustainability in an urbanizing planet. *Proceedings of the National Academy of Sciences*, *114*(34), 8935–8938. https://doi.org/10.1073/pnas.1606037114

Sharman, A., & Holmes, J. (2010). Evidence-based policy or policy-based evidence gathering? Biofuels, the EU and the 10% target. *Environmental Policy and Governance*, *20*(5), 309–321. https://doi.org/10.1002/eet.543

Shih, W.-Y., Mabon, L., & Puppim de Oliveira, J. A. (2020). Assessing governance challenges of local biodiversity and ecosystem services: Barriers identified by the expert community. *Land Use Policy*, *91*, 104291. https://doi.org/10.1016/j.landusepol.2019.104291

Steen Møller, M., Stahl Olafsson, A., Vierikko, K., Sehested, K., Elands, B., Buijs, A., & Konijnendijk van den Bosch, C. C. (2019). Participation through place-based e-tools: A valuable resource for urban green infrastructure governance? *Urban Forestry & Urban Greening*, *40*, 245–253. https://doi.org/10.1016/j.ufug.2018.09.003

Stevance, A. S., Bridgewater, P., Louafi, S., King, N., Beard, T. D., Van Jaarsveld, A. S., Ofir, Z., Kohsaka, R., Jenderedijan, K., Rosales Benites, M., Mulongoy, K. J., Chaudhari, K. L., Painter, J., & Meter, A. (2020). The 2019 review of IPBES and future priorities: Reaching beyond assessment to enhance policy impact. *Ecosystems and People*, *16*(1), 70–77. https://doi.org/10.1080/26395916.2019.1702590

Tarrasón, D., Ravera, F., Reed, M. S., Dougill, A. J., & Gonzalez, L. (2016). Land degradation assessment through an ecosystem services lens: Integrating knowledge and methods in pastoral semi-arid systems. *Journal of Arid Environments*, *124*, 205–213. https://doi.org/10.1016/j.jaridenv.2015.08.002

Tiwary, A., Vilhar, U., Zhiyanski, M., Stojanovski, V., & Dinca, L. (2020). Management of nature-based goods and services provisioning from the urban common: A pan-European perspective. *Urban Ecosystems*, *23*(3), 645–657. https://doi.org/10.1007/s11252-020-00951-1

Toxopeus, H., Kotsila, P., Conde, M., Katona, A., van der Jagt, A. P. N., & Polzin, F. (2020). How 'just' is hybrid governance of urban nature-based solutions? *Cities*, *105*, 102839. https://doi.org/10.1016/j.cities.2020.102839

Uchiyama, Y., & Kohsaka, R. (2019). Application of the City Biodiversity Index to populated cities in Japan: Influence of the social and ecological characteristics on indicator-based management. *Ecological Indicators*, *106*(May), 105420. https://doi.org/10.1016/j.ecolind.2019.05.051

United Nations. (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development*. https://doi.org/10.1201/b20466-7

Vallauri, D., Aronson, J., Dudley, N., & Vallejo, R. (2005). Monitoring and Evaluating Forest Restoration Success. In S. Mansourian, D. Vallauri, & N. Dudley (Eds.), *Forest Restoration in Landscapes: Beyond Planting Trees* (pp. 150–160). https://doi.org/10.1007/0-387-29112-1

van der Jagt, A. P. N., Kiss, B., Hirose, S., & Takahashi, W. (2021). Nature-Based Solutions or Debacles? The Politics of Reflexive Governance for Sustainable and Just Cities. *Frontiers in Sustainable Cities*, *2*, 583833. https://doi.org/10.3389/frsc.2020.583833

van der Jagt, A. P. N., & Lawrence, A. (2019). Local government and urban forest governance: Insights from Scotland. *Scandinavian Journal of Forest Research*, *34*(1), 53–66.

van der Jagt, A. P. N., Raven, R., Dorst, H., & Runhaar, H. (2020). Nature-based innovation systems. *Environmental Innovation and Societal Transitions*, *35*, 202–216. https://doi.org/10.1016/j.eist.2019.09.005

van der Jagt, A. P. N., Smith, M., Ambrose-Oji, B., Konijnendijk, C. C., Giannico, V., Haase, D., Lafortezza, R., Nastran, M., Pintar, M., Železnikar, Š., & Cvejić, R. (2019). Co-creating urban green infrastructure connecting people and nature: A guiding framework and approach. *Journal of Environmental Management*, *233*, 757–767. https://doi.org/10.1016/j.jenvman.2018.09.083

van der Jagt, A. P. N., Szaraz, L. R., Delshammar, T., Cvejić, R., Santos, A., Goodness, J., & Buijs, A. (2017). Cultivating nature-based solutions: The governance of communal urban gardens in the European Union. *Environmental Research*, *159*, 264–275. https://doi.org/10.1016/j.envres.2017.08.013

van der Jagt, A. P. N., Toxopeus, H., Tozer, L., Dorst, H., Runhaar, H., & Bulkeley, H. (2020). *Greening European Cities: Accelerating the uptake of urban nature-based solutions*. NATURVATION Deliverable 5.8.

van Oudenhoven, A. P. E., Aukes, E., Bontje, L. E., Vikolainen, V., van Bodegom, P. M., & Slinger, J. H. (2018). 'Mind the Gap' between ecosystem services classification and strategic decision making. *Ecosystem Services*, *33*(July), 77–88. https://doi.org/10.1016/j.ecoser.2018.09.003

van Oudenhoven, A. P. E., Schröter, M., Drakou, E. G., Geijzendorffer, I. R., Jacobs, S., van Bodegom, P. M., Chazee, L., Czúcz, B., Grunewald, K., Lillebø, A. I., Mononen, L., Nogueira, A. J. A., Pacheco-Romero, M., Perennou, C., Remme, R. P., Rova, S., Syrbe, R. U., Tratalos, J. A., Vallejos, M., & Albert, C. (2018). Key criteria for developing ecosystem service indicators to inform decision making. *Ecological Indicators*, *95*(August), 417–426. https://doi.org/10.1016/j.ecolind.2018.06.020

Viani, R. A. G., Holl, K. D., Padovezi, A., Strassburg, B. B. N., Farah, F. T., Garcia, L. C., Chaves, R. B., Rodrigues, R. R., & Brancalion, P. H. S. (2017). Protocol for monitoring tropical forest restoration: Perspectives from the atlantic forest restoration pact in Brazil. *Tropical Conservation Science*, *10*. https://doi.org/10.1177/1940082917697265

Wamsler, C. (2015). Mainstreaming ecosystem-based adaptation: Transformation toward sustainability in urban governance and planning. *Ecology and Society*, *20*(2). https://doi.org/10.5751/ES-07489-200230

Wamsler, C., Luederitz, C., & Brink, E. (2014). Local levers for change: Mainstreaming ecosystem-based adaptation into municipal planning to foster sustainability transitions. *Global Environmental Change*, *29*, 189–201. https://doi.org/10.1016/j.gloenvcha.2014.09.008

Wamsler, C., Niven, L., Beery, T. H., Bramryd, T., Jönsson, K. I., Osmani, A., Palo, T., & Stålhammar, S. (2016). Operationalizing ecosystem-based adaptation: Harnessing ecosystem services to buffer communities against climate change. *Ecology and Society*, *21*(1).

Wamsler, C., Wickenberg, B., Hanson, H., Alkan Olsson, J., Stålhammar, S., Björn, H., Falck, H., Gerell, D., Oskarsson, T., Simonsson, E., Torffvit, F., & Zelmerlow, F. (2020). Environmental and climate policy integration: Targeted strategies for overcoming barriers to nature-based solutions and climate change adaptation. *Journal of Cleaner Production*, *247*, 119154. https://doi.org/10.1016/j.jclepro.2019.119154

Wang, Y., van Roon, M., & Knight-Lenihan, S. (2021). Opportunities and challenges in water sensitive industrial development: An Auckland case study, New Zealand. *International Journal of Sustainable Development & World Ecology*, *28*(2), 143–156. https://doi.org/10.1080/13504509.2020.1783717

Watkin, L. J., Ruangpan, L., Vojinovic, Z., Weesakul, S., & Torres, A. S. (2019). A framework for assessing benefits of implemented nature-based solutions. *Sustainability (Switzerland)*, *11*(23). https://doi.org/10.3390/su11236788

Wendling, L., Rinta-Hiiro, V., Jermakka, J., Fatima, Z., zu Castell-Rüdenhausen, M., Ascenso, A., Miranda, A. I., Roebeling, P., Martins, R., & Mendonça, R. (2019). *Performance and Impact Monitoring of Nature-Based Solutions*. UnaLab Project Deliverable 3.1.

Whitfield, S., & Reed, M. S. (2012). Participatory environmental assessment in drylands: Introducing a new approach. *Journal of Arid Environments*, *77*(1), 1–10. https://doi.org/10.1016/j.jaridenv.2011.09.015

Wild, T., Dempsey, N., & Broadhead, A. T. (2019). Volunteered information on nature-based solutions—Dredging for data on deculverting. *Urban Forestry & Urban Greening*, *40*, 254–263. https://doi.org/10.1016/j.ufug.2018.08.019

Wild, T., Freitas, T., & Vandewoestijne, S. (2020). *Nature-Based Solutions: State of the Art in EU-funded projects*. Brussels: European Commission.

Workalemahu Habtemariam, L., Byskov Herslund, L., & Mguni, P. (2019). What makes a champion for landscape-based storm water management in Addis Ababa ? *Sustainable Cities and Society*, *46*, 101378. https://doi.org/10.1016/j.scs.2018.12.006

Xie, L., Bulkeley, H., van der Jagt, A. P. N., Toxopeus, H., Tozer, L., Pearl-Martinez, R., Dorst, H., & Runhaar, H. (2020). *Pathways for Systemic Integration of Nature-based Solutions*. NATURVATION Deliverable 5.10.

Yousefi-Sahzabi, A., Sasaki, K., & Yousefi, H. (2014). Thoughts on the Notion of Environmental Information Science. *Electronic Green Journal*, *1*(37). https://doi.org/10.5070/G313724195

Zevenbergen, C., Fu, D., & Pathirana, A. (2018). Transitioning to Sponge Cities: Challenges and Opportunities to Address Urban Water Problems. *Water*, *10*(1230). https://doi.org/10.3390/w10091230

Zorita, S., Garcia Perez, I., Murphy-Evans, N., Arlati, A., Rödl, A., Barone, E., & Casagrande, S. (2019). *D4.3 Monitoring strategy in the FR interventions*. CLEVER Cities Project Deliverable 4.3.

Zuniga-Teran, A. A., Staddon, C., Vito, L. D., Gerlak, A. K., Ward, S., Schoeman, Y., Hart, A., Booth, G., Staddon, C., Vito, L. D., Gerlak, A. K., Ward, S., Schoeman, Y., Hart, A., & Booth, G. (2020). Challenges of mainstreaming green infrastructure in built environment professions. *Journal of Environmental Planning and Management*, *63*(4), 710–732. https://doi.org/10.1080/09640568.2019.1605890

Appendix A – Research methodology

Interviews

For each of the Life-Lab cities, we interviewed 1-3 experts with knowledge on the assessment of NBS. In all, 13 local experts were interviewed, mostly from the municipality (see Table A1). Relevant interview contacts were identified in consultation with the Life-Lab facilitators, and in some cases through referrals made by existing contacts (i.e. snowballing sampling). The interviews were carried out between March and April 2021.

Using a semi-structured interviewing approach, we asked selected interviewees i.a. about current use of indicators for assessing the benefits of urban nature, the impact of these, current level of participation in assessment, and scope for adding more indicators. We also included questions about governance challenges around steering the actions of societal actors relevant to urban nature uptake, and possible ways to address these. A second part of the interviews was concerned with the current use of NBS guidance in each of the Life-Lab cities. This will be analyzed and reported on as part of CONEXUS Task 4.3.

Table A1. Overview of interviewed experts on the assessment of NBS for each of the Life-Lab cities (anonymized, with only the affiliation shown).

Interview number	Life-Lab city	Interviewee affiliation
1	Barcelona	Urban Ecology Area, Biodiversity Programme, Barcelona City Council
2		Directorates of Conservation and Green Spaces and Biodiversity, Department of the Environment, Barcelona City Council
3		Environmental Projects, Barcelona Regional
4	Bogota	Faculty of Environmental and Rural Studies, Pontificia Universidad Javeriana
5		Environmental Observatory of Bogotá - District Secretary of Environment, Bogotá City Council
6		Environmental Observatory of Bogotá - District Secretary of Environment, Bogotá City Council
7	Buenos Aires	Habitat Secretariat, Ministry of Territorial Development and Habitat, Government of Argentina
8		DG Public and Environmental Strategy, Environmental Protection Agency, Government of Buenos Aires
9	Lisbon	Deputy Mayor´s Office, Lisbon municipality
10	Santiago	Department of Public Spaces, Santiago Metropolitan Region
11		Ministry of Housing and Urban Development, Government of Chile
12	São Paulo	Municipal Secretariat for the Environment, São Paulo City Hall
13	Turin	Sustainability Policy and Strategic Planning, Mayor's Office, City of Torino

Interviews were conducted in either the English, Spanish or Portugese language, depending on language capacity within the research team and the preference of the interview contact. Materials such as the

information sheets and consent forms were translated to the preferred language of the interview contact. The duration of the interviews was approximately 1.5 hours. All of the interviews took place online using Teams or Zoom as communication platform. Interviews were audio-recorded, transcribed, and translated to English if necessary. The translations were made using the software package DeepL and validated by the interviewer before being analyzed.

The transcripts were thematically analyzed (e.g., see Bryman, 2016) using the software package ATLAS.ti. A staggered approach to data analysis was taken by first coding the material based on the relevant chapters in this report – inventory of existing assessment frameworks (Chapter 2), the uptake of participatory assessment (Chapter 3) and the development of comprehensive governance indicators (Chapter 5). In the next round, these 'parent' codes were split by sub-themes such as the different governance indicators for Chapter 5 and the different selection criteria to guide indicator selection for Chapter 4.

The primary research methods, comprising the interviews and the planned workshops applied as part of Task 4.1, have all been approved by the Social Sciences Ethics Committee of Wageningen University. All contacts who agreed with an interview were sent an information sheet with background information on the CONEXUS project, with the section on data storage and management tailored to this task and WP4. The information sheet was again presented at the start of the interview to ensure that the interviewee had read and understood it. Subsequently, interviewees were presented a consent form and asked to complete this before commencing the interview.

Scoping reviews

The report draws on the outcomes of two separate scoping reviews – the first aimed at identifying a comprehensive set of governance indicators relevant to NBS uptake (Chapter 5), and the second at building a case for participatory assessment, including a set of indicator selection criteria (Chapter 3). For both reviews we used the search engine Scopus.

For the first review on governance indicators, we entered the combinations of the keywords 'nature-based solutions' or 'green infrastructure', the term 'urban', the term 'governance' and the terms 'driver', 'opportunity', 'opening', 'pathways' or 'enabler'. This search was carried out in March 2021. A total of 86 publications met the search criteria. In a next step, we scanned the titles and abstracts of these and discarded those articles which were not explicitly relevant to the urban context and did not clearly study the role of governance in NBS uptake. As a result of this, we discarded 30 publications – the remaining 56 publications were studied in more detail to identify relevant drivers. In doing so, we focused on concrete action opportunities rather than expressed needs or challenges. For example, we did not include extracts on the need

for more funding or knowledge in the review, while we did consider those on specific funding options or training opportunities supporting the implementation of NBS.

Applying incident-by-incident coding, relevant paper extracts were identified and mapped onto the dimensional structure of the Nature-Based Innovation System framework (van der Jagt, Raven, et al., 2020) as a first way of organizing the data. This is a framework that was inductively developed to synthesize factors influencing nature-based innovation. Although clearly overlapping with the approach taken in that study, we adopt a much more explicit focus on governance whilst having a less explicit focus on innovation. In a next step, the contents coded under each of the main dimensions were grouped and organized into sub-dimensions. We derived the formulations of some of these from the NATURVATION portfolio of stepping stones for mainstreaming urban NBS (van der Jagt, Toxopeus, et al., 2020). A second governance expert then reviewed the material and the (sub)dimensions, resulting in the reallocation of some materials to other subdimensions, the amalgamation of some sub-dimensions, the renaming of (sub)dimensions, the escalation of some sub-dimensions to 'parent' dimensions, and the creation of a small number of new (sub)dimensions. The first author and reviewer moved through a number of iterations of revising and reviewing the framework before finally agreeing on a version in which there is a good balance between simplicity and complexity with (sub)dimensions with appropriate internal cohesiveness and external distinctiveness.

For the second review on participatory assessment, we ran two separate searches on Scopus, both in January 2021. The first of these we look for combinations between 'nature-based solutions', or the similar terms 'nature-based solutions', 'green infrastructure', 'ecosystem services', and 'participatory assessment' or similar terms such as 'collaborative assessment' or 'collaborative monitoring'. As we wanted to be absolutely sure to include all relevant research on the participatory assessment of nature-based solutions, we ran a second search combining the terms 'nature-based solutions', 'assessment' or 'monitoring' and 'participatory'. Together, these search actions returned 53 publications, of which we selected 25 for further analysis after scanning the titles and abstracts. Given the key focus of this chapter on criteria for participatory assessment, we also explored the Scopus database for papers citing the seminal paper by van Oudenhoven et al. (2018a) on this topic, resulting in the selection of an additional 10 publications. Following this, the selected articles were studied with these research questions in mind: What is a participatory assessment approach? What is the added value of a participatory over conventional assessment? How to integrate principles of participatory assessment into the CONEXUS assessment framework? Contents relevant to criteria to guide indicator selection were identified and grouped using a combination of deductive and inductive reasoning. In addition, we also extracted information on current operationalization of participatory monitoring and assessment and on impacts of participatory assessment, taking a similar approach to organizing the material.

Appendix B – Indicators for evaluating the governance of nature-based solutions in cities

1. Overview of indicators

Based on Chapter 5, the following dimensions, i.e. indicators, for successful NBS governance are identified:

1. Agency (e.g. nature-based solutions champions)
2. Governance structure (e.g. integrated working)
3. Legislation, regulations & policies
4. Collaborative arrangements
5. Active community engagement
6. Monitoring and assessment
7. Knowledge acquisition and sharing
8. Financing mechanisms
9. Valuing diversity, equity and inclusion

For each of these dimensions we developed an indicator, which can be assessed based on a survey with four questions. The survey questions are shown in Section 2. The survey questions are repeated for each of the eight dimensions. This means that a total of 32 responses (8 dimensions x 4 questions) is required to complete this survey.

The descriptions of the dimensions and the survey questions are presented from the perspective of the municipal administration, who tend to have the best overview for combined set of indicators. We therefore recommend the survey to be completed by the head of the most relevant department for strategic city wide green space planning (e.g., head of urban planning/green space planning department) or a public administrator with a good overview of green space planning and urban planning. Additional professionals could be surveyed through the snowballing technique to build a more comprehensive picture if needed.

2. Survey questions

The survey comprises four questions for each of the nine governance dimensions. This represents a mix of two questions with a Likert response scale (1-5) and two open questions. Section 3 provides a scoring rubric for each of the governance indicators.

The first two questions are about the manifestation of the governance dimension and ask about the extent to which it can be observed in a particular city, and how this has been achieved. The second set of questions is

about the perceived significance of the governance dimension. Here, respondents are asked to indicate the extent to which the governance dimension is considered decisive in determining the successful uptake of NBS in a particular city. Respondents are also asked to explain their response.

Below we provide an overview of the survey questions and response scales.

1.	a) To what extent are nature-based solutions initiatives being championed in your city? *Please rate your personal view between 1 (not at all) and 5 (to a great extent)*	*Not at all*	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	*To a great extent*
	b) If answered 3 or higher, please describe how this has been achieved by referring to particular actions taken: ...							
	c) To what extent is the championing of nature-based solutions a decisive factor for the successful uptake of NBS in your city? *Please rate your personal view between 1 (not at all) and 5 (to a great extent).*	*Not at all*	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	*To a great extent*
	d) Please explain your viewpoint, for example by referring to particular characteristics of your city and its people, environment, economy or political situation ...							
2.	a) To what extent is does the municipality in your city engage in integrated working across different policy domains for nature-based solutions? *Please rate your personal view between 1 (not at all) and 5 (to a great extent)*	*Not at all*	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	*To a great extent*
	b) If answered 3 or higher, please describe how this has been achieved by referring to particular actions taken: ...							
	c) To what extent is integrated working across different policy domains a decisive factor for the successful uptake of NBS in your city? *Please rate your personal view between 1 (not at all) and 5 (to a great extent).*	*Not at all*	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	*To a great extent*

d) Please explain your viewpoint, for example by referring to particular characteristics of your city and its people, environment, economy or political situation

...

3.

a) To what extent does your city have policies and regulation mandating urban greening action?

Not at all 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ *To a great extent*

Please rate your personal view between 1 (not at all) and 5 (to a great extent)

b) If answered 3 or higher, please describe how this has been achieved by referring to particular actions taken:

...

c) To what extent are compulsory urban greening measures a decisive factor for the successful uptake of NBS in your city?

Not at all 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ *To a great extent*

Please rate your personal view between 1 (not at all) and 5 (to a great extent).

d) Please explain your viewpoint, for example by referring to particular characteristics of your city and its people, environment, economy or political situation

...

4.

a) To what extent does your city engage in multi-stakeholder partnership working for nature-based solutions?

Not at all 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ *To a great extent*

Please rate your personal view between 1 (not at all) and 5 (to a great extent)

b) If answered 3 or higher, please describe how this has been achieved by referring to particular actions taken:

...

c) To what extent is multi-stakeholder partnership working a decisive factor for the successful uptake of NBS in your city?

Not at all 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ *To a great extent*

Please rate your personal view between 1 (not at all) and 5 (to a great extent).

d) Please explain your viewpoint, for example by referring to particular characteristics of your city and its people, environment, economy or political situation

...

5. a) To what extent does your city engage in active community engagement for nature-based solutions?

Please rate your personal view between 1 (not at all) and 5 (to a great extent)

Not at all 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ *To a great extent*

b) If answered 3 or higher, please describe how this has been achieved by referring to particular actions taken:

...

c) To what extent is active community engagement a decisive factor for the successful uptake of NBS in your city?

Please rate your personal view between 1 (not at all) and 5 (to a great extent).

Not at all 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ *To a great extent*

d) Please explain your viewpoint, for example by referring to particular characteristics of your city and its people, environment, economy or political situation

...

6. a) To what extent does your city engage in monitoring and assessment of nature-based solutions?

Please rate your personal view between 1 (not at all) and 5 (to a great extent)

Not at all 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ *To a great extent*

b) If answered 3 or higher, please describe how this has been achieved by referring to particular actions taken:

...

c) To what extent is monitoring and assessment a decisive factor for the successful uptake of NBS in your city?

Please rate your personal view between 1 (not at all) and 5 (to a great extent).

Not at all 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ *To a great extent*

d) Please explain your viewpoint, for example by referring to particular characteristics of your city and its people, environment, economy or political situation

...

7. a) To what extent does your city have access to broad expertise for nature-based solutions?

Please rate your personal view between 1 (not at all) and 5 (to a great extent)

Not at all 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ *To a great extent*

b) If answered 3 or higher, please describe how this has been achieved by referring to particular actions taken:

...

c) To what extent is broad access to expertise a decisive factor for the successful uptake of NBS in your city?

Please rate your personal view between 1 (not at all) and 5 (to a great extent).

Not at all 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ *To a great extent*

d) Please explain your viewpoint, for example by referring to particular characteristics of your city and its people, environment, economy or political situation

...

8.

a) To what extent does your city have the right financing mechanisms to deliver nature-based solutions?

Please rate your personal view between 1 (not at all) and 5 (to a great extent)

Not at all 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ *To a great extent*

b) If answered 3 or higher, please describe how this has been achieved by referring to particular actions taken:

...

c) To what extent are financing mechanisms a decisive factor for the successful uptake of NBS in your city?

Please rate your personal view between 1 (not at all) and 5 (to a great extent).

Not at all 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ *To a great extent*

d) Please explain your viewpoint, for example by referring to particular characteristics of your city and its people, environment, economy or political situation

...

9.

a) To what extent does your city recognizes and engages different sociocultural groups in decision-making about NBS?

Please rate your personal view between 1 (not at all) and 5 (to a great extent)

Not at all 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ *To a great extent*

b) If answered 3 or higher, please describe how this has been achieved by referring to particular actions taken:

...

c)	To what extent is valuing diversity, equity and inclusion a decisive factor for the successful uptake of NBS in your city? *Please rate your personal view between 1 (not at all) and 5 (to a great extent).*	*Not at all*	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	*To a great extent*

d) Please explain your viewpoint, for example by referring to particular characteristics of your city and its people, environment, economy or political situation

...

3. Descriptions of dimensions and scoring rubric

In this section, we provide short descriptions for each of the dimensions outlined in Section 1. The descriptive text for each of the dimensions is followed by a scoring rubric (in *italics*) to help with completing the survey. This serves as background information on how to score each of these dimensions.

Agency

Similar to other sustainability innovations, such as solar panels, electric vehicles and smart grids, a shift in established beliefs, routines and policy is required for NBS to be considered legitimate by a broad range of actors. For NBS to be implemented and mainstreamed, there is a need for people to stand up and convince others of why the mainstream way of doing things need to change. The impact of activities to support NBS implementation, and sustainability more broadly, is often strongest if carried out by people in leadership positions, such as mayors or elected politicians. This can be explained by their ability to influence decision-making, shift the discourse, lobby powerful organizations and affect public opinion, amongst other contributions. However, other committed staff members can also make a difference, e.g. in changing the organizational culture or improved partnership working, provided they manage to mobilize a sufficient number of colleagues. In addition, there is potential for other organizations, such as universities, NGOs, private firms and civil servants to champion NBS – for example through experimentation, knowledge sharing, policy making and public outreach. This can help to accelerate the uptake of NBS in cities, especially if multiple organizations are engaged.

Scoring rubric (question 1A):

Not at all (score=1): *There are no people in leadership roles acting as advocates for urban NBS. There is no supportive environment for staff and non-governmental actors aiming to get NBS higher on the agendas of decision-makers.*

Moderately (score=3): *There is a small number of people in powerful positions that endorse urban NBS development. A number of non-governmental actors and support staff also show a commitment to urban NBS development, and their efforts are acknowledged and incentivized by senior staff or political leaders.*

To a great extent (score=5): *NBS are championed by a range of actors in leadership positions at different institutions relevant to the city, resulting in the mainstreaming of NBS in urban development. There are examples of high-impact activities supporting urban NBS by other organizations and individuals too. Staff at municipalities and non-governmental organizations are enabled and, where possible, incentivized for their engagement with the topic of NBS.*

Governance structure

Nature-based solutions (NBS) have the potential to deliver a range of benefits that are relevant to the policy objectives of different municipal departments. For example, those responsible for public health, city marketing, spatial planning and mobility. To bolster NBS uptake in cities, there is a need for all these departments relevant to NBS uptake to work together on cross-cutting topics. Integrated working can be achieved in different ways, such as through joint meetings, projects and wide consultation on plans, resulting in policy support for NBS in a broad range of plans and policies. In addition, a person might be appointed with the specific role of identifying and discussing opportunities to strategically work together on particular topics. Some cities have also restructured parts of the municipal organization. For example, Barcelona City Council established an 'Urban Ecology Directorate', which integrates the environment, urban planning and mobility and infrastructure domains within the city council into a single organizational entity responsible for sustainability policy.

Scoring rubric (question 2A):

Not at all (score=1): *NBS are only considered viable measures by a small number of staff operating within a single department of the municipality or city administration Other departments are not clearly contributing to NBS planning and implementation.*

Moderately (score=3): *There are multiple departments contributing to the development of NBS planning and implementation. However, NBS is not integrated into plans and policies beyond those prepared by the Parks and Greenspaces section or department in the municipality or city administration.*

To a great extent (score=5): *The need for integrated working on cross-cutting sustainability innovations such as NBS is acknowledged and has resulted in a strategic collaborative working relationship between different departments, for example through the use of a multidisciplinary hub between, or environmental nuclei within, departments. As a result, a number of different departments are contributing to NBS planning and implementation for e.g. climate action, health promotion, the green economy, social justice and biodiversity enhancement. This has translated into NBS being incorporated as viable measures into multiple plans and policies prepared by different departments.*

Legislation, regulations & policies

Municipalities and higher levels of government can use a range of policies and measures supportive of NBS implementation, of which particularly the compulsory measures enable strong progress to be made over a short period of time. The creation of urban NBS can benefit from specific goals and objectives introduced as part of a city's Master Plan, Metropolitan Plan or Land Use Plan. For example, these can include ambitions around greening public land, the need to compensate for biodiversity losses as a result of construction projects or the introduction of minimum requirements around the quantity and quality of urban green- and bluespaces in urban neighbourhoods. Furthermore, regulations could be introduced around the protection of street trees, nature conservation areas, green infrastructure or heritage trees, both on public and private land. Other municipal policies and plans such as a Green Infrastructure Strategy, Biodiversity Action Plan or Climate Action Plan can also support NBS development, sometimes indirectly through knowledge development, improved assessment approaches and improved partnership working. Beyond this, public procurement regulation could be adapted with requirements around pro-environmental measures. Sustainability or nature programmes and policies at the regional, state or country level can also have a direct influence over NBS development in cities. For example, construction companies in England are mandated to include sustainable urban drainage systems in any medium-large housing construction project.

Scoring rubric (question 3A):

Not at all (score=1): *There are no or limited regulations protecting urban NBS against infringement by urban development or there are frequent breaches of planning regulation without repercussions. There are no particular requirements for NBS with regard to new urban development projects and no ambitions by local or higher levels of government to invest in NBS and improving the underlying conditions to manage these more effectively.*

Moderately (score=3): *Urban development is regulated in a way to ensure the incorporation of NBS in new neighbourhoods and to help protect existing NBS in the city. Regulations are actively enforced. There are some examples of government action plans or policies directly contributing to more NBS in the city or that improved the underlying conditions to manage these more effectively.*

To a great extent (score=5): *Housing, infrastructure and/or utility providers are mandated by one or more levels of government to incorporate NBS into their plans to such an extent that urban development generates more nature and biodiversity compared to the situation from before the project started. There are a number of government action plans or policies directly contributing to more NBS in the city, while also improving the underlying conditions to manage these more effectively.*

Collaborative arrangements

Beyond the need for more integrated working *within* organizations, there also should be an effort to build effective working relationships *between* different organizations, representing a broad range of disciplines and backgrounds, in order to pave the way for improved NBS uptake. Partnership working can fulfil different aims, including resource pooling, knowledge exchange and the discovery of new ideas. For example, a partnership between the government, the private and the third sector in The Netherlands serves to develop stakeholder guidance and new business models for green roofs, whilst it is also exploring ways of fiscally incentivizing rooftop greening. The concept of NBS could be introduced as a focus area in established networks, such as Business Improvement Districts or Local Biodiversity Partnerships, in parallel. Furthermore, there is also a need for collaboration across scales, such as between city, metropolitan region and province or state for the purpose of e.g. knowledge exchange and ensuring that urban NBS are adequately integrated into broader ecosystems.

Scoring rubric (question 4A):

Not at all (score=1): *The municipality or city administration does not engage in partnership working with businesses and NGOs on NBS development and implementation and there is no attempt to lobby other relevant stakeholders in sectors such as housing and infrastructure development to put the concept of NBS higher on their agendas. There is no collaboration across different levels of government to align urban policy on NBS and green infrastructure with that on e.g. regional or national level, or vice versa.*

Moderately (score=3): *The municipality or city administration sometimes engage in partnership working with businesses and NGOs on NBS development and implementation, but these involve only a narrow range of stakeholder groups. They have attempted to lobby other relevant stakeholders to put NBS higher on their agendas, but with limited success. There have been some examples of collaborative action across different levels of government, which strengthened connections between urban ecosystems and the hinterland.*

To a great extent (score=5): *The municipality or city administration actively initiates and participates in partnerships on NBS development and implementation that together mobilize a broad range of different representatives from the business sector and civil society. They have successfully lobbied powerful stakeholders not directly involved in these coalitions to put NBS higher on their agendas. There is an active working relationship between public institutions managing different levels of the (peri-)urban ecosystem with a view on creating and sustaining a multilevel network of natural corridors for wildlife and active travel.*

Active community engagement

Consulting citizens on plans and large-scale NBS projects as well as providing space for active participation of urban communities in NBS development and management has multiple benefits. It enables a better understanding of what citizens value about nature and how this varies between different demographic and sociocultural groups. In addition, it can boost public support for NBS, spark bottom-up urban greening action, include previously underrepresented groups in decision-making, and support the responsible use of nature on both public and private land. There are many ways to engage citizens, varying from collectively developing plans and scenarios in focus groups and citizen science to supporting citizens with knowledge, tools and funding to create and maintain NBS on public land. Community lease or transfer of public land could also be considered if groups have sufficient human capital to manage the land, provided clear agreements are made around, for example, public access and sustainable land use.

Scoring rubric (question 5A):

Not at all (score=1): *There is no or only passive participation of citizens in consultations on plans and projects related to urban NBS.*

Moderately (score=3): *There are some examples of citizen participation in the co-design of NBS projects and plans, collection of data (i.e. citizen science) and the collaborative management of NBS. There are a number of grassroot initiatives that have been granted permission to use public land for NBS development.*

To a great extent (score=5): *Examples of citizen participation in the co-design of NBS projects and plans, collection of data (i.e. citizen science) and the collaborative management of NBS can be found throughout the city. The municipality provides support to grassroots NBS initiatives by sharing knowledge, subsidies and other financial incentives. There are also examples of community lease or ownership of urban NBS.*

Monitoring and assessment

NBS are living interventions and in order to thrive these should be adapted to the context in which these are implemented. This requires a good understanding of environmental conditions, such as biodiversity levels, meteorological climate and urban heat island effects, as well as the sociodemographic and socioeconomic composition of the city. There is also a need to monitor and assess NBS following their implementation. Options include the creation of inventories of urban trees and other natural assets and the assessment of ecosystem services. At the same time, there should be an attempt to engage with potential threats by responding to nuisance reports and spatially mapping if NBS are fairly distributed across the city. There is a potential danger of NBS inadvertently contributing to increased value of real estate and associated rents, which could negatively impact on social justice. It is therefore important to track how NBS is influencing socioeconomic equality in the city. Ideally, all data relevant to NBS is stored in a single repository to make it transparent what information is available, who is responsible and how it is being used.

Scoring rubric (question 6A):

Not at all (score=1 *There is no attempt to systematically monitor urban NBS, resulting in knowledge gaps concerning the quantity, state and distribution of natural assets in the city. A data-informed picture of benefits provided to the city by urban NBS is lacking, and there is no attempt to map the distribution of NBS and its effects on socioeconomic inequality.*

Moderately (score=3): *There is an effort to monitor NBS, but there are some gaps in the knowledge about quantity, state and distribution of natural assets in the city. The benefits of a number of individual projects have been assessed but this is not done systematically over a longer period of time. Place-specific data is used in some cases for decisions about which NBS to develop in which location, but the effects of NBS on socioeconomic inequality are not recorded.*

To a great extent (score=5): *NBS in the city have been mapped and are regularly monitored based on a number of content and quality criteria. The city makes use of an assessment framework for monitoring urban NBS, which is applied to a number of projects at any one time to track the success of the NBS in addressing key urban challenges, including social justice. Decisions about what NBS to implement in which location are informed by a place-specific analysis of environmental, sociodemographic and socioeconomic conditions. All data relevant to NBS can be accessed from a single platform.*

Knowledge acquisition and sharing

NBS encompass a broad range of interventions, varying from sustainable urban drainage systems through to public access gardens and rooftop parks, and need to be adapted to place-specific environmental and sociocultural conditions. Following this, there is a range of expertise required, varying from design and engineering through to horticulture, ecology and landscape architecture, in order to implement NBS effectively. Spatial analysts and data experts are important for building relevant data repositories and analysing these to help understand how NBS help to address sustainability challenges. Moreover, there is a need for tacit knowledge in group facilitation, community outreach and team working, while access to policy and legal expertise is also required. In addition to recruiting or subcontracting staff with relevant expertise, municipal personnel also needs to have an openness to on-the-job learning of new skills and expertise related to NBS through professional training, participation in social learning activities and experimentation with NBS. Furthermore, there needs to be an effort to share available knowledge with stakeholders and the general public through information campaigns, demonstration projects and/or public events. At the same time, there needs to be a preparedness to flexibly respond to the needs of urban communities and other (potential) stewards of urban NBS with regard to policy-making and available support structures. Together, this enables a place-based approach to urban NBS governance that takes into account a variety of different forms of knowledge, as well as responds to locally relevant sustainability challenges that might shift over time.

Scoring rubric (question 7A):

Not at all (score=1): *There is no or limited access to the level of expertise required for the development of a broad range of urban NBS. There is no concerted effort to acquire new knowledge relevant to NBS or to engage in processes of social learning. There are no environmental education campaigns. There is limited policy responsiveness to NBS initiatives by non-governmental actors.*

Moderately (score=3): *There is access to the right level of expertise required for the development of some types of urban NBS. There are, however, limited opportunities for professional training or knowledge acquisition through pilot projects by municipal staff. There are some environmental education initiatives but these remain few and far between. There is occasional policy responsiveness to NBS initiatives by non-governmental actors.*

To a great extent (score=5): *There is good access to expertise required for the development of a broad range of urban NBS. Experimentation with NBS in pilot projects is taking place, resulting in innovative solutions adapted to the local context. Environmental education campaigns are provided at regular intervals. Urban NBS planning and design approaches evolve over time, informed by inclusive dialogue and deliberation.*

Financing mechanisms

Beyond compulsory measures, city administrations can also directly invest in NBS themselves or incentivize NBS development by other people and organizations through subsidies, grant programmes or waiving municipal charges. Additional revenue for urban greening measures could be generated by, for example, selling timber, food products, greenspace visitor parking charges or charges for festivals and events in public greenspaces. Public-private partnerships such as corporate sponsorships of NBS could be sought to increase private co-funding or to realize cost-savings through more efficient service delivery. However, this should not come at the expense of equitable access to urban greenspaces.

Scoring rubric (question 8A):

Not at all (score=1): *Finance for urban NBS is inadequate, resulting in poor maintenance and the loss of natural assets. There is no concerted effort to raise funds for NBS in alternative ways, such as through public-private partnerships.*

Moderately (score=3): *Sufficient finance is available for maintaining NBS to an acceptable standard as well as for creating new NBS if opportunities arise. There is some experience with raising funds for NBS by pursuing new revenue streams and partnership working with e.g. private firms, NGOs and universities.*

To a great extent (score=5): *Sufficient finance is available for maintaining NBS to a high standard as well as for accelerating the rollout of NBS in the city. There is ample experience with raising funds for NBS by pursuing new revenue streams and partnership working with e.g. private firms, NGOs and universities.*

Valuing diversity, equity and inclusion

The variety of sociocultural groups and subcultures in cities is large and often increasing. City administrations should respond to this by offering NBS that meet the use demands of these and other groups in society. The goal should be a patchwork of different types of multifunctional urban NBS that together offer something for everyone and provide opportunities to connect with nature. This implies that decision-making needs to represent the interests of different sociocultural groups. For example, by imitating and engaging with platforms for discussion and deliberation with citizens. In addition, there is a need to provide opportunities for participation in planning procedures, and for these to be organized in an inclusive and transparent way. Citizens may also express their needs and desires for urban NBS in different ways, such as by community-driven development of urban gardens or other types of NBS. It is important that such initiatives are supported if serving the public interest and that municipalities and other institutional stakeholders show a preparedness to learn from such initiatives. A fair and inclusive participation of a diversity of groups in decisiop-making is likely to lead to a fair distribution of NBS across the city. This is important to ensure equitable access to nature, but also to equitably distribute NBS benefits such as atmospheric cooling and flood risk mitigation across the city. To combat historic injustices in NBS distribution, more investment might be needed in disadvantaged than more wealthy communities.

Scoring rubric (question 9A):

Not at all (score=1): *There is no recognition of diversity in interests, knowledge, values, etc. between particular groups (age, gender, income, ethnicity) in society and no attempt to engage with this. There is no fair representation of different groups in society in decision-making processes relevant to NBS development. NBS are not distributed equitably across the city, resulting in different groups having different levels of access to nature and different levels of exposure to climate-related risk. There is no attempt to redress this.*

Moderately (score=3): *There is recognition of diversity in interests, knowledge, values, etc. between some, but not all relevant, groups (age, gender, income, ethnicity) in society. While some groups in society are represented in decision-making processes relevant to NBS development, others are not. NBS are not distributed equitably across the city, resulting in different groups having different levels of access to nature and different levels of exposure to climate-related risk. There have been attempts to redress this.*

To a great extent (score=5): *There is recognition of diversity in interests, knowledge, values, etc. between relevant groups (age, gender, income, ethnicity) in society. Different groups in society are fairly represented in decision-making processes relevant to NBS development. NBS are distributed equitably across the city, resulting in different groups having similar levels of access to nature and similar levels of exposure to climate-related risk.*

Appendix C – Graphs showing the researcher-led appraisals of indicators, split by Challenge Area

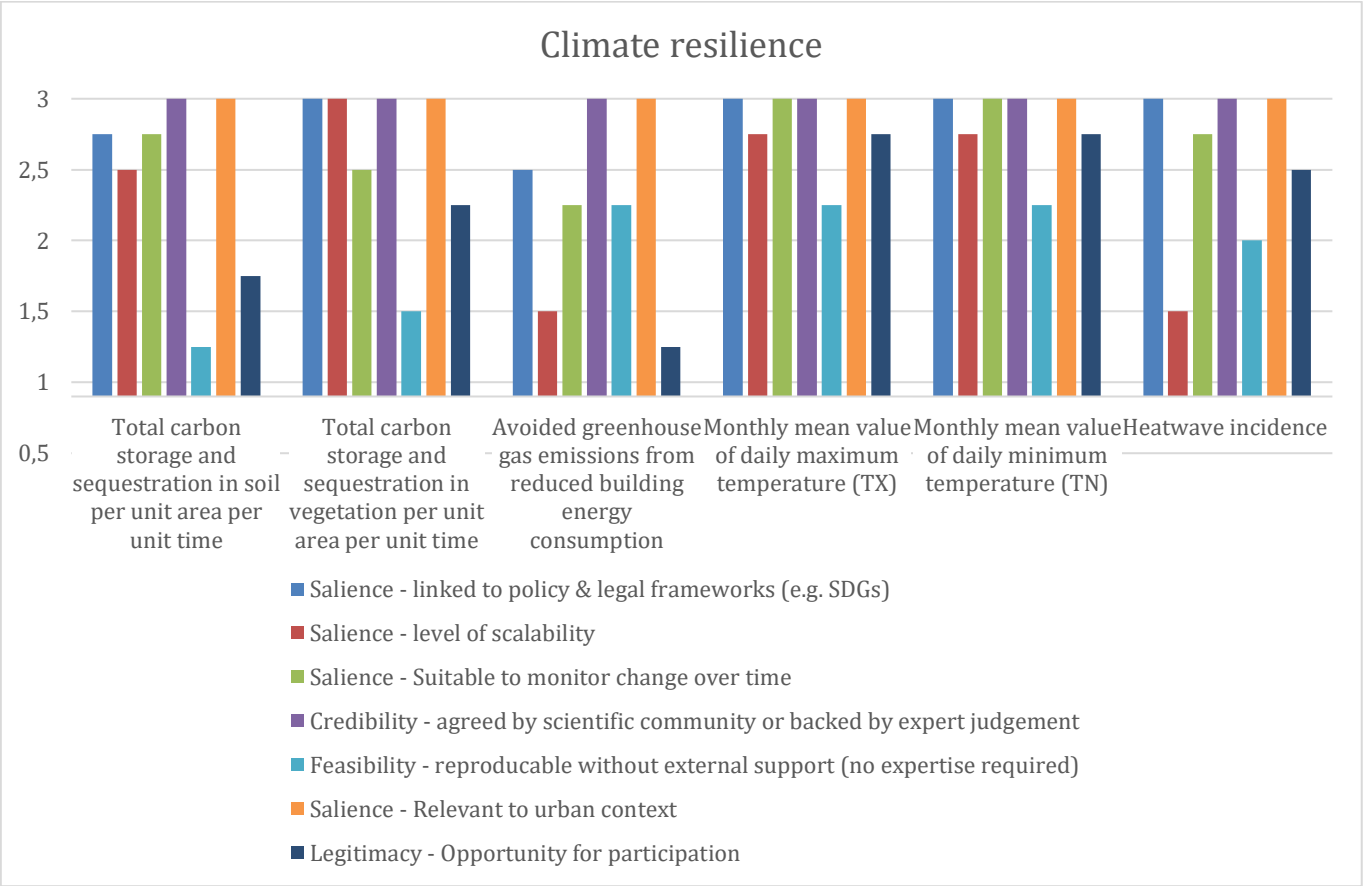

Figure A1. Evaluation of indicators – averages of the scores provided by the four independent reviewers – for the climate resilience challenge area.

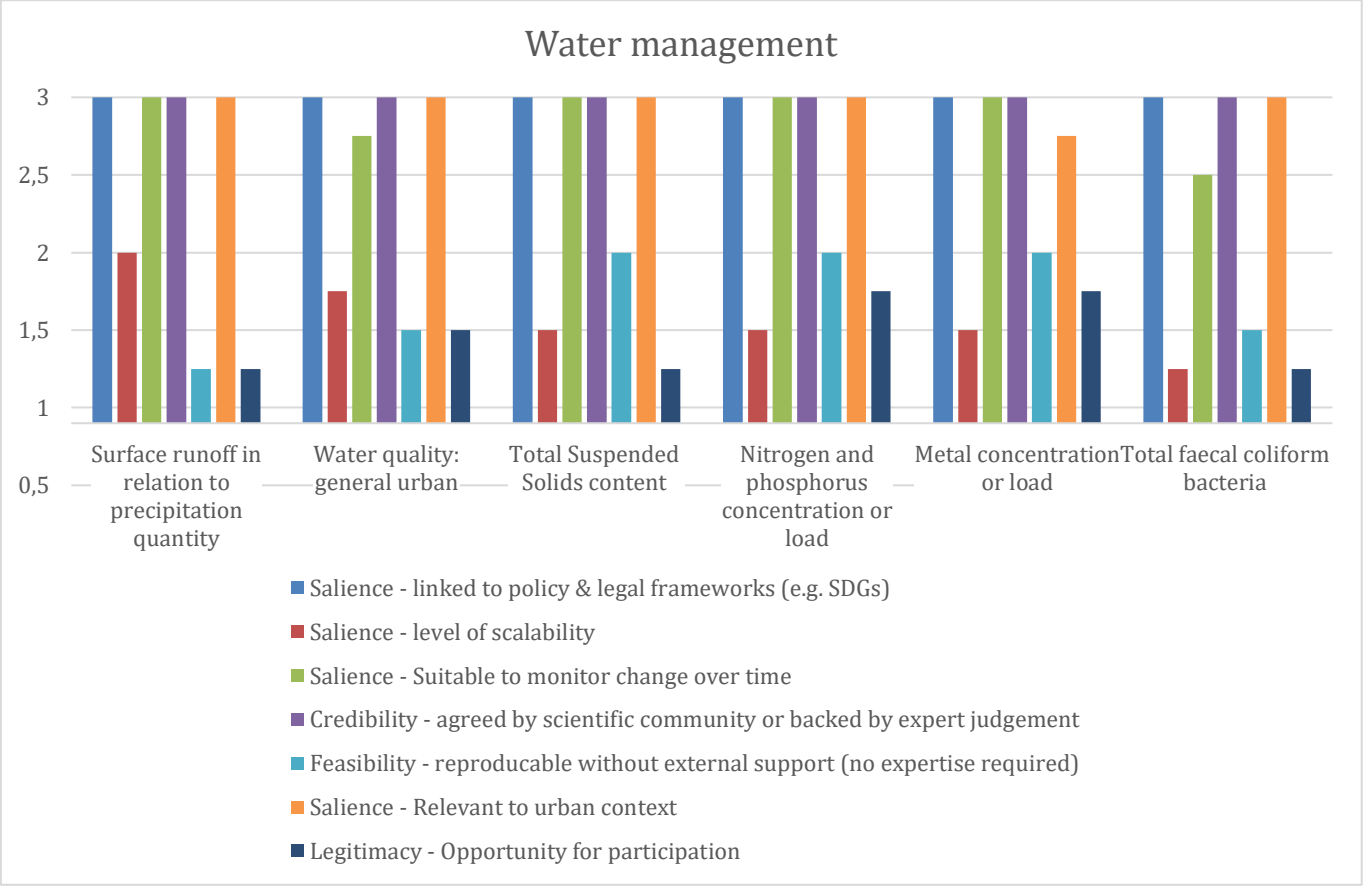

Figure A2. Evaluation of indicators – averages of the scores provided by the four independent reviewers – for the water management challenge area.

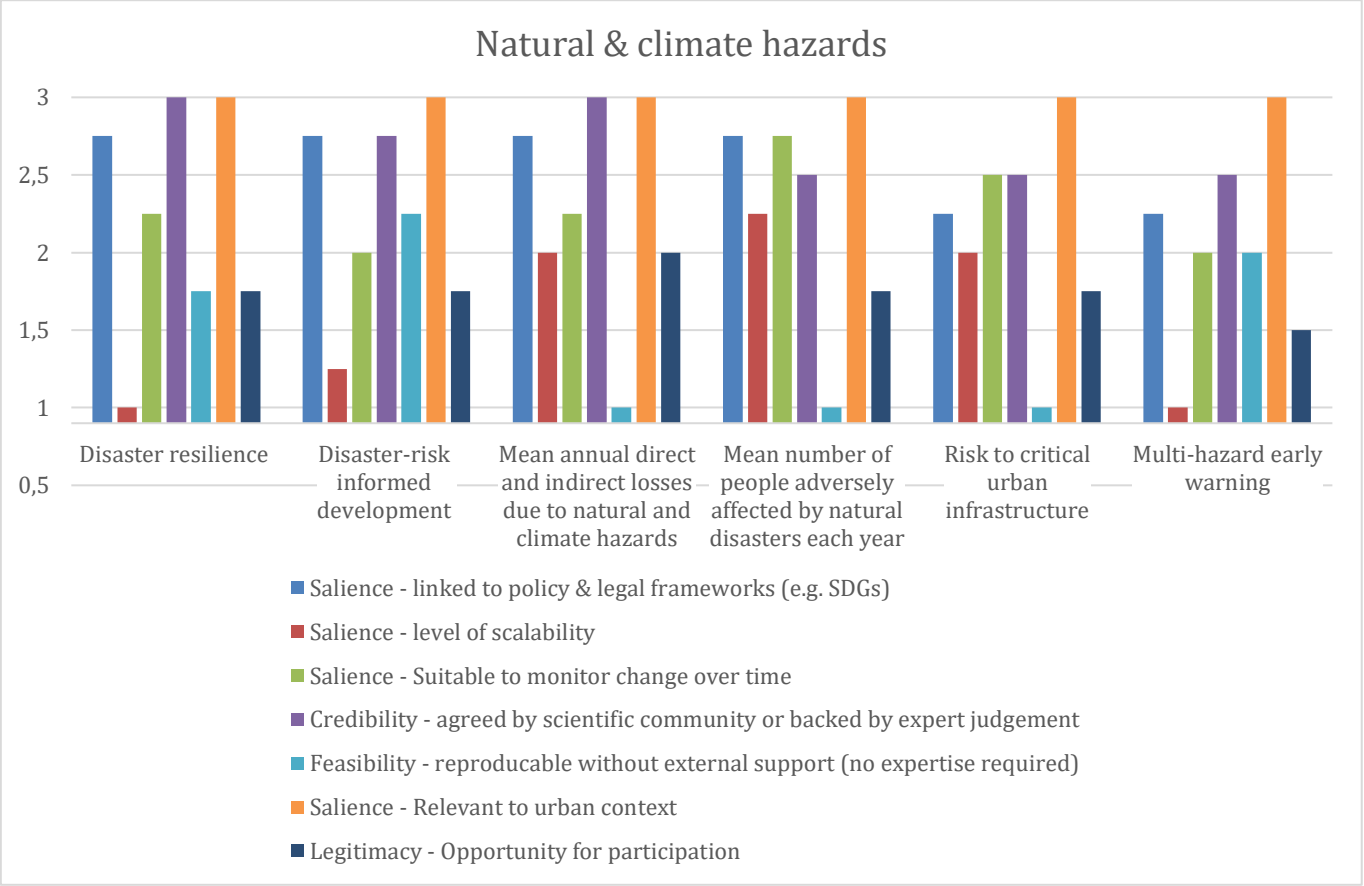

Figure A3. Evaluation of indicators – averages of the scores provided by the four independent reviewers – for the natural & climate hazards challenge area.

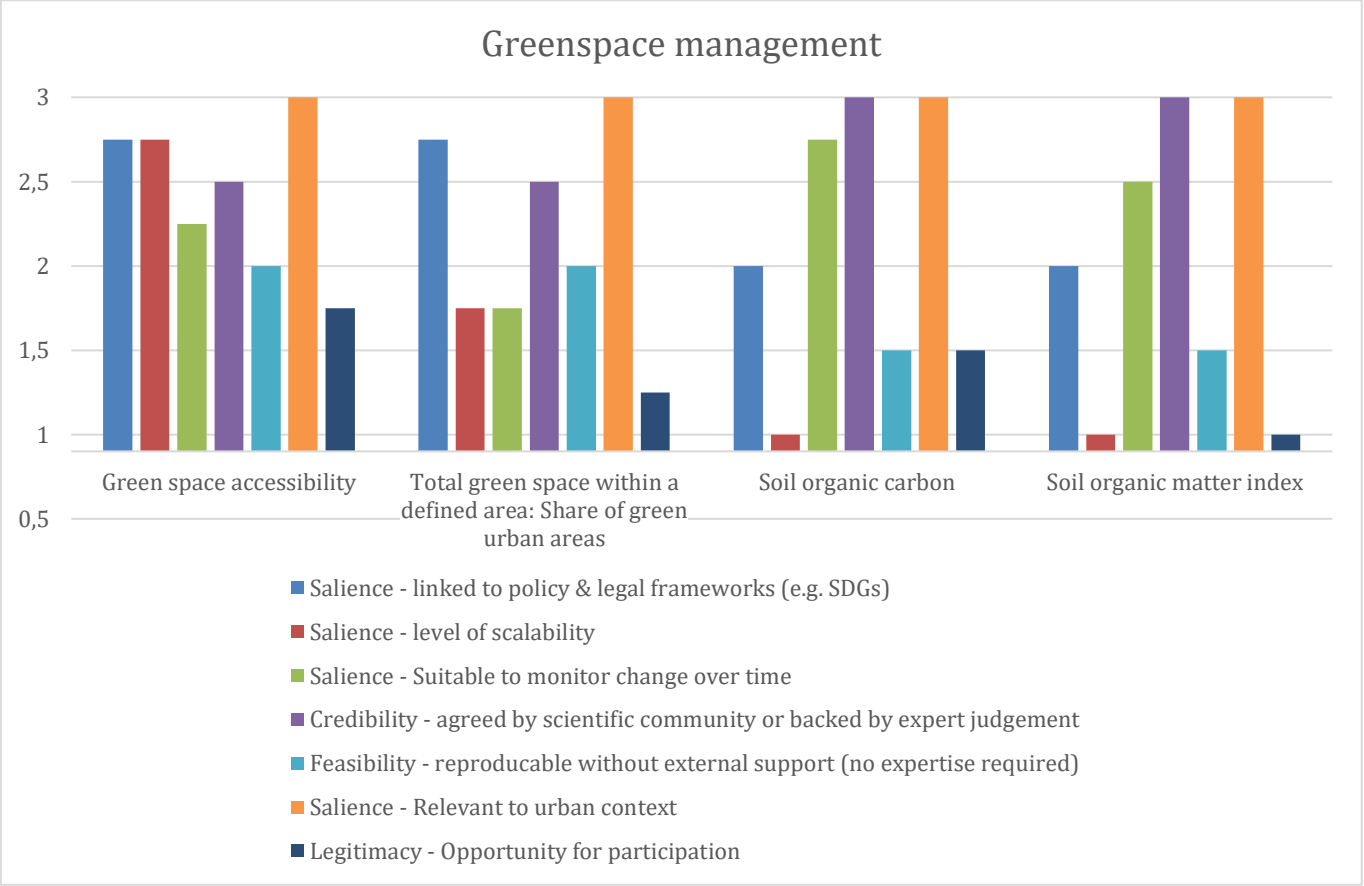

Figure A4. Evaluation of indicators – averages of the scores provided by the four independent reviewers – for the greenspace management challenge area.

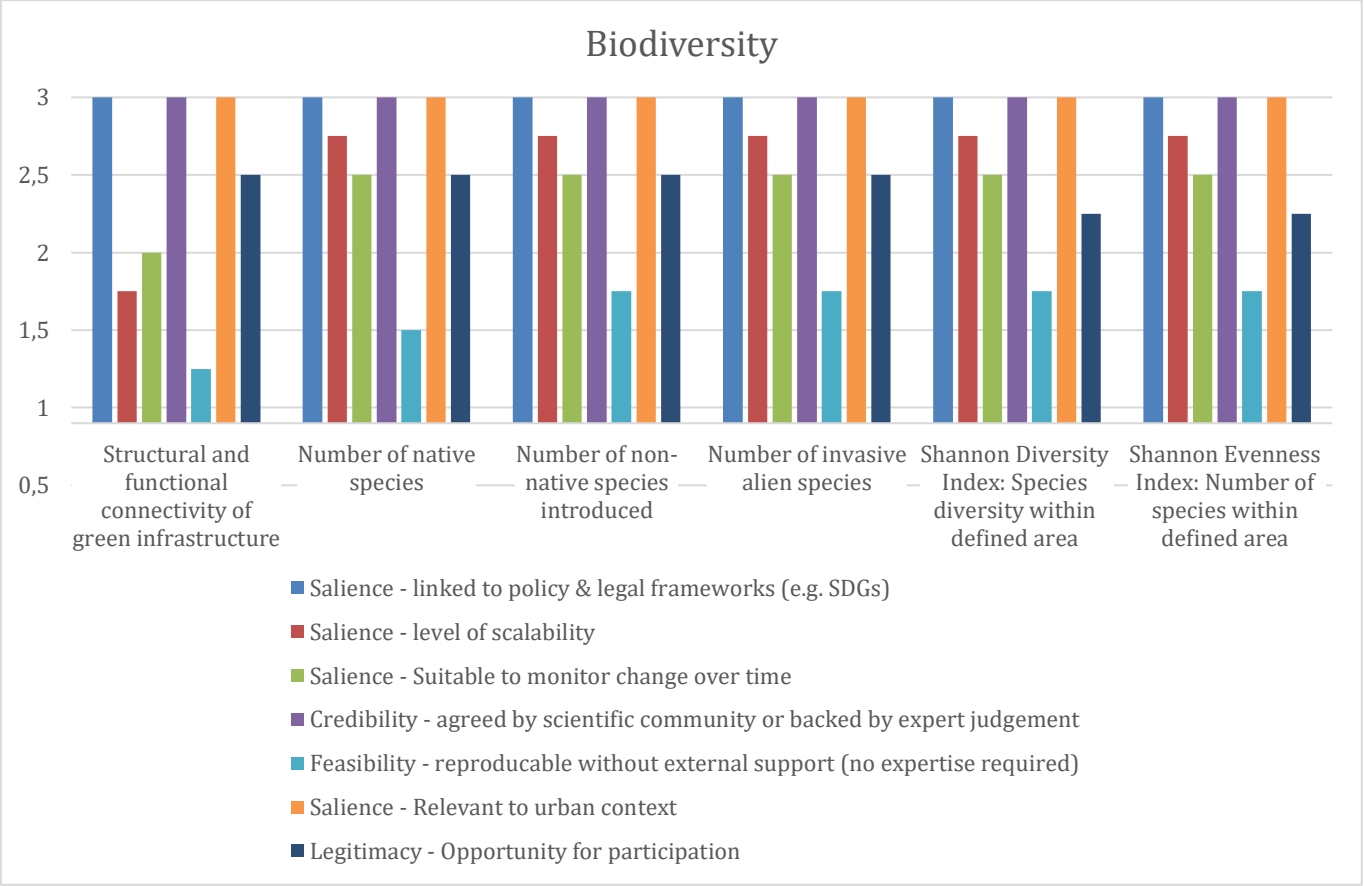

Figure A5. Evaluation of indicators – averages of the scores provided by the four independent reviewers – for the biodiversity challenge area.

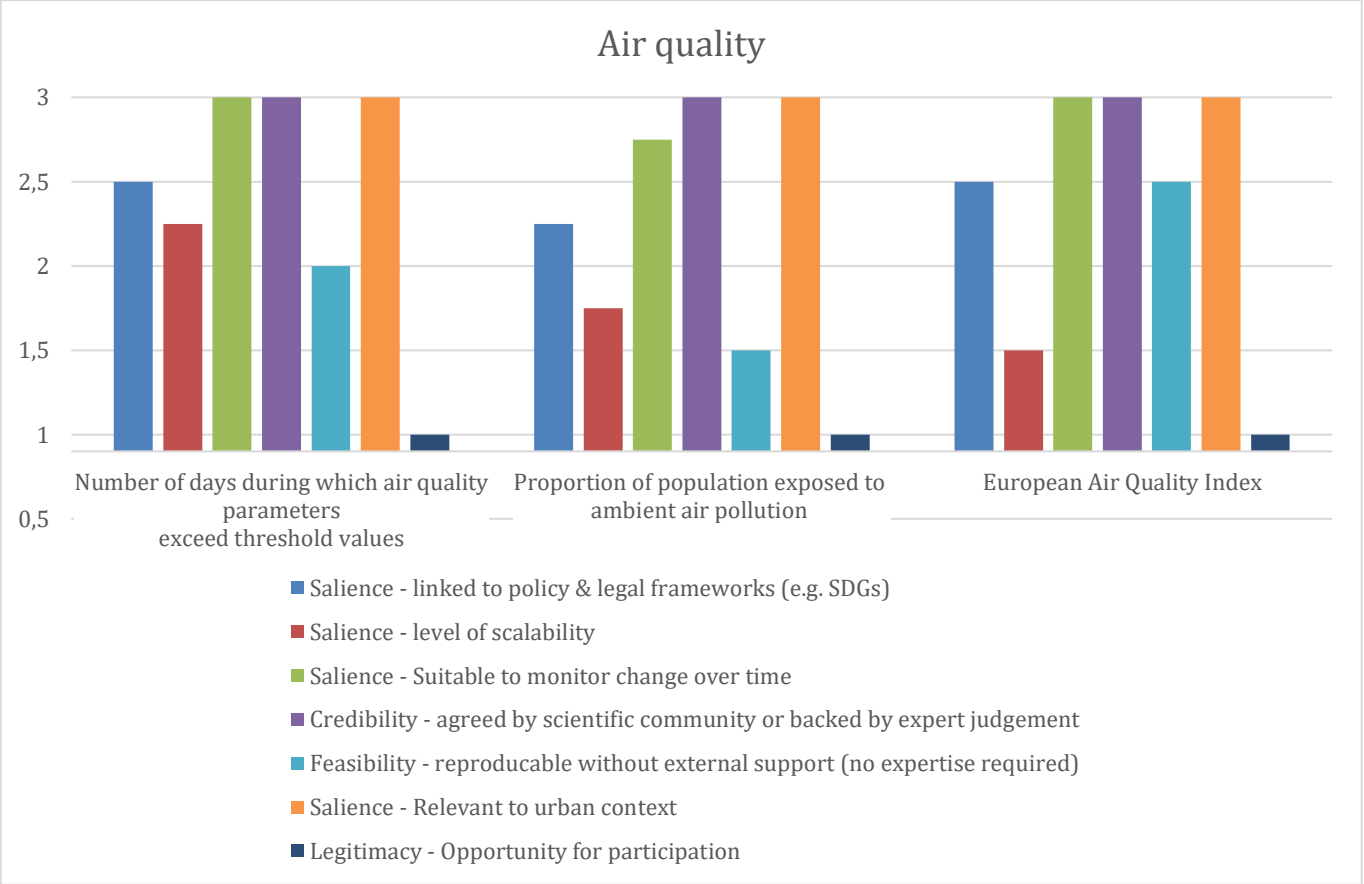

Figure A6. Evaluation of indicators – averages of the scores provided by the four independent reviewers – for the air quality challenge area.

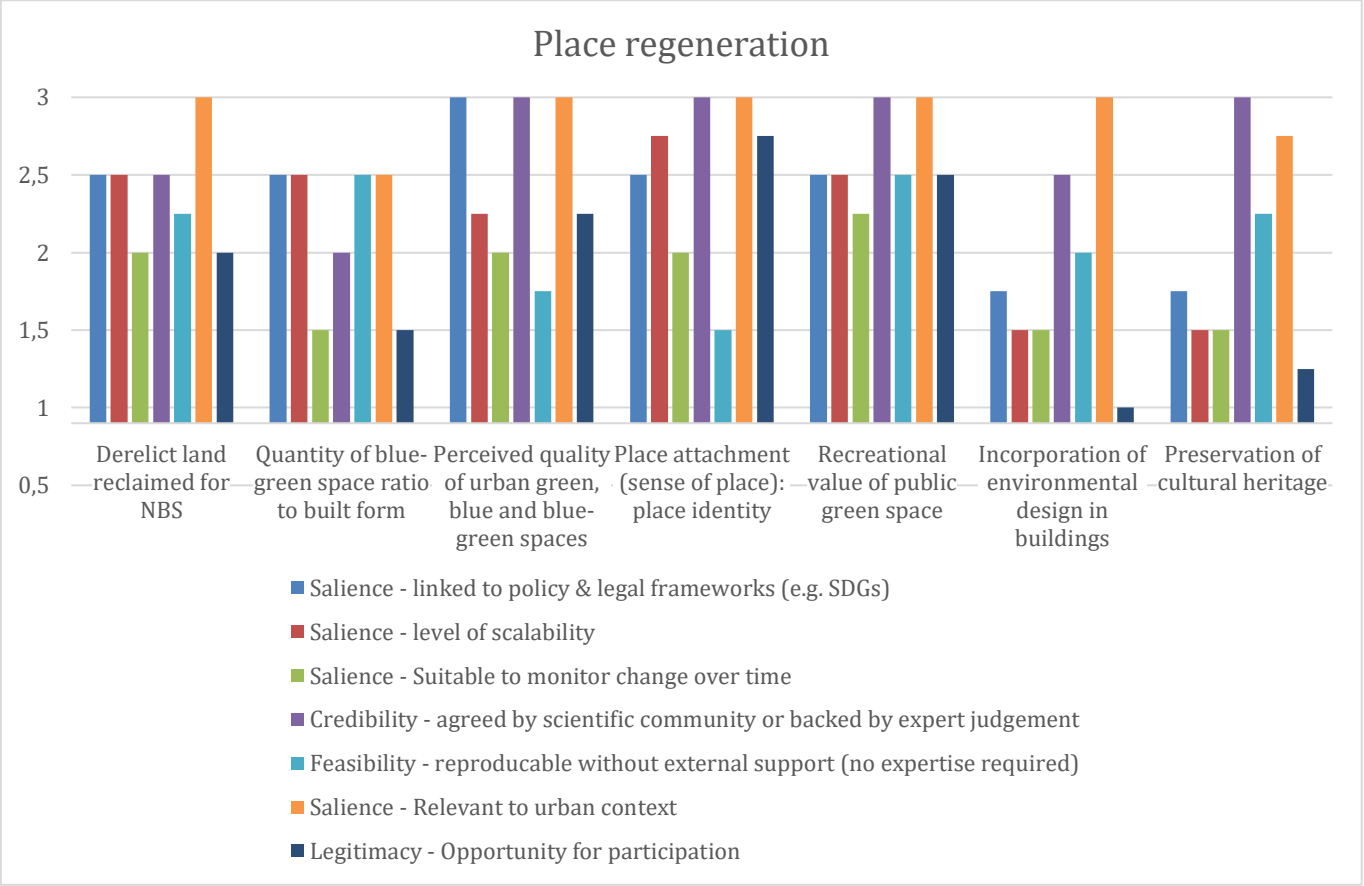

Figure A7. Evaluation of indicators – averages of the scores provided by the four independent reviewers – for the place regeneration challenge area.

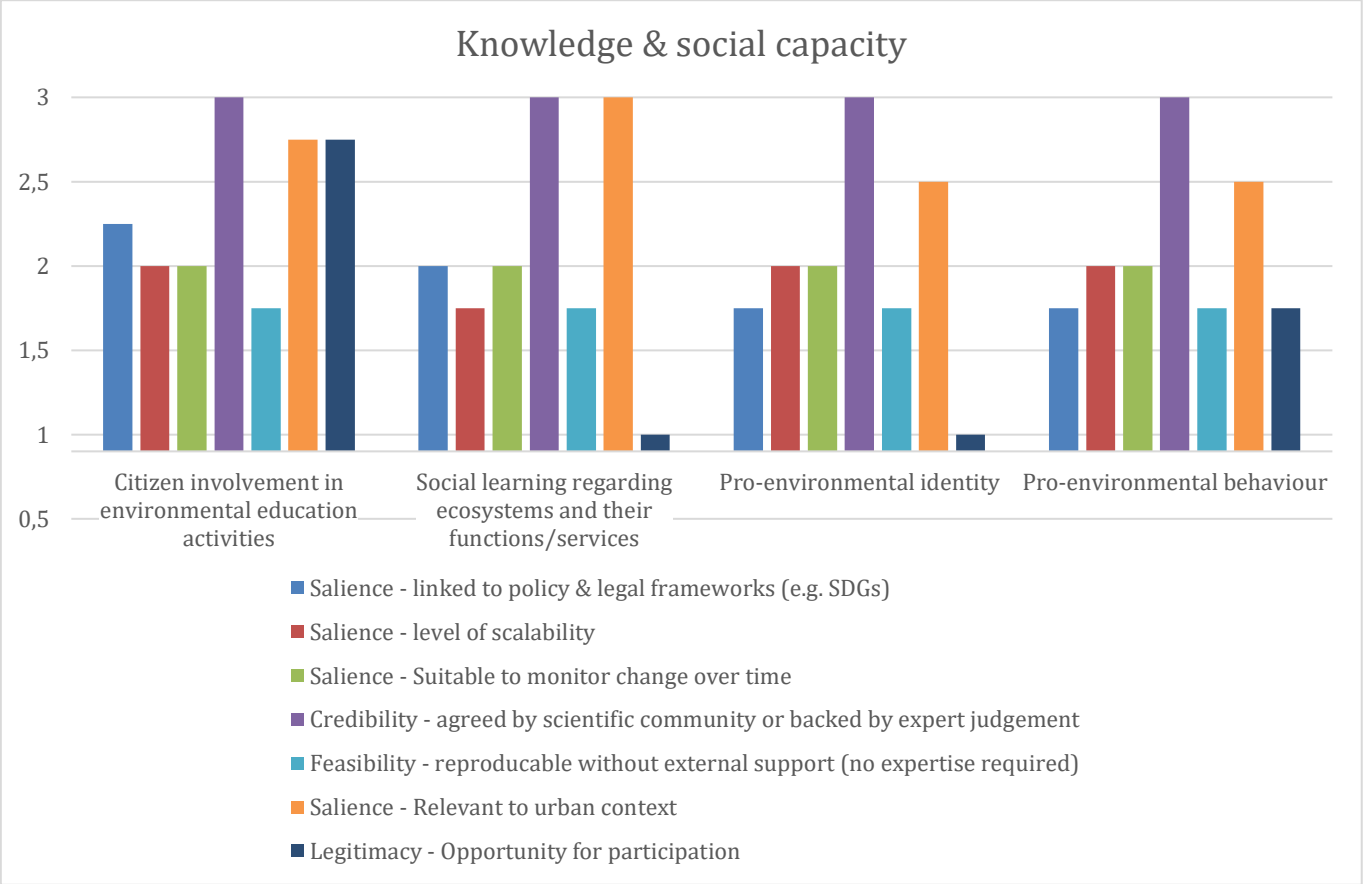

Figure A8. Evaluation of indicators – averages of the scores provided by the four independent reviewers – for the knowledge & social capacity challenge area.

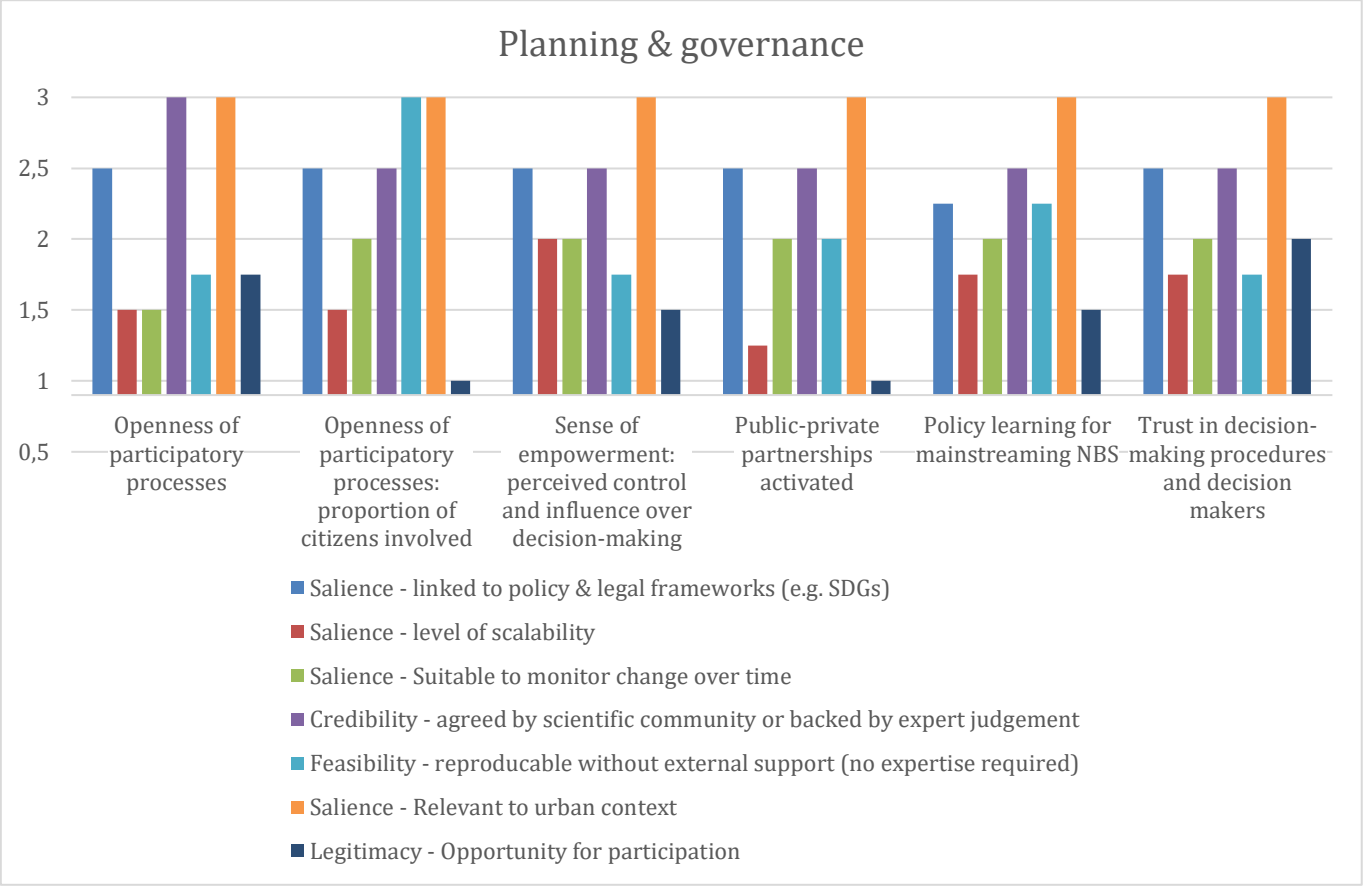

Figure A9. Evaluation of indicators – averages of the scores provided by the four independent reviewers – for the planning & governance challenge area.

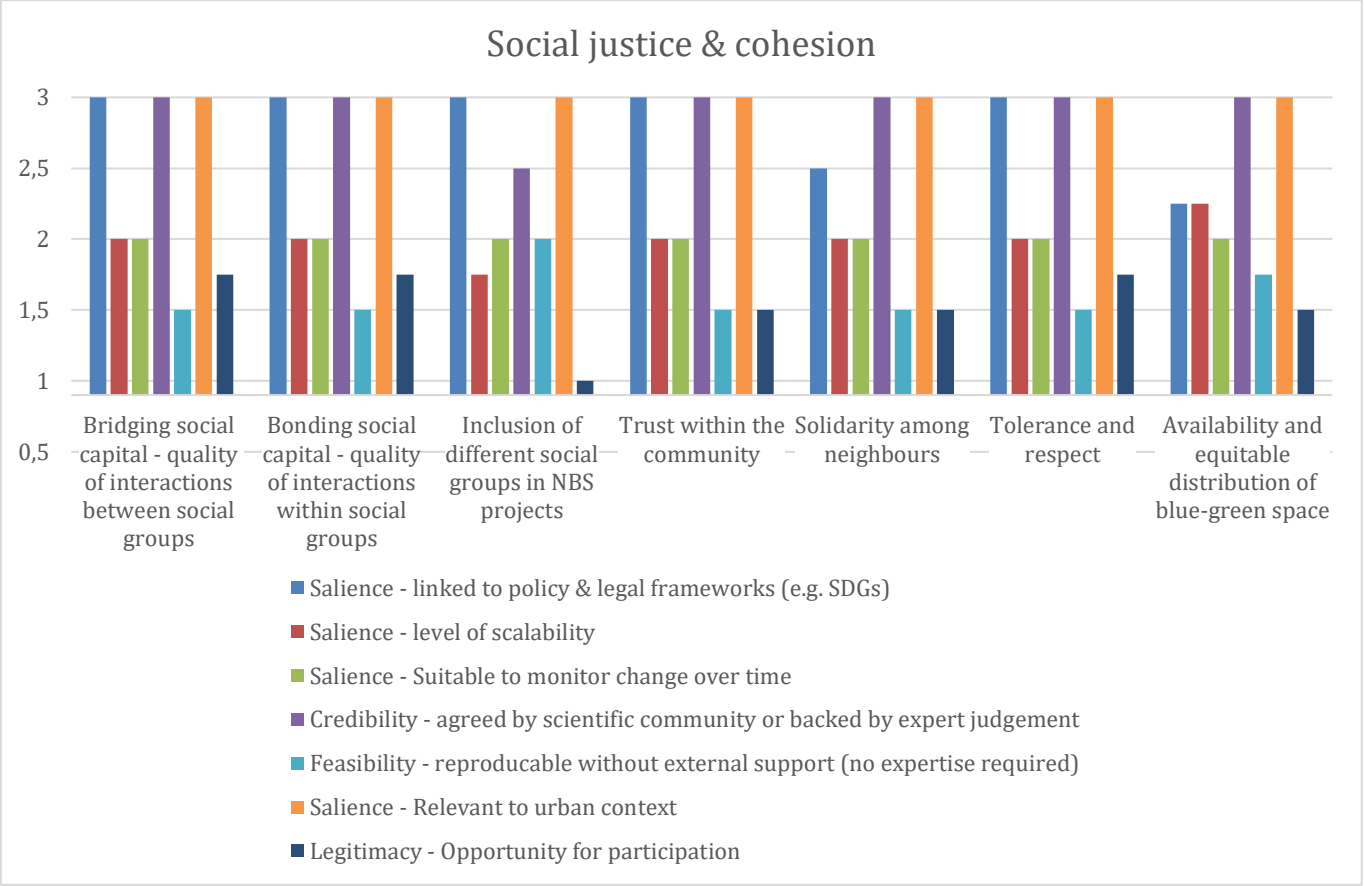

Figure A10. Evaluation of indicators – averages of the scores provided by the four independent reviewers – for the social justice & cohesion challenge area.

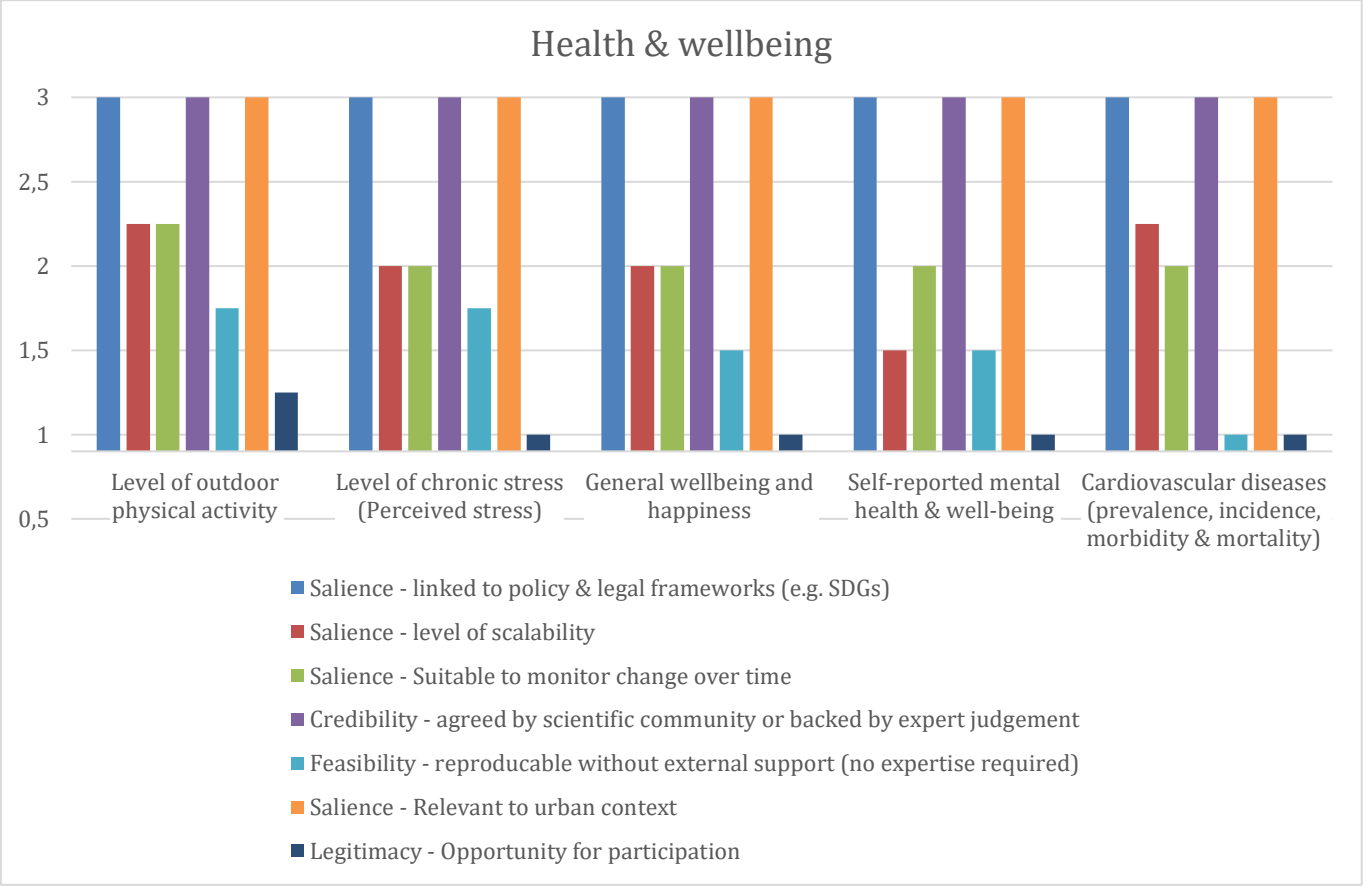

Figure A11. Evaluation of indicators – averages of the scores provided by the four independent reviewers – for health & well-being challenge area.

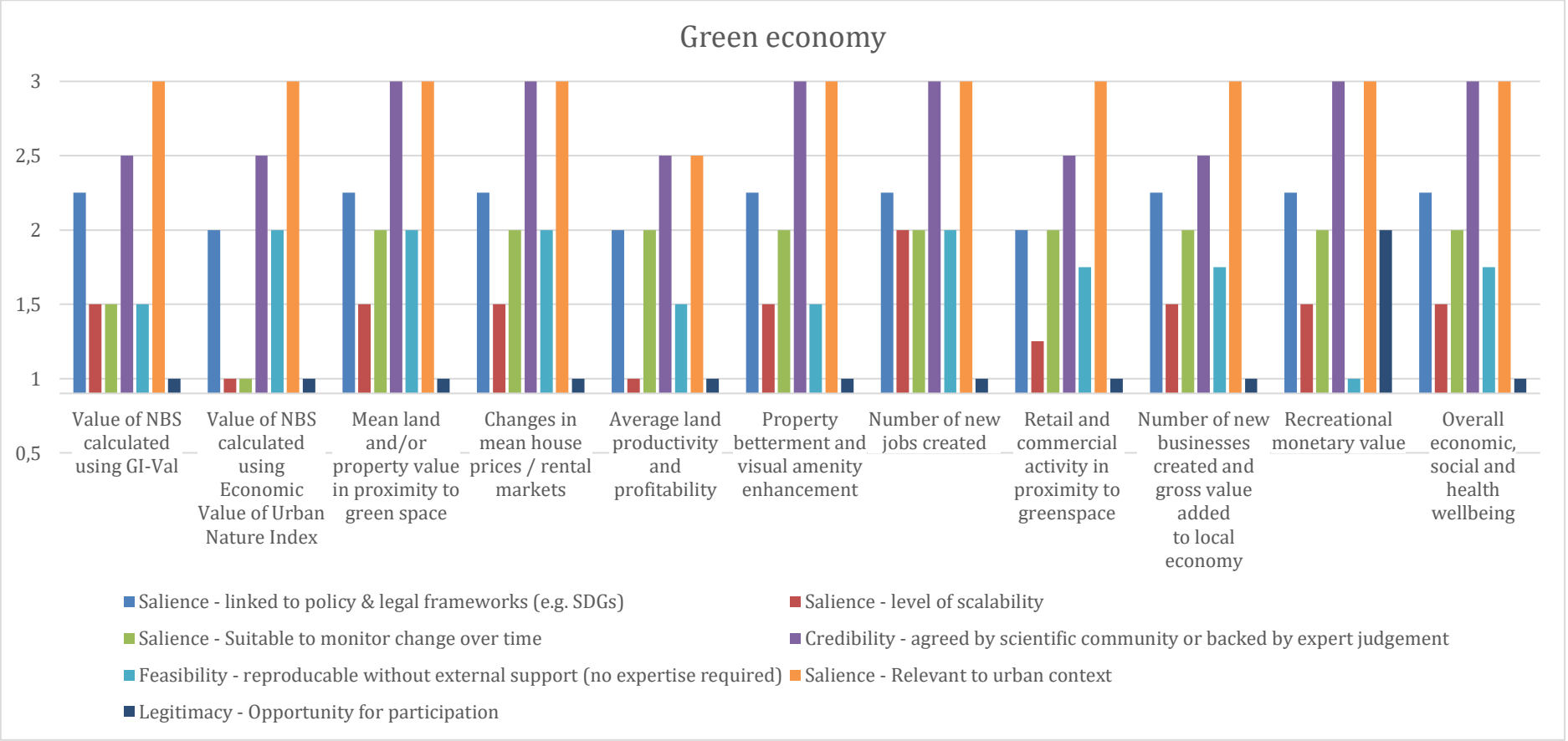

Figure A12. Evaluation of indicators – averages of the scores provided by the four independent reviewers – for the green economy challenge area.