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Deliverable 5: Nature-based solutions framework for frontrunner cities

DOCUMENT PROPERTIES

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Executive summary

This document presents the Nature-based Solutions Framework developed in the Connecting Nature project to support the planning, delivery and legacy of nature-based solutions on a large-scale in cities. The main aim of the framework is to provide a comprehensive standard that informs urban planning and policy practice to scale up urban resilience, innovation and empowerment via nature-based solutions in cities. The framework facilitates learning by and for cities on how to generate and connect diverse types of (e.g. technical, market, governance, social) innovations engendered by nature-based solutions. In this way, we generate innovation propositions for science and practice for the large-scale implementation of nature-based solutions and for making Europe a global leader in the innovation and implementation of nature-based solutions.

Our main premise lies in our understanding of nature-based solutions as 'living' sustainability transition experiments. A key challenge is the large-scale implementation – or 'up-scaling' – of nature-based solutions. This includes, for example, the replication or expansion of demonstration projects or the institutional embedding of new knowledge, skills and collaboration and financing mechanisms. Scaling nature-based solutions is therefore about more than the individual innovations: it is about how they are connected to each other and to their contexts. This requires new types of processes, partnerships, conditions, skills and knowledge to allow for multi-actor collaboration and synergies, design fit-to-context nature-based solutions that generate multiple benefits, and ensure early assessment of the transformations brought about in cities.

We have co-produced the Nature-based Solutions Framework, its translation to the frontrunner cities and the derivation of lessons through iterative interaction between researchers and planners of the cities in the Connecting Nature project. This means that we adopted a 'learning-by-doing' approach based on science-practice collaboration and cross-disciplinary cooperation. Our aim is to in this way integrate and generate new knowledge and ultimately to translate this knowledge into urban planning and policy frameworks and unlock existing barriers.

This document envelops the reports by the frontrunner cities Genk (Belgium), Glasgow (United Kingdom) and Poznań (Poland), which showcase how the cities made use of the framework to implement their nature-based solutions exemplars. It summarises how the cities' experiences contribute to (connecting) diverse types of innovations for the large-scale nature-based solutions implementation in cities.

The Nature-based Solutions Framework consists of seven building blocks to facilitate the planning, delivery, and legacy of nature-based solutions on city-scale in urban planning and policy practice:

(1) **Technical design:** The nature-based solution encompasses the detailed design of the nature-based solution exemplar and its features. This can be portfolio of nature-based solutions that connected embody one systemic solution.

(2) **Indicators:** the set of indicators that will be used as a reference for monitoring and evaluating nature-based solutions implementation and scaling that is adaptable to every city context and open to inputs over time;

(3) **Financing and Business Models:** the different sources of finances for the implementation of the exemplar as well as its long-term plan for maintenance and operation by the city and/or other urban actors and Business model, being co-developed with cities, SMEs and science partners to inform a new approach on the exemplar as a local business spin-off and attractor:

(4) **Entrepreneurship:** the potential of nature-based solutions to stimulate new market and business opportunities.

(5) **Governance:** the organisational conditions and skills for connecting different actors across sectors under the same vision of the nature-based solution exemplar for the city and facilitating that they are actively engaged and informed about the co-creation and reflexive monitoring.

(6) **Co-production:** the process of active involvement and part-taking in the making of all structural elements;

(7) **Reflexive monitoring:** the process of facilitated, continuous and adaptive monitoring and assessment of the whole process of co-creation to capture lessons learnt and on time valorize them into the planning/implementation process.

We identify the following lessons from the cities' experiences and taking the Nature-based Solutions Framework forward:

- **Lesson #1:** The framework aims to strengthen the connections between multiple innovations that together promote integrative, inclusive, and knowledge-based approaches to implement nature-based solutions in cities. Through finding, facilitating and strengthening these connections, the application of the framework will also result in embedding these solutions across city agendas and/or policy programs and establish collaborations across city departments and between private and public actors.

- **Lesson #2:** The innovations engendered by and necessary to scale nature-based solutions underscore how the scaling nature-based solutions requires the development of new skills and knowledge, as well as partnerships and collaborations to break siloes, connect goals and agendas and make solutions fit to context.

- **Lesson #3:** The application of the Nature-based Solutions Framework and changing urban policy and planning processes requires the development of new types of capacities for innovative and knowledge-based governance in cities, including new skills and knowledge about tools, multiple benefits of nature-based solutions and financing mechanisms.

The co-production experience so far is highly valued across all partners in the project – particularly the constructive and open engagement and interaction between the diverse partners. We identify several lessons for taking the co-production process between scientific partners, cities and SMEs forward:

- **Lesson #1:** Create a shared institutional space for learning to take time for exchanges and workshops (virtual and face-to-face).

- **Lesson #2:** Promote a sense of ownership of both the process and the outcomes of co-production and ensuring salience of knowledge co-produced to deal with different timelines and professional needs from partners.

- **Lesson #3:** Allow for adaptable and flexible processes and institutions to adapt the co-production approach as a complementary planning process.

1. Introduction

This document presents the Nature-based Solutions Framework developed in the Connecting Nature project to support the large-scale implementation of nature-based solutions in cities. The Nature-based Solutions Framework is a new reference framework that provides a standard to scale up urban resilience, innovation and empowerment via nature-based solutions in cities. In Connecting Nature, scientific partners and local city officers co-produced the framework, its translation to the cities' practices and the analysis and validation of key results and lessons. In this way, we aim to form a community of cities fostering peer-to-peer learning and to position Europe as global leader in the innovation and implementation of nature-based solutions.

This document envelops the reports by the frontrunner cities Genk (Belgium), Glasgow (United Kingdom) and Poznań (Poland), which showcase how the cities made use of the framework to implement their nature-based solutions exemplars. It summarises how the cities' experiences contribute to connecting and scaling diverse types of innovations for the large-scale nature-based solutions implementation with transformative potential in cities.

1.1 Background: towards the large-scale implementation of nature-based solutions in cities

The European Commission (2015, p. 4) defines nature-based solutions as "actions which are inspired by, supported by or copied from nature". Nature-based solutions are systemic and cost-effective solutions that provide multiple environmental, social and economic benefits for dealing with urban challenges, building resilience and creating better cities. They are able to simultaneously conserve and regenerate ecosystems and biodiversity, protect from flooding, mitigate urban heat islands, improve air quality, create space for recreation, enhance social cohesion and offer local business opportunities (ibid.; Connop et al. 2016; Lafortezza et al. 2018).

We approach nature-based solutions as 'living' sustainability transition experiments. Sustainability transition experiments aim to facilitate radical, long-term societal change for sustainability by testing "a range of new technical, regulatory and institutional configurations as well as social practices" (Williams 2016, p. 80) that challenge the status quo and produce new social relations and lessons for planning and governance (McLean et al. 2016; Crowe et al. 2016). Innovative nature-based solutions with transformative potential for cities generate multiple benefits and bring new ways of place-making in their contexts, including new ways of *organising* (e.g. institutional arrangements, rules), *thinking* (e.g. mindsets, perceptions, values), *doing* (e.g. practices, routines), *relating* (e.g. social relations, interactions, transactions), and *knowing* (e.g. new forms of knowledge production and sharing, new sources of knowledge) (Dumitru et al. 2018). This makes clear that nature-based solutions involve multiple innovations that together have the potential to transform urban systems.

Nature-based solutions innovate ways of *organising* (e.g. institutional arrangements, rules), *thinking* (e.g. mindsets, values), *doing* (e.g. practices, routines), *relating* (e.g. social relations, interactions) and *knowing* (e.g. new sources of knowledge, new processes of knowledge generation). Facilitating these innovations is necessary to implement nature-based solutions on a large-scale and ultimately to create sustainable and resilient cities.

The following types of innovations are both engendered by and necessary to scale nature-based solutions:

- **Technical innovations** (changes in technical design, construction, management and service delivery) advance technology readiness of nature-based solutions. If designed and sited appropriately, nature-based solutions can provide multiple benefits for addressing interrelated issues associated with human, environmental and economic wellbeing in cities (Connop et al. 2016). Technical innovations of nature-based solutions consider regionally-contextualised multifunctionality in the design, introduce system-oriented site selection, create interconnections between policy and planning fields (e.g. water management, mobility, urban regeneration), and facilitate long-term legacy focusing on the desired benefits.

- **Market innovations** (the creation of new financing models, markets and business opportunities) set the stage for exploiting new financing opportunities to replicate and scale nature-based solutions. They

incubate new business opportunities and financial models to develop products and businesses (e.g. green roofs or gardens can generate marketable produce that adds to local economic activity). Market innovations also exploit the financial value of the multiple benefits of nature-based solutions, such as cost savings to water management by flood damage avoidance or energy savings. This helps to overcome fragmented (costs and benefits do not accrue to the same stakeholders) and create multifunctional value chains.

- **Social innovation** (changes in social relations and social practices) activate and empower citizens and place-makers (Avelino et al. 2019; Haxeltine et al. 2016). Social innovations involve people doing things differently, alone or together (Franz et al. 2012). They are often driven by social entrepreneurs or grassroots initiatives, and can be fostered through the active involvement of residents, community leaders, and local businesses.

- **Governance innovations** (new processes of co-planning and co-design and reflexive learning) facilitate the emergence of a new governance paradigm for making nature-based solutions inclusive and multi beneficial and linking nature-based solutions to institutional contexts. The co-production of knowledge and action by residents, local businesses, planners and other relevant professionals is a governance process method for the participatory identification of needs and resources, paying attention to different institutional contexts and empowering diverse actors. Reflexive monitoring and evaluation are a key feature for adaptive policy making and planning to facilitate learning-by-doing and doing-by-learning in view of the intended multiple benefits.

- **Organisational innovations** (new organisational networks, resources and skills) facilitate the new governance processes for collaboration and reflexive learning. Leadership, network structures and provision of resources and skills manifest in the capacities to design, implement, operate and maintain nature-based solutions in a way that provides multiple benefits and connects diverse innovations.

- **Knowledge innovations** (new (processes for) knowledge creation) provide new scientific evidence as well as practical and accessible standards about designs, technical standards, benefits generated, financing and ongoing operation and legacy of nature-based solutions. Knowledge innovation also relates to a new way of science-practice partnerships and new ways of inquiring and generating knowledge such as processes for the co-production of knowledge (Popa et al. 2015; Frantzeskaki and Kabisch 2016).

The next step challenge is to achieve the large-scale implementation of transformative nature-based solutions in cities. The transformative impact of transition experiments is derived from their potential to create "positive outcomes that are replicable, transferable, and scalable to society at large" (Luederitz et al. 2017, p. 62). Accordingly, the large-scale implementation of nature-based solutions refers to their 'scaling up', for example through the replication of demonstration projects, expansion, and the organisational and market roll-out on city scale (Ehnert et al. 2018; Gorissen et al. 2018; van Winden & Carvalho 2016). Scaling nature-based solutions is therefore not focusing on the diffusion or scaling of single innovations but rather a relational process of connecting different innovations to generate an amplification effect towards transformation to more sustainable, liveable, resilient places and cities in Europe.

The large scale-implementation of nature-based solutions is a 'living' transition experiment at city scale: it is about generating and connecting the sets of diverse innovations engendered by and necessary to scale nature-based solutions. Literature on sustainability transition experiments found that when multiple innovative ideas and solutions are connected to each other and to strategic priorities this can produce "the cascade of resources required to bring innovation to markets and scale it up" (Westley et al., 2011, p. 767). In this way, the large-scale implementation of nature-based solutions contributes to systemic change of various urban systems. In line with this, the different ways that the diverse innovations connect and amplify systemic nature-based solutions innovations at city scale will evince of multiple planning and implementation pathways for achieving climate resilient, just and inclusive, sustainable and liveable places and cities.

A key challenge is the large-scale implementation – or 'up-scaling' – of nature-based solutions in cities as a whole. This includes, for example, the replication or expansion of demonstration projects or the institutional embedding of new knowledge, skills and collaboration and financing mechanisms in the city government.

Key challenges for facilitating the large-scale implementation of nature-based solutions centre on the question of how to facilitate the emergence and connection of these multiple innovations. This requires new types of processes, partnerships, conditions, skills and knowledge to allow for multi-actor collaboration and synergies, design fit-to-context nature-based solutions that generate multiple benefits, and ensure early assessment of the transformations brought about in cities (Raymond et al. 2017; Hölscher et al. 2019a; Frantzeskaki et al. 2019b). More often than not, existing urban policy and planning processes make decisions in sectoral silos and start from fixed problem definitions and the delivery of short-term benefits without participation of local communities (Kabisch et al., 2017; Sekulova and Anguelovski, 2017). This impedes the large-scale implementation of nature-based solutions, which depends on appropriate funding, political and social support, enabling regulatory frameworks and knowledge about benefits and how to fit nature-based solutions to diverse contexts (Connop et al. 2016; Kabisch et al. 2016).

1.2 Aims: casting an eye on the landscape of innovations for large-scale nature-based solutions implementation

We aim to develop a new reference framework that informs urban planning to take a comprehensive perspective on how to generate and connect innovations for the large-scale implementation of nature-based solutions in cities. To this end, we co-produce together with scientific partners and cities a Nature-based Solutions Framework. In this way, we generate innovation propositions for science and practice for the large-scale implementation of nature-based solutions and for making Europe a global leader in the innovation and implementation of nature-based solutions.

In summary, the key contributions of the Nature-based Solutions Framework are as follows:

- To **capture, facilitate, and connect** the diverse types of innovations emerging and interleaving through nature-based solutions implementation and scaling;
- To **facilitate learning and internal and external communication** by the Connecting Nature cities with regard to how they are developing and scaling their nature-based solutions exemplar;
- To **generate standards for interventions** that serve as a process initiation to be transferred to other cities and that helps them identify what they need to consider and to push nature-based solutions excellence.

Importantly, even though our aim is to develop a framework, this is not meant as a static process but it is rather to be applied in an iterative and non-linear way – the starting points and order of steps being determined by the cities' contexts and needs.

1.3 Outline of this report

Here, we present our Nature-based Solutions Framework, including our co-production steps for its development, the conceptualisation and key results from its application. The report includes:

- The methodological approach for 'co-producing' the Nature-based Solutions Framework and its application in the Connecting Nature frontrunner cities (Section 2);
- The conceptualisation of the Nature-based Solutions Framework and its building blocks for the large-scale implementation of nature-based solutions (Section 3);
- The analysis of the diverse types of innovations and connections of innovations ('the landscape of innovations') in the frontrunner cities of Connecting Nature, and key implications of the framework as a new planning framework for large-scale nature-based solutions implementation (Sections 4 and 5).

This report is complemented by various documents (Figure 1).

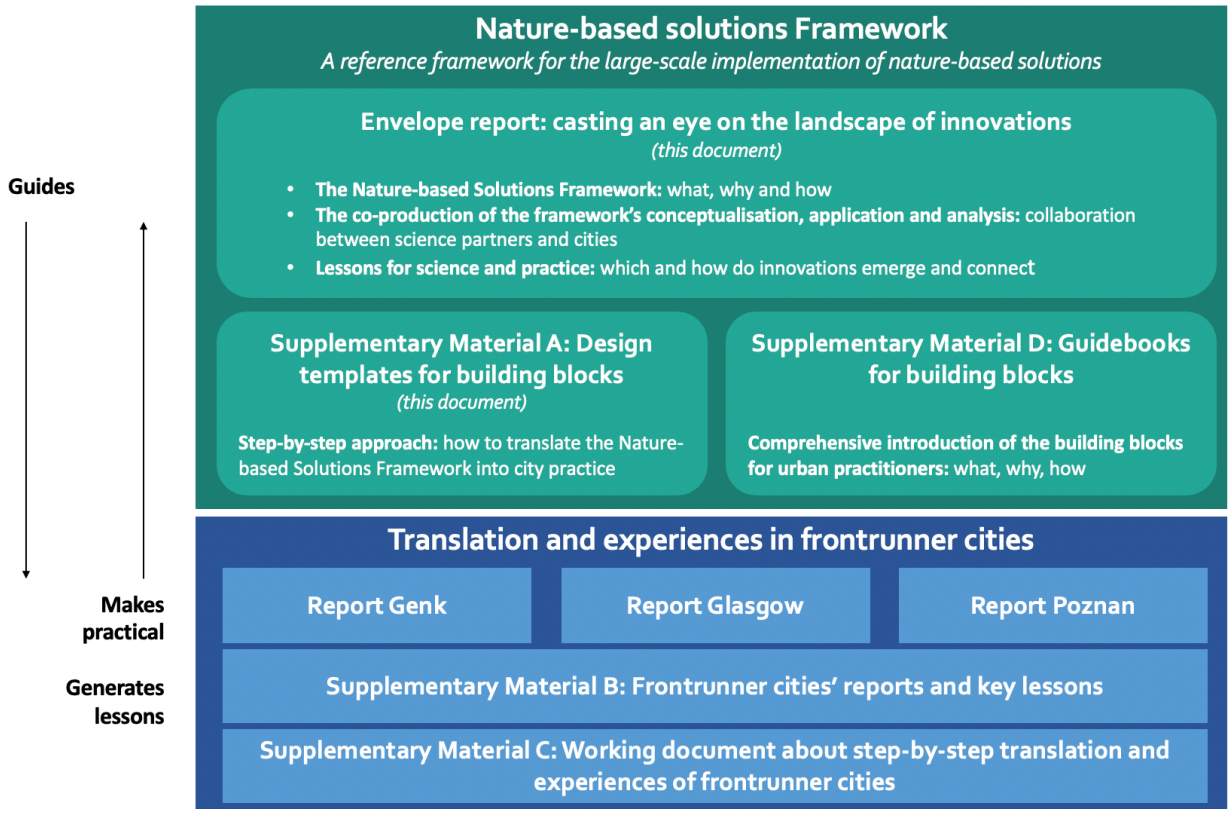
Firstly, it envelops the reports by the Connecting Nature frontrunner cities Genk (Belgium), Glasgow (United Kingdom) and Poznań (Poland) (Supplementary Material B.1 (Genk), B.2 (Glasgow) and B.3 (Poznań), which

showcase how the cities made use of the framework to implement their nature-based solutions exemplars and what were key steps and lessons learned.

Secondly, the operational application of the Nature-based Solutions Framework is underpinned by a comprehensive set of steps and guiding questions per building block that were used by the cities to design, implement and report on their exemplar (Supplementary Material A). This document is still to be updated on an iterative basis. Following these detailed steps, the frontrunner cities have also prepared detailed reports with in-depth descriptions about how they address each of these steps (Supplementary Material C.1 (Genk), C.2 (Glasgow) and C.3 (Poznań)). Importantly, these documents represent living documents that show the current status of the framework application in each city and will be updated on an iterative basis.

Thirdly, guidebooks on the individual building blocks of the Nature-based Solutions Framework will be developed and updated throughout the course of the Connecting Nature project. Preliminary guidebooks on the Business Model Canvas, Co-production and Reflexive Monitoring have already been developed (Supplementary Material D.1 (Business Model Canvas), D.2 (Co-production) and D.3 (Reflexive Monitoring)).

Figure 1. Deliverable 5 building blocks



2. Methods

We have co-produced the Nature-based Solutions Framework, its translation to the frontrunner cities' contexts and practices and the derivation of lessons from the application through iterative interaction between researchers and planners of the cities in the Connecting Nature project. This means that we adopted a 'learning-by-doing' approach based on science-practice collaboration and cross-disciplinary cooperation. Our aim is to in this way integrate and generate new knowledge and ultimately to translate this knowledge into urban planning and policy frameworks and unlock existing barriers.

Our 'co-production team' brings together researchers from diverse disciplines – including ecology, business, psychology, governance, monitoring/evaluation and transformation research – and urban planners from the three frontrunner cities – Genk (Belgium), Glasgow (United Kingdom) and Poznań (Poland) (Box 1). We have started to engage the eight fast-follower cities – A Coruña (Spain), Bologna (Italy), Burgas (Bulgaria), Ioannina (Greece), Màlaga (Spain), Nicosia (Cyprus), Pavlos Melas (Greece) and Sarajevo (Bosnia and Herzegovina) – to begin to test and transfer the learning emerging from the frontrunner cities' process.

In this section, we outline our rationale and approach to co-production (Section 2.1) and the concrete co-production steps we have undertaken both on the overarching framework level as well as regarding the individual building blocks (Section 2.2).

Box 1: The Connecting Nature frontrunner cities and their nature-based solutions exemplars

Each Connecting Nature city has a nature-based solutions exemplar which will be implemented through the support of the Connecting Nature and will be used to embed the implementation of nature-based solutions as an established form of city making. So far, we have worked with the three frontrunner cities to co-develop their approach to the design and implementation of their exemplar, as well as to identify lessons learned that will benefit other cities.

Genk (Belgium, population around 65.000) is developing a multifunctional blue-green urban valley – the Stiemerbeek Valley, a neglected corridor of 8 kilometres running through the city and suffering from poor water quality. The objectives are to connect nature with nature, citizens with nature, citizens with citizens, and nature with entrepreneurship by facilitating connections between sites urban neighbourhoods and nature. A suite of pilot projects have been selected for implementation – including the Gardens of Waterschrei, Slagmolen, SUDS and SODA and the Valleyroute – that range from redeveloping a former mill as an arts and information centre and gateway to the Stiemer, to engaging with private landholders to develop rain gardens and other sustainable urban drainage system (SUDS) features to attenuate rainwater across the Stiemer catchment.

The Scottish city of Glasgow's (United Kingdom, population around 590.000) approach to developing a scaled-up nature-based solutions exemplar is underpinned by its strategic Open Space Strategy (OSS) and accompanying Local Context Analysis. Based on a wealth of data and spatial analysis, the OSS aims to provide a strategic vision on, and coordinate the responsibilities associated with, the open spaces to ensure a well-managed, well-located and well-connected network of open spaces that operate as part of a wider green network and offer multiple benefits and address multiple pressing challenges. The 15 Local Context Analyses show how to translate the strategic goals into operational projects within 15 areas of the city, with the aim that local communities will be embedded in developing projects at this scale.

Poznań (Poland, population around 540.000) aims to develop and up-scale small-scale nature-based solutions – such as natural playgrounds and open gardens in kindergartens – in different parts of the city and in this way create a rich green network. Poznań's historic city-wide system of green wedges and rings based on the Warta river valley is threatened by development pressures and the dense city core lacks green spaces. The scaled-up exemplar is an initiative led by the municipality to reinvigorate the existing green system by developing a number of green 'stepping stones' within the dense urban core that increase the accessibility of greenspace and enrich the multifunctionality (including recreation and cultural potential) of the green wedges. These are being developed as open gardens in kindergartens. The open gardens are complemented educational programmes aiming to change the relationship of Poznań's (youngest) citizens with nature and a 'toolbox' through which the municipality supports citizens setting up bottom-up nature-based solutions initiatives.

2.1 Co-production as science 'with' cities[1]

Co-production is a mode of transdisciplinary research, focusing on the interface between science and decision-making (Jasanoff and Wynne 1998; Kirchhoff et al. 2013). Most fundamentally, co-production involves multiple producers in the generation of multiple products – it is "never just a science project; it is always also a political project" (Miller and Wyborn 2018, p. 3) with the aim to move beyond new knowledge generation and also alter social behaviours and societal arrangements to improve sustainability outcomes (Kates et al. 2001). Co-production thus challenges "the presumed dichotomies between […] production and use of knowledge" (Popa et al. 2015, p. 48). Research becomes "a mediated process of problem-solving based on experimentation, learning and context specificity" (ibid.; see also Miller and Wyborn 2018).

Co-production responds to the recognition that traditional science production models fail to inform effective decision-making particularly when it comes to complex problems that require balancing scientific information, local needs and values and the role of local knowledge (Djenontin and Meadow 2018). Knowledge co-production promises to increase the salience and usability of science for society (Cash et al. 2002; Lemos et al. 2012; Wiek et al. 2012). As such, co-production has been taken up in the design and implementation of international sustainability research and action – for example Future Earth defined knowledge co-production as a core design principle for its work (Future Earth 2013; Future Earth 2014, cf. Miller and Wyborn 2018).

Our co-production approach resonates a new approach to science 'with' cities. Specifically, "by shifting the terms of engagement from 'on' and 'in' to 'with', the 'researched' are not only given voice, but play an active role in the research process itself with the idea of enacting some form of social action to improve the current situation" (Newton et al., 2012, p. 592). The complexity and uncertainty inherent in the design and implementation of nature-based solutions requires knowledge from scientists, from practitioners and from the communities of influence within the cities, to be co-produced and therefore fitted to city needs and contexts (Nel et al. 2016; Cowling et al. 2008; Thompson et al. 2017). In Connecting Nature, cities and small-medium enterprises (SMEs) are equal project partners who co-develop, co-apply and co-learn together with the scientific partners about processes, skills, conditions and impacts in relation to the large-scale implementation of nature-based solutions. This allows us to develop our scientific approaches with a practice-oriented mind-set, to support and tailor the concepts to the individual cities' contexts and to derive applicable lessons that can be transferred to other cities.

We do science 'with' cities to develop scientific approaches with a practice-oriented mind-set. This means that we co-produce the Nature-based Solutions Framework, as well as how it is tailored to the frontrunner cities' contexts and practices. This builds on close interactions between researchers and planners of the cities in the Connecting Nature project.

Co-production that is inter- and transdisciplinary is not without challenges, and researchers and practitioners continue to struggle with the complexities involved in collaborative, inter- and transdisciplinary research (Djenontin and Meadow 2018; Freeth and Caniglia 2019). Making co-production work requires creating the conditions for teams and individual researchers to learn to communicate and collaborate with others (Freeth and Caniglia 2019; Gibson et al. 2018; Ferretti et al. 2016). It is important for leading, or facilitating, co-production processes to ensure a common language and common understanding of the objectives and solutions being addressed between scientists and planners (McPhearson et al. 2017). Similarly, it also requires new skills and conditions for conducting research and weaving together diverse knowledges (Tengö et al. 2017; Reale et al. 2018). This also means that co-production challenges preconceived roles of both researchers and 'the researched' (Wittmayer and Schäpke 2014). In collaborative research, partnerships interface with policymaking, design/management and community, and researchers often fulfil multiple roles including a brokerage role between community and policy that needs to be reflected upon for safeguarding objectivity and legitimacy of the value of research (Frantzeskaki and Kabisch 2016; Loorbach et al. 2017). In addition, the co-production of knowledge is inherently and inevitably political, involves political conflict and power differences in and among scientists, communities and others (Miller and Wyborn 2018).

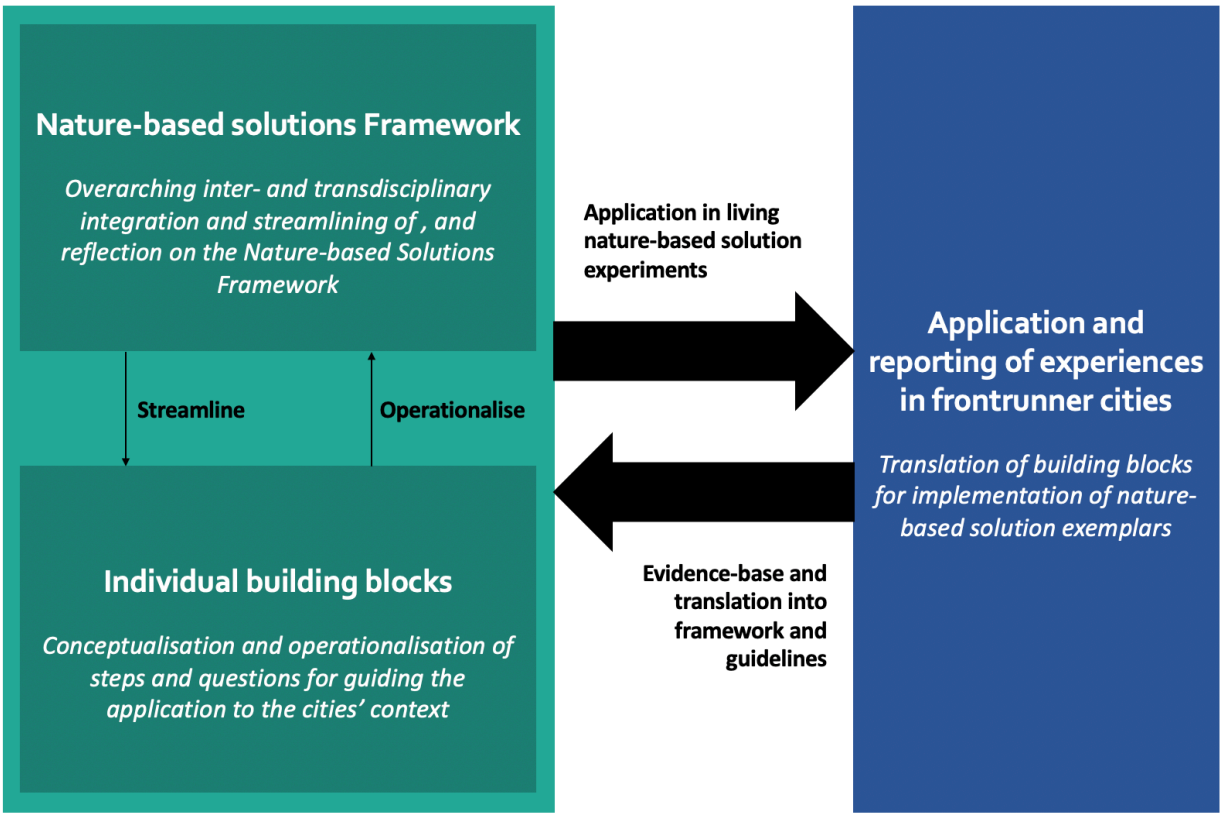
[1] Note that here we refer to co-production as the research mode we adopt in the Connecting Nature project. This is in its rationale related to but different from the co-production process we develop and translate to the cities' context as a mode of collaborative governance (see Section 3.6, Hölscher et al. 2019a and the Co-production Guidebook in Supplementary Material B.2 (Frantzeskaki et al. 2019a)).

This prompts critical and thorough analyses of co-production processes and results, starting with questions such as who is involved, who defines research problems and goals, and how conflict and inequalities are addressed (ibid.). We sought to address these challenges by taking a proactive and collaborative attitude, nurturing openness to look from each other's perspectives and ensuring sufficient time for communication and (face-to-face) interactions (see Section 2.2).

2.2 Co-production steps

Our co-production process builds on a two-tiered approach that combines (1) the conceptual development of the Nature-based Solutions Framework's building blocks, and (2) the overarching inter- and transdisciplinary integration and streamlining of, as well as reflection on, the Nature-based Solutions Framework (Figure 2). Across these two dimensions we work to translate the framework and building blocks to the Connecting Nature cities, as well as to learn from these applications.

Figure 2. The co-production set-up in Connecting Nature



Across these two dimensions, we aim to iteratively

(a) develop and operationalise each building block, including the formulation of concrete guidelines and steps for interventions that can be transferred to other cities.

(b) facilitate the translation into the Connecting Nature cities to support their implementation of the nature-based solutions exemplars; and

(c) identify the innovations and connections of innovations that result from the cities' implementation processes and lessons learned that will benefit other cities interested in developing and scaling nature-based solutions, e.g. including the starting considerations/objectives, when and how (not) to connect to which types of actors, opportunities and challenges encountered.

In line with our co-production approach, we undertook several iterative activities between all work package leaders and the frontrunner cities so as to include all the elements that are required (from the experience, knowledge and perspective of the Connecting Nature project team) to successfully and effectively scale nature-based solutions at city level (Table 1). The interactions served to design the Nature-based Solutions Framework and the step-by-step template (Supplementary Material A), facilitate the application as well as reporting and communicating of the cities, and to learn about the innovations generated.

Table 1. Co-production steps in Connecting Nature

When	What
Overarching framework approach	
September 2018	A webinar with all frontrunner cities and Work Package leaders, plus additional science partners (UBER and UVT) to discuss the Nature-based Solutions Framework, its goals, building blocks and how it can inform the exemplar implementation process.
November 2018	Focus group with frontrunner cities and Work Package leaders at DRIFT in Rotterdam, the Netherlands to discuss the overall aims and to provide suggestions for the better adaptation of the template fields to the real-life practices.
November 2018 – March 2019	Frontrunner cities started to fill in the template of the Nature-based Solutions framework to advance the planning of and reporting on their exemplar.
January 2019	During the first Knowledge Transfer workshop in Nicosia, the Nature-based Solutions Framework was presented to the fast-follower cities and frontrunner cities, follower cities and scientific partners discussed and reflected on the framework and each building block together.
Mid-April – mid-May 2019	All Work Package leaders provided written feedback to each of the frontrunner cities' reports and per building block webinars between each city and respective Work Package leader were held. In addition, DRIFT provided overarching feedback on each report and the consistency.
June 2019	A webinar with all frontrunner cities and Work Package leaders was held to reflect on the experiences with the Nature-based Solutions framework and to further advance and streamline the template.
June – August 2019	Frontrunner cities revised their Nature-based Solutions reports.
August 2019	All Work Package leaders provided written feedback to each of the revised frontrunner cities' reports, in some cases additional webinars for individual building blocks were held. In addition, DRIFT provided overarching feedback on each report and the consistency.
September 2019	DRIFT held webinars with each frontrunner city to reflect on the process so far, provide overarching feedback and discuss aims and next steps. Also a webinar between all Work Package leaders took place to reflect on the process so far and discuss next steps.
October 2019	During the second Knowledge Transfer workshop in Màlaga in October 2019, the frontrunner cities led the fast-follower cities through a practical exercise that encompassed each of the building blocks.
October 2019	During the AGM in Màlaga, all Connecting Nature partners reflected together on the process and output innovations generated through the Nature-based Solutions Framework implementation.
Technical solutions	
October 2017	A database of more than 1.500 emerging nature-based solution examples from across Europe was generated and analysed. Analysis included criteria such as budget, motivation, beneficiaries, and stakeholders.
October 2017	A literature review of nature-based solution delivery was carried out to develop an overview of the multiple processes involved in delivering nature-based solution reported in peer-reviewed scientific literature. This was based on a review of key literature related to nature-based solution delivery and evaluation (Balian et al. 2016; Connop et al. 2016; Kabisch et al. 2016; Collier et al. 2017; Raymond et al. 2017; Xing et al. 2017). The review was designed to capture state-of-the-art in relation to what is required to deliver nature-based solution successfully.
November 2017	An interview process was held with each frontrunner city. One-to-one interviews were held with a diverse selection of stakeholders associated with nature-based solution delivery in each of the frontrunner cities to explore each city's delivery experience with nature-based solution: what has worked in the past and what has not. It was also designed to explore where each city was at the time in relation to local challenges, and where the city wanted to be in relation to nature-based solution delivery.
December 2017	Production of a report summarising the results of the interview process to iteratively feedback the diverse experiences across each frontrunner city to respective frontrunner city Connecting Nature team, and receive input on the conclusions drawn during the reporting.
January 2018	A stakeholder workshop was held with the interviewees and other nature-based solution stakeholders in each frontrunner city to feedback the results of the interview, to explore whether a consensus could be reached in relation to the development of an exemplar, and to begin the planning of the exemplar with a capacity mapping exercise.

March 2018	A filtering process was carried out for each of the frontrunner cities that comprised taking the results of the workshops and reports and distilling them into a series of drivers/assets and barriers/challenges in relation to up-scaling nature-based solution in the city.
November 2018	A follow-up workshop was held in each frontrunner city to co-develop a strategy for nature-based solution exemplar delivery and to explore the results of the filtering process for barriers. Barriers were categorised and prioritised in relation to the urgency of need to address them for each frontrunner city.
January 2019	A workshop was held during the first Knowledge Transfer event in Nicosia with all frontrunner city and fast-follower city partners to explore the experiences of the frontrunner city in addressing the barriers and to investigate the relevance of the frontrunner city barriers to the frontrunner cities.
July 2018	A knowledge transfer process was carried out whereby the results of the literature review and workshops were used to shape the development of a questionnaire capturing a holistic overview of the technical, governance, and economic aspects of nature-based solution delivery for three case studies in each frontrunner city.
July 2019	Distillation of information from previous steps into the creation of a series of guiding questions designed to support and prompt the decision-making process involved in up-scaling nature-based solution delivery from localised innovation to city-wide delivery. The questions were designed to cover the complexity of issues associated with technical aspects of nature-based solution. From the distillation of the information generated in the previous steps, it was clear that technical nature-based solution delivery comprises three stages: design/planning, delivery and legacy management. These three stages of implementation were reflected in the structure of the guiding questions.
Indicators	
October 2017-October 2018	A comprehensive scoping of 1500 nature-based solution projects in Europe was carried out to identify the key dimensions influencing the success or failure of nature-based solution projects and their implications for developing robust indicators.
November 2017-March 2018	Interviews with key experts across Europe to identify the characterising elements of innovative emerging experiments involving nature-based solutions and their transformative elements; implications for indicators were also drawn, and a clear differentiation between process and outcome indicators was established.
January 2018-present	An expert group on indicators was established who reviewed the literature on nature-based solution environmental, social, health and economic indicators, and proposed a selection of most robust indicators that were used as a basis for the co-production work with the cities.
October 2017 – November 2018	Three rounds of workshops were held with each of the frontrunner cities of Genk, Glasgow and Poznań. The first series focused on drawing the connections between each city´s strategic objectives, the specific objectives to be addressed with the nature-based solution, expected nature-based solution implementation actions, expected nature-based solution outcomes, potential anticipated trade-offs between outcome categories, and between targeted social groups; and potential anticipated disservices – through the first version of the I-APT (Impact Assessment Planning Tool). The second series of workshops focused on drawing the connections between each city´s objectives, the SDGs, and zooming into specific indicator categories that most closely reflected the expected outcomes of each nature-based solution case study and exemplar. The third workshop was held with all the cities together and had the objective of rating indicators in each category on: relevance to exemplar; to case studies; geographical scale; KPIs/policy relevance; SDG goals); and highest scoring indicators were selected, adjusting for similarity (creation of umbrellas) and overall diversity (covering challenges). Core indicators were considered those that would be absolutely needed for a robust assessment of the multifunctionality of nature-based solution.
June 2018	A workshop was held with the fast-follower cities during the AGM in Ioannina, where these cities worked on drawing the connections between their city strategic objectives and those of potential nature-based solution that were considered for implementation and to do an analysis of their experience with nature-based solution evaluation.
May 2019	A webinar was held with each frontrunner city to provide feedback on their plans for indicator selection, hosted by WP2 coordinators.
August 2019	Factsheets with key information on each indicator to support the preparation of the Monitoring and Assessment Plans in each frontrunner city were finalised.
July 2019	Excel files with brief descriptions of each indicator were sent to each frontrunner city, asking them to review and identify sources of available data that could be used to assess particular impacts.
(ongoing) October 2019 – April 2020	A workshop was held at the AGM in Malaga with the frontrunner cities, where an overview analysis of existing data for the core indicators was presented and discussed with the cities and next steps were planned to develop the monitoring and evaluation plans over the next six months.
Governance	
September 2017 – December 2018	Semi-structured Interviews with key city personnel and stakeholders in each of the frontrunner cities to get data on nature-based solution-related policies, processes and practice.
October 2017 – January 2018	Analysis and synthesis of interviews followed by linked workshops in each frontrunner city to review and verify findings.
February - April 2018	Frontrunner cities collate strategic KPIs from city policy documents. Frontrunner cities produce city organograms to show hierarchies and relationships between departments and where Connecting Nature teams sit.

April – May 2018	Develop an alignment template for frontrunner cities to show how city strategic KPIs link to nature-based solutions frameworks and the UN SDGs. (Milestone 9)
June – September 2018	Frontrunner cities draft narratives for their exemplars
June – November 2018	Frontrunner cities complete templates to align each city's strategic KPIs, UN SDGs, Connecting Nature and their exemplar
October – December 2018	Capacity building workshops in each frontrunner city to introduce governance strategies to scaling up and delivery of exemplars
January 2019 – ongoing	Literature review, analysis, development of academic paper on nature-based solution policy needs
March – May 2019	Produce infographics to visually capture alignment in each frontrunner cities of KPIs, UN SDGs, nature-based solutions and exemplars. Produce summary on each frontrunner city exemplar and progress, including linkages to strategic KPIs, Deliverable 9.
January 2019 – December 2019	Review of all data gathered to identify organisational and governance needs and capacities in frontrunner city
Ongoing	Monthly frontrunner city peer-to-peer calls to share and review progress on exemplar delivery, challenges and activities
Financing, business models and entrepreneurship	
Ongoing	Continuous literature review on sustainable business model theory, public sector management models in relation to financing and governance and comparative review with environmental governance theory.
Ongoing	Conceptualisation of 'heartbeat model' identifying three distinct phases of nature-based solution financing and challenges and enablers associated with each phase.
February – April 2018	Capacity building workshop I on Financing, Business Model & Entrepreneurship Workshops in frontrunner cities addressing pre-identified knowledge gaps and barriers and identifying barriers and enablers to large-scale implementation of nature-based solutions.
May 2018	Presentation of preliminary findings on barriers and enablers to financing of nature-based solutions and validation of findings at an international workshop as part of the 'Transforming Cities' science-policy interface conference in A Coruna, Spain.
June 2018	Preliminary findings were discussed and validated in two workshops with local government representatives from all Connecting Nature cities across Europe at the AGM in Ioannina, Greece.
June – September 2018	In response to the challenges identified in literature and on the ground in frontrunner cities, the nature-based solution Business Model Canvas tool was developed.
September 2018	Preliminary research findings were presented at the academic symposium of the Social Enterprise World Forum in Glasgow.
October – December 2018	Collection of baseline data on the public sector management models of three frontrunner cities and the financing, business and governance models of 10 case studies of nature-based solutions to complex urban challenges through on-site visits, conference calls and exchanges with each of the frontrunner cities and completion of 15 semi-structured one-to-one interviews with different departments in frontrunner cities (planning, environment, regeneration, finance), regional government agencies, independent consultants, nature-based solution investors and NGOs across all three frontrunner cities.
October – December 2018	Capacity building workshop II pilot-testing the nature-based solution Business Model Canvas tool with frontrunner cities.
October – December 2018	Entrepreneurship Strategy Workshop was piloted with frontrunner cities in workshops.
January 2019	Based on iterative feedback from capacity building workshops the nature-based solution Business Model Canvas Guidebook was co-created with frontrunner cities and first published.
January 2019	Deliverable 19 was submitted
January 2019	Capacity building webinar I on Financing, Business Model & Entrepreneurship delivered to the fast-follower cities.
January 2019	Capacity building workshop III focusing on knowledge exchange and peer-to-peer learning between frontrunner cities and fast-follower cities was delivered in Nicosia during the 'Learning Transfer Workshop'.
February – April 2019	Co-creation of the nature-based solutions Business Model Canvas and Entrepreneurship workshop format between Trinity and SME partner Horizon Nua.
April 2019	Preliminary research findings were presented in a panel on 'Public management and the environment' at the IRPM.
May 2019	Preliminary research findings were presented at the Think Nature Science-Policy Dialogue in Paris.

June 2019	Pilot testing of the nature-based solutions Business Model Canvas in fast-follower cities Bologna and Màlaga.
August – December 2019	Subsequent deployment of the nature-based solutions Business Model Canvas by Horizon Nua in all fast-follower cities.
	Close collaboration with other projects (Naturvation, Nature4Cities, GrowGreen) on financing and business models facilitated by Task Force 3 e.g. contribution to GrowGreen financing guidebook and circulation to Connecting Nature cities.
Co-production	
Ongoing	A literature review on conceptualisations, approaches and lessons about co-creation and co-production, with a specific focus on the application in cities extending the design co-production guidelines of Frantzeskaki and Kabisch (2016).
Ongoing	Literature review on organisational barriers and strategies for dealing with co-producing nature-based solutions from an organisational perspective (Dumitru et al., 2018 and further extended). The review included studies on innovation, co-creation and organisational change in both private and public sector organisations to identify the most common resources and barriers in knowledge transfer, innovation diffusion in the organisation, co-creation and change. A short-list was made of those identified in the literature and based on frontrunner city workshops (next bullet).
February – April 2018	Frontrunner city workshops in every frontrunner city – in Genk (26.02.2018), Glasgow (11.04.2018), Poznań (26.04.2018) – with focus groups to assess (a) organisational conditions, barriers and strategies, (b) policy needs and (c) experiences with co-production, to explain, co-create and tailor the co-production and reflexive monitoring methodology for their city, to identify good practices per co-production principle of the framework.
June – July 2018	Two online meetings were held in the summer of 2018, with two of the three frontrunner cities (Genk in 27.06.2018 and Poznań in 12.07.2018).
June 2018	Peer-to-peer learning and reflecting on own practices for co-production with all frontrunner cities and fast-follower cities as reflectors in the General Assembly meeting of the Connecting Nature project held in Ioannina, Greece.
July 2018	A workshop with the Brazilian multiplier cities about the co-production principles by the ICLEI team in Brasilia.
November 2018	A webinar with all frontrunner cities to present and discuss the first draft version of the co-production guidebook.
November 2018	A focus group with all frontrunner cities to present the co-production processes they put in place for the nature-based solution exemplars in Rotterdam, the Netherlands.
January 2019	A webinar to introduce the co-production framework and principles to the fast-follower cities.
January 2019	A workshop on co-production principles and good practices from the frontrunner and the fast-follower cities with a peer-to-peer learning set up in Nicosia during the 'Learning Transfer Workshop'.
April – May 2019	Analysis of frontrunner cities' reports on their co-production processes, including translation of the co-production principles, presentation of their activities and methods and reflection on lessons, opportunities and barriers. Results were presented in Deliverable 4 and the first draft of the Co-production Guidebook.
Reflexive monitoring	
June – September 2018	A literature review about reflexive monitoring approaches and tools, with a specific focus on how to bring lessons from reflexive monitoring to co-production practice and scaling of nature-based solutions.
September 2018	A webinar with all frontrunner cities to co-produce the complete reflexive monitoring framework, process steps and tools.
September 2018 – January 2019	Monthly online reflexive monitoring coaching sessions with each frontrunner city. These sessions contributed to the further co-production of the reflexive monitoring framework and to coach the cities on how to apply the reflexive monitoring tools in practice. Genk: 1.10.2018; 9.10.2018; 6.11.2018; 6.12.2018; 8.1.2019 Glasgow: 3.10.2018; 16.10.2018; 13.11.2018; 18.12.2018; 15.01.2019; 22.01.2019 Poznań: 5.10.2018; 15.11.2018; 5.12.2018; 8.01.2019
November 2018	Learning experience workshop to further adapt the reflexive monitoring framework and facilitate peer-to-peer learning on the initial learning experiences about the co-production process and how to apply the tools between all frontrunner cities and scientific partners in Rotterdam, the Netherlands (20.11.2018).
December 2018	A webinar to introduce the reflexive monitoring framework to the fast-follower cities (12.12.2018).
January 2019	A workshop on the reflexive monitoring framework and good practices from the frontrunner and the fast-follower cities with a peer-to-peer learning set up in Nicosia during the 'Learning Transfer Workshop' (23.01.2019).
January 2019	Reflection with scientific partners on the reflexive monitoring framework resulting in including the scientific partners into the monthly online reflexive monitoring coaching sessions to better align and facilitate between the learning questions of the frontrunner cities and the various tasks in the project and expertise of the scientific partners (23.01.2019).

February – July 2019	Monthly online reflexive monitoring coaching sessions with each frontrunner city and the WP-leads. These sessions contributed to the further co-production of the reflexive monitoring framework, to coach the cities on how to apply the reflexive monitoring tools in practice, and to align and facilitate between the learning questions of the frontrunner cities and the various tasks in the project and expertise of the scientific partners. Genk: 14.02.2019; 2.04.2019; 5.06.2019 Glasgow: 19.02.2019; 19.03.2019; 18.04.2019; 21.05.2019; 18.06.2019 Poznań: 12.02.2019; 15.03.2019; 26.03.2019; 10.04.2019; 17.05.2019; 11.06.2019
February – April 2019	Development of an analysis framework for analysing the effectiveness of the reflexive monitoring framework and the impact on the nature-based solution framework building blocks.
May 2019	Analysis of frontrunner cities' reports on their Learning History Narratives that include reflections on their key learning outcomes for their co-production processes as well as on their experiences with the reflexive monitoring methodology for Deliverable 4.
June 2019	Learning experience webinar to further adapt the reflexive framework and facilitate peer-to-peer learning on how to apply the tools between all frontrunner cities and scientific partners. In this webinar the reflexive monitoring analysis framework was also presented and discussed with the frontrunner cities and the scientific partners. Additionally, a new structure for the coaching sessions was discussed, which puts more emphasis on learning outcomes. In the discussed new structure of the coaching sessions, the identification of learning outcomes generated throughout the process becomes an integral part of the ongoing reflexive monitoring process (20.06.2019).
May – August 2019	Analysis of effectiveness of the method reflexive monitoring framework and the impact on the nature-based solution framework building blocks.
June – September 2019	Analysis reflexive learning outcomes per frontrunner city based including further specification of the level of/qualification for reflexivity and the impact on the nature-based solution framework building blocks for Deliverable 5.

3. The Nature-based Solutions Framework

The Nature-based Solutions Framework consists of seven building blocks to facilitate the planning, delivery, legacy of nature-based solutions on city-scale in urban planning and policy practice. It is also used to report on, communicate and derive lessons from this practical application. Supplementary Material A includes the comprehensive set of steps and guiding questions per building block that were used by the cities to design, implement and report on their exemplar (see for the city reports Supplementary Materials B and C).

The Nature-based Solutions Framework is a new reference framework that informs urban planning and policy practice to take a holistic perspective on the planning, delivery and legacy of nature-based solutions on a large-scale in cities. The framework facilitates learning by and for cities on how to generate and connect diverse types of (e.g. technical, market, governance, social) innovations engendered by nature-based solutions.

The framework is not meant as a static process but it is rather to be applied in an iterative and non-linear way – the starting points and order of steps being determined by cities' contexts and needs.

Figure 3 gives an overview over the different building blocks of the framework and how they interrelate over the course of the design, delivery and legacy of nature-based solutions.

The first group of building blocks are the structural conditions in terms of new ways of designing (technical design), organising (governance), funding and financing (financing), connecting and generating city-based innovations (entrepreneurship), assessing multiple benefits of nature-based solutions in city life (impact indicators) that underpin the planning, delivery, and legacy of nature-based solutions:

(1) **Technical design:** The nature-based solution encompasses the detailed design of the nature-based solution exemplar and its features. This can be portfolio of nature-based solutions that connected embody one systemic solution.

(2) **Indicators:** the set of indicators that will be used as a reference for monitoring and evaluating nature-based solutions implementation and scaling that is adaptable to every city context and open to inputs over time.

(3) **Financing and Business Models:** the different sources of finances for the implementation of the exemplar as well as its long-term plan for maintenance and operation by the city and/or other urban actors and Business model, being co-developed with cities, SMEs and science partners to inform a new approach on the exemplar as a local business spin-off and attracto.

(4) **Entrepreneurship:** the potential of nature-based solutions to stimulate new market and business opportunities.

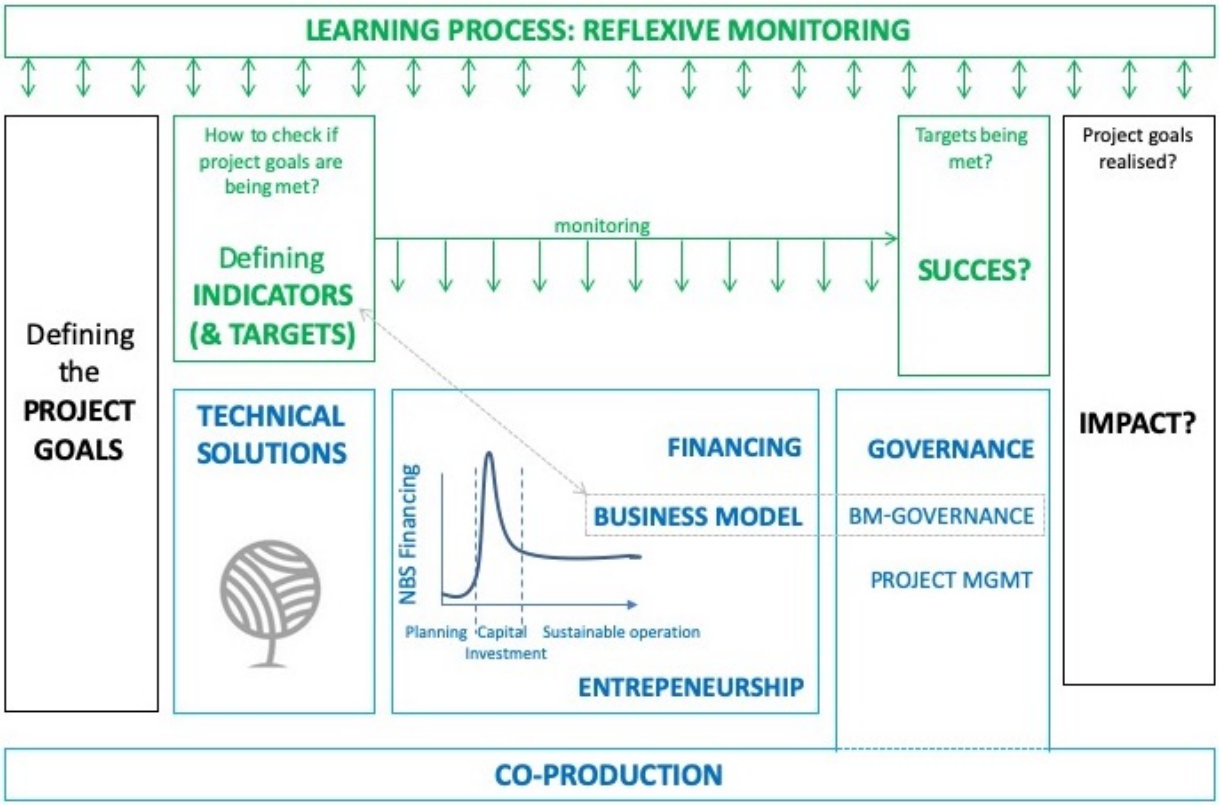
(5) **Governance:** the organisational conditions and skills for connecting different actors across sectors under the same vision of the nature-based solution exemplar for the city and facilitating that they are actively engaged and informed about the co-creation and reflexive monitoring.

Two *processes* underpin how the structural conditions for the planning, delivery and legacy are put in place:

(6) **Co-production:** the process of active involvement and part-taking in the making of all structural elements;

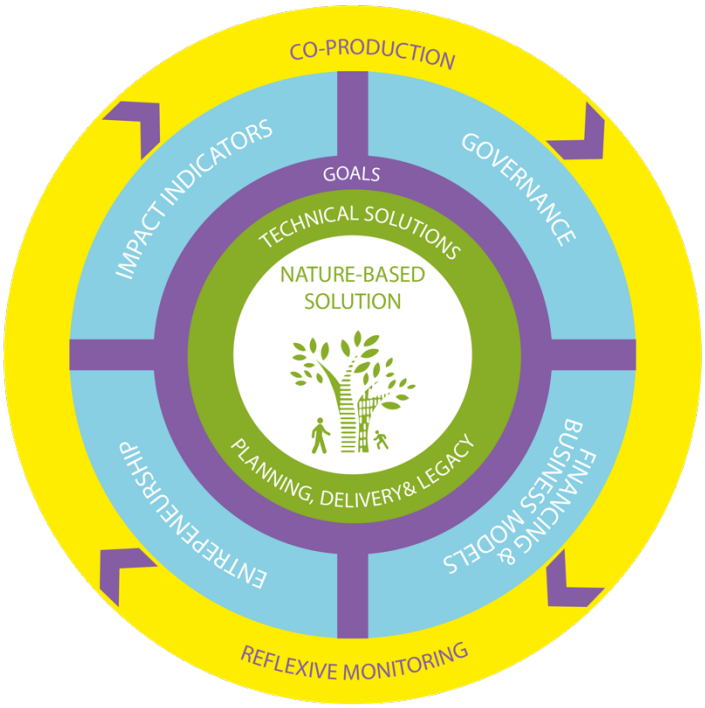
(7) **Reflexive monitoring:** the process of facilitated, continuous and adaptive monitoring and assessment of the whole process of co-creation to capture lessons learnt and on time valorise them into the planning/implementation process.

Figure 3. The Nature-based Solutions Framework: process view



As shown in Figure 4, the Nature-based Solutions Framework positions the nature-based solution and its goals at the centre of a three-layered 360° planning cycle. The goals permeate all building blocks as they give an orientation for how nature-based solutions are designed, delivered and maintained.

Figure 4. The Nature-based Solutions Framework: dynamic view [work-in-progress]



3.1 Technical solution: What is the nature-based solution

Authors: Stuart Connop, Caroline Nash, Diana Dushkova, Dagmar Haase

What is the design, delivery and legacy of the technical solution about?

Nature-based solutions are living solutions inspired and supported by nature that simultaneously provide environmental, social, and economic benefits and help to build resilience (European Commission 2016). In order to delivery these benefits, nature-based solutions bring more nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions (Nesshöver et al. 2017; Raymond et al. 2017). Whilst reintroducing biodiversity into cities is at the heart of this nature-based solutions concept, it is not sufficient to merely implement an area of greenspace in a city and expect this broad array of benefits to be delivered (Connop et al. 2016; Nesshöver et al. 2017). Consideration must be given to the technical design of a nature-based solution to ensure that the desired outcomes are achieved and sustained long-term, and that trade-offs are avoided where possible (Connop et al. 2016; Kabisch et al. 2016). The term 'Technical Solutions' therefore refers to the technical design, construction and management legacy of the nature-based solution. This includes both the practical construction aspects in relation to the typology (Damas 2018), for example: what kind? where? how big? what plants? what additional infrastructure is needed?, and the broader contextualisation in relation to the character and needs of the locality, region, and landscape into which it is being introduced (Pedersen Zari 2015; Connop et al. 2016; Mang and Haggard 2016; Nash et al. 2019).

Why consider the technical aspects of nature-based solutions?

Until recently, nature-based solution delivery has typically been based on localised examples of innovation (Kabisch et al. 2015; Faivre et al. 2017; Frantzeskaki 2019). In order to ensure that nature-based solutions are delivering benefits at a city-scale, supporting the aspiration of achieving sustainable, resilient and liveable cities, there is a necessity to up-scale and out-scale these examples of innovation for all communities (Frantzeskaki et al. 2019). When moving from this isolated delivery to a city-wide delivery there is an increased need to consider the interrelatedness of technical design and scale (Cohen-Shacham et al. 2019) rather than merely replicate a generic solution. This is to ensure that decisions guiding design, delivery, and legacy management take into account ecosystem, and ecosystem service needs across a range of spatial contexts. Without such consideration of the spatial links between technical design and locality, opportunities to address local challenges will be missed. Up-scaling and out-scaling nature-based solutions also requires innovation in relation to the temporal aspects of implementation

(Baycan-Levent and Nijkamp 2009). Over greater spatial scales, the challenge of long-term sustainability of schemes also becomes greater. Without detailed planning of the spatial and temporal implications of scaled-up delivery, nature-based solutions implementation risks, at best, to miss key delivery targets and, at worse, to be seen as a failure that creates a barrier to further delivery.

How to ensure the design, delivery and legacy of nature-based solutions?

We outline five iterative process steps to support the design, delivery and legacy of technical aspects of locally contextualised nature-based solutions (Figure 5). The key starting point to ensure the technical performance of nature-based solutions is that the design must be underpinned by a thorough understanding of place (Pedersen Zari 2015; Connop et al. 2016). When working across a city-scale this design should be shaped by different scales of influence: from a landscape ecosystem scale, through a city strategic scale, to a scale associated with the needs of the immediate locality. This local context must be fed into the design through a clear rationale of targeted benefits, co-benefits, and an understanding of trade-offs (Haase et al. 2012; Connop et al. 2016). Capturing and communicating the potential (multiple) benefits associated with these scales of influence is necessary to ensure that they are integral considerations through the other processes related to nature-based solutions implementation – i.e. indicator identification and monitoring, financing, business models, entrepreneurship, co-production, reflexive monitoring and governance. Incorporation of these aspects must be considered through the planning, delivery and legacy phases to avoid loss of benefits/co-benefits and support the management of trade-off decisions. To ensure this, technical performance must build from a foundation of sound design experience and must be accompanied with appropriate monitoring to ensure that lessons can be learnt, and evidence-based good practice shared. The framework and examples from frontrunner cities are reported in the Technical Guidebook (in preparation).

Figure 5. Iterative process steps for the design, delivery and legacy of the technical solution

3.2 Indicators: Assessing the baseline and the transformation achieved

Authors: Adina Dumitru

What is an impact monitoring and evaluation framework for nature-based solutions?

Cities all over the world are confronting intertwined environmental, social and economic problems and aim to become resilient to climate change and promote wellbeing for all their citizens. Nature-based solutions have been proposed as a promising policy approach to addressing urban problems for the potential they have to deliver multiple benefits and foster health and wellbeing for individuals and communities. Existing research has supported the view that nature-based solutions have the potential to simultaneously provide social, environmental and economic benefits (Haase et al. 2014), such as climate change mitigation and adaptation, improved quality of life, physical and mental health (Kabisch et al. 2017), social cohesion, well-being (Brink et al. 2016), and a sense of belonging and place (Hartig et al. 2014; Sullivan, Kuo & de Pooter 2004; Keniger et al. 2013; Gulsrud et al. 2018).

However, the evidence for their multiple benefits is rather scarce and highly fragmented, and more robust frameworks for the monitoring and assessment of their impacts are needed to guide urban policy-making (Brink et al. 2016). Single case studies, limited sets of impacts considered, one-time evaluations, or an overemphasis on particular types of nature-based solutions characterise existing evaluations (Raymond et al. 2016; Samuelsson et al. 2018). A clear delineation of impacts of nature-based solutions, of synergies and trade-offs between different types of impacts, and robust, flexible and cost-effective methods for their monitoring and evaluation are essential to building an evidence base for the performance of nature-based solutions. The development of a robust impact evaluation framework for nature-based solutions also entails the choice of appropriate indicators to capture impacts across multiple categories.

Why do we need robust indicators for nature-based solutions?

Nature-based solutions have been defined as "actions which are inspired by, supported by or copied from nature" (EC 2015) and the potential to fulfil multiple, simultaneous objectives has been attributed to them (Faivre et al. 2017). However, nature-based solutions evaluations often fail to plan for the assessment of multiple outcomes across different categories of impacts (i.e. environmental, social, economic, etc). Choosing and/or developing robust indicators to assess impacts of nature-based solutions allows cities to assess the strengths and weaknesses of specific interventions in achieving strategic city goals and provide an essential tool to make adaptations to their design and implementation in real time, thus increasing their performance. Robust indicators also support cities in building the case for investments in nature-based solutions, by providing evidence regarding the types of impacts they are able to deliver. Finally, evaluation is necessary for a change in mainstream ways of planning for urban resilience and regeneration, still dominated by redundancies that derive from understanding ecological, social and economic objectives as separate and sometimes at odds with each other and reflected in the silo-thinking of urban policy practice.

How to develop a set of robust indicators for the impact monitoring and assessment of nature-based solutions?

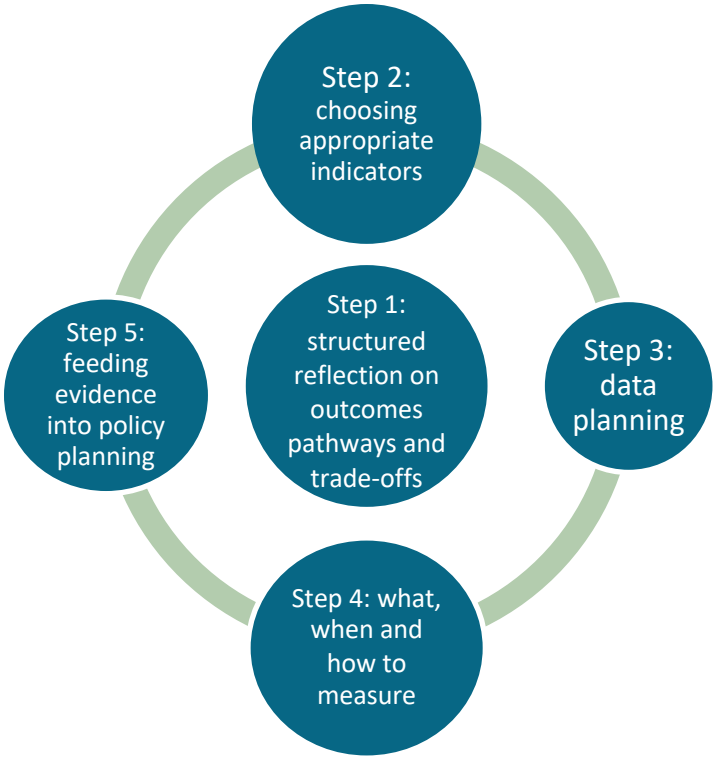
We propose the following five steps in choosing appropriate and robust indicators to assess multiple impacts of nature-based solutions (Figure 6). The first step is to engage in a structured reflection regarding the strategic city objectives to be reached with nature-based solutions, specify expected outcomes, identify the appropriate scale of implementation, and create a conceptual map of the pathways through which nature-based solutions are expected to generate particular impacts, as well as likely trade-offs between impact categories and across social groups. Within WP1, Connecting Nature will create an impact assessment and planning tool (I-APT) to support this process in cities.

The second step entails choosing appropriate indicators to assess impacts identified in step 1. Expert support is helpful at this stage, to choose indicators that form a coherent impact evaluation framework and are, at the same time, context- and exemplar-specific. When choosing indicators, it is important to consider the following factors: scientific soundness; geographical and temporal scale of application; monetary and human costs required in their application; possibilities for longer-term or ongoing evaluation; as well as opportunities for participatory processes in monitoring and assessment.

Step 3 focuses on identifying existing data already being collected and planning for additional data collection by going beyond simple descriptive measures (e.g. number of people using a particular nature-based solutions) to evaluation of outcomes for different social groups.

Step 4 focuses on the development and implementation of monitoring and assessment plans: answering the questions of what, when and how to measure specific impacts. The evidence produced will then be processed and fed back into the policy planning process (Step 5).

Figure 6. Iterative process to develop a monitoring and assessment plan for nature-based solutions



3.3 Governance: Conditions for collaboration and coordination for multifunctional nature-based solutions

Authors: Paula Vandergert, Sam Jelliman

What is governance of nature-based solutions?

Governance of nature-based solutions involves diverse actors – including city departments, regional bodies, strategic partnerships, social enterprises, private sector partners – as well as the formal and informal institutions, processes and rules that determine the delivery, legacy and scaling of nature-based solutions in a city or city-region (cf. Kooiman 1993; Biermann et al. 2009). Because of the multifunctional benefits that can be achieved from nature-based solutions, their delivery is often aligned with broader social, political and business priorities and goals of a city and of city-regions. Therefore, the governance of nature-based solutions cannot be separated from urban governance of other policy priorities and goals such as mobility, health, climate resilience etc., and requires cross-sectoral, multi-scale and inclusive approaches in terms of who is best placed to ensure development, delivery and ongoing sustainability of the nature-based solution and how effective governance networks can be fostered (Buijs et al. 2018; Pauleit et al. 2017; Kabisch et al. 2017).

Why to innovate existing urban governance for nature-based solutions governance?

So far, nature-based solutions have been of limited scale and broadly have been funded by public funds to achieve mono- or bi-functional nature-based solutions (Sekulova and Anguelovski 2017; Haase and Dushkova 2019). Facilitating governance for cross-sectoral, multi-scale and inclusive nature-based solutions can be a significant challenge to the 'business as usual' way of working within city governments and other organisations, that are used to working in (e.g. departmental) silos and not involving the broader public (Frantzeskaki et al. 2019b; Connop et al. 2016). This means that there is a need to re-think the organisation of urban governance to facilitate nature-based solutions governance, including the organisational and institutional conditions such as skills, legal frameworks, resources and partnerships, to facilitate collaboration and coordination across scales, sectors and societal spheres (Frantzeskaki et al. 2019b; Hölscher et al. 2019a).

How can we create the conditions for the governance of nature-based solutions?

We have identified three steps to develop the conditions for nature-based solutions governance:

1. **Identify the departmental home(s) of the nature-based solution and legal framework**

Nature-based solutions will most likely continue to be led by local government, or at the very least involve them in delivery, so it is important to identify the most appropriate departmental home for the project and map all of the other departments who need to be involved in the various stages of nature-based solution design, implementation and stewardship. This may be aligned with broader policy or regulatory functions within the city government – so again, mapping those and their strategic goals and key performance indicators (KPIs) can help make visible the connections and also the multifunctionality of the nature-based solution. Figure 7 shows how such projects can be visually represented to link with broader city and sustainability goals (such as UN Sustainable Development Goals -SDGs) and nature-based solutions frameworks) as a way to show the relevance to colleagues and potential partners.

2. **Develop an organisational project structure and identify collaborators**

The lead team within the city government will need to think laterally about how to foster an operational structure to develop, implement and manage the nature-based solution so it delivers the multiple strategic benefits and embeds an appropriate collaborative model of working. Undoubtedly, this will include other city teams and external partners such as regional authorities, strategic developers, citizens groups. The team needs to analyse and reflect on the existing hierarchies and decision flows which can operate as barriers or opportunities for scaled up nature-based solutions. There may be a need to get a third party to act as a 'broker' or intermediary to convene the different actors so that all feel they have an equal status in the outcomes (Vandergert et al. 2015; Kampelmann et al. 2016).

3. **Identify skills and conditions to overcome organisational barriers and mobilise opportunities for multi-functional and scaled-up nature-based solutions**

The necessary skills and conditions to create the capacities for collaborative nature-based solutions governance are both personal and institutional-organisational (cf. Hölscher 2019; Innes and Booher 2003; González and Healey 2005). These include organisational resources (e.g. leadership, knowledge about nature-based solutions design and benefits), institutional structures (e.g. networks and partnerships, legal structures) and individual skills (e.g. mediation, trust-building) (Frantzeskaki et al., forthcoming; Hölscher 2019). Developing these skills and conditions may require additional professional training. The organisational culture may also hinder or facilitate new ways of working. This requires analysis and may involve finding the intermediary or 'broker' as referenced above) who can operate within existing and/or foster new organisational cultures. Here, broad attributes of leadership (not just by known 'leaders') and collaborative working are key alongside professional skills and other expertise.

Figure 7. Example connections between city strategic goals, UN SDGs and nature-based solutions frameworks

3.4 Financing and Business Models: Mobilising resources for implementation and long-term sustainability

Authors: Siobhan McQuaid

What do we mean by financing and business models of nature-based solutions?

Financing has been identified as one of the main barriers in transitioning from nature-based solution experimentation to large-scale city-wide implementation. However financing and business model literature on urban/sustainable/nature-based solutions remains nascent (Sousa-Zomer and Cauchick Miguel 2018). Through an inductive research approach, we have identified three major phases of financing (see Figure 8) of nature-based solutions which may reoccur many times over the lifetime of a nature-based solution:

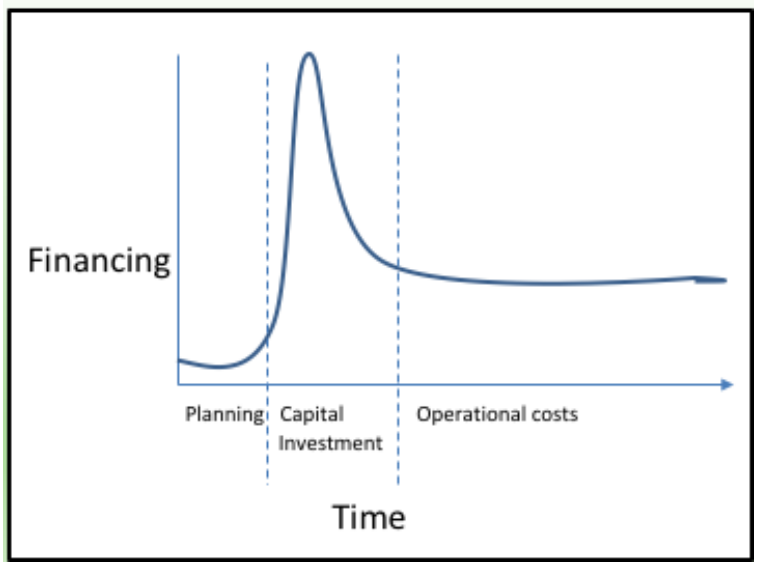
- **Financing the planning and design of a nature-based solution:** The planning and design of a nature-based solution, in particular large-scale infrastructure-type projects, can take a long time, involve many organisations and can often be very expensive.

- **Financing capital investment in nature-based solution:** The highest costs associated with a nature-based solution project are often the capital costs associated with the initial states of implementation and nature-based solution delivery. These costs are usually incurred over a short period of time.

- **Financing ongoing operational costs:** The costs of maintaining a nature-based solution are often considerable and occur over a long period of time. Sometimes ongoing costs can be financed through revenue generation activities but in many cases nature-based solutions are considered a public good and revenue generation opportunities to finance ongoing operational costs are limited. The ongoing costs of a nature-based solution and revenue generation opportunities are core elements of the business model of the solution.

While the financing and business model for a nature-based solution should be considered together at the planning stage (Toxopeus and Friedemann 2017), our research has shown that this is rarely the case with a predominant focus on securing financing for capital investment with little consideration given to sustainable business models in the long-term.

Figure 8. Phases of nature-based solutions financing

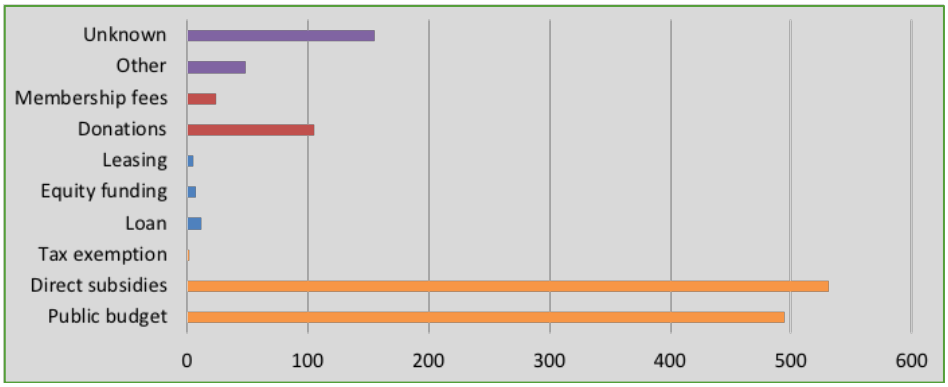


Why do we need to innovate in financing and business models?

To date financing and governance of nature-based solutions has been primarily led by the public sector (see Figure 9). The lack of consideration of sustainable business models for nature-based solutions has further sustained this

dependency on public sector financing of nature-based solutions. However increased pressure on public sector resources combined with a shift towards more collaborative governance models has raised concerns about future public sector management and financing of nature-based solutions (Sekulova and Anguelovski 2017). Conversely this withdrawal of state involvement presents opportunities for innovation in financing and business models. Studies of alternative sources of nature-based solutions financing have identified dependencies on both the ecological domain and the scale of financing required (Toxopeus and Friedemann 2017). For example, small scale urban agriculture projects such as community gardens may have a higher mix of community funding secured through instruments like crowd-funding (Calic and Mosakowski 2016) whereas at the other end of the scale the financing of large-scale nature-based solutions like sustainable urban drainage systems (SUDS) is more similar to large scale infrastructure investment projects (Bryson 2014).

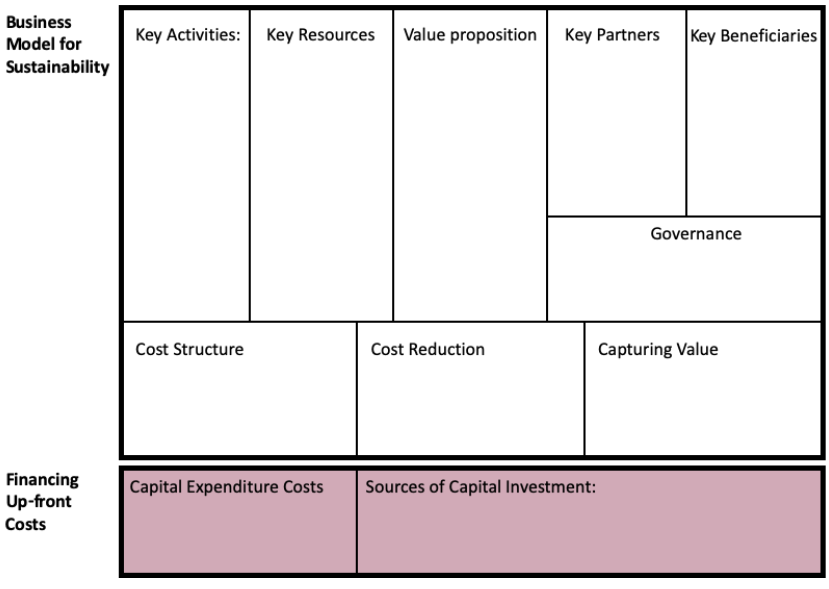
Figure 9. Sources of nature-based solutions financing (source: Naturvation Atlas 2018)



How to support innovation in financing and governance models?

As presented in the methodology section, academic and frontrunner city partners collaborated together in a bottom-up approach to co-produce a new approach to stimulating innovation in financing and business models. Drawing on sustainable business model theory (Lüdeke-Freund 2009; Bocken, Short et al. 2014) and reflecting the well-established Business Model Canvas (BMC) tool (Osterwalder, Pigneur et al. 2005; Osterwalder and Pigneur 2010), we developed a new business model support tool and guidebook for cities which addresses the wider value proposition of nature-based solutions (Figure 10).

Figure 10. Connecting Nature Business Model Canvas for nature-based solutions



In a 1-day workshop facilitated by Connecting Nature SME partner Horizon Nua, cities work through each of the sections of the nature-based solution BMC (see Figure 10), beginning with the **elaboration of the wider value proposition of the nature-based solution** as identified by the IUCN and EC (Balian 2014; Faivre, Fritz et al.

2017). This is followed up by a clarification of **how this value will be delivered** through key activities and key partners/beneficiaries. This approach prompts cities to reflect on the governance structure required to deliver the value proposition and how key partners and beneficiaries will be involved in this governance structure. Finally, cities are asked to consider **how this value will be captured**. This involved identifying ongoing costs and opportunities to reduce those costs e.g. through volunteers or meet costs through revenue generation opportunities. The approach begins with a consideration of the sustainable business model for the nature-based solution and then works backwards to **explore potential sources of up-front financing** which reflect the business and governance models identified.

This business model approach has been empirically tested in the three frontrunner cities and the scaling-out to the eight fast-follower cities will be completed by the end of 2019.

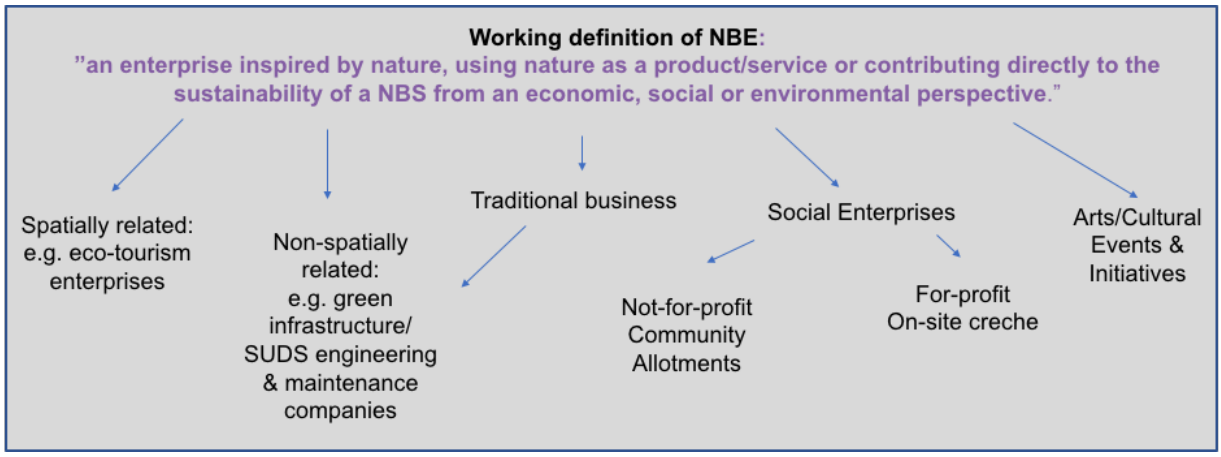
3.5 Entrepreneurship: Engaging community and commercial enterprises in the design, implementation and long-term delivery of nature-based solutions

Authors: Siobhan McQuaid

What do we mean by Nature-Based Entrepreneurship?

An ongoing literature review on nature-based entrepreneurship shows that this term has predominantly been used in the context of the tourism or agri-tourism sector: "Nature-based entrepreneurship offers, for example, tourism products, handicrafts and food products that have their foundation in nature" (Lahdesmaki 2005). We propose a wider definition related to the planning and design, implementation and sustainable management/legacy of nature-based solutions. Figure 11 shows an initial working definition of Nature-Based Enterprises (NBEs) as "*an enterprise inspired by nature, using nature as a product/service or contributing directly to the sustainability of a nature-based solution from an economic, social or environmental perspective*".

Figure 11. Working Definition of Nature-Based Enterprises (NBEs)



This broad definition allows for the inclusion of NBEs such as creative enterprises using nature as inspiration for the organisation of arts or cultural activities. It includes NBEs directly located on-site in a nature-based solution, e.g. eco-tourism enterprise or social enterprises such as not-for-profit community allotments. It also encompasses off-site NBEs who contribute expertise to the design, planning and implementation of nature-based solutions, e.g. environmental consultants or green infrastructure companies. This definition encompasses both 'for profit' and 'not-for-profit' enterprises. The common denominator is that each NBE contributes to the sustainability of an nature-based solution from a social, environmental or economic perspective. A narrower definition of a NBE which has emerged from initial consultation meetings with frontrunner cities is "*an enterprise which uses nature as a fundamental element of their product/service offering*". This definition will be further refined as a catalogue of NBEs are identified and profiled across Connecting Nature cities over the duration of this project.

Why is Nature-Based Entrepreneurship important?

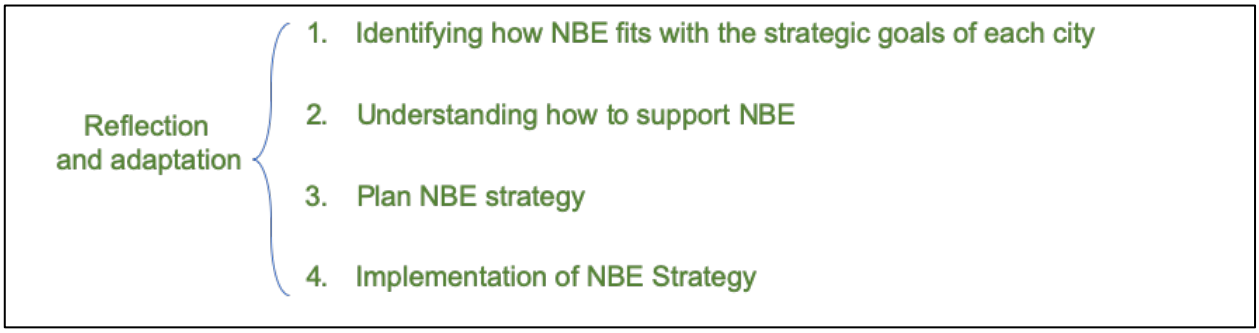
As identified in the previous section (Section 3.4), historically public sector agencies both financed and managed nature-based solutions on an ongoing basis. Nature-based solutions such as forests or urban parks were managed by specialised agencies or public sector 'parks and maintenance departments'. However, pressure on public sector resources combined with successive waves of public sector management reforms and a shift towards more collaborative governance models has seen the increased outsourcing of public sector services to third parties (Osborne 1993; Pestoff, Osborne et al. 2006). These changes present opportunities for market innovation both in the form of new public-private governance entities such as Community Interest Companies (CICs) and the emergence of product and service innovation. In Poznań, for example, we have seen public investment in nature-based solutions stimulating product and service innovation in the private sector.

How to support innovation in Nature-Based Entrepreneurship?

Our approach to stimulating innovation in NBE is still at an early stage of development and is likely to evolve based on:

- the findings of the literature review;
- a bottom-up survey of the specific challenges and enablers facing nature-based entrepreneurs to be undertaken across all Connecting Nature cities at the end of 2019;
- the outcomes from initial entrepreneurship strategy development workshops undertaken in frontrunner cities from October-December 2018 and in fast-follower cities from June-December 2019. This workshop supports cities to develop entrepreneurship strategies based on the four steps identified in Figure 12. Through reflexive monitoring and bilateral calls with cities, the task leader will use a bottom-up approach to identify challenges and enablers facing cities as they collaborate with other innovation eco-system actors in introducing policies, programmes and specific measures to stimulate NBE.

Figure 12. Steps in NBE development strategy



Distilling the findings from these three research methodologies, a Guidebook will be developed to support Connecting Nature cities and cities outside the consortium in supporting NBE.

3.6 Co-production: Engaging and mobilising diverse actors in searching for and implementing shared nature-based solutions

Authors: Katharina Hölscher, Niki Frantzeskaki, Marleen Lodder

What is co-production about?

Co-production is a novel form of collaborative governance, which allows for deep participation to leverage and weave together local, expert and tacit knowledge and ultimately to address complex urban problems in an inclusive way (European Commission, 2015; Frantzeskaki, 2019; Frantzeskaki and Kabisch, 2016). Co-production promotes collaborations, partnerships and knowledge integration for the design, implementation, stewarding and scaling of nature-based solutions. It responds to the need to create new institutional spaces for multiple perspectives and knowledges to come together (Vingola et al., 2009, p. 694; Devolder and Block, 2015) and to account for "competing value systems" (Gulsrud et al., 2018, p.165). For example, co-production may bring together civil

servants from across city departments to create synergies between different policy priorities and goals and connect nature-based solutions to other strategies, agendas and financial means. Co-production might also bring civil servants together with local entrepreneurs and business actors, experts (e.g. researchers, advisors, consultants) and communities. In this way, co-production weaves together knowledge about how to develop new business cases, expert knowledge about technical solutions and civic-tacit knowledge about local needs.

Why to co-produce nature-based solutions?

Given that in cities, knowledge about problems, needs, and solutions lies in diverse actors, co-production is a suitable approach to bridge and weave the knowledge across multiple diverse actors. Co-production is a process that can facilitate and organise how to simultaneously develop solutions that will benefit the city and its inhabitants as a whole. It can also facilitate the building of partnerships and ensure political and societal commitment and resources (Frantzeskaki, 2019). Co-production spurs new relationships between diverse actors – including civil servants, citizens, planners, entrepreneurs, architects, scientists and engineers – that are normally not in contact with each other. This facilitates the generation of new and more integrated knowledge that leads to the design of multifunctional nature-based solutions (pertaining not only to their mere technical design but also to their financing, business models and social innovations) addressing local needs and mobilising local opportunities. Through entering a process of co-production, actors have the opportunity to learn about each other's realities. This generates novel and shared problem framings and visions, enables deeper relationships and empowers joined-up service delivery by professionals and citizens (Voorberg et al., 2014; Hölscher et al., 2017; Frantzeskaki and Kabisch, 2016).

How to co-produce nature-based solutions?

Setting up high quality, viable and effective co-production requires good process designs, knowledge about the right tools and methods, as well as enabling conditions that provide the basis for co-production. We outline six iterative process steps to design co-production processes, combining principles for good design, tools and methods for facilitation and capacities to enable co-production (Figure 13). The framework and examples from frontrunner cities are reported in the Co-production Guidebook and in Hölscher et al. (2019a).

Figure 13. Iterative process steps to design co-production processes

3.7 Reflexive monitoring: a real-time instrument for nature-based solution implementation

Authors: Marleen Lodder, Daan Sillen, Niki Frantzeskaki, Katharina Hölscher, Igno Notermans

What is reflexive monitoring about?

Reflexive monitoring is a participative and dynamic monitoring and learning process that enables urban practitioners to gain insight into the progress and direction of their nature-based solution project in real time, not just retrospectively (van Mierlo et al. 2010; Bussels et al. 2013). It is about taking a reflexive mindset: reflexivity is the ability to interact with and alter the environment within which one operates (Beers and van Mierlo 2017). This allows urban practitioners to take actions that influence the context in which they work for the implementation of their nature-based solution – including for example institutions, practices, discourse and relations. As a method, reflexive monitoring enables to systematically embed continuous and collaborative learning into urban policy-making, planning and other project management practice from the start. It is especially helpful in iterative processes aimed at addressing complex societal challenges and facilitating systemic innovations. Specifically, the reflexive monitoring methodology helps to identify (institutional) barriers that block the desired structural change of the project, and to formulate actions to address, navigate and mobilise these (Arkesteijn et al. 2015). Reflexive monitoring thus becomes an instrument for learning that helps to evaluate the day-to-day activities, decisions and progress, and how these align with the long-term ambitions of the nature-based solution. In this way, reflexive monitoring allows for direct adjustments and improved actions. Through reflexive monitoring not only direct impacts of nature-based solutions can be captured, but also diffuse and indirect impacts in the form of learning outcomes.

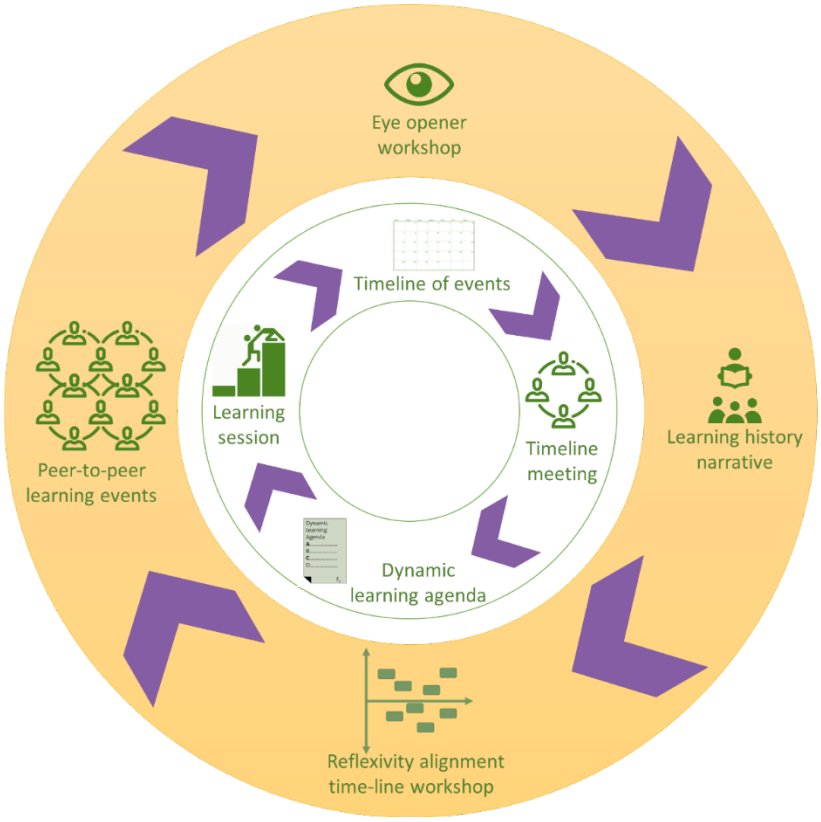
Why apply reflexive monitoring to nature-based solutions?

Reflection, and co-reflection amongst participants, is advocated as an important process for the success of nature-based solutions because they are transdisciplinary projects that require collaborations between different disciplines, combining tacit and expert knowledge, and supporting capacity building amongst all quadruple helix actors involved (Harris and Lyon 2010; Roux et al. 2010). In addition, it is not possible to aim at rigidly and pre-set outcomes and related indicators because the process needs to allow for the emergence of innovations due to the complexities and new knowledges involved. These innovations might influence the previously intended direction of the nature-based solution because they offer a novel way to address the complex societal challenges and generate systemic change in a better way. The reflexive monitoring methodology – as well as the deeply rooting reflexive mind-set – prompts continuous reflection about how a nature-based solution relates to its context and whether solution-finding efforts indeed contribute to the intended sustainability objectives (Beck et al. 1994). As such, reflexive monitoring helps to respond to challenges in line with the long-term perspective because of its novel and systemic perspective on goals and processes (Van Mierlo et al. 2010).

How to apply reflexive monitoring?

We composed a coherent set of eight monitoring tools, which facilitate the implementation of the reflexive monitoring method for the co-production of nature-based solutions by urban practitioners. This framework (see Figure 14) comprises of an inner cycle representing the basis for the internal reflexive monitoring activities and an outer cycle with tools to communicate about the reflexive monitoring process to peers and stakeholders outside the project. The framework and examples from frontrunner cities are reported in Lodder et al. (2019) and Hölscher et al. (2019a).

Figure 14. Eight monitoring tools to implement the Reflexive Monitoring Framework


Eye opener workshop
Timeline of events
Learning session
Timeline meeting
Dynamic learning agenda
Peer-to-peer learning events
Learning history narrative
Reflexivity alignment time-line workshop

4. Results: the landscape of innovations for large-scale nature-based solutions

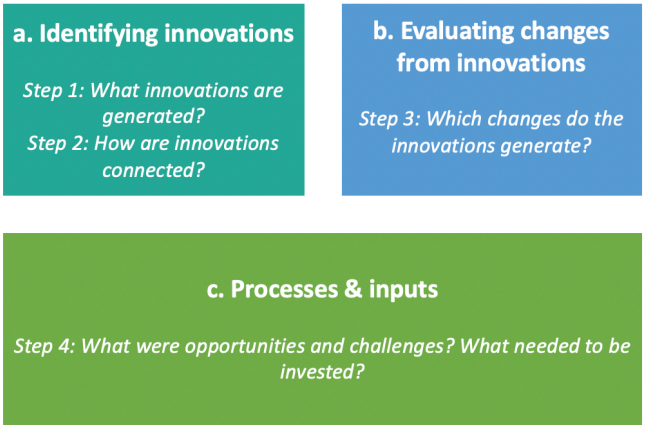
In this section we synthesise the (connections of) innovations and learnings that emerged in the frontrunner cities from applying the Nature-based Solutions Framework.

We identify the types of innovations that were generated in the frontrunner cities through their nature-based solution exemplar and analyse their connections and impacts, as well as how this was accomplished (Figure 15). To this end, we adapt the impact evaluation framework developed by Luederitz et al. (2017) to support design, learning about and evaluation of sustainability transition experiments. We simplify the steps and do not assess the outcomes accomplished by the experiment in terms of sustainability.

According to these steps, we first describe the landscape of innovations that emerges through the Nature-based Solutions Framework (Section 4.1). We then dive deeper into the kind of changes that are created by the innovations (Section 4.2), and identify the new types of capacities emergent in the cities that facilitate the application of the Nature-based Solutions Framework (Section 4.3). Finally, we present examples of reflexive learning outcomes that signify the learning the cities experience when applying the Nature-based Solutions Framework (Section 4.4).

The Nature-based Solutions Framework has been introduced as a holistic process initiation tool to develop nature-based solutions on a large scale in cities. As shown above, it indeed nurtures and connects multiple innovations by giving attention to and supporting diverse dimensions around nature-based solutions implementation. In this section, we focus on the specific conditions that are fostered through the Nature-based Solutions Framework, and that manifest in capacities of cities to walk through the different steps and to overcome existing barriers and challenges. This view on enabling conditions provides valuable lessons learned for both the frontrunner cities themselves as well as for other cities.

Figure 15. Steps to identify and analyse innovations (adapted from Luederitz et al. 2017)



4.1 Which innovations are generated and connected?

We identify diverse innovations that were generated and nurtured in the frontrunner cities by applying the Nature-based Solutions Framework (Table 2). Most of the innovations become manifest in all frontrunner cities – if they relate to specific cities this is mentioned in the table.

We identify innovations on two levels: Firstly, on an aggregate level that marks the overall change in what and how nature-based solutions are designed, delivered and maintained. Overall, it becomes clear that the different building blocks of the framework challenge the status quo and provide new ways to support urban planning practice for nature-based solutions. The key difference is that the framework promotes integrative, inclusive, knowledge-based and flexible approaches to generate nature-based solutions with multiple benefits. It also facilitates the embedding of these nature-based solutions in other city agendas, establishes collaborations across city departments and between private and public actors.

Secondly, we dig deeper into which changes these innovations generate. This helps to qualify the different types of (e.g. technical, social, market, governance) innovations engendered (see Section 1.1). It also underscores how diverse innovations are connected in facilitating and scaling nature-based solutions. For example, co-production is a novel method that facilitates integrated technical solutions design and delivery that is fit to local contexts and needs, provides synergies and opens up new opportunities for collaboration and financing. New knowledge generation about multiple benefits of nature-based solutions broadens the definition of values delivered through such solutions and thus boosts political and societal support and promotes new forms of collaborative financing.

The Nature-based Solutions Framework facilitates generation and connection of diverse types of innovations that mark an overall change in what and how nature-based solutions are designed, delivered and maintained. The framework promotes integrative, inclusive, knowledge-based and flexible approaches to generate nature-based solutions with multiple benefits. It also facilitates the embedding of these nature-based solutions in other city agendas, establishes collaborations across city departments and between private and public actors.

We also identify what is needed to facilitate the innovations, as well as which challenges and barriers the cities face in generating them. While we can see these innovations emerging in all cities, in none of the cities they are yet fully matured. It becomes clear that nature-based solutions implementation at a large scale and in a holistic manner challenges existing urban policy and planning processes, requiring particularly new forms of collaborations, knowledge generation and skills – such as facilitation of co-production and knowledge about diverse stakeholders and financing opportunities. This analysis therefore also helps to identify which innovations to strengthen, potential strategies to achieve this and what barriers need to be overcome. Section 4.3 provides further analysis of this.

Boxes 2-4 highlight examples for the innovations visible in the frontrunner cities, including illustrations of the changes generated as well as how these came about and the challenges. The frontrunner city reports (Supplementary Materials B and C) provide in-depth insights into how the cities have applied the framework, which innovations emerged as a result and how they have mobilised opportunities and dealt with challenges in the process.

Table 2. Overview of innovations, enablers and barriers

Innovation	What is this innovation about?	Enablers	Challenges and barriers
Multifunctional technical design that balances local needs and local landscape context	*Technical innovation:* integrated and fit-to-context design *Knowledge innovation:* knowledge about local needs and landscape context and synergies *Governance innovation:* collaboration between multiple actors *Social innovation:* increased accessibility to green space to wider user groups	Systems' thinking and new problem definition for dealing with social, environmental, health and economic concerns Co-production between diverse actors from the beginning, e.g. collaboration with university and experts, communities New knowledge about local needs and impacts, synergies and trade-offs	Lack of expertise in relation to multifunctional design Designing to manage trade-offs Lack of knowledge and capacity to collect/assemble knowledge (e.g. local knowledge, accessible/centralised knowledge, interdisciplinary knowledge) Complex distribution of responsibilities in city administration Conflicting interests and dealing with legitimacy questions
New mechanisms for long-term and collaborative financing	*Market innovation:* new collaborative business models *Knowledge innovation:* wider value propositions for nature-based solutions *Knowledge innovation:* identification of financing partners *Governance innovation:* new partnerships and collaborations	New knowledge about wider values of nature-based solutions leading to increased confidence in new business models Capacity building in financing and business models among 'environmental' managers Cross-silo communication with finance and economics departments Recruitment of specialised resources to address skills gaps Including external funding from beginning Strong political support and pressure to find new business models to	Unfamiliar job specification for recruitment of economic positions in environment departments Viable business cases are not clear Lack of expertise in business planning – capacity building an ongoing requirement in this nascent field Uncertainty about public sector financing budget leading to uncertainty about required external stakeholder investment Lack of clarity on planned activities of external stakeholders and associated costs

Innovation	What is this innovation about?	Enablers	Challenges and barriers
		reduce dependency on public sector resources (Genk) Development of asset management strategy (Glasgow)	Decision- making power still in the hands of political representatives and public sector – risk aversion
Opening up opportunities for nature-based entrepreneurship	*Market innovation:* new products and services, stimulation of new enterprises *Knowledge innovation:* wider value propositions for nature-based solutions *Knowledge innovation:* identification of potential nature-based enterprises and partners *Social innovation:* new relationships with businesses *Governance innovation:* new forms of flexible, collaborative governance between public and private sector	Capacity building to increase awareness and interest among cities in supporting nature-based entrepreneurship Dedicated resources to bridge cross-departmental silos in support of entrepreneurship Public sector de-risk process by investing in product/service innovation (first customer) (Poznań)	'Chicken and egg': companies will be attracted by improved urban areas, but this also risks gentrification Siloes across city departments, especially those working on nature-based solutions and the wider innovation ecosystem Skills gap in entrepreneurship and collaboration with business community Considerable efforts required to raise awareness and discuss individual deals (Genk: Stiemer Deals) Only small-scale deals emerging so far (Genk)
Collaborative approach for joint city-making and empowerment	*Social innovation:* empowerment of and buy-in from local communities *Social innovation:* new relationships between public and private actors *Governance innovation:* new processes and methods for co-production *Organisational innovation:* linking multiple strategic goals *Organisational innovation:* establishing channels and spaces for communication and exchange *Knowledge innovation:* identification of diverse actors in the city for collaboration and engagement *Knowledge innovation:* development of skills for co-production (e.g. facilitation)	Promotion and branding ('telling a good story') to spread the notion of nature-based solutions and benefits Trust building and development of shared language Stakeholder mapping (workshops) Involving stakeholders from the beginning and in different phases Appointing professional facilitator and community coordinator Expectations management Creation of space (co-production costs more time) Political will	Legitimacy questions and how to reach agreement when multiple actors and opinions are involved Citizen willingness, can be fed up with getting involved
Adaptive and learning-based approaches	*Knowledge innovation:* new tools for continuous knowledge generation, monitoring and evaluation *Knowledge innovation:* new insights along the way to adapt solutions and processes *Organisational innovation:* creation of space for learning and adaptation *Governance innovation:* reflexive monitoring as new governance process	Capacity building about tools and methods for indicator identification, data collection and reflexive monitoring Openness and creation of space for learning and adaptation Showing and communicating lessons about what works and what does not (and why), as well as impacts Connecting goals to indicators for monitoring and evaluation of impact	Hierarchical and rigid ways of working within city governments Need to pre-define problems and solutions

Box 2: A new approach to collaborative financing and stimulating entrepreneurship: the Stiemerdeals in Genk

The 'Stiemerdeal' concept is a solution to stimulate social innovation in the Stiemervalley and a way to allow multiple and diverse actors to take ownership within the program. A Stiemerdeal is a voluntary agreement between the Stiemer Programme (city of Genk) and a partner (other city services, citizens, organizations, companies) in which both parties help each other to achieve their objectives (or dream) so that this agreement is a win-win situation – within the framework of the objectives of the Stiemervalley. In this tailor-made agreement, clear agreements are made about the objective of the deal, the mutual expectations, the division of roles, the mutual commitment and contribution, the results to be pursued and the related actions.

To coordinate the Stiemerdeals, a social innovation officer and business model expert were hired by the Genk city government to focus explicitly on facilitating the co-production and collaboration between diverse actors. In addition, extensive branding and communication has been undertaken to promote the regeneration of the Stiemer Valley as well as the idea of the Stiemerdeals. However, getting the Stiemerdeals into motion took a lot of time and effort. It is also challenging to get individual deals off the ground because of some teething problems in aligning city and stakeholder goals. So far, only small-scale deals are emerging with limited impact on the overall goals for the Stiemer Valley.

Box 3: New tools for collaborative making of open space: the co-production of an interactive open space map in Glasgow

The city of Glasgow is developing a new interactive map for mapping and monitoring existing open space in this city and encouraging citizens to take action. The main aim of the interactive map is to identify opportunities for open spaces and nature-based solutions that people can recognise and utilise. For example, the map will show opportunities for raingardens and people can then see that in their street is one such opportunity. At the same time, the map allows to bring back the data flow about what is happening in the city. For example, when people make a raingarden on their own they can click on the map and inform about it. Finally, the map gathers information about where people want something and what kind of ideas and support they have. Altogether, the map provides novel opportunities for collaboratively making and monitoring open space in Glasgow, for example building on citizen science approaches. It also creates new business opportunities by indicating potentials and needs for innovative products and services.

Box 4: A small-scale approach to upscaling nature-based solutions with multiple benefits at city scale: open gardens and nature-oriented playgrounds in Poznań

With the idea of open gardens and nature-oriented playgrounds, Poznań seeks to multiply small-scale nature-based interventions with a special focus on those areas that are densely urbanised and inhabited by citizens who currently have limited access to greenery. Such an "up-scaling approach" allows to extend the network of green infrastructure in Poznań and also complements the green wedges which run through the city, from north to south and from east to west. In this way, a natural system is created, building a stepping-stone for increasing connectivity between them, as well as for increasing accessibility of users to green space.

Co-production was critical for the implementation of the first open garden and nature-oriented playground in kindergarten no. 42 in the Wilda district. Co-production helped to generate new and more complete knowledge, especially about the users' needs, to ensure co-ownership and establish new partnerships. The main goal was to involve as many people as possible, who could present their point of view and contribute to the project. Co-production brought more opportunities in terms of ideas and money resources to develop and maintain the place when the project is already there. Next to external co-production with various stakeholders (e.g. neighbours, teachers, parents), co-production was also important across city departments to establish new collaborations for co-funding the nature-based solution. Co-production was a novel methodology for the city, and required the development of new skills and also the employment of professional facilitators in the process.

To facilitate up-scaling of the idea of open gardens and nature-oriented playgrounds the city of Poznań has created a nature-based solutions catalogue in collaboration with the local University of Adam Mickiewicz. This catalogue is an important tool for architects, teachers and others who would like to implement open gardens and nature-oriented playgrounds. However, despite the need to create verifiable and replicable standards, flexibility and openness for new ideas and opportunities are important to allow different design approaches of both managers of the kindergartens and other local stakeholders. This closely links to the co-production of nature-based solutions, which involves multiple actors in the design and implementation but especially also in the identification of financing opportunities. It also means that the active promotion among stakeholders and institutions who might be able to support the funding of the idea is needed.

4.2 Which changes do the innovations bring about?

Looking at the diverse types of innovations engendered by and connected through the Nature-based Solutions Framework allows identification of the specific changes in urban policy and planning that are brought about and how they facilitate the large-scale implementation of nature-based solutions (Table 3).

The innovation outcomes highlight the diversity and comprehensiveness of results coming from the Nature-based Solutions Framework applications that extend in multiple dimensions. These outcomes address the various governance needs that were identified in relation to nature-based solutions implementation and scaling (Frantzeskaki et al. 2019b; Hölscher et al. 2019a), including knowledge about technical design and multiple benefits, partnership building and empowerment. This shows that the framework is indeed a useful approach to foster new skill development, establish partnerships and collaborations to break silos and generate new knowledge needed for the development of nature-based solutions, including sound and multi-functional design, financing opportunities and empowerment, on city-scale.

The multiple innovations engendered through the Nature-based Solutions Framework provide the organisational and institutional conditions, knowledge, skills, support mechanisms and financing opportunities to change urban policy and planning for the large-scale implementation of nature-based solutions.

Table 3. Types of innovations, outcomes and opportunities for scaling nature-based solutions

Type of innovation	Innovation outcomes	Opportunities for scaling nature-based solutions
Technical innovation	Integrated and fit-to-context design for multi-functional nature-based solutions	Knowledge and standards for multi-scale approach to nature-based solutions and how individual solutions fit into the urban fabric and ecosystems
Market innovation	New collaborative business models New products and services Stimulation of new enterprises	New financing opportunities also for the long-term
Social innovation	Increased accessibility to green space to wider user groups Empowerment of and buy-in from local communities New relations between public and private actors	Social support and benefits for nature-based solutions Nurturing community action for designing and stewarding nature-based solutions
Governance innovation	New forms of collaborative governance between public and private sector New processes and methods for co-production and reflexive monitoring	Innovative participatory strategies for improving urban resilience, financing and stewarding Finding new ways of engaging actors and supporting them Giving a voice to the communities and addressing local needs Breaking silos in city government Reflexive and learning-based approaches for flexible strategies
Organisational innovation	Linking and aligning multiple strategic goals Channels and spaces for communication and exchange Creation of space for learning and adaptation	Embedding and prioritising of nature-based solutions Facilitating collaboration and coordination for synergies Using nature-based solutions to add value to existing projects
Knowledge innovation	New knowledge about local needs and landscape context New evidence about impacts, synergies and trade-offs New skills and process tools for co-production, monitoring and evaluation, financing New knowledge about diverse actors in the city for collaboration and engagement	Change in perception of nature-based solutions and wider value propositions Identification of partners for financing and other forms of collaboration Capacity development for co-production, reflexive monitoring, financing

4.3 Governance capacities: how to create the conditions for the innovations to emerge and connect

The Nature-based Solutions Framework has been introduced as a holistic process initiation tool to develop nature-based solutions on a large scale in cities. As shown above, it indeed nurtures and connects multiple innovations by giving attention to and supporting diverse dimensions around nature-based solutions implementation. However, the application of the Nature-based Solutions Framework and changing urban policy and planning processes requires the development of new types of capacities for innovative and knowledge-based governance in cities, including new skills and knowledge about tools, multiple benefits of nature-based solutions and financing mechanisms.

In this section, we focus on the specific conditions that are fostered through the Nature-based Solutions Framework, and that manifest in governance capacities of cities to walk through the different framework steps and to overcome existing barriers and challenges. This view on governance capacities provides valuable lessons learned for both the frontrunner cities themselves as well as for other cities. Importantly, even though our aim is to develop a framework, this is not meant as a static process but it is rather to be applied in an iterative and non-linear way. The capacities allow exactly this: to adapt and translate the framework in line with the cities' contexts and needs.

We employ the concept of governance capacity to bridge between the activities of actors and the conditions that (need to) be in place for the design, delivery and legacy of transformative nature-based solutions on city-scale (cf. Hölscher 2019). We start from an understanding of governance as "a moving process of ideological framing, institutional restructuring, political struggle and social adaptation" (Peck 2016, p. 11), which becomes manifest in the conscious creation of institutions to influence social behaviour and interaction (Kooiman 1993). Along these lines, governance capacity is an emergent property of governance systems: governance capacity is emergent through the formal and informal collaboration and learning processes between multiple governance actors and how they interact with their institutional and organisational contexts – including governmental institutions, politics and other social worlds – to solve collective problems (Innes and Booher 2003; Koop et al. 2017). This understanding shifts attention from the design of projects and policies and their impacts to the co-constitutive design of the institutional infrastructure, expressed in formal rules and structures, informal norms and practices, which determines what projects and policies emerge, and what impacts are on identities, knowledge, resources, interactions and cultural assumptions as well as material outcomes (González and Healey 2005). Central to this idea of governance capacity is collaborative learning: "learning by individuals about which of their own actions is effective, by organizations about the results of their actions, and by the larger economic and political systems in which they are embedded about how to respond creatively and adapt in the face of change, crises and simply new information" (Innes and Booher 2003, p. 8).

The notion of governance capacity therefore allows to capture policy learning, which in turn helps to showcase the value of the Nature-based Solutions Framework process for advancing the planning practice and governance of cities.

The Nature-based Solutions Framework promotes new capacities for the large-scale implementation of nature-based solutions. As the framework challenges existing urban policy and planning processes, new capacities are needed to enable new forms of collaborations, space for learning and innovation and knowledge generation and skills development.

4.3.1 Capacity to develop adaptive and systemic solutions

The capacity to develop adaptive and systemic solutions includes conditions to bring together diverse actors in an open-ended way and with systemic perspectives to boost innovation and learning for multifunctional solutions. The Nature-based Solutions Framework starts from a systemic perspective on social, environmental and economic goals for nature-based solutions, that permeate the definition of value (e.g. for financing) and the identification of indicators. The reflexive monitoring methodology provides a new process tool to facilitate adaptive and flexible processes (Section 3.7). The cities started to apply the nature-based solutions framework more widely as a project

management and evaluation tool, because they found that it provides otherwise unavailable critical feedback throughout the process (rather than only at the end), stimulates new and more open conversations (also across departments) and makes the process more clear (e.g. in terms of barriers and next steps).

Table 4. Conditions that contribute to capacity (building) for learning and systemic solutions

Conditions	What does the condition do?	How to build the condition?
Systemic perspective on nature-based solutions benefits across scales and sectors	Facilitates the development of multifunctional nature-based solutions that balance local needs and local landscape context, including financing for wider value delivery	• Systems thinking for defining problems, goals, value and indicators in line with social, environmental, health and economic concerns • Generate new knowledge about local needs and impacts, synergies and trade-offs • Connecting goals to indicators for monitoring and evaluation of impact
Long-term monitoring and evaluation	Generates data and knowledge for monitoring and evaluation in real-time and during planning, delivery and legacy	• Identify indicators for monitoring and learning • Collect data in an ongoing and collaborative way • Establish knowledge partnerships (e.g. between the city governments and local universities) • Recruitment of specialised resources to address skills gaps
Space and skills for learning and reflexivity	Creates institutional and organisational space and mindsets for on-going reflexivity and learning	• Capacity building about tools and methods for indicator identification, data collection and reflexive monitoring • Building support for and showing benefits of new methods (e.g. reflexive monitoring learning outcomes) • Ensuring time and resources (e.g. human capital) in day-to-day organisational processes

4.3.2 Capacity to innovate processes and solutions

This capacity is especially about equipping cities with the skills needed for engaging with new types of process tools that innovate urban planning and policy processes. The main function of this capacity is to create institutional and organisational space for innovation, both in terms of processes and ultimately solutions, as well as to ensure that the necessary skills are present.

In all frontrunner cities, applying the Nature-based Solutions Framework has been challenging as it departed from conventional policy and planning processes, required new skills and time. At the same time, the framework provides several specific process tools and methods, such as the Business Model Canvas (Section 3.4) and co-production (Section 3.6), that cities can apply for nature-based solutions planning, delivery and legacy. For example, the Business Model Canvas was appreciated as a novel way to discuss and plan projects, stimulating at the examination of opportunities from new angels and exploring mixes of public-private financing.

Table 5. Conditions that contribute to capacity (building) to innovate processes and solutions

Conditions	What does the condition do?	How to build the condition?
Space and support for new processes and tools	Creates institutional and organisational space and support for new processes and tools	• Building and mobilising (e.g. political) support for and showing benefits of new methods (e.g. reflexive monitoring learning outcomes) • Ensuring time in day-to-day organisational processes

Conditions	What does the condition do?	How to build the condition?
		• Promotion and branding ('telling a good story') to spread the concept of nature-based solutions and their associated new processes and benefits • Showing and communicating lessons about what works and what does not (and why), as well as impacts
Skills and knowledge about new processes and tools	Ensures the procedural and content-wide quality of co-production process	• Capacity building about tools and methods for indicator identification, data collection and reflexive monitoring • Developing skills and identifying skills gaps, recruitment of specialised resources to address skills gaps
Embedding new processes and tools	Embeds and mainstreams new processes and tools into daily urban policy and planning	• Amending processes and tools to fit local contexts • Integrating tools and methods into other ongoing project activities, identifying 'regular' activities of our city hall that can be enriched with the nature-based solution • Informing and showcasing colleagues from other departments about tools, showing benefits • Identifying proof-of-concept lessons from innovation to facilitate replicating and embedding of nature-based solution in other programs and agendas • Translating new solutions into guidelines or new strategies (e.g. asset management strategy)

4.3.3 Capacity to align actors for coordination and collaboration

The capacity to align actors for coordination and collaboration enables the establishment of new types of partnerships across city departments and between private and public actors. This helps to deliver multifunctional nature-based solutions, pool knowledge and resources, set up collaborative governance models (e.g. for design and collaborative financing), and connect nature-based solutions implementation to other strategic agendas, processes and networks. Strategically aligning actors and mediating across multiple different institutions boosts the large-scale implementation of nature-based solutions in cities.

In all cities it became evident that multi-functional solutions nature-based solutions cannot be implemented through siloed approaches but require the active search for synergies in terms of how different problems relate to one another and how addressing one problem might reproduce another. This requires for example "guerrilla-type" strategies to engage colleagues from within the city government and to influence how people within the government look for opportunities for nature-based solutions. In Glasgow, this is achieved via regular lunchtime slots that include interactive workshops during which the strategy could be presented, or placing posters in a space where people often stand/walk (e.g. near coffee machines). This also opened up discussion about where to add nature-based solutions, to reach uninterested colleagues and create a shared narrative.

Table 6. Conditions that contribute to capacity (building) to align actors for coordination and collaboration

Conditions	What does the condition do?	How to build the condition?
Strategic alignment under common vision for city development and nature-based solutions	Aligns multiple actors, agendas and goals with each other towards a common, long-term and integrated future direction	• Developing and linking nature-based solutions to long-term sustainability and resilience goals • Identifying and measuring synergies and trade-offs between different programs and actions

Conditions	What does the condition do?	How to build the condition?
		• Involving multiple actors from different city departments and private organisations in strategy formulation/from the beginning • Public outreaching and participation • Trust building and development of shared language
Formal and informal connection nodes and channels for knowledge sharing and trust building	Facilitates exchange, collaboration and trust building between diverse actors across sectors and scales	• Identifying and engaging actors for collaboration • Forming informal 'coalitions of the willing' • Dedicated resources to bridge cross-departmental silos in support of specific themes (e.g. entrepreneurship, co-production) • Establishing central connection nodes for pooling sustainability and nature-based solutions efforts at multiple levels
Framework conditions for long-term co-benefits	Generates opportunity contexts for long-term and synergistic design, delivery and legacy of nature-based solutions	• Carry the story of the co-production process and outcomes to increase visibility, support and uptake • Redefining responsibilities (e.g. for carrying costs, legacy) • Translating new (wider) value propositions into institutional frameworks

4.4 Reflexive learning outcomes for large-scale nature-based solutions implementation

The reflexive monitoring process (see Section 3.7) explicates what the cities learned while implementing their large-scale nature-based solution. The learning outcomes are the result from analysing the reflexive monitoring material produced by the cities together with the cities themselves and the scientific partners. The impact of the learning outcomes can be related to the seven building blocks of the Nature-based Solutions Framework.

Learning outcomes are reflexive when they increased reflexivity in the frontrunner city teams with regards to: 1) rules guiding actors' practices (organisationally, legally, politically, symbolically), 2) relations between actors, and between the initiative and context, 3) practices (common ways of working) and 4) discourse related to the future of the initiative's sector.

4.4.1 Technical solution Poznań: Demonstrating the legitimacy of nature-based kindergartens through a lecture at local conference

Through building relations with experts on natural preschool playgrounds, the Poznań project team gained insights in what is important for the schools were the natural preschool playgrounds should be implemented. These insights made the Poznań project team see the importance of organising a session on the safety considerations regarding natural preschool playgrounds. They noticed that if these safety considerations are not addressed in natural playgrounds, it would be very difficult for these innovative playgrounds to be adopted. The Poznań project team therefore organized a local conference entitled 'Education for the public space' and a lecture in this conference with a designer of natural playgrounds. They learned that bringing in an expert to demonstrate the legitimacy and safety of the natural preschool playgrounds was an effective strategy to make managers and teachers aware of the benefits of natural preschool playgrounds and give them the right argumentation to explain to the parents that these new types of playgrounds are safe for the children. Many of the teachers were positively encouraged to follow the idea, because of an expert demonstrating the safety of the project. The followed strategy was thus effective for encouraging and maintaining the willingness of various actors to cooperate in the co-production process. Safety issues might be a very important obstacle for some pre-school managers to decide on choosing for natural preschool

playgrounds. Generating and presenting positive examples of how these safety issues are addressed with natural preschool gardens are important aspects of delivering a successful technical design of the nature-based solution.

4.4.2 Governance example Genk: From cooperation issues with other departments to strategies for more effective internal co-production

The Stiemer programme team, which is part of the department of environment and sustainable development, faced collaboration issues with various departments in the City Council. After reflecting on these collaboration issues, the Stiemer programme team identified strategies to overcome these issues, which they now apply in practice. For example, for the Stiemer programme the team has to work closely with the department of neighbourhood development. This is an important collaboration, since creating spatial connections along and across the Stiemer Valley for connecting city sites and neighbourhoods is an essential aspect of the Stiemer programme. The team realised a reason for tensions between them and the department of neighbourhood development was a mismatch in expectations. It was not clear for both sides what they could expect from the collaboration. Therefore, when they start a collaboration with a new department, they now have a meeting to explicate each other's expectations from the collaboration. This is done through defining clear roles and responsibilities and to make the cooperation on a concrete case. Once the collaboration started, they now also evaluate it based on whether the expectations are still being met on both sides. They do this in a team meeting, by going over the different city departments they collaborate with and discussing whether the collaboration is still effective. Furthermore, since the collaboration with the department of neighbourhood development is key for the successful implementation of the Stiemer programme, the team realised that it is important to maintain a close connection with this department. The team therefore decided to establish a long-term connection with the department of neighbourhood development by having one of its team members working in the office of the department of neighbourhood development for one day per week. This team member is also present at the team meetings of the department of neighbourhood development, to represent the Stiemer programme values and follow-up on the work being carried out by the department of neighbourhood development. By physically being present in the other department it has become easier to represent what they want to achieve with the Stiemer programme and both parties can understand each other better. That way a close connection is formed between the team and the department of neighbourhood development.

Based on the lessons learned from the cooperation issues with the department of neighbourhood development, the Stiemer programme team developed a strategy to overcome cooperation issues with the department of construction and infrastructure as well. The team noticed that it is challenging to establish a good partnership with the department of construction and infrastructure. They learned that an effective strategy to overcome this, is to identify a person within the department with which the team has a good personal connection and to extend the partnership from there.

4.4.3 Financing example Glasgow: A solution for procurement challenges

At the beginning of the project, it was already clear that the city's procurement system would make it challenging to procure consultancy services. To get around this, it was decided to 'top-slice' some of Glasgow's Connecting Nature budget to Greenspace Scotland and invite them to be partners in the project. In addition, Glasgow enhanced its membership to be a 'gold' member of Greenspace Scotland. This means that Glasgow is able to work with them and use their services without following a complicated procurement process. Glasgow is currently using Greenspace Scotland's services to undertake four stakeholder engagement workshops across the city to map nature-based solutions activity and without this previous agreement this would not be a straightforward process.

This collaboration contributed to extending institutions: by partnering with the NGO Green Space Scotland, the Glasgow project team circumvented their city's procurement procedures. For future projects the Glasgow team is investigating how they can make the Glasgow City Council procurement process fit this purpose. For example, a recent issue with procurement is about trying to procure an environmental specialist to undertake a review of all the Sites of Importance for Nature Conservation (SINCs). In order to get this through the procurement process, the Glasgow team is liaising with colleagues in Neighbourhoods and Sustainability, Legal and the City Deal team. Whilst this is progressing, it has not yet been resolved.

4.4.4 Entrepreneurship example Genk: The Stiemer conclave allowed deeper reflection and resulted in the Stiemer deals for facilitating social entrepreneurship

The Stiemer programme team holds conclaves twice per year to have moments of deeper reflection on strategic challenges, opportunities or persistent barriers. In these conclaves the members of the team intensively work together for two days. The team learned that doing this is an effective way for deeper reflection on, and rethinking of, key elements of the project. For example the governance structure of the Stiemer programme. The team sees the Stiemer as a program and divided their work in different strategic projects they would like to implement. A key part of this programme are the Stiemer deals, which is a solution for organising the team's strategy for co-production, social innovation and entrepreneurship. Concretely, the Stiemer deals are a novel approach to make deals with different kinds of stakeholders (e.g. organisations, citizens, entrepreneurs), to see how they can help the Stiemer programme team create impact. It is a way to make the collaboration between local initiatives and local government explicit. The Stiemer deals are a solution to the governance question the team faced. They felt that effectively co-producing the Stiemer programme requires a platform to have a concrete basis for collaboration, to bring together various actors, to make the collaboration explicit and to start collaborating. Stiemer deals offer a platform to allow various actors to start cooperating with the Stiemer programme team and to facilitate this collaboration.

4.4.5 Co-production example Poznań: Temporary summer garden at Wilda District: From failed collaboration to co-production strategy

The experience with the temporary summer garden at Wilda District was disappointing because of the lack of responsibility and ownership of the local project manager responsible for the delivery and maintenance of the nature-based solution. Reflecting on this experience the Poznań team realised they needed to define clear roles and responsibilities from the start and to discuss these with the actors involved. For future nature-based solutions that will be implemented by local project managers the Poznań team developed a procedure for establishing good partnerships. This new procedure starts with an actor analysis to identify and motivate key actors to create ownership and develop a communication strategy to effectively communicate with the partners involved. This communication strategy ensures effective implementation and stewarding of the nature-based solution. The team developed a novel co-production strategy for the effective implementation and stewarding of the nature-based solutions by local actors. This strategy starts with an actor analysis to select local actors. They then organised a meeting to discuss the goals of the nature-based solutions and motivate the project manager to engage in both the delivery and maintenance. This is a new way of facilitating co-production activities.

5. Conclusions

We co-produced the Nature-based Solutions Framework as a new reference framework that provides a – non-linear and agile – standard to scale up urban resilience, innovation and empowerment via nature-based solutions in cities. From the experiences of the frontrunner cities Genk, Glasgow and Poznań until now we can already derive lessons on how cities can make the framework applicable to their contexts, which innovations the framework brings about for the large-scale implementation of nature-based solutions and what conditions need to be put in place for putting the framework into urban planning and policy practice.

We conclude both on the key lessons learned from applying the framework in city making practice (Section 5.1), as well as on the co-production process to develop, apply and identify lessons about the framework (Section 5.2).

5.1 Key lessons about the Nature-based Solutions Framework

The Nature-based Solutions Framework provides a new and holistic framework for planning, delivering and maintaining nature-based solutions on a large-scale in cities. In particular, cities have stated that the multidimensional approach of the framework is valuable to think holistically about all aspects of complex projects; it "makes you think outside your bubble".

We identify several lessons for taking the Nature-based Solutions Framework forward.

Lesson #1: The framework aims to strengthen the connections between multiple innovations that together promote integrative, inclusive, and knowledge-based approaches to implement nature-based solutions in cities. Through finding, facilitating and strengthening these connections, the application of the framework will also result in embedding these solutions across city agendas and/or policy programs and establish collaborations across city departments and between private and public actors.

Applying the Nature-based Solutions Framework generates and nurtures diverse innovations that mark an overall change in urban policy and planning processes in what and how nature-based solutions are being developed, implemented and maintained. As such, the different building blocks of the framework provide new ways to support urban planning practice for nature-based solutions in an iterative way. The framework promotes integrative, inclusive, knowledge-based and flexible approaches to generate nature-based solutions with multiple benefits. It also facilitates the embedding of these nature-based solutions in other city agendas, establishes collaborations across city departments and between private and public actors.

Lesson #2: The innovations engendered by and necessary to scale nature-based solutions underscore how the scaling nature-based solutions requires the development of new skills and knowledge, as well as partnerships and collaborations to break siloes, connect goals and agendas and make solutions fit to context.

The different types of (e.g. technical, social, market, governance) innovations engendered and connected by the Nature-based Solutions Framework manifest in diverse changes in urban policy and planning, including new types of knowledge, value propositions, new processes and tools (e.g. co-production, Business Model Canvas), new mindsets (e.g. reflexivity) and new collaborations. This shows that the framework is indeed a useful approach to facilitate the large-scale implementation of nature-based solutions by prompting shifts in urban policy and planning. These different types of innovations are intrinsically connected. For example, new knowledge generation about multiple benefits of nature-based solutions broadens the definition of values delivered through such solutions and thus boosts political and societal support and promotes new forms of collaborative financing.

Lesson #3: The application of the Nature-based Solutions Framework and changing urban policy and planning processes requires the development of new types of capacities for innovative and knowledge-based governance in cities, including new skills and knowledge about tools, multiple benefits of nature-based solutions and financing mechanisms.

While we can see multiple innovations emerging and connecting in all cities, in none of the cities are they yet fully matured. This is because nature-based solutions implementation at a large scale and in a holistic manner challenges existing urban policy and planning processes, requiring in particular new forms of collaborations, knowledge generation and skills – such as facilitation of co-production and knowledge about diverse stakeholders and financing

opportunities. We identify which new governance capacities are needed to facilitate the innovations, in order to mobilise and create enablers and overcome challenges and barriers.

5.2 Key lessons about the co-production process

The co-production experience so far is highly valued across all partners in the project – particularly the constructive and open engagement and interaction between the diverse partners. During conversation it was stated that this is where most learning took place. Especially between the scientific partners and cities these interactions were pivotal to create understanding for the different perspectives and thus aid learning for both the practical application of the Nature-based Solutions Framework as well as the communication and operationalisation of the building blocks from the scientific perspective.

We identify several lessons for the future development of the co-production process between scientific partners, cities and SMEs.

Lesson #1: Create a shared institutional space for learning to take time for exchanges and workshops (virtual and face-to-face).

Within the inter- and transdisciplinary research team, we needed to make our respective concepts understandable and develop a common understanding of our objectives and approaches. Other research showed that it is important to bridge different knowledge between academics and planners (Thompson et al. 2017; cf. Frantzeskaki et al. 2019a). This role is often assigned to those policy entrepreneurs or other intermediaries that are skilled to translate academic knowledge to planning-ready knowledge (McPhearson et al. 2017; Frantzeskaki et al. 2019a).

We addressed this by taking time for exchange and face-to-face meetings especially in the beginning. This also facilitated trust-building, ensuring understanding of words and formulations (for example by paraphrasing) and developing a 'dictionary' with key concepts. The Knowledge Transfer workshops provide unique opportunities for city peer-to-peer learning and knowledge exchange.

Lesson #2: Promote a sense of ownership of both the process and the outcomes of co-production and ensuring salience of knowledge co-produced to deal with different timelines and professional needs from partners.

We need to be aware of our different professional mindsets and demands – for example the pressure to publish scientific journal articles vis-à-vis the pressure emerging from the day-to-day urban policy-making practices and political cycles. A key challenge for collaborative partnerships is aligning timeframes (Frantzeskaki et al. 2019a). Innovative approaches can be used to address perceived mismatches in timeframes – for example, staging projects through pilot studies leading on to larger, more comprehensive studies or perhaps adopting shorter timeframes with more restricted project scope. Although nature-based solutions may be driven by short- term needs and must operate within relatively short-term political cycles, the slower temporal scale of research may be well suited to understanding the longer-term effects and successes (and failures) of nature-based solution projects.

This is a continuous challenge, but a key opportunity is the good understanding and high levels of trust and collaboration present in the overall Connecting Nature project team. In addition, we found it crucial to ensure that the scientific knowledge is made relevant and directly made applicable to the cities' context – this fundamentally relies on the creation of a co-production learning space and continuous communication (see Lesson #1). By partnering with cities through multiple and targeted research- and innovation-focused projects, greater efficiencies in the understanding of specific problems will be generated and the communication and fostering of coproduced research questions will be enabled (Frantzeskaki et al. 2019a). There are also opportunities for researchers to be embedded in city practice to improve understanding of city perspectives. Similarly, there are roles for city practitioners to be more actively involved in guiding academic decision-making, through, for example, project steering and oversight committees.

Lesson #3: Allow for adaptable and flexible processes and institutions to adapt the co-production approach as a complementary planning process.

Adaptability and flexibility were critical conditions for our co-production process. Over the course of the project so far, several adaptations have been undertaken, including the reframing of what used to be called 'Masterplan' to the Nature-based Solutions Framework – with the intention to reflect the breadth of the work developed in Connecting

Nature. Similarly, while our project funding requires us to produce deliverables at certain moments in time, we agreed to make for example the city reports into working documents that allow them to be continuously adapted to include the future learning process rather than being a final product at this moment in time.

Overall, the lessons underscore the need for setting up more interactions. There is already some literature about how to facilitate communication and collaboration in inter- and transdisciplinary research. Freeth and Caniglia (2019) introduce the concept of learning space and formulate strategies for individual researchers' learning to collaborate by cultivating particular orientations, knowledge and skills. A key principle is to create opportunities for learning in situ and together from challenging experiences, including creating a project structure and procedures that inspire a sense of safety and trust, give time for face-to-face interaction, nurture team culture and sharing mistakes. In this sense, the extension of the monthly reflexive monitoring coaching calls with the frontrunner cities (see Section 2.2) already reflects a step towards this. In addition, we are continuously discussing with the involved partners about how to improve our interactions – for example, thinking about how to adapt the reflexive monitoring method to facilitate reflexive monitoring of our overall Nature-based Solutions framework process.

Box 5: Reflexions on the co-production process from the Poznań team

The Nature-based Solutions Framework helped us to think about and report on the activities that we implement in Poznań to meet the challenges that appear in every European city when it comes to the implementation of nature-based solutions. Overall, working with the framework and collaborating with the partners in the Connecting Nature project was a new challenge for the Poznań team, taking into consideration the complexity and diversity of the subject. We started to translate the framework by focusing on the individual building blocks, and in support of the different scientific partners involved in these. This was accompanied by numerous discussions during webinars both on the individual building blocks as well as on the alignment of the framework overall.

The work with the framework helped us to understand our current knowledge and experience in implementing innovative nature-based solutions. We could reflect on our organisational structure and how we have established new cooperations with other entities both within the city government (e.g. the Education Department) and with external entities (e.g. local kindergartens). We started to pay attention to new processes and ideas when implementing our activities, such as co-production and finding financing models, and to what challenges and barriers we need to overcome to ensure that we are able to push through the activities in Poznań. Some of the topics and processes were new to us or we had worked with them in different way, including reflexive monitoring and co-production. The reflexive monitoring approach drew our attention to reflectiveness, that it is not only necessary to sit down in a team and discuss, brainstorm but regular monitoring it will improve the whole process.

We highly appreciated the interaction with and support by the scientific partners, as it helped us to better understand the novel processes and steps we needed to take and how they could help us to deliver natural playgrounds and open gardens in kindergartens in our city. However, we also found it important to translate the more scientific and conceptual knowledge to our own context. The situation in Poznań is very dynamic – every day we implement diverse activities and undertake a lot of actions to achieve multiple strategic goals for environmental and urban sustainability. It is said that reflexive monitoring meetings should in principle be held in regular way, but in our case the lack of time limits it. It results from current administrative work which is priority. This is one of the examples of why we need to translate science into practice and practitioners' need.

Overall, we found the process and work very challenging and time-consuming. Especially writing the report on each building block of the framework was a demanding task, requiring long and systematic individual work on the specific chapters, as well systematic cooperation with different Connecting Nature team members – both internally within the Poznań team and externally in the project consortium. This came on top of our day-to-day administrative work. It was also complicated because we often failed to discuss what we wanted to include in the document and we duplicated our input. Before the final version was decided, several previous ones were tested, wondering which form would be the most readable for the recipient, but also which version would be the most interesting as a basis for describing knowledge and experience by us – one of the frontrunner cities.

In the end we were able to finalise this task, and we consider it our success. We treat the document a bit like a guidebook. Creating the document gave us the opportunity to systematise the knowledge we had and to describe

the experience gained in our work. We were able to draw lessons from all the different discussion. Saying openly what went wrong and allowing ourselves to ask a question why it didn't work out and how we can improve it are important parts of the process. Regularity in reflection on action improves the functioning and operation of our team and we believe that one day such methods will be widely used in the city government. For example, we learned that the co-production methodology enriched our tools and practices and allowed us to apply them to enhance and support nature-based solutions implementation in Poznań. The work with the framework helped us to assess the value of individual stages in the project, the significance of stakeholders at various levels of co-production, and it confirmed the value of broad involvement of diverse actors in our city, e.g. residents but also the policy. It underlined the importance of being open to new ideas and flexibility of public administration despite many organizational barriers.

We would like our experiences to be an inspiration for our addressees, colleagues from Polish and foreign cities, and everyone interested in our work and the Connecting Nature project. We are very happy that we could write such document and that we had the opportunity to share our knowledge and experience with other partners.

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