

nature-based urban innovation

NATURVATION

project

PATHWAYS FOR SYSTEMIC INTEGRATION OF NATURE-BASED SOLUTIONS

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Led by Durham University, NATURVATION involves 14 institutions across Europe working in fields as diverse as urban development, innovation studies, geography, ecology, environmental assessment and economics. Our partnership includes city governments, non-governmental organisations and business. We will assess what nature-based solutions can achieve in cities, examine how innovation is taking place, and work with communities and stakeholders to develop the knowledge and tools required to realise the potential of nature-based solutions for meeting urban sustainability goals.

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EXECUTIVE SUMMARY

This report identifies and elaborates the key stepping stones – pivotal actions– that can unlock the potential for mainstreaming urban nature-based solutions. Using the examples of climate change and biodiversity, we examine how stepping stones can be aligned to generate promising pathways for mainstreaming nature-based solutions that can contribute to diverse sustainability agendas in cities.

The analysis which underpins this report drew on research undertaken in the Netherlands, Sweden, the United Kingdom (UK), Spain, Germany, Hungary and the European Union (EU), focusing on the regulatory, financial and urban development domains of the urban infrastructure regimes that shape the uptake of nature-based solutions in cities. To catalyse and support the mainstreaming of nature-based solutions, stepping stones that work across these three domains and that can overcome barriers or make use of opportunities for implementing and maintaining nature-based solutions are crucial. This report takes up the task of identifying the key stepping stones that have been found to have significant potential across the different contexts in which our research has been undertaken.

In total, 20 stepping stones were identified as pivotal for mainstreaming urban nature-based solutions. Each of them is explained with details and practical examples in this report. They are:

| NUMBER | NAME | DESCRIPTION |
|--------|--|---|
| 1 | Provide a public mandate | The mainstreaming of nature-based solutions can benefit from policy-makers and investors giving a clear mandate for nature-based solutions to be included in urban development through tender and procurement policies, policy instruments (e.g. land use planning guidance), and where possible mandatory regulation. |
| 2 | Regulate for No Net Loss | No-net-loss / net gain regulation for urban nature (biodiversity) has the potential to generate greater interest in nature-based solutions across Europe. Developing harmonised regulation across Europe with strong monitoring and sanctioning to increase effectiveness has the potential to support nature-based solutions mainstreaming. |
| 3 | Include in contractual requirements | Utilities (e.g. water, waste, energy) and network service providers (e.g. road and rail authorities, waterway authorities) are either publicly owned or operate on long-term contracts that are bound by regulatory requirements for service provision. Including nature-based solutions as required for the delivery of mandated functions (e.g. water quality treatment) or for the upkeep of land-holdings (e.g. train sidings, roadside verges) provides an important avenue for mainstreaming. |
| 4 | Align with strategic priorities | Positioning urban nature-based solutions as generating benefits for prioritised policy goals through generating narratives and evidence (i.e. climate change mitigation & adaptation, circular economy and healthy urban living) can widen their relevance and community of practice. |

| NUMBER | NAME | DESCRIPTION |
|--------|--|--|
| 5 | Create intermediaries | In order to overcome institutional silos within both public and private sector organisations, new organisational forms that work across these divisions are required. Intermediary units can either be established within organisations or outside (by external bodies) and provide co-ordination between departments as well as platforms for innovation. |
| 6 | Generate partnerships | Stimulating partnerships between public, private and third sector organisations for the co-design, development and maintenance of urban nature-based solutions is critical for generating initial action on the ground and increasing support for mandatory urban greening policies. |
| 7 | Establish demonstration projects | Demonstration or pilot nature-based solutions projects, often involving research, can create shared learning and knowledge development as well as providing tangible demonstrations of how nature-based solutions can work in practice, creating confidence amongst partners about their potential. |
| 8 | Engage insurance sector | Engage the insurance sector to support upscaling of urban nature-based solution based on their risk reduction needs and damage cost expertise |
| 9 | Facilitate community-based action | Facilitate and support community-based action for local urban nature-based solutions through improving citizen awareness and support |
| 10 | Provide economic incentives | Facilitate and support community-based action for local urban nature-based solutions through improving citizen awareness and support |
| 11 | Develop markets | Positioning nature-based solutions as a sustainability solution offering wide societal and reputational benefits can support the development of demand for nature-based solutions projects which in turn can stimulate supply |
| 12 | Build co-financing arrangements | Build governance arrangements between the public and private sectors to enable co-funding for nature-based solutions development and maintenance |
| 13 | Work with investment cycles | Integrating urban nature-based solutions into infrastructure projects and renovation cycles increases their (multi)functionality and can save costs by reducing the need for additional outlay and drawing on existing budgets |
| 14 | Stimulate institutional investment for risk reduction | Institutional investment for urban nature-based solutions is likely to be forthcoming based primarily on their climate risk reduction value (adaptation and mitigation), and specific data/modelling may be required to realise this potential. |
| 15 | Target areas of low land value | Nature-based solutions can face competition from other land-uses which provide a higher return on investment. Using urban space with a lower value can suit some forms of nature-based solutions and provide a more cost effective means of urban greening (e.g. street green, pocket parks and building-integrated green) |
| 16 | Improve data & monitoring | Mainstreaming nature-based solutions will require the development of evidence on their performance urban nature-based solutions, through the use of 'big data' and new assessment tools that can support effective monitoring, evidence-building and assessments of their effectiveness in addressing key urban goals |

Individually, each of these stepping stones can generate change towards the uptake of nature-based solutions. The potential effect of each individual stepping stone can be significantly reinforced when they are aligned with others which enable remaining barriers to be overcome or allow the full range of opportunities to be realised. It is through the alignment of stepping stones that we can create pathways for mainstreaming. Since stepping stones can be aligned in different ways, we suggest that there can be multiple pathways available for mainstreaming nature-based solutions.

For diverse urban sustainability agendas, the relevance and importance of different stepping stones varies. For example, stimulating institutional investment for risk reduction and engaging insurance sector can be explicitly effective for mainstreaming nature-based solutions for climate change mitigation and adaptation, while stepping stones such as regulating for No Net Loss and promoting certification schemes are critical for mainstreaming nature-based solutions for biodiversity. As a result, the most promising pathways for mainstreaming nature-based solutions vary in terms of the urban sustainability challenges that are being addressed. Aligning stepping stones that are unique for one sustainability goal could result in nature-based solutions that marginalise or even undermine efforts to reach other goals. To mainstream nature-based solutions that can contribute to multiple sustainability goals thus requires efforts to be built on the critical stepping stones that work for all of these goals.

CONTENTS

| | |
|--|-----------|
| 1. INTRODUCTION | 9 |
| 2. METHODOLOGY | 11 |
| 2.1 Stage 1: Domain Specific Analysis | 11 |
| 2.2 Stage 2: Synthesis of Stepping Stones | 12 |
| 2.3 Stage 3: Composition of Mainstreaming Pathways | 12 |
| 3. STEPPING STONES | 14 |
| 3.1 Provide a Public Mandate | 14 |
| 3.2 Regulate for No Net Loss | 16 |
| 3.3 Include in contractual agreements | 16 |
| 3.4 Align with strategic priorities | 18 |
| 3.5 Create intermediaries | 21 |
| 3.6 Generate partnerships | 21 |
| 3.7 Establish demonstration projects | 24 |
| 3.8 Engage insurance sector | 25 |
| 3.9 Facilitate community-based action | 27 |
| 3.10 Provide economic incentives | 30 |
| 3.11 Develop markets | 32 |
| 3.12 Build co-financing arrangements | 33 |
| 3.13 Work with investment cycles | 35 |
| 3.14 Stimulate institutional investment for risk reduction | 37 |
| 3.15 Target areas of low land value | 38 |
| 3.16 Improve data and monitoring | 40 |
| 3.17 Advance valuation models | 41 |
| 3.18 Grow practitioner expertise | 42 |
| 3.19 Incorporate in green investment products | 45 |
| 3.20 Promote certification schemes | 46 |

| | |
|--|-----------|
| 4. PATHWAYS FOR MAINSTREAMING NATURE-BASED SOLUTIONS FOR ADDRESSING URBAN SUSTAINABILITY CHALLENGES | 48 |
| 4.1 Mainstreaming nature-based solutions for addressing climate challenges | 48 |
| 4.2 Mainstreaming nature-based solutions for biodiversity | 51 |
| 4.3 Mainstreaming nature-based solutions for both climate and biodiversity | 53 |
| 5. CONCLUSION | 56 |
| References | 58 |
| Appendix 1: Overview of the placements | 59 |
| Appendix 2: Conceptual framework | 60 |



1. INTRODUCTION

Nature-based solutions can provide a range of ecological, social and economic benefits and are increasingly positioned as practical solutions for addressing urban sustainability challenges. However, despite their promise, to date the uptake of nature-based solution has been limited. The NATURVATION project has examined the conditions, barriers and opportunities for accelerating the uptake of nature-based solutions in European cities (van der Jagt et al. 2020a). In this report, we explore the key **stepping stones** – pivotal actions – that can unlock the potential for mainstreaming nature-based solutions. **By bringing together these pivotal stepping stones, multiple pathways for mainstreaming nature-based solutions for diverse sustainability agendas can be realised.**

Our starting point is that mainstreaming nature-based solutions requires that they are taken up within and become a normal part of urban infrastructure regimes. Urban infrastructure regimes are “the stable configurations of institutions, techniques and artefacts which determine ‘normal’ sociotechnical developments in a city and thus shape general urban processes and the urban metabolism” (Monstadt 2009: 1937) and which operate over multiple scales. Urban infrastructure regimes are shaped by regulatory, financial and urban development domains which shape how actors engage in the approaches to urban sustainability challenges (Dorst et al. 2018).

To catalyse and support nature-based solutions mainstreaming, coordinated actions across these three domains that can overcome barriers or seize opportunities for implementing and maintaining nature-based solutions are critical. These coordinated actions or “stepping stones” are pivotal for mainstreaming because they open up the possibilities for alternatives to current practices and demonstrate their potential, for example through bringing new agents of change together, generating new capacities, forms of resource or thinking about urban problems and their solutions. Individually, each of these pivotal stepping stones can generate incremental change towards the uptake of nature-based solutions. When stepping stones are aligned with one another – when they create a **pathway** – their impact is increased. Given that these stepping stones can be aligned in different ways, our work suggests that there are multiple pathways available for mainstreaming nature-based solutions. The most promising pathways for mainstreaming nature-based solutions will vary in terms of the nature-based solutions involved, the challenges that are being addressed and the contexts in which nature-based solutions are being embedded.

Drawing on research undertaken in the Netherlands, Sweden, the United Kingdom (UK), Spain, Germany, Hungary and the European Union (EU), this report provides a detailed analysis of the core stepping stones that we found to be pivotal to mainstreaming nature-based solutions in European cities. In the next section, we explain the methodology used. In Section 3, we elaborate on each of the twenty stepping stones and provide examples of their use across the case-studies that have formed the basis of our research. Using the examples of climate change and biodiversity, Section 4 outlines how stepping stones can be aligned to generate promising pathways for mainstreaming nature-based solutions. Section 5 concludes the report by summarising and reflecting on the key findings and suggesting how this analysis can be used by decision-makers seeking to enhance the uptake of nature-based solutions in cities across Europe.

¹ Initial analysis of the key stepping stones and promising pathways for mainstreaming nature-based solutions in the three domains has been presented in three individual reports: regulatory (van der Jagt et al. 2020b); finance (Toxoepus et al. 2020); and urban development (Tozer et al. 2020). A series of reports has presented the promising pathways for mainstreaming nature-based solutions to address: climate change (Tozer and Xie 2020); biodiversity (Xie 2020); economic regeneration (van der Jagt et al. 2020c); social inclusion (Armstrong 2020) and the sustainable development goals agenda (Gerstetter et al. 2020). There are also two briefing notes providing a snapshot of the 20 stepping stones identified to be pivotal for mainstreaming nature-based solutions (Pearl-Martinez 2020a & 2020b). This report brings these findings together and systematically documents the methodology behind them. It provides a comprehensive account of each of the pivotal stepping stones while also explores their applications to shape important pathways for mainstreaming nature-based solutions to address different and multiple sustainability challenges in cities.



This report is built upon qualitative case studies of how the regulatory, financial and urban development domains of six European countries – United Kingdom (UK), Germany, Hungary, Spain, Sweden and the Netherlands² – as well as that of the EU as a whole shape the uptake of nature-based solutions. Each case study involved a desk study of relevant grey literature and policy documents, a total of 243 interviews with key actors of the three domains (Sweden: N=33; the UK: N=26; Germany: N=36; Hungary: N=38; The Netherlands: N=40; Spain: N=35; EU: N=35), and participant observation through placements of researchers involved in producing this report at relevant organisations, network or event.³ The data was collected between June 2018 and November 2019, and covered a broad range of potential sustainable development goals to which nature-based solutions can contribute. A series of reports has provided detailed analyses and overviews of the data collection process for: the regulatory domain (van der Jagt et al. 2020b); the financial domain (Toxopeus et al. 2020); and the urban development domain (Tozer et al. 2020). From this basis, we developed our analysis through three main stages: 1) Domain specific analysis; 2) Synthesis of stepping stones; and 3) Composition of mainstreaming pathways, and each of these involved several steps.

2.1 STAGE 1 – DOMAIN SPECIFIC ANALYSIS

The first stage focused on identifying the key stepping stones in the regulatory domain, the financial domain and the urban development domain respectively, drawing on the empirical findings of the seven cases. It should be noted that in each domain there are a variety of actors and dynamics included that operate in relation to the economy, knowledge, infrastructure, governance and community, such that some ‘economic’ instruments are identified by actors in the urban development domain as critical for their use of nature-based solutions or that, for example, those in the finance domain recognise the importance of regulation or policy as central to the flow of investment (see Appendix 2). The analysis of each case explored a set of key questions: what are the current roles of decision makers, civil society, financiers and other actors in the urban infrastructure

² The six countries were selected since they host the six cities –Barcelona, Utrecht, Leipzig, Malmö, Gyor and Newcastle, which are partners in NATURVATION and convene urban-regional innovation partnerships (URIPs) with strategic urban government, business and civil society organisations.

³ An overview of the interview contacts for each case (six countries and the EU level) for each domain studies was provided in van der Jagt et al. (2020b), Toxopeus et al. (2020), and Tozer et al. (2020). Appendix 1 provides an overview of placements carried out as part of the data collection.

regime; what are the key barriers and opportunities regarding nature-based solution development and mainstreaming; and what are promising pathways to overcome these challenges and seize the available opportunities (Dorst et al. 2018)? For each case study (country level and EU), we prepared three working papers – one for each of the domains – providing a narrative of which barriers and opportunities influence the uptake of nature-based solutions and how these are linked to the underlying conditions of each jurisdiction. Working iteratively, the three researchers leading analysis in each domain together with the Project Coordinator analysed the key challenges and opportunities for undertaking nature-based solutions and identified the key actions that are promising for accelerating the mainstreaming of nature-based solutions. This led to the identification of the pivotal stepping stones in the regulatory, finance and urban development domains (see van der Jagt et al. 2020b; Toxopeus et al. 2020; Tozer et al. 2020), resulting in a total of 48 stepping stones – 21 in the regulatory domain, 11 in the urban development domain, and 16 in the finance domain (see Table 1, 2 & 3 below).

2.2 STAGE 2 – SYNTHESIS OF STEPPING STONES

To identify overlaps between the recommended actions across the regulatory, finance and urban development domains, the second stage of analysis focused on clustering the three sets of domain-specific stepping stones into a 'master list' of generic stepping stones. To accomplish this, the three leading researchers (one for each domain) worked independently to group the domain-specific stepping stones into broader clusters of related actions. These clusters of actions could transcend domain boundaries, and are not case-specific but instead potentially transferable to other urban settings. Following this, the three researchers reconvened to discuss their clustering and areas of con- and divergence. Together with the principal investigator of the NATURVATION project, they continued to develop several versions of the stepping stones master list until agreement was reached. This resulted in a total of 20 generic stepping stones (see Table 4).⁴

2.3 STAGE 3 – COMPOSITION OF MAINSTREAMING PATHWAYS

In parallel to the process of synthesising stepping stones, the third stage of the analysis focused on the identification of promising pathways for mainstreaming nature-based solutions. Rather than seeking universal pathways capable of accelerating the uptake of nature-based solutions in all contexts and for all goals, we find that diverse combinations of stepping stones can support the mainstreaming of nature-based solutions for addressing different urban sustainability challenges. In our analysis, we focused on five key sustainability goals: climate change, biodiversity, economic regeneration, social inclusion and the sustainable development goals agenda. These are the five issue areas where nature-based solutions are most often identified as having the potential to make a contribution within national and international policy. For each sustainability goal, the analysis was conducted by one or a group of researcher(s) under an agreed procedure and framework, as elaborated below.

The analysis started from extracting information and evidence from each working paper that particularly speaks to the nexus between nature-based solutions and a specific sustainability goal in cities. For each of the sustainability goals, we developed an analytical framework that identified the key concepts or themes that comprise any specific goal from the existing literature. For example, for climate change, we focused on the effects of nature-based solutions on climate change mitigation and adaptation; for biodiversity, we focused on the contributions of nature-based solutions to conserve and restore biodiversity, as well as to enable cities to thrive with nature; and for economic regeneration, the analysis focused on economic vitality and the creation of attractive places to live and work. Using an Excel template, we extracted relevant material under each of these themes from the 21 working papers prepared previously – one for each of the three domains (regulatory, finance and urban development) of each of the six countries as well as the EU level. This was done separately for each sustainability goal. For

⁴ This process has been briefly outlined in van der Jagt et al. (2020a).

each of the extracts copied from the working papers, the researcher(s) also provided an interpretation of the copied content in their own words. Through the process, evidence and knowledge of the linkages between nature-based solutions and each of the five sustainability goals was accumulated and aligned with the domain-specific stepping stones that they were most closely related to.

Subsequently, we created ‘heat maps’ for each sustainability goal to bring together the data across the seven cases (six countries and the EU). The heat maps counted the number of times that different stepping stones had shown a match with extracts from the working papers. This was indicated with colour shading in which a darker shade indicated higher frequency. Therefore, it provided a first indication of which steps were likely most important to mainstream nature-based solutions for a particular sustainability goal.

Taking into account the outcomes of the heat map exercise and by aggregating the evidence/extracts under the 20 synthesised stepping stones (created in Stage 2), the next step of the analysis involved brainstorming how the key stepping stones identified could be clustered to generate a maximum four-five promising pathways for accelerating the uptake of nature-based solutions. Again, this was done separately for each sustainability goal, resulting in different pathways for each of the five sustainability goals. Brainstorming ended when all researcher(s) responsible for that sustainability goal agreed that a set of pathways had been formulated that adequately captured the most important stepping stones. A series of reports presented the recommended pathways for mainstreaming nature-based solutions for climate change (Tozer and Xie 2020); biodiversity (Xie 2020); economic regeneration (van der Jagt et al. 2020); social inclusion (Armstrong 2020); and the sustainable development goals agenda (Gerstetter et al. 2020).

For different urban sustainability agendas, the relevance and importance of diverse stepping stones varies. Therefore, aligning stepping stones that are particularly important for one urban sustainability goal could result in mainstreaming nature-based solutions that marginalise or even undermine efforts to reach other goals. To mainstream nature-based solutions that can contribute to multiple urban sustainability goals simultaneously thus requires efforts to be built on stepping stones that are pivotal for all these goals. Figure 1 below summarises the overall analytical process, using the climate change (CC) and biodiversity challenges as examples.

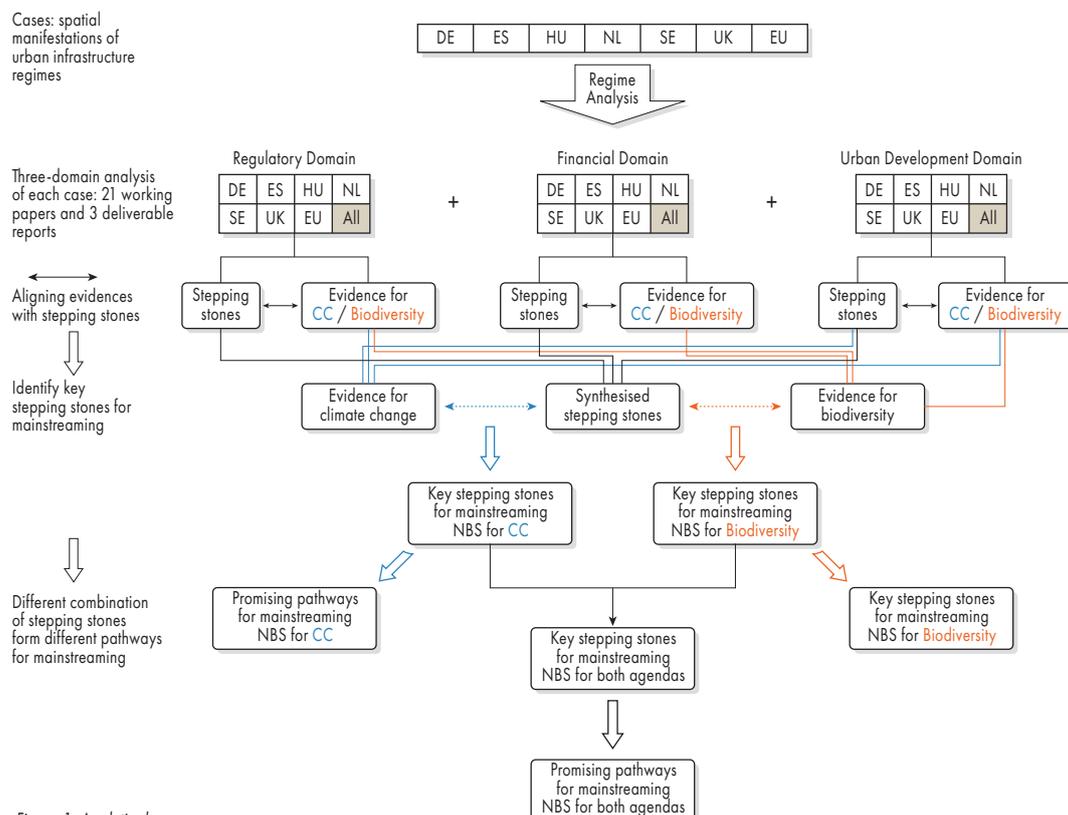


Figure 1: Analytical process



3. 20 STEPPING STONES

3.1 PROVIDE A PUBLIC MANDATE

The mainstreaming of nature-based solutions can benefit from policy-makers and investors giving a clear mandate for them to be included in urban development through tender and procurement policies, policy instruments (e.g. land use planning guidance), and where possible mandatory regulation.

Providing a public mandate for nature-based solutions in urban development can establish a clear direction and requirements and enable private investment. Often, it will be a slow and uneven process to rely on real estate enterprises or private infrastructure developers to implement nature-based solutions from their own commercial interest (Tozer et al. 2020). Many urban stakeholders have highlighted the lack of mandatory urban greening policies as a major barrier for the wider uptake of nature-based solutions. Public policy agendas and related funding streams supporting nature-based solutions can help to promote a diffusion and awareness of the concept and its potential to provide multiple benefits, and thus can boost mainstreaming.

Options for establishing a public mandate include tender and procurement policies, broader policy instruments, or mandatory regulation at European, national and regional levels. In some cases, opportunities for nature-based solutions were linked to national policies. Examples include the mandatory Biodiversity Net Gain in England and Spain's Public Procurement Law, which encourages municipalities to consider additional environmental and social criteria in procurement processes and allows them to offer long-term contracts to large companies. Such regulations can facilitate higher private investment in urban nature-based solutions, so as to meet the binding targets associated to firms' products and services. In other cases, local governmental policies play an effective role in promoting the integration of nature-based solutions in urban development. For example, Stockholm's Green Space Factor stipulates a certain proportion of green space in new development projects (see example in Box 1). At the EU level, the European Regional Development Fund (ERDF) Operational Programmes sometimes support nature-based solutions-related projects, which presents future opportunities to further expand this role and upscale its support for nature-based solutions (van der Jagt et al. 2020b).

It is to be noted, though, that mandatory requirements for urban greening will not always incentivise multifunctional nature-

based solutions. Without clear instructions and details of the design requirements, policies that demand the cultivation of nature-based solutions in new development could produce poor-quality green spaces with low biodiversity value (Tozer et al. 2020). Meanwhile, policies with a focus on one kind of benefit (e.g. biodiversity) often cannot incentivise actions that can address multiple sustainability challenges at once, and even run the risks of marginalising or exacerbating other sustainability issues in cities. Therefore, a key aspect for this stepping stone is to ensure that policies include details about achieving high quality urban nature that is accessible and specify solutions that can achieve multiple sustainability goals.

Box No. 1

Green Space Area Factor

Green Space Area Factor has been an influential tool for nature-based solutions in urban development in Europe. Originally developed in Germany (as Biotope Area Factor), and now used in Malmö and Stockholm in Sweden, Green Space Area Factor is a planning tool that assigns weights to different types of green infrastructure for the social and environmental features they offer, and awards points accordingly. Local governments have used it to require that developers meet a particular threshold for urban greenery when they develop land owned by the municipality, while allowing some flexibility in how exactly that threshold is achieved. The tool incentivises quality green space that offers important functions to cities, such as heat island effect mitigation, biodiversity, or space for play activities.

The Greater London Authority's Living Roof and Wall Policy

As a part of the Mayor's London Plan, the Living Roofs and Walls scheme focused on creating green roofs and recreational living roofs and green walls to help London adapt to the risks of climate change such as flooding, overheating, drought; and reducing the urban heat island effect in the city.⁵ This policy provides the basis of the planning approach to extensive green roofs in the UK capital. The London Plan also has some measurable objectives, including a no net loss of designated Sites of Importance for Nature Conservation over the plan period and no net loss of functional flood plain. An Urban Greening Factor has also been introduced into the London Plan to ensure that all new major development includes an element of greening which contributes to making the city healthier, wilder or more resilient.

Compulsory Urban Greening Measures Stipulated by the Binding Land Use Plan

In many German cities, green roofs became a compulsory measure in new development projects by leveraging the Binding Land Use Plan. The Federal Building Code stipulates that Land Use Plans (i.e. plans stipulating regulations for spatial development at the regional, municipal and district/area specific levels) need to be prepared in agreement with the requirements and measures laid down for an area in the Landscape (Master) Plan. This holds for both to the Preparatory Land Use Plan prepared at the level of the municipality, as well as the Binding Land Use Plans prepared at the level of a district or smaller area. The Preparatory Land Use Plan can serve as an instrument to integrate many different strategies relevant to urban development (e.g. urban greening, climate change adaptation, mobility) within a single vision for urban development. The Binding Land Use Plan can be a powerful instrument to enforce urban greening measures as part of new urban development projects; about fifty percent of German towns and cities higher than 10,000 inhabitants had made green roofs a compulsory measure as part of new developments in at least one of the areas covered by a Binding Land Use Plan in 2016/17.

⁵ GLA (2008), Living Roofs and Walls, Technical Report: Supporting London Plan Policy, Greater London Authority, London. Available from: <https://www.london.gov.uk/sites/default/files/living-roofs.pdf>

3.2 REGULATE FOR NO NET LOSS

No-net-loss / net gain regulation for urban nature (biodiversity) has the potential to generate greater interest in nature-based solutions across Europe. Developing harmonised regulation across Europe with strong monitoring and sanctioning to increase effectiveness has the potential to support nature-based solutions mainstreaming.

Urban greening regulation to reduce Net Loss, or to increase Net Gain, of biodiversity recognises the value of biodiversity in urban landscapes and provides ongoing investment flows for green infrastructure. The policy paradigm of Biodiversity No-Net-Loss/Net Gain requires mitigating and offsetting the negative environmental impact of urban development through on-site or off-site practices that deliver biodiversity gains. As such, it holds strong potential to counteract the current dominance of grey infrastructure in urban development and presents significant opportunities for mainstreaming nature-based solutions.

To position nature-based solutions as an effective biodiversity protection or offsetting strategy requires the development of evidence of the biodiversity benefits of nature-based solutions. In addition, since the initial adoption and the upscale of biodiversity regulations are often facilitated by experimental pilot projects or policy lobbyist or consultee (e.g. NGOs and city network), developing demonstration projects and stimulating partnerships between governments of different levels and with private and third sector organisations can be critical for shaping and improving urban biodiversity regulations, which can then influence the uptake and management of nature-based solutions for biodiversity.

The multitude of building regulations poses a challenge for integrating urban nature-based solutions into new developments. Thus, developing harmonised regulation across Europe could upscale these solutions and strengthen monitoring and sanctioning to increase effectiveness. The challenges of effective offsetting include limited urban space, locating offsetting projects in central urban areas without greenery, delays in implementing natural habitat offsets, and ensuring/monitoring that offsets are actually implemented. Another major concern of the biodiversity offsetting is that it would allow (or even encourage) new grey development, which is the major course of biodiversity loss in the first place.

In the UK, mandatory Net Biodiversity Gain for new developments sites is planned to be included in the Environment Bill, which has until recently resumed its passage through Parliament after a pause due to the coronavirus outbreak. Developers and planners will be required to apply the DEFRA Biodiversity Metric to all new developments, to achieve 10% net gain from the site's baseline, and maintain this for at least 30 years. Meanwhile, Germany also has biodiversity offsetting regulations for new developments. Details of these two examples can be found in Box 2.

3.3 INCLUDE IN CONTRACTUAL AGREEMENTS

Utilities (e.g. water, waste, energy) and network service providers (e.g. road and rail authorities, waterway authorities) are either publicly owned or operate on long-term contracts that are bound by regulatory requirements for service provision. Including nature-based solutions as a requirement for the delivery of mandated functions (e.g. water quality treatment) or for the upkeep of land-holdings (e.g. train sidings, roadside verges) provides an important avenue for mainstreaming.

Nature-based solutions can be included as a requirement in contracts for utilities, such as water, waste, and energy, and for entities that manage roads, railways and waterways. The provision of these services is usually either publicly owned or operated on long-term contracts bound by regulatory requirements. Therefore, municipalities can require urban nature-based solutions to be integrated into the development or redevelopment of utility infrastructures. In Sweden, Trafikverket is a national transport agency responsible for long-term transportation infrastructure planning. The company developed green infrastructure guidelines articulating its priorities for ecosystem services while simultaneously meeting transportation needs. Integrating nature-based solutions into infrastructure development agreements and continues to expand infrastructure

Box No. 2

Biodiversity Net Gain regulation in the UK

Biodiversity Net Gain is one example of regulating for No Net Loss. Rather than the usual approach of mitigating negative environmental impacts, Biodiversity Net Gain incentives developers to enhance natural habitat in their projects, by adapting the design of their project, enhancing biodiversity on-site, or offsetting impacts off-site. In the UK, many developers are already adopting voluntary commitments and the Department for Environment, Food and Rural Affairs is considering a mandate of 10 percent net biodiversity gain on new developments through the mitigation of impacts using design, on-site biodiversity enhancement and offsetting in the local area. The approach shifts development from a detriment to nature to a potential driver of enhancing biodiversity, smoothing planning processes and reducing costs for developers. Stakeholders anticipate that this will leverage private developer contributions to urban greening to compensate for any loss of greenspace and biodiversity as a result of development activity, and thus create significant opportunities for nature-based solutions.

Biodiversity Offsetting Regulations in Germany

Building on biodiversity offsetting regulation that has been mandatory in Germany since the 1970s, the City of Hamburg developed the NATURCENT regulation paid by taxes and the EINGRIFFSREGELUNG regulation paid by real estate developers. Essentially an accounting system for urban nature, these measures incentivise real estate developers to minimise the loss of natural habitat in their developments, and in cases where this cannot be avoided they can allocate funds or space, or both, to create or enhance natural areas in other parts of the city. Due to the high competition for urban space, the NATURCENT program specifically focuses on the quality, rather than the quantity, of nature in the city, for example by investing more in maintenance of urban parks.

companies' interest in multifunctional benefits of nature-based solutions can thus open great opportunities for their mainstreaming (see example in Box 3).

Looking for long-term thinking opportunities is a key to activate this stepping stone. Besides urban infrastructure providers, urban development stakeholders have recognised that developers or organisations that intend to own building or infrastructure assets for decades are also motivated to implement sustainability initiatives with long-term benefits, such as nature-based solutions (Tozer et al 2020). This is particularly important for mainstreaming nature-based solutions into new building development, since these developments often involve a transfer of ownership between the construction and operation phases, leading to the reluctance of adopting sustainable solutions with long-term benefits during the design and construction process (Tozer et al. 2020). Targeting stakeholders that have enduring interests in sustainably managing urban buildings and infrastructures is more likely to integrate nature-based solutions in contractual agreements and thus in development. For example, in Sweden, public housing companies often seek to bolster green credentials while also have a long-term perspective for their investments and developments. They have thus been targeted by urban development stakeholders for sustainability projects like nature-based solutions (Tozer et al. 2020). Similarly, due to their large and long-term ownerships of housing stock in cities, housing corporations in the Netherlands are viewed as critical players in urban development to drive the sustainability transformation. Moreover, technical tools (e.g. Building Information Modelling, lifecycle analysis) can also introduce long-term thinking into development processes.

Including nature-based solutions in contractual agreements also means that the cost of delivering urban nature-based solutions can be drastically decreased, by drawing existing funds earmarked for construction and renovation of real estate and infrastructure. Reducing the cost of nature-based solutions can also be accomplished by linking green infrastructure such

⁶ <https://www.gov.uk/government/news/environment-bill-resumes-passage-through-parliament>.

as gardens with grey infrastructure such as buildings, so as to avoid the high land use cost for developing stand-alone nature-based solutions. Besides promoting the mainstreaming of nature-based solutions, this stepping stone can, to some extent, also help prevent ongoing loss of urban nature due to construction activities.

Box No. 3

Integrating nature-based solutions into transportation infrastructure investment in Sweden

Nature-based solutions are integrated into some of Sweden's transportation infrastructure investments. The transportation company owned by the national government, Trafikverket, developed green infrastructure guidelines articulating the company's priorities for ecosystem services alongside transport needs. And the city of Malmö combined the public departments that manage streets and parks, which provided opportunities for road engineers, landscape architects and planners to interact more frequently and negotiate trade-offs and innovations. These efforts address the challenge of traffic departments that are mandated to maintain road infrastructure but may be unwilling to compromise road performance in order to seek multiple benefits.

The DFBMO Contracting Framework in the Netherlands

The DFBMO (Design, Finance, Build, Maintain, Operate) contract was named as a potentially beneficial framework for the inclusion of nature-based solutions into urban development processes. This contract type ensures that agreements on responsibilities along the entire project life cycle are made at the project outset (often spanning 25-30 years), which enables a fairer consideration of nature-based solutions benefits. Such contracting framework also helps to address the issue of high maintenance costs of nature-based solutions as it transfers responsibility for maintenance to the developer for at least part of the life cycle of a new development.

3.4 ALIGN WITH STRATEGIC PRIORITIES

By positioning urban nature-based solutions as a way to generate benefits for prioritised policy goals through generating narratives and evidence (i.e. climate change mitigation & adaptation, circular economy and healthy urban living) their relevance and community of practice can be widened.

Cities are confronted with many sustainability challenges, including energy transition, climate change adaption and mitigation, water supply and management, and health enhancement. Often, policies do not have to be specifically focused on nature-based solutions to present opportunities for their mainstreaming. Instead, nature-based solutions can also be advanced by aligning with existing priorities in cities (e.g. climate change, circular economy, and healthy urban living) and by generating narratives and evidence that articulate the relevant benefits of urban nature-based solutions. For instance, state level planning in Spain has introduced the concept of ecological connectivity; 'green infrastructure' ties in nicely with this specific urban planning approach. Similarly, a national policy in Sweden requires that urban greenery and ecosystem services are integrated into the planning, building and administration of cities by 2025. Such growing emphasis on ecosystem services is creating opportunities to integrate nature expertise into new projects at earlier stages and to promote multifunctional nature-based solutions implementation, even if the main narrative is slightly different (Tozer et al. 2020). Moreover, in Hamburg, the ambitious green roof strategy was developed as part of the climate adaptation plan, offering a route to mainstreaming a specific type of urban nature-based solutions under a different policy objective.

Building on synergies at the European Union level is one means to realise these opportunities. The European Union's Biodiversity Strategy was positioned by various EU institutions as an integral part of the broader Europe 2020 Strategy, and of relevance to ministers for economic and financial affairs, rather than only the Environment Council. Action to address climate

change is also a policy priority in European countries and cities. Significant climate change impact events (e.g. flooding, heatwaves) created a new focus on retrofitting the existing city for climate change adaptation. Therefore, framing urban nature-based solutions as an effective biodiversity and climate solution can access the resources and funding dedicated for biodiversity conservation and restoration, as well as climate change adaptation and mitigation, which can further promote nature-based solutions mainstreaming.

This stepping stone highlights the multi-functionality of nature-based solutions while also recognises the highly departmentalisation of urban governance. The mainstreaming of nature-based solutions thus can benefit from integrated urban policy-making and planning that transcends current boundaries between policy domains (van der Jagt et al. 2020a). Moreover, creating synergies between different agendas and tapping the full potentials of multifunctional nature-based solutions require the coordination of strategic priorities in institutional policy-making at the EU, national and local levels. It also requires the development of evidence to raise awareness and involves working across silos within or between government departments and public, private and the third sectors.

Box No. 4

The Environmental and Planning Act of the Netherlands promotes nature-based solutions for health

The Environmental and Planning Vision of the Netherlands built on synergies with the Environment and Planning Act (Omgevingswet) to establish health promotion and protection as a key pillar of spatial planning. The Act streamlines legislation across multiple domains such as environmental management, spatial planning, water management, and mobility. Since local and regional authorities have the option to add an additional layer of environmental regulation based on local challenges, the Council for the Environment and Infrastructure advised regional and local authorities how to pursue health promotion and protection in their policies and visions. Nature-based solutions play an important role in health promotion through improving recreation, social cohesion, mental wellbeing, and absorbing pollutants.

Cape Town: Atlantis Aquifer Clearing Pilot Project funds nature-based solutions to supply water

Cape Town experienced severe drought from 2015 to 2018 and the city came close to running out of water. One pilot project seeks to increase the water supply to Cape Town by removing invasive plant species, which are thought to remove millions of litres of water from the catchment area annually and use significantly more water than indigenous species. A pilot project run by The Nature Conservancy is removing invasive species from the area that recharges the Atlantis Aquifer, the largest aquifer supplying Cape Town. The initiative also acts as a job creation and training program by employing teams from nearby disadvantaged communities to do the plant clearing work. Importantly, the pilot project feeds into the creation of a Water Fund for Cape Town, which in the form of a public-private partnership, will convene various levels of government, industry representatives and other stakeholders to find new ways to fund and coordinate wider efforts to clear invasive plant species as a water supply strategy.

Barcelona: Climate Commitment Drives Urban Greening⁷

In Barcelona, the Climate Strategy is important for urban greening. Drawing on the 2017 Global Covenant of Mayors for Energy and Climate and the 2015 Paris Declaration, Barcelona's Climate Plan 2018-2030 sets out the city's strategy to reduce carbon emissions by 45% on route to becoming carbon neutral by 2050. The plan includes references to urban green infrastructure for climate change adaptation in particular related to reducing the urban heat island effect and supporting vulnerable people. Goals and targets set up by the Plan include building over 34,000m² of green roofs and walls, and increasing urban green space by 1.6 km². 'Many more green areas' is one of the 18 lines of actions specified in the Plan, and it refers to the Green Infrastructure Plan and its implementation programme, as well as the Tree Master Plan (2017-2037) for implementation measures. It also describes some new actions such as producing an inventory of tree species with information on their climate resilience and improve knowledge of how climate change impacts on natural systems and the threats they face.

⁷ https://www.c40knowledgehub.org/s/article/Barcelona-s-Climate-Action-Plan-2018-2030?language=en_US.

3.5 CREATE INTERMEDIARIES

In order to overcome institutional silos within both public and private sector organisations, new organisational forms that work across these divisions are required. Intermediary units can either be established within organisations or outside (by external bodies) and provide co-ordination between departments as well as platforms for innovation.

Efforts to mainstream nature-based solutions face challenges in coordinating actions across siloed government departments and dispersed authority for governing urban land and infrastructure. Meanwhile, benefits of and responsibility for nature-based solutions are split across different sectors in urban infrastructure regimes and involve a multiplicity of urban stakeholders. Intermediaries, key individuals or organisations, which work within and across public and private bodies, can enhance coordination among various actors and also provide platforms for innovation.

Silos within governmental organisations have been widely recognised as an obstacle for integrated planning and actions towards urban sustainability in European cities (van der Jagt et al. 2020b). This is especially challenging for nature-based solutions, since their multi-functionality means their benefits landed in multiple policy domains and consequently multiple governmental departments (e.g. energy, mobility, housing, health). The lack of collaboration within municipalities can also result in the lack or inadequate support provided to citizen's initiatives, which further discourage the potential efforts to develop or maintain nature-based solutions in cities (van der Jagt et al. 2020b).

This stepping stone highlights the significant role played by intermediaries in bridging silos. Intermediaries can be a person, a professional group or an organisation who or which facilitates the communication, collaboration and coordination between different sectors or organisations. For instance, the 'unburdening arrangement' established by the Building Agenda policy programme in the Netherlands incentivises individual actions towards urban sustainability by organising single contact points that coordinate the implementations of sustainability solutions (see example in Box 5). Similar types of arrangements also apply to professional groups or organisations, which were established or assigned/institutionalised to deal with the entire process of nature-based solutions implementation and maintenance. This could facilitate the integration of nature-based solutions into urban development projects, as it mitigates the risks for actors who are unfamiliar with nature-based solutions. For instance, adding a green roof to the design of an office building is less of a risk when all aspects of its implementation and maintenance are guaranteed to be taken care of by one responsible party. Here, the emphasis is on creating clarity over responsibilities – uncertainties around responsibility are often implicit in objections to nature-based solutions integration. Relatedly, establishing or institutionalising a new role within the sector can also facilitate the adoption and implementation of nature-based solutions.

Barcelona's Urban Ecology Municipal Directorate

In Spain, the regional ministry of Catalunya created a Department for Territory and Sustainability, bringing together mobility, infrastructure, environment and spatial planning in one place. This is mirrored in the city of Barcelona where the Urban Ecology Directorate brings together the Mobility, Environment and Planning departments to enhance coordination between departments that deliver on the city's climate change plans. The directorate develop city-wide policies on sustainability, such as the city's Climate Plan, in which urban greening plays an important role, as well as sustainability innovations such as the Superblocks programme. It also enhances exchange of critical information, for example databases from the Institute of Informatics. In this context, Barcelona is experimenting with 'superblocks' where fragments of roads and their junctions are converted into pedestrian areas with green infrastructure, playgrounds benches, bike lanes, and bus networks.

Intermediaries in Municipally Driven Initiatives in Europe

Municipally-driven initiatives in Europe often employ project managers or create teams dedicated to the nature-based solutions project. For instance, Augustenborg Ecocity in Malmö (Sweden) has been initiated by multiple municipal actors and committed individuals, which aims to transform a run-down neighbourhood into a socially, economically and environmentally more sustainable and attractive place to live (1998-2002). When governmental funding was provided for the plans, a project manager was employed by the district administration for this specific task. At the same time, the Leidsche Rijn water system was initiated in Utrecht (the Netherlands), which is a sustainable closed-circuit water system including natural wetlands, bioswales, pumping stations and permeable paving which filters stormwater organically. The Leidsche Rijn was facilitated and managed by a project office, with its own director and councillor, created inside the municipal structure for this specific project, with different groups working on different aspects of the development. In both cases, this internal municipal organisation contributed to the projects' success. However, while Malmö struggled with decision making being more-or-less dependent on established municipal processes, the Leidsche Rijn created a project office which simplified the decision-making process and made it relatively independent, in turn adding legitimacy and transparency, and facilitating pioneering activities.

'Unburdening Arrangements' in the Netherlands

In the Netherlands, the Building Agenda is a four-year policy programme intended to set in motion (or accelerate) the sustainable transformation of the building sector, particularly around climate-proofing, circularity and the energy transition. To address the issues that arise from the sector's fragmented nature, and the challenges that this brings for communication, collaborative working and delivering sustainability solutions, the Building Agenda task force aims to promote 'unburdening arrangements', establishing an intermediary coordinates between energy suppliers, project developers, and financiers to offer sustainability solutions through a single contact point. It simplifies the process of making sustainability improvements to private housing property by the owners. The 'unburdening arrangements' demonstrate the effectiveness of creating intermediaries to navigate a fragmented sector and ease communication to facilitate better collaboration processes along the entire development process of sustainability solutions, such as nature-based solutions, through formalised procedures.

3.6 GENERATE PARTNERSHIPS

Stimulating partnerships between public, private and third sector organisations for the co-design, development and maintenance of urban nature-based solutions is critical for generating initial action on the ground and increasing support for mandatory urban greening policies.

Partnerships between public, private, and civil society organisations are critical for increasing awareness and support, and generating initial action for nature-based solutions. As mentioned in the above Stepping Stone – Create Intermediaries, one of the persistent challenges to nature-based solutions mainstreaming is the existence of silos between and within different kinds of public and private organisations. The inability to coordinate between multiple stakeholders to take joint action on realising urban nature-based solutions could result in missed opportunities in creating synergies, lowering cost and sharing responsibilities in developing and maintaining nature-based solutions. It is to be noted, however, that silos also exist across different disciplines (e.g. architecture, planning, ecology, engineering), which could lead to a lack of integrated knowledge in implementing nature-based solutions in urban developments.

Generating partnerships and fostering collaboration can further remedy the knowledge gaps in designing and implementing nature-based solutions by enabling mutual learning and hands-on practice. For example, The Urban Forest Strategy and its related actions in the City of Melbourne or the BiodiverCity project in Malmö bring together researchers, policy makers, businesses and local communities to co-create urban nature-based innovations in demonstration projects, facilitating knowledge development and mobilising agency and resources, while contributing to the further development of urban policies. Partnerships among different stakeholders also form the basis for establishing co-funding and co-governance mechanisms for nature-based solutions.

There are multiple strategies that governments can take to promote partnership building among a broad range of actors (van der Jagt et al. 2020b). For example, in the United Kingdom, Local Nature Partnerships and Water Catchment Partnerships bring together public, private, NGO and local community organisations to support the development of a green economy as well as climate adaptation through nature-based solutions and other cost-effective solutions. Besides, government in the UK (as well as in the Netherlands) is also experimenting with City Deals, which are government-sponsored meetings among various urban actors around better alignment of policy and practice through partnership-working, so that any policy barriers preventing nature-based solutions can be reconsidered to better support these processes (van der Jagt et al. 2020b).

Funding structures can also be designed to incentivise collaboration. It is found that EU funding programmes and competitions, e.g. European Green Capital award, prompted the development of the green infrastructure concept in Hungary, which then led to the growing cooperation among different departments in Budapest in developing urban greening. Also, knowledge tools and exchange platform can also facilitate collaboration by demonstrating design benefits of nature-based solutions to diverse partners. It is important to note, however, generating partnership is important for not only initiating nature-based solutions, but also maintaining them after implementation.

The Network of Local Governments + Biodiversity

The Network of Local Governments + Biodiversity, a Spanish federation convening over 300 municipalities, works to improve policy and knowledge in support of biodiversity and nature-based solutions, and is one of the key contributors to the National Strategy on Green Infrastructure. In partnership with a national federation of municipalities and provinces, as well as associations that represent green infrastructure companies and parks, the Network created a guide for municipalities that outlines best practices on green infrastructure. Barcelona's participation in international networks such as ICLEI, United Cities and Local Governments, and C40 Cities network has facilitated alignment with other major cities and provides access to inspiring global examples.

Edinburgh: Little France Park

Little France Park is a multi-stakeholder initiative to develop new parkland for the local community of Craigmillar, as well as the staff of the adjacent hospital and research campus (under construction). Craigmillar is a socio-economically disadvantaged neighbourhood and the park aims to improve interactions between professionals working in this area and the local community, as well as their health and well-being, in part through the implementation of an active travel route through the area. In addition, as part of Edinburgh's green belt, it connects green spaces and habitats. However, land use at the site is contested, with different municipal departments having different objectives. The original area designated for park development was larger, and land has been sold off to construction companies. To avoid further fragmentation of the green space, the Department of Parks and Greenspaces of the city has initiated a public-private partnership, which is led by the Edinburgh and Lothians Greenspace Trust. This trust has been working to gain local people's support for turning arable land of low perceived quality into a park. The second part of park development is still awaiting approval amidst increased pressure from real estate developers in its southern section.

The Green Deal Green Roofs in the Netherlands

A government-funded partnership between public and private actors that aimed to develop innovative business models for green roofs is the Green Deal Green Roofs (now called the National Roof Plan) in the Netherlands. This network connects all relevant stakeholders in the green roof sector, including municipalities, water utilities, roofing firms and homeowners. It specifically aimed to improve structural conditions for mainstreaming green roofs across the country, for example, by lobbying for sewage tax breaks for green roof homeowners. Besides financially supporting the mainstreaming of green roofs, it also promotes the development of multifunctional green roofs by bringing all stakeholders together to share visions and expertise. As a result, green roofs that are developed under the scheme can deliver multiple benefits, including biodiversity, aesthetics, cooling, and water retention.

Newcastle: Brunton Park Flood Alleviation Scheme

The Brunton Park Flood Alleviation Scheme was a sustainable drainage schemes (SUDS) taking place along the Ouseburn river that flows through the urban, suburban and semi-rural areas of Newcastle. The Scheme included attenuation ponds, new water-dependent habitats, such as wet woodland and willow, 400-metre channel re-alignment, and a new 250-metre flood wall. Completed in 2016, the Brunton Park Flood Alleviation Scheme represented a public-public partnership in governing local nature-based solutions. Responsibilities are allocated among multiple actors. The Newcastle City Council manages the entire planning process and is responsible for flood risk across the city. Groundwork (a non-profit organisation) manages the nature-based solutions, while the Northumbrian Water and Environment Agency manages surface water and river flood risk. Newcastle University also provides some funding and monitoring of the river and impacts of the project.

3.7 ESTABLISH DEMONSTRATION PROJECTS

Demonstration or pilot nature-based solutions projects, often involving research, can create shared learning and knowledge development as well as providing tangible demonstrations of how nature-based solutions can work in practice, creating confidence amongst partners about their potential.

Demonstration projects can offer tangible examples of how nature-based solutions work in practice, building knowledge and confidence about their performance. Often, benefits of nature-based solutions are context-specific, which remain difficult to quantify and/or to communicate. Experimentation or demonstration projects in different regions and cities with varying social and ecological conditions thus can be effective in developing locally relevant knowledge for implementing nature-based solutions. For example, in response to flooding, the UK Environment Agency invested in a large multi-year pilot project in natural flood management, complementing existing expertise in grey infrastructure engineering.

Besides generating applied and place-specific knowledge, pilot/demonstration projects can also showcase the multi-functionality of nature-based solutions, which can address various urban sustainability challenges (e.g. climate change, biodiversity, health and well-being etc.) at the same time and in a cost-effective way. Such demonstration is crucial because the performance of nature-based solutions can be more uncertain than grey infrastructure (which has more widely understood performance metrics and calculations of risk), which is identified by urban stakeholders as a key barrier for wider uptake of nature-based solutions (Tozer et al. 2020).

Pilot/demonstration projects can also be eye-catching ways to create more public awareness of nature-based solutions, while create shared learning opportunities, allowing stakeholders to gain familiarity with these solutions and to learn how to navigate conflicts while working together (Tozer et al. 2020). This is particularly important for establishing new connections across sectors and silos. For example, Budapest's biodiversity trail that demonstrates roof gardens, improves collaboration between private and academic partners.

Working at the district or city level to establish demonstration projects can create examples that have a ripple effect (Tozer et al. 2020). Governments can act as frontrunners in greening their own assets, such as the eco-districts in industrial areas of Sweden (see BiodiverCity in Malmö example in Box 7).

It is important to note that pilot/demonstration projects also require regular monitoring, evaluation and follow up to obtain and further harness the practice-based knowledge which they create (Tozer et al. 2020). Also, ensuring that such expertise on urban nature-based solutions is widely shared and available can inspire and further facilitate their wider uptake in urban development in both the local areas and other places and contexts.

Natural Flood Risk Management Demonstration Project in Glasgow

Glasgow City Council, with funding from the Scottish Government's Green Infrastructure Strategic Intervention (GISI), is enhancing urban nature alongside a canal in north Glasgow. This blue-green infrastructure project implements cutting edge insights of international surface water and flood risk management. It is one of the projects funded by GISI to demonstrate how green infrastructure can achieve multifunctional outcomes, including benefits related to climate change, biodiversity, and better places to live. These demonstration projects can enhance communities, while at the same time developing broad understanding of the multifunctional benefits of green infrastructure and informing the future implementation and maintenance of nature-based solutions.

MALMÖ: BiodiverCity

BiodiverCity is a three-step project that was run by Malmö municipality during 2012-2017. The aim of the project is to increase biodiversity by developing new products, services and processes, contributing to a vision of a green, attractive and healthy city. Over the implementation phase of two years, almost 30 different green structures were established in different parts of the city including urban biotopes, green roofs, green walls and mobile plant systems. These permanent demonstrations serve as a basis for evaluation, learning, and dissemination of innovative solutions for urban greenery. Meanwhile, the project has also experimented with a variety of governance practices, partly through the collaboration of a multitude of public and private actors working together in multidisciplinary teams on the design, implementation and maintenance phases of the nature-based solutions. In BiodiverCity-Koggen (in the new development area of Western Harbour in Malmö), the housing company, as one of the collaborating actors, offered the roofs of its rental buildings for testing new processes and products to improve urban ecosystem services, increase biodiversity, re-create the local flora, improve aesthetics and reduce maintenance. One of the main outputs of this nature-based solutions is a novel maintenance plan, including new ways to maintain green structures, biodiversity and how to pass knowledge on to staff responsible for maintenance.

Porous Alley in Boston: a testing ground for new road material

The Porous Alley in Boston is a nature-based solutions project tied to roads, mostly involving the installation of porous asphalt to increase the permeability of pavement and underground water storage. In this case, the measure has mixed funding from the Massachusetts department of Environmental Protection and the City of Boston as a testing ground for new green technology. Porous asphalt was applied in streets and alleyways to recharge groundwater levels, in turn reinforcing the structural integrity of nearby buildings, while cleaning and filtering runoff to prevent pollution of the Charles River. The project provided the city and relevant stakeholders the opportunity to learn by doing, but also enabled the monitoring and evaluation systems necessary to systematically test the technology's efficacy in a Boston-specific setting. The importance of collaboration between numerous municipal departments, including those responsible for utility lines, parking, and construction project management, are highlighted here.

3.8 ENGAGE INSURANCE SECTOR

Engage the insurance sector to support upscaling of urban nature-based solutions based on their risk reduction needs and damage cost expertise.

The reinsurance and insurance industries are increasingly viewed as sectors that can play an important role to help manage risks, by improving disaster risks reduction and loss prevention. Given their considerable needs of risk reduction and their expertise on damage cost, engaging these actors can be effective in mainstreaming nature-based solutions.

Our previous analysis has identified four key roles played or can be played by the (re)insurance sectors in mainstreaming nature-based solutions: expert, influencer, innovator and partner (Toxopeus et al. 2020). In brief, the insurance industry,

especially reinsurance firms, is the expert when it comes to damage risks and costs for a development project, an existing building, a community and even a city. Some (re)insurance firms even develop its own tools or models to identify and measure risk associated with climate change so as to support making better risk assessments to drive decision around investment management and capital expenditure (e.g. the BlueLabel developed by the Dutch insurance firm Achmea – see example in Box 8). With this data and knowledge, the insurance sector can act as the influencer by either campaigning key stakeholders (such as governments, financial institutions) in adopting or investing on nature-based solutions, or pricing climate change-related risks and reflecting such risks in their premiums charged to clients, incentivising customers to implement nature-based solutions. Although rarely, the insurance industry can also exert influences on the uptake of nature-based solutions by requiring the firms they are invested in to implement nature-based solutions. Insurance sector can also act as an innovator by developing new, complementary products and services that support and promote nature-based solutions. Lastly, due to their broad connection with different stakeholders through their insurance and asset management activities, insurance sectors have the potential to be the key partner, collaborating with other multiple stakeholders in designing, funding, implementing and maintaining nature-based solutions.

As can be seen, the engagement of insurance sectors can overcome a number of barriers for the mainstreaming of nature-based solutions. These include, for example, the lack of knowledge and awareness of the benefits of nature-based solutions (especially in risk reduction), the lack of cash flow directed towards their implementation, the lack of dialogues and understanding between different stakeholders in cities. Benefited from their national/international scope, the engagement of insurance sector can also help overcome the challenge of scalability of nature-based solutions (Toxopeus et al. 2020), further boosting their mainstreaming.

Dutch Insurance Firm Promotes Nature-based Solutions

In the Netherlands, the firm Achmea insures about 70 percent of municipalities and spearheads efforts that promote nature-based solutions. Through its climate risk data tool, BlueLabel, the company uses its claim data to inform homeowners and municipalities of the climate risk of a specific house or geographic area. This helps signal vulnerability to extreme weather and design effective interventions, increasing the value and potential of nature-based solutions. Motivated by rising claims for water damage in its portfolio, the company's subsidiary, Interpolis, ran a national marketing campaign to stimulate green roofs. The company collaborates with a green roof firm to offer a standard low price, making the process easier and financially accessible for homeowners. The insurance firm Interpolis is investing in awareness and increasing the market demand for green roofs in the Netherlands, from a perspective of lowering roof-related damage costs in their portfolio.

ClimateWise – a UK-based Network for Insurance Companies

ClimateWise is a voluntary initiative based in the UK with global membership from the insurance industry. ClimateWise strives to reduce the impact of climate change on the insurance industry and society. Its members, including insurers, reinsurers and other industry members, report on the ClimateWise principles annually, which are fully aligned with the TCFD recommendations as of 2019. In 2016, the ClimateWise Insurance Advisory Council was established to lead research into ways the insurance industry can support the transition to a low carbon economy as well as sharing knowledge and expertise and assessing physical risks of climate change. Meanwhile, ClimateWise is working on a Resilient Cities project focused on how insurers can use the investments side to increase the resilience of cities. Essentially, ClimateWise helps its members to identify climate risks and opportunities through a reporting framework and research. Such focus and interest on resilient cities and the extension of knowledge of risk in the insurance industry is only an opportunity if nature-based solutions are firmly recognised as a solution that reduces climate risks.

UNEP Principals for Sustainable Insurance (PSI) Initiative

The UNEP Principals for Sustainable Insurance (PSI) Initiative is a collaboration between UNEP and the insurance industry dealing with environmental, social and governance risks in the insurance industry. Many insurance companies are signatories of the UNEP Principles for Sustainable Insurance (PSI), including AEGON, Allianz, Swiss RE. The PSI initiative proposed the establishment of consolidated frameworks for financial institutions which would provide guidance. Frameworks currently available are: 1) Green Bond Principles; 2) UNGC Roadmap on SDG bonds; and 3) OECD Due Diligence Guidance for Responsible Business Conduct (UNEP Finance Initiative, 2018). Through these frameworks, PSI promotes knowledge sharing and tackles the challenge of an uneven global playing field between insurance firms by developing and committing to common industry-led guidelines. Such industry partnership is critical in realising collective action from insurance sector at a global level, affecting the EU level as well, and can drive the mainstreaming of nature-based solutions.

3.9 FACILITATE COMMUNITY-BASED ACTION

Facilitate and support community-based action for local urban nature-based solutions through improving citizen awareness and support.

Nature-based solutions form a part of everyday life for urban citizens, whether that is a visit to a local park or passing by a favourite tree. Their involvement in the development and implementation of new initiatives is therefore critical. Promoting active citizenship can increase understanding of nature-based solutions, empower local communities (especially the marginalised ones), create greater senses of ownership, and enhance urban citizenship and belonging. Engaging citizens and local communities in the design, and implementation and maintenance phases of nature-based solutions provides a fertile ground on which various community-based initiatives can grow and flourish, with great potential for mainstreaming nature-based solutions in cities.

To facilitate and support community-based action, it is important to enhance the governance mechanisms that can support active citizenship. Allocating specific contact persons that navigate the different municipal departments to address questions and issues experienced by citizens, for example, can better support the development and implementation of citizen-led urban greening initiatives (van der Jagt et al. 2020b). Meanwhile, providing financial support for community-based initiatives is also critical. Local crowdfunding platforms for local initiatives organise support for 'green' projects, which is particularly relevant when public funding is lacking.

Environmental education is also key to citizen mobilisation and there is a role for government in educating citizens about the value of nature-based solutions in their cities. This can be achieved by preparing educational events around nature-based solutions targeting school children and/or adults, or through interactive BioBlitz events in which volunteers – mainly children – are joining experts in collecting data on local wildlife (van der Jagt et al. 2020b). More generally, awareness of the benefits from urban nature-based solutions can raise public spending on urban green through citizen engagement. Knowledge also needs to be made easily accessible to citizens and community groups involved in urban greening initiatives (van der Jagt et al. 2020b).

Facilitating community-based actions is challenging and often involves a learning process for all relevant stakeholders. Understanding and working through existing power relationships is a key factor in tackling barriers to participation. Promoting community-based actions also implies reaching out to those who will be affected but may not be able to afford, or simply unwilling, to participate (Armstrong 2020). Therefore, it is important to involve diverse types of stakeholders by using creative methods and providing a variety of opportunities such as workshops, exhibitions, festivals, social media, website interaction, broadcasts, events, etc. (Armstrong 2020).

Madrid: Policy for Promoting Urban Gardens

In 2015, Madrid implemented a novel policy measure allowing residents to submit an application to develop areas labelled as green zones into public urban gardens. Every two years, applications are renewed if certain conditions are met, including no commercial or private use of the space. The rise of urban agriculture dovetailed with a growing social justice movement mobilised to make significant demands of the city council. Government support for community initiatives such as these could be leveraged to create incentives and opportunities for implementing urban nature-based solutions.

Utrecht: Roerplein Pocket Park

The Roerplein pocket park is an example of a Neighbourhood Green Plan project. Neighbourhood Green Plans are an initiative of Utrecht municipality to financially support the bottom-up 'greening' of neighbourhoods (public-citizen partnership). Citizens can propose a variety of often quite small-scale plans that enhance the neighbourhood by means of green spaces, social cohesion and thereby community identity. The Roerplein public square was transformed into a green space by way of a participatory process, assisted by a social entrepreneur. The project aims to reduce heat stress, enhance social cohesion and the attractiveness of the neighbourhood, promote biodiversity and support recreation. The design, implementation and maintenance of the Roerplein pocket garden has been through continuous communication and knowledge exchange between citizens and a social entrepreneur, which in turn supports nature-based solutions continuity. Maintenance is a shared responsibility between a self-organised group of neighbours and the municipality: while citizens do the maintenance work, the tools and materials are provided by the municipality.

Sheffield: Heeley Development Trust⁸

Various ownership and management models are being implemented for green space, providing diverse sources for financing nature-based solutions. These models often involve different kinds of engagement from the community. In Sheffield in England, the Heeley Development Trust is the charity that came out of the community's work to transform the derelict space that was left after the road plans were shelved, in 1996. In 1997, having raised funding, the Trust took ownership of the 3.5 hectares of land through a 125-year lease from Sheffield City Council. In the past, the Trust depended on grants for their capital projects and maintenance. Recently, they have asked for voluntary subscriptions from nearby households to contribute to fund costs. The new funding idea is to try to save the derelict heritage buildings in their community. The rent will pay for restoration and maintenance of heritage buildings and all remaining funding goes directly back into maintaining the Heeley People's Park. In the meantime, the Trust also provides adult education in the community and runs projects like Recycle Bikes, hosts the Heeley Festival and The Big Boulder in the park; most recently the Trust has played a key role in keeping Meersbrook Hall in community hands.

The Hague: Sea Heroes Community Garden

The Sea Heroes Community Garden was initiated by citizens in a disadvantaged neighbourhood with no green spaces. While planning guidance – the Development Plan of Sea Heroes Quarter – identified the lack of green space in the neighbourhood, there were no plans to create new green spaces. To rectify this, citizens collected 2,500 signatures from the neighbourhood, convincing the municipality of The Hague that more green spaces were required and supporting the development of the community garden. The key goal was to create a garden in which children can play, fruit and vegetables can be grown organically, and people can enjoy recreation. Local citizens formed a board to oversee the project and coordinate activities. The garden itself was designed by DGJ architects and volunteer students from the Technical University of Delft, based on ideas put forward by citizens and drawings from school children. The project was financed by Stichting De Versterking, a foundation that bought the land from the housing corporation HaagWonen; various private funds (Fonds 1818, Jantje Beton and Oranjefonds); a bank (Rabobank); the municipality of The Hague; a health care facility (Zorg Hotel Residence Haganum) and citizens themselves. Neighbourhood residents and volunteers of the organisation De Groene Eiland maintain the garden. The creation of such green spaces supports activities and recreation, and promotes the health and well-being of citizens, which is particularly important for the elderly.

3.10 PROVIDE ECONOMIC INCENTIVES

Provide economic incentives (tax cuts, subsidies) to support the development and uptake of nature-based solutions.

Providing economic incentives can help create the right market conditions to encourage the establishment of nature-based solutions schemes. Currently, a prominent barrier for mainstreaming nature-based solutions is the high financial cost associated with urban greening measures in dense cities. Meanwhile, investment in nature-based solutions is constrained by uncertainty around the return on investment. As a result, grey infrastructure solutions are often preferred in urban development decision-making processes.

Tax reform (e.g. land use tax, wastewater charges) is one of the indirect measures that could incentivise the use of nature in urban development (van der Jagt et al. 2020b). For example, imposing a heavier tax on the use of resources (e.g. material, energy) can disincentivise harmful practices to the protection of urban nature. Tax reductions or subsidies for integrating nature-based solutions in built infrastructure and environment structures, in turn, could promote private investment. For example, granting public subsidies for construction of green roofs is one of the most used methods to achieve the public benefits of green roofs (see examples in Box 10).

Moreover, innovative financing models (such as crowdfunding, cooperative finance, green bonds, etc.) that support integrated approaches to sustainable development or even stipulate integrated ways of working as a requirement for external funding can be vital to stimulating green initiatives in cities. Funding mechanisms that stipulate projects to foster integrated ways of working will challenge silos and promote new and innovative partnerships, and thus can further facilitate the wider uptake of nature-based solutions. For instance, EU funds have been instrumental to the development of urban green infrastructure for the past several years and have sparked multidisciplinary cooperation on green infrastructure across municipal departments in Budapest.

Other fiscal mechanisms that can be used to leverage private investment for nature-based solutions include, for example, support for loans (payment of interests or guarantees), development fee waivers or building permit fee discounts, and income tax relief for owners/occupiers who invest in nature-based solutions. Besides fiscal mechanisms, regulatory instruments such as rent controls, or ceilings for home and land prices, are also effective in helping to avoid the financialisation of assets located close to new or refurbished nature-based solutions.

Hamburg: Green Roof Subsidies

In Germany, Hamburg is the first city to have developed a comprehensive Green Roof Strategy. The goal of the Strategy is to plant a total of 100 hectares of green roof surface in the metropolitan area in the next decade. The Hamburg Ministry for Environment and Energy is providing financial support for the creation of green roofs to the sum of € 3 million until the end of 2019. Building owners can receive subsidies to cover up to 60% of installation costs. Additional benefit stems from lower maintenance costs due to the longer lifetime of green roofs, lower energy costs because of improved building insulation and a 50% reduction on rain water fees thanks to the rain water retention function of green roofs. The subsidy will be paid both for refurbishing the roof as well as green roofs in new buildings. The subsidy system of the Green Roof Strategy also encourages the multi-functionality of green roofs – while a basic subsidy creates incentives to build a basic green roof while additional funding encourages more specialised, sustainable measures. Since Hamburg plans to have green roofs to be compulsory by law from 2020 onwards, one option for continuing subsidies is using them to enhance the quality of green roofs.⁹

Green Roof Subsidies in the Netherlands

In The Netherlands a green roof policy fits in a strategy to increase the natural capital of the city, in order to improve cities' liveability and make them future- or climate proof. Subsidies are applied in many Dutch municipalities often under the conditions of a certain amount of rainwater retention, a minimal surface of green roof, and an obligation for a careful design and construction. For example, in Rotterdam, the green roof policy started in 2008 maps out several measures to promote the construction of green roofs in the city. A subsidy scheme provides a financial incentive for building green roof. The municipality also stimulates building owners with reduction of levies, information days, actions and personal advice. All types of green roofs are allowed that use proper layers, have a surface of at least 10 m², can store water of at least 15 L/m², have a decent design and are carefully constructed. In 2019, there were 400.000 m² of green roofs in Rotterdam, and almost 235.000 m² of green roofs are applied (van der Meulen, 2019).

NRW Green Infrastructure funding in Germany

In the 2014-2020 period, a German federal state and the largest metropolitan area of the country (North Rhine Westphalia - NRW), provided a €88 million funding package for urban green infrastructure development, drawing on European (joint ERDF, EAFRD and ESF 'Strong Quarters - Strong People' call) and state funding. The fund is specifically targeted at employing urban green infrastructure to combat poverty and social exclusion. The 11 winning projects within the state all prepared 'integrated action plans', resulting in the planned development of green infrastructure in urban areas that are socio-economically disadvantaged and suffer from a negative stigma. Eligible applicants included municipalities and regional associations, providing match funding to a level which is set based on their financial circumstances. This case exemplifies the employment of economic instruments for integrated development of urban green infrastructure, particularly in areas of multiple deprivation.

⁹ See more details: <https://climate-adapt.eea.europa.eu/metadata/case-studies/four-pillars-to-hamburg2019s-green-roof-strategy-financial-incentive-dialogue-regulation-and-science>

3.11 DEVELOP MARKETS

Positioning nature-based solutions as a sustainability solution offering wide societal and reputational benefits can support the development of demand for nature-based solutions projects which in turn can stimulate supply.

Providing economic incentives can help create the right market conditions to encourage the establishment of nature-based solutions schemes. Currently, Developing markets for nature-based solutions can help both increase demand and stimulate supply. Stakeholders that value a “green” reputation are most likely to adopt sustainability solutions like nature-based solutions (Tozer et al. 2020). Our analysis found green roof companies in Sweden have already targeted commercial developers that hold green value. In the UK, as homeowners increasingly seeking for high quality green space, framing nature-based solutions as a cost-effective measure that can deliver sustainability benefits can tap into this growing market. Besides private companies and individual households, governments and public agencies that seek to bolster their green credentials can also be targeted (Tozer et al. 2020). One strategy to make this stepping stone particularly effective is to find ways to bundle demand from different customers, so as to incentivise the creation of more standardised and cost-effective nature-based solutions (Tozer et al. 2020).

In most cases, there is still a low perceived demand for nature-based solutions from clients and citizens. In Sweden, the construction company, Skanska, has considered offering climate adaptation services for its customers. But due to the shortage of demand from clients for integrating these services in new developments, the motivation to expand into this area is limited. In the Netherlands, however, there is a perceived societal change towards attention for urban sustainability and urban nature. This is reflected in the increasing demand for BREEAM and WELL certified buildings by both public and private clients (e.g. investors or office users). In Hungary, Biopolus, a group of environmental engineering companies specialising in urban water systems for neighbourhoods, established an open innovation platform and cooperation between companies, research institutions, and private individuals to usher in a broader market impact (see example in Box 11). Such initiatives that create and capitalise on demand for sustainability solutions present an effective measure in promoting the wider uptake of nature-based solutions.

It is important to note, however, preferences for nature vary, and the most biodiverse type is not necessarily the most preferred one by clients and citizens. In Germany, it is found that citizens like nature-based solutions when it looks good and can be used for recreation (Tozer et al. 2020). However, this can be challenging to build biodiverse nature-based solutions that tend to look ‘messy’ and sometimes are perceived as unsafe. Therefore, it would require communication amongst all stakeholders, especially between developers and end-users. Education that could raise the awareness of the urban residents about the potential benefits of nature-based solutions in the city and that could catalyse wider cultural change can also promote the demand and adoption of these solutions.

Green Roof Marketing Campaign organised by Dutch Insurance Firm

In order to address rising roof damage costs in its portfolio, home insurance firm Interpolis helped to stimulate the green roof market in The Netherlands by running a national marketing campaign featuring well-known media personalities demonstrating installations. The marketing campaign posed the question to consumers, 'What is your contribution to a sustainable world'? The campaign explained that homeowners can prevent environmental damage by turning roofs 'from grey to green,' contributing to insect habitat, improving rain run-off absorption, and reducing urban heat islands. To make green roofs more attractive for homeowners, Interpolis offered a free roof inspection and a standard low price through a collaboration with a green roof installation firm.

Biopolus' Wastewater Treatment Technology

Biopolus is a group of environmental engineering companies specialising in urban water-based solutions. Biopolus consists of two separate legal entities, one is the Biopolus Institute, which is a private, not-for-profit, research and development (R&D) organisation. And the other is Biopolus Technologies Inc. which is a for-profit entity, designed and build to commercialise the technologies and solutions developed by the R&D entity. Through integrating different types of knowledge and experimentation, Biopolus developed nature-based innovations that are attractive to clients and citizens. For example, Biopolus identified an opportunity around integrating knowledge in biochemistry and biorefinery in the development of nature-based solutions as to facilitate processes of urban metabolism and biological transformation. Using this knowledge, they are experimenting with ways that plants can be used in an urban wastewater treatment facility to support microbial ecosystems that clean wastewater on a very small surface if complemented by synthetic root structures also supporting these communities. These wastewater treatment facilities can be made to look like botanical gardens and can be integrated in dense urban environments, which makes them interesting from a visitor perspective. They are also economically attractive because they use less space compared to traditional wastewater installations.

3.12 BUILD CO-FINANCING ARRANGEMENTS

Build governance arrangements between the public and private sectors to enable co-funding for nature-based solutions development and maintenance

Governance arrangements that involve both public and private sector actors can help facilitate innovative co-financing for nature-based solutions. Traditionally, the planning and development of urban greening often fall under municipal jurisdiction. But in some countries (e.g. the UK), due to (central) government austerity, municipal budgets for the delivery of urban greenspace have significantly declined. Increasingly, stakeholders such as banks, insurance companies, other institutional investors and donor agencies play a role in shaping the funding landscape for nature-based solutions. However, coordinating between different stakeholders that each capture some of the (multiple) values of an urban nature-based solutions project was confronted with great challenges. Another significant challenge of investing on nature-based solutions is the hesitation of both public and private actors in taking responsibility for the ongoing maintenance costs, which is often perceived to be higher and more uncertain than traditional grey infrastructures (Toxopeus et al. 2020). Consequently, although it is recognised that nature-based solutions can deliver more co-benefits compared to their grey alternatives, there is limited incentive to consider them in the decision-making process at both the public and private funding bodies (Toxopeus et al. 2020).

Innovative co-governance mechanisms that stimulate co-funding into urban nature-based solutions can help to address these financing challenges. Co-funding nature-based solutions through new or existing financial instruments (e.g. green bonds) can enable all involved parties to share not only the cost but also the overall risks of developing and maintaining nature-based

solutions (Toxopeus et al. 2020). The stakeholders involved in a co-funding programme could be different public actors responsible for different policy agendas, private actors such as corporations that are valuing their green reputations, and non-governmental organisations (NGOs) that are increasingly working with local authorities and developing sustainability programmes for urban areas (Armstrong 2020). There is in particular a potential to include communities/citizens, water utilities and the insurance sector as co-funders. In Sofia, for example, Vrana Park is managed by a state company while welcoming the voluntary work of citizens for its maintenance. Citizen involvement like this can help overcome financial shortfalls and create a sense of responsibility and care for urban nature. Meanwhile, there are some potential actors that could co-finance urban nature-based solutions but are still largely absent in this field, such as the health insurers who are likely to obtain a significant cost reduction from nature-based solutions interventions (Toxopeus et al. 2020).

A typical mechanism that could help realise the co-financing of nature-based solutions is through a government-led or neutral third-party fund, which can pool a variety of actors as well as their parts of investments (Toxopeus et al. 2020). Examples of such funds include the Urban Forest Fund set by Melbourne municipality and the Water Funds set up by The Nature Conservancy (see both examples in Box 12). To ensure an efficient and effective operations, these mechanisms would require a transparent governance structure with clear investment criteria jointly decided by all parties, as well as a monitoring approach that can ensure the multiple benefits sought by different stakeholders are actually realised (Toxopeus et al. 2020). A public accountability structure would also be needed if nature-based solutions are developed on public space, to secure the fair distribution of funds while also preventing for-profit actors from excessively influencing public space in exchange for their funds (Toxopeus et al. 2020).

Melbourne: Urban Forest Fund (UFF)

The City of Melbourne launched the Urban Forest Fund (UFF) in May 2017 to provide financial support to new greening projects on privately-owned land which entails 75% of its total urban land area. The UFF specifically targets businesses, developers, property owners to undertake greening measures, such as green roofs, walls, tree planting and rainwater collection on private grounds. The UFF currently has AUS\$1.2 million in seed funding and the City of Melbourne's aim is to increase this through contributions from organisations and individuals either as supporters or as partners. Under the public-private partnership scheme, the UFF aims to increase the amount of green infrastructure across the city area by fund-matching greening projects dollar for dollar.

Mexico City: The Co-funded Landscape Conservation Pilot Project

In Mexico City, the first landscape conservation pilot project (587.76 ha) in Topilejo cost around 27.1 million pesos (~€1.164 million). The initial funding of this pilot project came from the local government, while all partners contributed to its implementation cost. This pilot includes 'active' (i.e. restoration of degraded land) and 'passive' (i.e. preservation of areas in a good state) conservation limiting the growth of agricultural production with the goal of maintaining and improving infiltration and recharge. It also includes productive reconversion (201.53 ha) for the development of agricultural activities compatible with maintaining forest cover, which facilitates infiltration and recharge, economic viability, and landscape-quality improvements. The budget is shared 50-50 between a new non-profit *Por el Agua de la Ciudad de México* (For the Water of Mexico City) who manages the Water Fund (which was initiated by the Nature Conservancy), and the Mexico City Secretariat of Environment. The transparency and credibility of this new governance structure

Local Crowdfunding platform

In the 2014-2020 period, a German federal state and the largest metropolitan area of the country (North Rhine Westphalia - NRW), provided a €88 million funding package for urban green infrastructure development, drawing on European (joint ERDF, EAFRD and ESF 'Strong Quarters - Strong People' call) and state funding. The fund is specifically targeted at employing urban green infrastructure to combat poverty and social exclusion. The 11 winning projects within the state all prepared 'integrated action plans', resulting in the planned development of green infrastructure in urban areas that are socio-economically disadvantaged and suffer from a negative stigma. Eligible applicants included municipalities and regional associations, providing match funding to a level which is set based on their financial circumstances. This case exemplifies the employment of economic instruments for integrated development of urban green infrastructure, particularly in areas of multiple deprivation.

3.13 WORK WITH INVESTMENT CYCLES

Integrating urban nature-based solutions into infrastructure projects and renovation cycles increases their (multi)functionality and can save costs by reducing the need for additional outlay and drawing on existing budgets

Integrating nature-based solutions into building developments and renovations can reduce costs by drawing on existing budgets and can also expand the functionality of existing infrastructure. Finance is often seen as one of the key challenges for the development and implementation of nature-based solutions in cities. While seeking additional funds specifically for nature-based solutions can be challenging, making use of existing investments in urban development presents an impactful solution for financing nature-based solutions (Toxoepus et al. 2020).

In the EU, building sector accounts for 40% of overall energy consumption, and approximately two thirds of the buildings across Europe were built before energy performance standards even existed. Renovating and retrofitting building stock will help pave the way for a decarbonised and clean energy system. Seeking to meet the targets and goals set by the Paris

Agreement, countries across Europe are developing policy-driven renovation financing instruments, such as the ‘building-based financing’ in the Netherlands, and renovation subsidies and loans in Spain, Germany, and the Netherlands (Toxopeus et al. 2020). Recently, this momentum has been further enhanced as the European Commission published a new strategy on 14 October 2020 to boost renovation called “A Renovation Wave for Europe – Greening our buildings, creating jobs, improving lives’. With aims to double annual energy renovation rates in the next decade, this strategy is likely to stimulate massive building renovations. This presents a great opportunity for mainstreaming nature-based solutions, since their integration into planned renovation and retrofitting projects can capitalise on the funding and investments flow towards building renovation.

Moreover, due to their multi-functionality, nature-based solutions can deliver synergistic urban infrastructure comparing to the often single-objective grey infrastructure. Since the provision of urban infrastructure and its management are mainly the responsibility of local governments, mainstreaming nature-based solutions into urban infrastructure projects can draw public spending in this regard (Toxopeus et al. 2020). Such integration can also make use of the lower-value and fragmented spaces in cities, when identifying and competing for large vacant land becomes extremely difficult.

Box No. 13

Green development of urban infrastructure in Sweden

Municipal investment in urban infrastructure in Sweden offers a substantial opportunity for synergies and cost savings through multi-functional infrastructure that delivers on climate adaptation, mitigation, and ecosystem services. The government articulated that urban greenery and ecosystem services must be integrated into the planning, building and administration of Swedish cities by 2025. Significant investment in transportation, public housing, culture, and recreation flows through local governments, supported by revenue from taxes. Green streetscapes can be pursued through transportation budgets, for example, rather than environmental protection budgets. Overcoming the perceived conflict between policies that promote dense urban infrastructure and policies on urban greening will help unlock public infrastructure investment for nature-based solutions.

Sustainable Urban Drainage System (SuDS) in the UK

In the UK, nature-based solutions are often linked to issues of flooding and water treatment. Sustainable Urban Drainage Systems (SuDS) are not mandatory across the UK, but environmental regulators and many local authorities and developers are keen to implement this approach in addition to traditional urban drainage systems. Some water utilities are increasingly interested in SuDS where they were previously focused on pipes and sewers. Thames Water, for example, aims for SuDS implementation to be expanded in a five-year period. They recognise that nature-based solutions not only can address everyday water management, but also have additional benefits for climate change risk mitigation. Taking advantage of increasing investment in SuDS from water utilities and finding mechanisms to encourage multi-functional SuDS beyond water management present great opportunities for nature-based solutions mainstreaming.

Network Rail Commits to Support Biodiversity

In the UK, infrastructure providers are developing biodiversity plans and strategies in the context of a planning system that is headed towards mandatory biodiversity net gain for new large developments. In particular, Network Rail has been working with Natural England to look for opportunities to incorporate net biodiversity gain into infrastructure projects. Network Rail is in a unique position to deliver improvements in biodiversity within the UK. As one of Britain’s largest publicly funded bodies and one of its largest landowners, it is responsible for 20,000km of track and 52,000 hectares of land. Its railways run through some of the most fragile and valuable habitats, and provide important corridors for wildlife. In July 2019, the Department for Transport directed Network Rail to address biodiversity in a report called Enhancing Biodiversity and Wildlife on the Lineside. This represents an opportunity for integrating nature-based solutions into existing spending on urban infrastructure. The knowledge tools developed around biodiversity offsetting and net gain have been particularly helpful for these stakeholders.

¹⁰ <https://www.euneighbours.eu/sites/default/files/publications/201802/Clean%20energy%20for%20all%20Europeans.pdf>

¹¹ https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1835

3.14 STIMULATE INSTITUTIONAL INVESTMENT FOR RISK REDUCTION

Institutional investment for urban nature-based solutions is likely to be forthcoming based primarily on their climate risk reduction value (adaptation and mitigation), and specific data/modelling may be required to realise this potential.

Increased awareness of climate (and biodiversity) risks at public authorities and mainstream financial institutions holds great potential in driving investment into nature-based solutions. As climate change impacts increase in scope and severity, more countries and cities are developing climate change adaptation (CCA) plans that feature measures to combat extreme weather events such as heat waves and strong rainfall. Simultaneously, financial sector players across Europe (banks, institutional investors and insurers) are required to respond to the EU regulatory requirement for increased transparency on the exposure of their investment portfolios to climate-related risks. Disclosure requirements of climate risk in institutional investment portfolios is currently being pushed forward by the guidelines developed by the Taskforce for Climate-related Financial Disclosures (TCFD). As a next step, the Dutch Central Bank is also actively pushing for disclosure of biodiversity risk in investment portfolios.

The combined momentum at both public authorities and at financial institutions to consider and disclose climate change risks in their decision-makings and practices could lead to increasing funding geared towards CCA measures (Toxopeus et al. 2020). While grey infrastructure such as sewage pipes, flood walls, and air-conditioning in buildings has long been preferred in CCA funding, nature-based solutions that use biodiversity and ecosystem services to help people to adapt to the adverse effects of climate change provide a convincing alternative solution. Nature-based solutions involve activities such as planting vegetation on slopes to prevent landslides, restoring coastal habitats to address sea level rise and storm surges, applying integrated water resource management to address water shortages, and managing forests sustainably to prevent erosion and regulate water flow. Due to their great potentials in both managing urban environment and lowering energy demands and absorbing greenhouse gas emissions, positioning nature-based solutions firmly as an effective adaptation and mitigation measure can thus draw on urban climate investment and funding (Toxopeus et al. 2020). Additional interest in nature-based solutions investment to reduce climate and other physical risk is generated by the cost-effectiveness of green and blue infrastructure in the face of multiple urban sustainability challenges. The scale of current and projected impacts (of climate change and biodiversity loss for example) makes some grey infrastructure solutions unfeasible, which also presents significant opportunities for nature-based solutions.

To make the case for nature-based solutions and to draw public and private investments, nevertheless, would require the development and dissemination of valuation models that specify the different (monetised) benefits and costs of these solutions (see stepping stone 17 – Advance valuation model). Understanding the cost and benefits of nature-based solutions intervention can also facilitate the establishment of new partnerships between the public and private sector actors that have shared interests in reducing climate risks (e.g. insurers and property owners) and make use of new or existing financial instruments (e.g. green bonds) to co-fund nature-based solutions.

Natural Climate Solutions in Swedish Cities to Address Flooding and Heat Waves

While climate change mitigation has been a priority in Sweden, recent heavy rainfalls and heat waves have increased the focus on climate change adaptation. In some Swedish cities, growing concern about climate impacts is starting to redirect financial resources, shift the priorities of agencies, and motivate changes to planning rules in order to adapt to extreme weather. In recognition of this growing interest, the climate adaptation benefits of nature-based solutions are increasingly being recognised in cities like Malmö.

The Potential of Sweden's Green Bond Market in Driving Urban Nature Investment

Sweden's green bond market is expanding rapidly, driven by national pension funds that are required to take environmental impact into account in their investments. Since green bond investors do not need to report on physical risks of green bond projects, attention to climate risk is currently limited. However, implementation of disclosure requirements of climate risks could stimulate investment into nature-based solutions as a route to lowering climate risk in investment portfolios. Green bonds are well-suited for upscaling urban nature investment, because they are priced more attractively for municipalities and offer added transparency on environmental impact compared to regular bonds.

Platform Carbon Accounting Financial (PCAF) developed in the Netherlands

Financial firms in the Netherlands have jointly set up an industry initiative called Platform Carbon Accounting Financials (PCAF), aiming at integrating accounting for carbon emissions within all investment portfolios. It shows how financial institutions can work together to develop joint knowledge paradigms that underpin their sustainable investments and loans. While starting in the Netherlands, PCAF is now being spread at a cross-country level. The approach also offers a blueprint for what financial institutions could undertake at a sector level for biodiversity accounting, perhaps helped by the expertise of frontrunners like ASN Bank and Triodos Bank, who actively aim for a biodiversity-positive investment portfolios and work hard to develop indicators that allow this to be monitored (Platform Biodiversity Accounting Financials, PBAF).

3.15 TARGET AREAS OF LOW LAND VALUE

Nature-based solutions can face competition from other land-uses which provide a higher return on investment. Using urban space with a lower value can suit some forms of nature-based solutions and provide a more cost-effective means of urban greening (e.g. street green, pocket parks and building-integrated green).

Land in urban areas varies in value, from premium land that can command high investment and returns in commercial areas, to smaller and fragmented parcels of land that are considered to be of lower development potentials. Meanwhile, there are also many underutilised spaces in cities, such as the terraces, rooftops and balconies of various buildings, structures, bridges, etc. It is often such 'low value' land and underutilised spaces that can provide considerable opportunities for nature-based solutions.

Currently, while the importance of urban nature-based solutions in the context of climate change has been widely recognised by policy makers across Europe, an important issue of urban planning and development is the dire need of affordable housing in cities. Many municipalities in the Netherlands, Germany, Sweden and the UK have prioritised the provision of additional housing. Reasons (which partly overlap) underlying this include projected population growth, increasing housing demand due to urbanisation, increasing per-capita living area in cities, speculative real estate investment in urban areas and decreasing amounts of affordable housing within the existing housing stock (Toxopeus et al. 2020). Under such increased pressures, many cities chose to grow densely on available slots within the already built area instead of horizontally towards

their green and rural surroundings (Toxopeus et al. 2020). This however leads to a significant challenge for nature-based solutions to compete for spaces within the city, due to the increasing land-use opportunity cost.

Local governments often have limited capacity to develop green-blue infrastructure and to find and create spaces for nature-based solutions. Consequently, targeting areas of low land values or attaching 'green' to 'grey' buildings and infrastructures in the city can be cost-effective and can be a promising approach for promoting nature-based solutions. In low-income areas of densely populated cities, in particular, small vacant lots and other plots of land that face less competition from other uses presents great opportunities to develop nature-based solutions, which in turn can greatly promote people's access to urban nature, as well as social inclusion and environmental justice.

Box No. 15

Finding spaces for nature in Hamburg

In Hamburg, steep competition for plots of land due to private ownership or land earmarked for housing development creates a challenge for new green areas. The growing density of the city fuelled a strategy of expanding green roofs, and identifying alternative locations for urban nature. Building on biodiversity offsetting regulation that has been mandatory in Germany since the 1970s, Hamburg developed an accounting system for urban nature that incentivises real estate developers to create or enhance natural areas in other parts of the city. While hampered by implementation delays and offsets sometimes landing at the city outskirts, competition for urban space has driven a focus on quality over quantity of urban nature, for example increased spending on maintaining urban parks.

Scottish Green Infrastructure Fund

Marginalised groups in cities are more likely to live in disadvantaged areas with limited access to green space. Therefore, developing nature-based solutions in those areas, and in particular utilising areas of low value land, can produce significant social benefits for marginalised groups and hence contribute to social inclusion. For example, a project of the Scottish Government's Green Infrastructure Fund developed a former primary school site that was inaccessible and severely contaminated – into nature-based solutions. The site was transformed into a Community Green Space with areas of biodiverse plantings, raised bed allotments, recreational areas for children, outdoor exercise equipment, and outdoor education areas. The project also offered information about the historical heritage of the area. While multiple benefits can emerge from targeting areas of low land value, such initiatives should be accompanied by rent controls or measures that maintain housing prices in order to prevent a new wave of gentrification.

Green Bus Stops in Utrecht

Bus stops offer an ideal surface for greening providing an attractive green space in the concrete dominated urban streets. The living vegetation installed on the bus stop is in a prime position to filter pollution and particulates from transport exhausts thereby protecting the health of waiting passengers. It also highlights sustainable design and green travel in attempts to reduce impacts of climate change. Greening the bus shelters demonstrates the value of attaching green to urban grey infrastructures. In Utrecht, in response to a tender by the municipality for ideas to promote healthy urban living, an advertisement agency installed green roofs on in total 316 of Utrecht's bus stops. These green bus stops contribute not only to a good publicity but also to support local biodiversity.¹³

¹³ See <https://naturvation.eu/blog/20200507/vertical-forests-and-green-bus-stops-utrecht-raises-bar-rooftop-greening>

3.16 IMPROVE DATA & MONITORING

Mainstreaming nature-based solutions requires the development of evidence on their performance, through the use of 'big data' and new assessment tools that can support effective monitoring, evidence-building and assessments of their effectiveness in addressing key urban goals.

Developing evidence of the performance of nature-based solutions, through effective monitoring, assessment tools, and the use of 'big data,' is central to mainstreaming these solutions in cities. Often, grey infrastructure solutions are preferred over nature-based solutions in urban development decision-making processes. This status quo is reinforced by urban development practices that value, for example, engineering expertise, established quantitative data, and single-objective solutions with proven effectiveness to what is perceived as a 'more risky' longer-term delivery of multiple benefits through nature-based solutions. As the urban development sector relies on quantifiable data to make planning decisions, the often case-specific nature of nature-based solution's design and benefits can generate significant pushback from engineers and technicians. Meanwhile, the lack of universal indicators, which would provide a comparison between green and grey infrastructures and calculate the added value to urban areas, establishes another big obstacle to securing support for nature-based solutions.

Improving data and monitoring around the value of nature-based solutions can help to overcome scepticism towards these solutions. It can also make the case for investing in certain solutions and establish the business case by delivering evidence on risk reduction potential and other benefits. While qualitative indicators are needed for systematically assess the multifunctional benefits of nature-based solutions, improved quantified data could be influential in determining whether or not they are funded and incorporated, especially in the earlier stage of the development process. In Sweden, for example, there is a need for quantitative indicators of nature-based solutions impact in order to integrate them as investable projects through green bonds. Moreover, while site-specific evidence is available in many cases, upscaling or transferring it to another region or context while ensuring accuracy remains difficult.

Data portals, maps and other digital tools can improve monitoring and quantify the evidence. In the Netherlands, some municipalities invest in their own internal knowledge base on sustainable urbanisation, which could also be used in reporting for the 2030 Agenda. Private and public sector actors in the insurance and banking sector can also contribute important knowledge in this regard. For example, sustainable banks in the Netherlands have developed methods to calculate the ecological footprint of their loan and investment portfolios by sector, often using water and land use indicators. The Spanish public insurer Consorcio de Compensación de Seguros is actively mapping all flood losses in Spain and shares this data with the academic community and public sector upon request. New knowledge tools that can better recognise nature-based solutions benefits also allow practitioners to embrace such solutions (Tozer et al. 2020). For example, Building Information Modelling (BIM) is a software tool for building design that can show stakeholders how these solutions benefit other parts of the project objectives and where they would fit best. Similarly, lifecycle assessment methods are a helpful tool to acknowledge the costs and benefits of development projects beyond the construction phase, so that potential benefits of nature-based solutions are more clearly shown. Such tools could lead to the wider uptake of nature-based solutions.

LIFE – My Building Is Green

The overall objective of the LIFE – My Building Is Green project is to contribute to increasing the resilience of social buildings and educational centres by implementing nature-based solutions as prototype of climate adaptation and improve well-being. Three pilot schools are being greened in Spain/Portugal. This project (LIFE-My building is Green) develops evidence through monitoring of how building-integrated greening for schools can combat the heat island effect. Such knowledge could be used to support economic regeneration as minorities and poorer citizens are often hit hardest by excessive heat in cities, resulting in negative effects on health and productivity.

Monitoring Involved in Nature-based Solutions that Serve Insects

Nature-based solutions initiated to serve insects often carry elements of social and technological innovations. Urban beekeeping has turned into a space for experiments with forms of smart urban development, such as monitoring of hives, learning and experimentation, and data-sharing orientated toward biodiversity protection and environmental education. In Newcastle, new beekeeping practices have been introduced through the use of advanced digital hive monitoring equipment, which was developed by the Urban Observatory and Arnia (a private business) and provided for free to beekeepers. The long-run monitoring of hives leads to conservation-related learning and enables beekeepers to more effectively and efficiently look after their hives. In Győr, beekeeping is also monitored, and key performance bio-indicators are analysed by the University of Sopron. These bio-indicators, based on the analysis of the honey, beeswax and pollen, can show pollutants and thus enhance long-term environmental knowledge. The approach of using bio-indicators

RESILIO project in Amsterdam¹⁴

RESILIO stands for “Resilience nEtwork of Smart Innovative cLimate-adaptive rOoftop” and is testing a solution that combines the positive effects of a green, planted roof surface with a water reservoir installed underneath. These smart blue-green roofs are designed to help the city of Amsterdam to adapt to climate change by reducing impacts of heavy rain, urban heat island effects and drought while improving building insulation, biodiversity and the well-being of city dwellers. Aiming to disseminate and scale up the solution in the future, the multiple effects of a 450 m² pilot roof, so called “Innovation Lab”, are being measured and monitored. For example, researchers investigate how much water is saved and also look into the effects of evaporation to evaluate the roof’s reuse of rainwater.

3.17 ADVANCE VALUATION MODELS

Making the case for nature-based solutions requires that we develop and disseminate valuation models that specify the different (monetised) benefits and costs of nature-based solutions, to facilitate public and private investment decisions.

Valuation models that monetise the benefits and costs of nature-based solutions can help governments and investors steer investment toward sustainable infrastructure. While energy efficient and green buildings are highly valued in Europe, there is limited awareness of the possibilities of nature-based solutions to realise this. Concerns about the cost of nature-based solutions go beyond the site-specific expertise demanded for their implementation, but also relate to uncertainty about construction and long-term maintenance costs and the relative long-term payback in developing urban infrastructures. Also, although understanding of the various benefits of nature-based solutions (e.g. health and well-being) is increasing, developers often do not consider such wider benefits, as these often take the form of public goods and are not limited to those financing the nature-based solutions. This is compounded by the lack of accepted methodologies to account for the full range of nature-based solutions benefits (extending beyond their main objective), let alone to translate these into monetary figures. This thus further limits their consideration alongside grey infrastructure options.

¹⁴ <https://www.uia-initiative.eu/en/uia-cities/amsterdam>.

Improving data, modelling, and performance metrics to increasing the valuation of nature-based solutions thus plays a key role in mainstreaming nature-based solutions. In the context of conflicting options, economic valuation of nature-based solutions through cost-benefit analysis can assist decision-making. An example of a valuation tool is the 'Green Benefit Planner' (GroeneBaten Planner), which was developed in the Netherlands. It provides an estimate of the monetary value associated with nature-based solutions, making it easier to include these into investment decisions. When city planners and investors are informed about these added benefits, they could be more likely to support and initiate nature-based solutions, especially in a dense city with high opportunity costs for green space. Another example here is I-Tree, a tree valuation software developed in the US, has been taken up by municipalities as a way to quantify the value of (different types of) urban trees.

While appropriate quantification of nature-based solutions data will help, their mainstreaming will also require accommodating new ways of understanding risk and performance. In the insurance sector, valuation models inform catastrophe risk modelling and risk management. Existing models include Sustainable Asset Valuation (SAVi), which assigns financial value to economic, social, and environmental risks and shows how these risks affect the financial performance of infrastructure projects.

Standardised and quantified evidence regarding the (monetary) advantages of urban nature-based solutions could leverage more private investment in developing them. It can also be effective to express the environmental and social benefits of nature-based solutions in a monetised way. In many Dutch cities (e.g. Rotterdam and Amsterdam), analysis has been conducted to evaluate the cost-effectiveness of urban green spaces (Toxopeus et al. 2020). Social return on investment (SROI) is a method for measuring values that are not traditionally reflected in financial statements, including social, economic, and environmental factors. Using SROI to translate the multiple values of urban nature-based solutions into monetary terms can be impactful in increasing investment into urban nature-based solutions.

It is to be noted, however, while monetising nature and its contribution and benefits for people can to some extent and in some cases, incentivise environmental behaviour in municipalities and for corporations (such as integrating nature-based solutions in their decision-makings), we should recognise that nature has an intrinsic value that money cannot measure correctly, and that whether and how to value nature should be gauged carefully considering the ecological and social contexts and consequences (Kallis et al. 2013). Advancing valuation model that can capture and present both the direct and indirect benefits and costs of nature-based solutions is thus a key.

Natural Capital Accounting in the UK

Natural Capital Accounting is an established valuation model in the UK. An independent government advisory committee composed of academics, Natural Capital Committee, advises the national government on the value of the UK's natural assets to the economy and provides input on policy. The Committee tests out their guidance on valuing natural capital in specific places by partnering with five Pioneer Projects throughout the UK, and other local governments have piloted natural capital accounting for their jurisdictions. The Office for National Statistics produces annual reports on natural stocks in the UK and ecosystem services provided by green space in urban areas, such as cooling and property value increases. Natural capital is also embedded in the country's Industrial Strategy.

Green Benefit Planner in the Netherlands¹⁵

The Green Benefit Planner is a tool developed by RIVM public health agency in the Netherlands to deepen decision makers' understanding on the effects of spatial planning on ecosystem services and how this, in turn, affects a city's inhabitants. It does so by quantifying ecosystem services and evaluating fluctuations in values given the application of different scenarios. Ecosystem service indicators adopted can reflect physical quantities (e.g. particulate matter retention by plants), social quantities (e.g. the effects of particulate matter retention on human health), and monetary quantities (e.g. the reduced health costs associated with increased particulate matter retention). The Green Benefit Planner adopts models from the Natural Capital Model (NK-Model). Additional models were developed to generate a general overview of the benefits of ecosystem services produced by urban green infrastructure to human health and well-being, and to evaluate the linkages that exist among them.

The Natural Capital Atlas in the Netherlands

Natural Capital Atlas (Atlas Natuurlijk Kapitaal – ANK) is one of the instruments developed with funding by the national government of the Netherlands to quantify the benefits of nature-based initiatives. ANK is a repository for spatial maps visualising different kinds of ecosystem services (e.g. soil fertility or historic features), enabling a better awareness of natural capital at local levels. Given that this instrument is still in the development stage, the impacts on actual realisation of urban nature-based solutions has not yet been widely explored.

3.18 GROW PRACTITIONER EXPERTISE

Make practitioner-oriented expertise on urban nature-based solutions available to facilitate integration of nature-based solutions in the actual urban development process (i.e. practitioner guides and collaborative design).

Practitioner expertise is integral to the inclusion of nature-based solutions in urban development processes. A crucial cross-cutting challenge for mainstreaming nature-based solutions relates to the lack of expertise on their design, implementation and upkeep. This is related to their multifunctional characteristics, which not only do not neatly match the expertise in established professional disciplines or policy areas, but also tend to be challenging in adequately fitting with place-specific conditions affecting the delivery of those various values (Tozer et al. 2020).

To overcome knowledge deficits, there is a need for new knowledge developed through ongoing experimentation (see 'Establish demonstration projects'), and through research activities that seek to develop evidence base, valuation metrics and tools, as well as implementation guidance for nature-based solutions. Meanwhile, the dissemination and sharing of already available relevant expert knowledge as well as lessons learned from existing practices with practitioners are also impactful. The German government, for instance, produced a White Paper called 'Green Spaces in the City' to compile all

available expert knowledge on how nature-based solutions function in cities; and in Spain, a local government network developed a guide to direct municipalities on managing and financing green infrastructure and urban nature-based solutions (see examples in Box 18).

It is also important to note that practitioner expertise needs to be integrated from the outset of the design and implementation of specific projects. Poor understanding of the local conditions and the lack of knowledge on particular nature-based solutions could result in ill-designed projects that would have reverse effects or could cause 'implementation gaps', which means that the outcomes do not match the original goals. Collaborative design processes can be helpful here, since it can convene diverse partners to work together, so as to pool different expertise possessed by different stakeholders but needed for designing and implementing practical nature-based solutions.

Box No. 18

Spain: The Guide of the Municipal Green Infrastructure

The Guide of the Municipal Green Infrastructure was jointly developed by the Spanish Federation of Municipalities and Provinces (FEMP), the Network of Local Governments + Biodiversity, Association of Green Infrastructure Management Companies (ASEJA) and the Spanish Association of Parks and Public Gardens (AEPJP), with the technical advice of a specialist. This broad comprehensive document (515p including annexes), meant to be used as handbook for green infrastructure development, and thus it is written in a simple language that can be understood by any audience. It includes definitions and examples of green infrastructure, nature-based solutions, ecosystem services as well as several financing pathways to implement or improve these projects and examples from different countries. A compact version of the document will include feedback from the different municipalities/users and can be used as a technical guide.

Germany: The Green and White Paper on Urban Green Spaces

In June 2015, the Federal Government of Germany published the "Urban Green Spaces" Green Paper, which contains a survey of the functions of public green spaces and urban green infrastructures. The Green Paper triggered an integrated and long-term process as well as a broad dialogue on the future value of urban green spaces and open spaces. On the basis of the Green Paper, a White Paper on Urban Green Spaces was drafted and officially presented in May 2017. In the White Paper, ten fields of action with concrete measures for protecting and enhancing urban green and open spaces are presented. The Federal Government has also produced a range of means to support the work of municipalities and other actors in the field.

Munich: Greening Office

The Greening Office is part of a non-governmental organisation (NGO) called Green City. It aims to increase awareness and engage citizens and the private sector in implementing greening measures on private plots across the city. Green City was founded in 1990 by a handful of dedicated citizens with the goal of creating a people-friendly green Munich; today it is the biggest environmental organisation in Munich. The NGO is supported by the City Council as part of its climate protection program. The Greening Office, created with co-financing from the city of Munich, offers free-of-charge expert knowledge and advice on green walls, green roofs, and other issues relevant for greening private lots. By doing so, it not only facilitates the uptake of greening activities, but also increases awareness of and supports climate adaptation.

3.19 INCORPORATE IN GREEN INVESTMENT PRODUCTS

Include urban nature-based solutions into (existing and new) green/impact/sustainable investment products in order to enable projects to access this source of finance.

Finance will flow more readily to nature-based solutions if they are specifically targeted by green investment products. Despite the growing demand and momentum for sustainable investment across Europe, nature-based solutions are often difficult to be incorporated into the standard investment procedures of large, institutional investors (Toxopeus et al. 2020). This could be for many reasons. For instance, nature-based solutions are often seen to be too innovative to be trusted and to be implemented. Their place-specific benefits, the lack of unified assessment/valuation methods, and the lack of practical knowledge on their implementation and maintenance deter investors and developers from investing on them. Being excluded from the most salient sustainability criteria may also play a role for the limited investment on nature-based solutions. Moreover, the features of diverse types of nature-based solutions may also play a role. While certain types of nature-based solutions such as urban agriculture that provide marketable products are more easily privately financed, some nature-based solutions such as urban forests deliver nature-based value with mostly public good characteristics (e.g. improving air quality) are unattractive to private investors. In addition, small-scale projects (such as a green roof) are often difficult to be financed alone, and those require long-term operation and maintenance to demonstrate their effects (such as sustainable urban drainage systems) might just cannot fit into the relatively short-term investment. For these different reasons, there exists a mismatch between investment needs on the municipality level and actual investment on urban nature-based solution (Toxopeus et al. 2020).

While there is a rising consumer demand for investments that deliver on environmental outcomes, international financial entities have raised the profile of climate risk and responsible investment. Therefore, sustainable investment products have the potential to allow investors to directly support nature-based solutions. Local government bonds that support sustainable urban infrastructure are growing and can facilitate the investment and development of a variety of smaller scale projects. In Sweden, banks and project representatives can apply for their projects to be included in the green bond market and judged for their level of 'greenness' by an expert committee. This also confirms that scaling up, pooling of projects and standardisation of metrics can help address the 'mismatch' in the market, and lower the transaction costs for institutional investors of investing into urban nature-based solutions. Developing quantitative indicators on the performance of nature-based solutions that are compatible with green bond reporting, and developing green investment products that recognise qualitative indicators, will help channel more support to these solutions.

Institutional investment in urban sustainability could benefit from the financial sector providing greater transparency on the sustainability of their funds. The EU Taxonomy is a regulatory classification system under which companies and organisations may define which of their economic activities or products are environmentally sustainable. The regulation also requires certain companies to report and disclose the extent to which their business activities are consistent with the Taxonomy's definition of sustainable. Making sure urban nature-based solutions are clearly defined as a green investment for real estate and infrastructure development in the EU Taxonomy can thus create an opportunity for promoting the mainstreaming of nature-based solutions into institutional investment portfolios (Toxopeus et al. 2020).

The Natural Capital Finance Facility

The Natural Capital Finance Facility helps ensure that nature-based solutions are clearly defined as a green investment in European infrastructure development. Loans of at least 5 million Euros are granted through this facility and require the generation of a nominal income stream in addition to delivering natural capital improvements such as tree planting, green roofs, or sustainable drainage systems. The European Investment Bank, a major provider of climate finance, collaborated with the European Commission to establish the facility, which comes with technical assistance and requires that projects are funded by multiple sources. Other banks such as European Bank for Reconstruction and Development and ASN Bank are also engaging in finance for green infrastructure.

The Natural Capital Investment Plan of the Greater Manchester

Investment in urban nature-based solutions specifically could be aided by the development of investment funds linked to natural assets, as demonstrated by the Natural Capital Investment Plan developed by the Greater Manchester Combined Authority. Drawing on a natural capital accounting exercise, Manchester has created a pipeline of proposed natural capital projects that are investment ready and combined them into a portfolio in order to attract investors. A key goal of the plan is to attract and blend public and private finance. The Investment Readiness Fund under the plan collects investment grade projects with known locations that are cross-referenced with natural capital accounts so that they can evaluate where investments are likely to have ecosystem benefits. They have identified three funding models in particular: 1) Place-based portfolio models, 2) Habitat and carbon banking, and 3) Sustainable urban drainage systems. The place-based portfolio model involves leasing green and blue infrastructure to citizen groups or Trusts, which could then exploit revenue opportunities (e.g. café). Habitat and carbon banking involve selling credits from actions that increase biodiversity or carbon storage to organisations to compensate for unavoidable impacts. Sustainable urban drainage systems already have a revenue mechanism through a reduced water connection charge for developments.

3.20 PROMOTE CERTIFICATION SCHEMES

Integrate urban nature-based solutions criteria into green certification schemes, in particular for buildings and infrastructure, based on recognition of the contribution nature-based solutions can make towards sustainability goals.

Integrating nature-based solutions into existing tools that play an influential role in the urban development sector can open up significant opportunities for their mainstreaming (Tozer et al. 2020). Certification schemes are often goal- and target-oriented and provide indications of progress on sustainability in the urban development sector. Certification processes encourage developers and engineers to a higher quality of standards in designing, constructing and managing buildings sustainably. Certification schemes and building standards can also provide knowledge for integrating nature-based solutions into urban projects, offering clear indicators and monitoring tools to establish and harmonise the value that is obtained from these solutions. They can bring siloed stakeholders together during project planning processes so as to demonstrate the multiple benefits of nature-based solutions. They can also coordinate joint investment and developments.

In general, inclusion of urban nature-based solutions into existing or new certification schemes is likely to increase investment into these solutions as well as provide a starting point for developing non-voluntary standards through regulation (Toxopeus et al. 2020). Our analysis found that sustainability certification schemes are taken into account in portfolios of real estate investment in the Netherlands, UK and Sweden (Toxopeus et al. 2020). Through these schemes, investments can be assessed for their sustainability performance, which can incentivise the adoption of nature-based solutions. Scaling up certification schemes to institutional investment levels and including them in regulatory guidelines can further promote the mainstreaming of nature-based solutions.

While not a legal requirement, certification schemes are increasingly used across Europe. For instance, one third of offices in Budapest in Hungary now have a green certificate. In Sweden, adherence to green bond standards is a way of including urban nature-based solutions into real estate investments and development. In other countries, like Spain and the Netherlands, a focus on circular building certification is deemed to provide an opportunity for building-related green (such as green roofs, walls, parking lots and surrounding). LEED, BREEAM, DGNB, and WELL are among various sustainable building certifications that are currently being used. BREEAM and LEED measure sustainable supply chains of used materials and building performance, while the WELL certification is more user-oriented with a stronger focus on human happiness and productivity, assessing opportunities for interaction with nature in building design. These certifications do not necessarily highlight nature-based solutions and often their focuses lie with energy efficiency and material use. It may also be challenging to integrate nature into their core requirements. However, these certifications carry considerable institutional support and extensive industry expertise, which can be critical for greater inclusion of nature-based solutions. Meanwhile, new certification schemes have been developed that focus specifically on urban nature-based solutions, like the program 'Building with Nature' in the UK (see example in Box 20), which aims to limit or offset the environmental impacts of developing thousands of new homes and promote healthy communities that are closer to nature.

Box No. 20

The 'Building with Nature' Accreditation Scheme

The Building with Nature certification program in the UK uses green infrastructure standards to ensure that the building of new homes also delivers for the natural world and allows people to live closer to nature. Under the scheme, developers can apply to have their development assessed and planners can apply to have their policy documents accredited, and awards are given out to incentivise the delivery of high-quality green infrastructure. Developers choose to pursue the voluntary certification due to direction from local government, the competitive advantage of green certification, or to reduce the time and cost in the planning approval process. The program also serves as an opportunity to educate developers about the cost of not pursuing green infrastructure.

The DGNB Certification Scheme

The DGNB (German Sustainable Building Council) certification scheme is the dominant green building certification tool in Germany. Differing from the other certifications (e.g. LEED and BREEAM), the DGNB certification scheme solely assesses whether goals are met, but not how, leaving room for diverse measures (such as nature-based solutions) to be taken, so that measures can for instance be adapted to other environmental conditions. Criteria for the DGNB certification are decided upon by a mixed team of academics and practitioners, among other things to come to a consensus about what can be realistically expected. It is, however, unclear whether such 'realism' means good or bad news for the integration of nature-based solutions, particularly in light of the uncertainties regarding costs, benefits and the distribution of benefits (e.g. those who invest may not be the biggest beneficiaries). Such uncertainties may result in urban development professionals vetoing criteria that would benefit nature-based solutions.

Certification Schemes for Sustainable Buildings in The Netherlands

In the Netherlands, three sustainability certification schemes are predominantly used in the urban development domain: BREEAM, LEAD and WELL. The BREEAM certification scheme, developed in 1991 in the UK and managed for the Dutch market by the Dutch Green Building Council (DGBC), is suited to assess five types of developments: new construction and renovation, in-use buildings, area developments, demolitions & disassembly and 'bespoke' developments, i.e. tailor-made assessments for projects that do not fit any of the previous categories. It assesses sustainability on various variables, such as management, health, energy, transport or pollution. The LEED (Leadership in Energy and Environmental Design) scheme was developed by the United States Green Building Council (USGBC) and awards buildings with a sustainability score for nine criteria such as water savings, energy efficiency, materials selection and indoor environmental quality. The WELL Building Standard focuses specifically on the health and well-being of office users, assessing criteria such as light, water, air quality or comfort. These certification schemes are not mandatory by law, but meeting a certain degree of certification is an increasingly common request in project tenders.



4. PATHWAYS FOR MAINSTREAMING NATURE-BASED SOLUTIONS FOR ADDRESSING URBAN SUSTAINABILITY CHALLENGES

For diverse urban sustainability agendas, the relevance and importance of these 20 stepping stones varies. Taking the examples of climate change and biodiversity, in this Section we demonstrate how combining different stepping stones can generate promising pathways through which nature-based solutions can be mainstreamed either to meet key agendas or to realise different sustainability goals simultaneously.

Importantly, this analysis shows that the pathways for mainstreaming nature-based solutions are not uniform – depending on the challenges that nature-based solutions are intended to address, different stepping stones become pivotal and create diverse pathways through which they can be mainstreamed. In the case of climate change and biodiversity, while there are some pivotal stepping stones that can be aligned in order to address both agendas simultaneously this requires a strategic choice: simply seeking to mainstream nature-based solutions for either climate or biodiversity is no guarantee that the stepping stones needed to accelerate action for the other agenda will fall into place.

4.1 MAINSTREAMING NATURE-BASED SOLUTIONS FOR ADDRESSING CLIMATE CHALLENGES

Tackling climate change and building resilience have become strategic priorities for many cities across the world. Substantial resources (both financial and human) have been dedicated to support and innovate policies and concrete actions that can reduce climate impacts (adaptation) and greenhouse gas emissions (mitigation). However, there is a long-standing preference of grey infrastructure over nature-based solutions in urban development decision-making process. This status quo is reinforced by urban development practices that value, for example, engineering expertise, established quantitative data, quick effect, and single-objective solutions with proven effectiveness. Besides the missing data, lack of understanding of the benefits of nature-based solutions, as well as silos between sectors and areas of expertise are big obstacles for forging cross jurisdictional and multilevel institutional connection to promote nature-based solutions that can combat the cross-cutting climate issues. These and other factors limit the adoption of urban nature-based solutions for climate change.

Several stepping stones are particularly effective in making most of opportunities and overcoming the challenges to mainstream nature-based solutions that can address urban climate crisis. For example, aligning nature-based solutions with urban **strategic priorities** can access not only the public and institutional budget and existing capacity dedicated for climate change mitigation and adaptation, but also those earmarked for other related prioritised paradigms in cities (such as circular economy, healthy urban living, and ecosystem services, etc.). Meanwhile, **generating partnerships** between public, private and third sector organisations and **creating intermediaries** that can work across sectors (both horizontally and vertically) can address persistent institutional and knowledge silos. As there is a growing interest of financial sectors in dealing with risks associated with climate change, **stimulating institutional investment for risk reduction** and **engaging insurance sector** can not only direct investments and funds towards nature-based solutions, but also bring industry knowledge (e.g. insurers' expertise on risk evaluation) into the development of nature-based solutions. Moreover, **improving data and monitoring** and **developing valuation models** are critical since they can evidence the effectiveness of nature-based solutions and further support collaborations between stakeholders. This can be facilitated by demonstration projects, which can not only showcase the multiple innovative workings of nature-based solutions, which can build up awareness and knowledge, but also demonstrate the performance of nature-based solutions in combating climate risks and in generating benefits for urban ecology, local community and wider society. Other important stepping stones that we identified include: **provide a public mandate, provide economic incentives, build co-finance arrangements, and grow practitioner expertise.**

Each of the stepping stones listed above is promising in promoting the adoption of nature-based solutions for climate change. However, each also faces constraints. In order to ensure that they reach their full potential, stepping stones can be aligned to overcome these constraints. When these aligned stepping stones are implemented together – forming a pathway - they can generate much more momentum for mainstreaming nature-based solutions than individual actions would be able to achieve.

For example, **stimulating institutional investment for risks reduction** can unlock and (re)direct existing and new funding earmarked for climate adaptation measures to nature-based solutions. Nevertheless, financial institutions often rely on quantifiable data to make investment decisions. Making the case for nature-based solutions for climate change and to draw public and private investments thus requires **advancing valuation models** that can specify the (monetised) benefits and costs of nature-based solutions. Meanwhile, while different urban stakeholders and financiers can each make significant contributions to fund and implement nature-based solutions, **building co-financing arrangements** within and among the public and private sector actors can ensure that nature-based solutions that might not be cost-effective for any one actor are financially viable. Co-funding nature-based solutions through new or existing financial instruments (e.g. green bonds) is much more likely to render nature-based solutions cost-effective, since it can enable all involved stakeholders to share not only the cost but also the overall risks of developing and maintaining nature-based solutions. **Engaging insurance sector** is particularly critical in such collaboration, as nature-based solutions can provide cost-effective means through which to reduce risks while these organisations also have significant expertise on damage cost reduction that can feed into making the case for nature-based solutions, as well as their close links with other key stakeholders (e.g. government, rating agencies, firms and property owners). As can be seen, these four stepping stones reinforce each other and together, they can form a strong pathway through which nature-based solutions can be mainstreamed to deal with climate risks in cities. This pathway – Invest in nature-based solutions to reduce climate risk – can stimulate the generation of new forms of investment and workable business models for nature-based solutions.

In the same vein, aligning different but mutually supportive stepping stones together can form other promising pathways for mainstreaming nature-based solutions that can contribute to climate change mitigation and adaptation. Figure 2 below presents the total four pathways we identified to be promising for mainstreaming nature-based solutions.¹⁶

¹⁴ See details of these pathways in Tozer and Xie (2020).

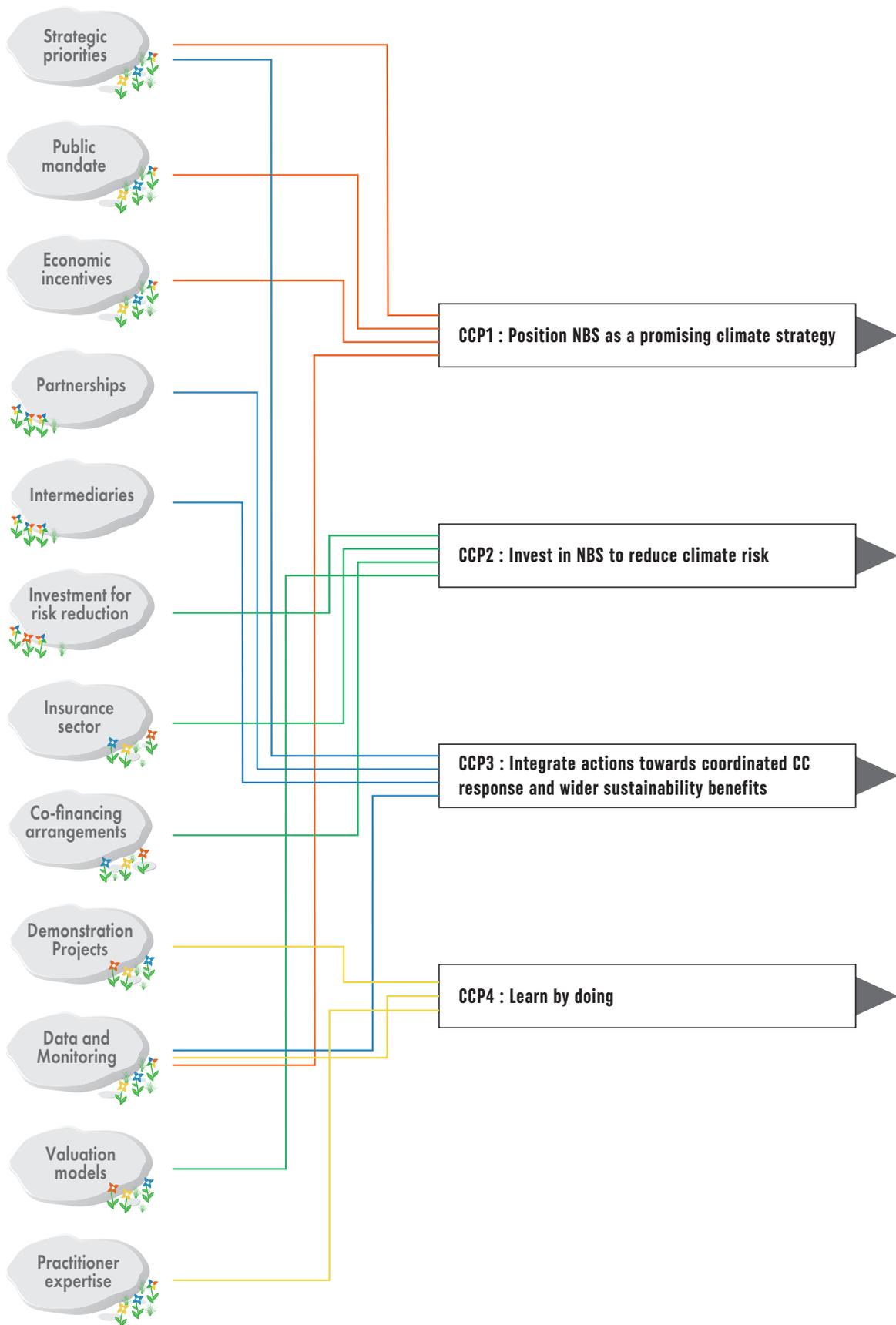


Figure 2: Key stepping stones and promising pathways for mainstreaming nature-based solutions for climate change mitigation and adaptation

4.2 MAINSTREAMING NATURE-BASED SOLUTIONS FOR BIODIVERSITY

Compared to climate change, biodiversity has been relatively marginalised in urban policymaking and planning process. However, the upcoming fifteenth meeting of the conference of parties to the UN Convention on Biological Diversity (CBD) – also called COP15, is generating new momentum around this agenda. As the process of developing a new global biodiversity framework that will be adopted in the COP 15 is ongoing, local and subnational governments are increasingly being recognised for their critical roles in leading biodiversity actions and in realising the 2050 Vision of “Living in harmony with nature”. Due to their multifunctional nature, nature-based solutions have come to be seen as a key means through which effective urban biodiversity governance can be achieved, as clearly indicated in the 2019 IPBES Global Assessment report and the Zero Draft of the Post-2020 Global Biodiversity Framework published in January 2020 (Díaz, S. et al. 2019; CBD 2020).

Cities can work with nature-based solutions to conserve nature, restore nature, and to thrive through harnessing nature’s contribution to people (Xie and Bulkeley 2020). Similar to climate change, there are a set of stepping stones that are of particular significance for promoting the uptake of nature-based solutions for biodiversity gains. **Regulate for No Net Loss** is one of those most prominent actions. In the UK, the biodiversity Net Gain policy requires developers to achieve 10% net biodiversity gain through first impact mitigation and then on-site enhancement or offsetting elsewhere. Such regulation can incentivise greater investment in initiatives that can conserve biodiversity or compensate the loss in one area by balancing with gain elsewhere. Another key stepping stone we found is to align biodiversity goals as well as nature-based solutions with other **strategic priorities** in cities so as to piggyback on existing prioritised agendas (such as energy transition, climate adaptation and health enhancement). Meanwhile, **building co-financing arrangements** between public and private sectors can enable co-funding for developing and maintaining nature-based solutions that can benefit urban biodiversity. Since land use conversion and new urban development (including real estate and infrastructure construction) are the main threats for urban biodiversity, a number of stepping stones are especially effective in driving the adoption of nature-based solutions in urban development. These include **providing a public mandate** to integrate nature-based solutions through tender and procurement policies and other policy instruments like land use planning guidance, and **including nature-based solutions in contractual agreements** to encourage or demand utilities (e.g. water, waste, energy) and network service providers (e.g. road, rail, and waterway authorities) to practice nature-based solutions. Integrating nature-based solutions into **green certification schemes**, can also incentivise their adoption by developers in designing and managing buildings. Other effective stepping stones for mainstreaming nature-based solutions for biodiversity in cities include: **generate partnerships**, **provide economic incentives**, **develop markets**, **develop data and monitoring**, **advance valuation models**, and **establish demonstration projects**.

Similar to climate change, while each of the stepping stones holds great potential in catalysing wider uptake of nature-based solutions that can protect or enhance biodiversity in cities, such positive impacts can be significantly boosted when stepping stones align with one another in promising pathways. For example, by **aligning with strategic priorities**, nature-based solutions that aim for biodiversity gains can make use of resources and capacity dedicated to existing prioritised agendas in cities. However, urban governance is highly departmentalised – issues of different sustainability agendas (e.g. energy, transportation, health, water, etc.) are often dispersed across different governmental departments and authorities. Similarly, the benefits and responsibilities for nature-based solutions are also split across different sectors (both public and private). To unite actions towards different sustainability goals, more specifically, to promote multifunctional nature-based solutions, thus requires bridging silos. This can be achieved by **creating intermediaries** that work within and across public and private bodies and across different levels. It can also be supported by **generating partnerships** among different stakeholders, who might have diverse interests but can join forces to design, implement and maintain nature-based solutions. To convince different urban actors of the multi-functionality and cost-effectiveness of nature-based solutions, it is essential to **improve data and monitoring** that can demonstrate the advantages and co-benefits of nature-based solutions. Therefore, these four

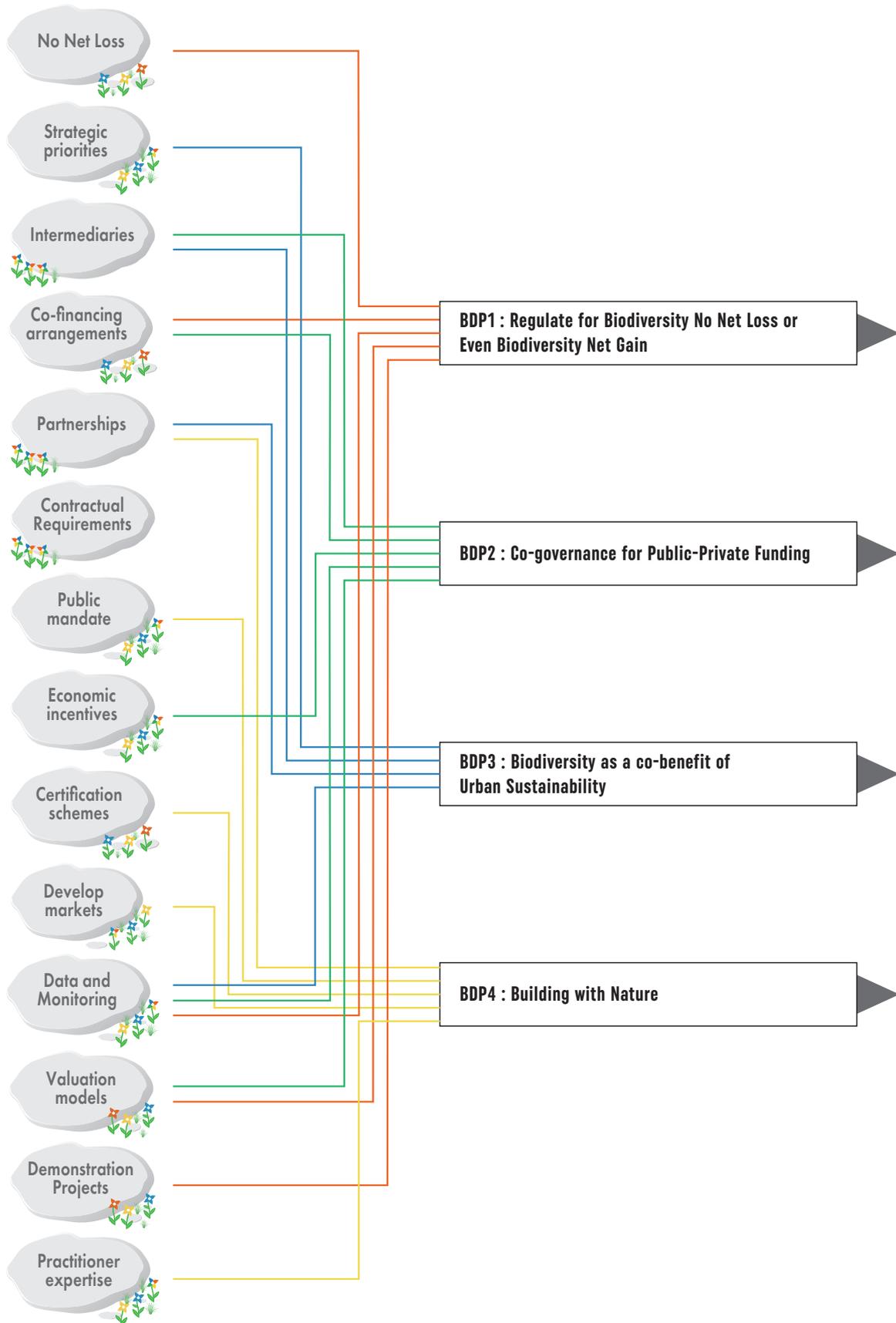


Figure 3. Key stepping stones and promising pathways for mainstreaming nature-based solutions for biodiversity

stepping stones together form a promising pathways for mainstreaming nature-based solutions that can contribute to urban biodiversity goals. This pathway – *Biodiversity as co-benefit of urban sustainability* – highlights that policies do not have to be specifically focused on biodiversity in order to present opportunities for mainstreaming nature-based solutions for biodiversity.

Similarly, we identify three other promising pathways for mainstreaming nature-based solutions that can benefit urban biodiversity. Each of the pathways consist of a set of stepping stones that are interrelated and mutually support one another. Figure 3 above presents the key stepping stones as well as the pathways they form for facilitating the mainstreaming of nature-based solutions for biodiversity.

4.3 MAINSTREAMING NATURE-BASED SOLUTIONS FOR BOTH CLIMATE AND BIODIVERSITY

A number of stepping stones are found to be important for mainstreaming nature-based solutions for both climate and biodiversity. However, there also exist some stepping stones that are particularly important for one agenda but not so for the other. For example, stimulating institutional investment for risk reduction and engaging insurance sector can be effective for mainstreaming nature-based solutions for climate change, but often are not related to urban biodiversity goals. In turn, stepping stones such as regulating for No Net Loss and promoting certification schemes that are crucial for mainstreaming nature-based solutions for biodiversity are not pivotal for addressing climate risks and impacts in cities. As a result, aligning stepping stones that are unique for one sustainability goal could result in nature-based solutions that marginalise or even undermine efforts to reach other goals. For example, a narrow focus on implementing biodiversity No Net Loss or Net Gain regulation without concern for the other benefits that nature-based solution could result in interventions that either take place in parallel or opposition to efforts to work with nature-based solutions driven by climate change mitigation or adaption. This in turn could led to the existing capacity in cities to respond to climate change not being harnessed for biodiversity efforts, actors charged with implementing nature-based solutions received confusing signals about their purpose and value, and important opportunities to reach both goals together could be missed.

To mainstream nature-based solutions that can deliver co-benefits for climate change and biodiversity in cities thus requires efforts to be built on stepping stones that are pivotal to realising both agendas. These include: (1) Align with strategic priorities, (2) provide a public mandate, (3) provide economic incentives, (4) generate partnerships, (5) create intermediaries, (6) build co-financing arrangements, (7) establish demonstration projects, (8) improve data & monitoring, (9) advance valuation models, and (10) grow practitioner expertise (see figure 4 below). Similarly, different configurations of these common stepping stones can form multiple pathways for mainstreaming nature-based solutions that can deliver benefits for both climate and biodiversity. For example, **establishing demonstration projects** can not only experiment on place-specific nature-based solutions that work for both climate and biodiversity, but also demonstrate the co-benefits or even multiple benefits of nature-based solutions and can further increase awareness and build knowledge. This however requires data development and consistent and effective monitoring, which can allow performance assessment and timely adjustment of the projects. Besides **improving data and monitoring**, **growing practitioner expertise** can also play a crucial role in supporting the local uptake nature-based solutions. In turn, the experimentation of nature-based solutions on the ground can enable the further development of the often space-specific practitioner expertise. Therefore, these mutually reinforcing stepping stones can together form a promising pathway – *Experiment, evaluate and demonstrate* – for mainstreaming nature-based solutions for both climate and biodiversity.

Similarly, based on the three stepping stones of **generating partnerships**, **building co-financing arrangements** and **advancing valuation models**, another pathway – Develop integrated financing for actions that can deliver co-benefits – can be formed that holds great promises to bolster nature-based solutions mainstreaming that can contribute to both climate and biodiversity. This pathway focuses on developing integrated financing for actions that can deliver co-benefits for both climate

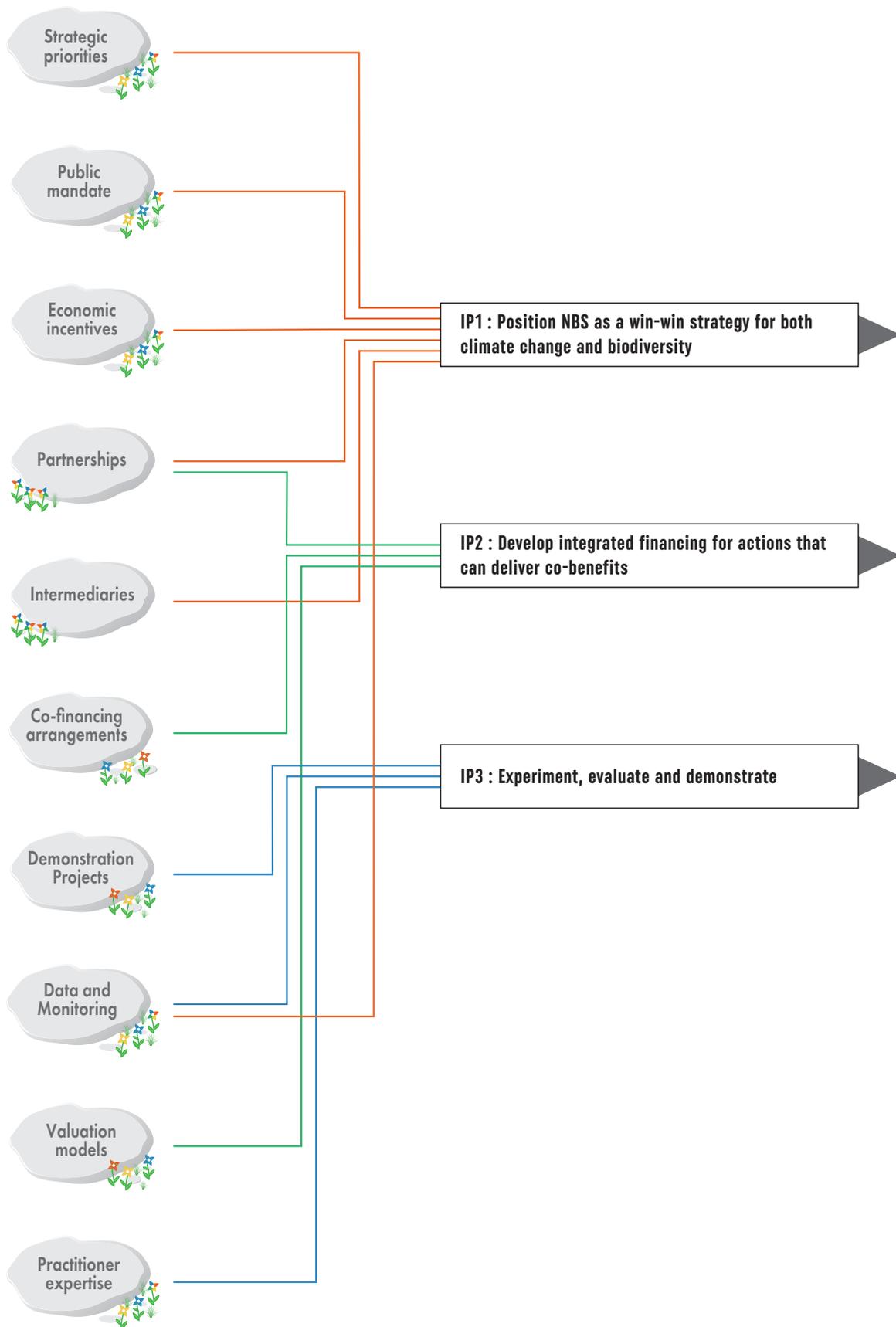


Figure 4. Key stepping stones and promising pathways for mainstreaming nature-based solutions for both climate change and biodiversity

change and biodiversity. As there is a growing consensus that climate change and biodiversity should be tackled together, both public and private financial sectors increasingly concern both climate and biodiversity impacts of their products. Forging partnerships between them can thus pool their resources together and synthesise different knowledge and techniques harnessed by different stakeholders. It enables the achievement and maximisation of synergy and can promote nature-based solutions implementation and maintenance.

Figure Four presents the key stepping stones as well as the promising pathways we identified for mainstreaming nature-based solutions for both climate change and biodiversity.



Nature-based solutions hold great potentials in addressing socio-economic and environmental challenges in cities. To unlock such potentials requires actions to be taken that can remove the barriers and seize the opportunities for the wider uptake of nature-based solutions. In this report, we identified and elaborated the 20 pivotal stepping stones based on the case studies of six European countries (UK, Germany, Hungary, Spain, Sweden and the Netherlands) and at the EU level. These stepping stones work across the regulatory, financial and urban development domains of the urban infrastructure regimes that shape the approaches to urban sustainability challenges. While with different emphasis and each holds great potentials in mainstreaming, these stepping stones are often intertwined and mutually reinforcing each other. Aligning them with one another can activate their synergy and create more effective pathways for promoting the mainstreaming of urban nature-based solutions.

Using climate change and biodiversity as examples, we also demonstrated how stepping stones can be aligned to generate promising pathways for mainstreaming nature-based solutions that can contribute to one or multiple urban sustainability agendas. For different sustainability goals, the relevance and importance of different stepping stones vary. Meanwhile, since there can be different configurations of stepping stones, mainstreaming pathways can be various. Aligning stepping stones that are particularly important for one sustainability goal could result in nature-based solutions that marginalise or even counteract efforts to reach other goals. Therefore, to mainstream nature-based solutions that can address multiple sustainability challenges simultaneously, identifying their common stepping stones and following the pathways built on them are crucial.

As we focused on the key actions and promising pathways through which the potentials of nature-based solutions are most likely to be realised, issues that arise on the ground in terms of what is enabling or constraining the particular uptake of nature-based solutions, in particular where contestation comes from and where opposition to nature-based solutions is located, are not addressed in this analysis (but see Kiss et al. 2019). Therefore, it is recommended that the findings presented in this report

¹⁸ See <https://naturvation.eu/>.

to be read in relation to other research outputs of the NATURVATION project¹⁸ in order to understand the full scope of the dynamics of implementing nature-based solutions.

Future study could further explore how different types of nature-based solutions and the contexts in which they are being embedded affect the key stepping stones and critical pathways for their mainstreaming. Policymakers and other interested in pursuing nature-based solutions can identify the most pivotal stepping stones that align with their particular contexts and goals and follow the pathways that are built on them.

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APPENDIX 1: OVERVIEW OF THE PLACEMENTS

A total of 12 placements were carried out at key organisations, network or event influencing the uptake of urban nature-based solutions (Table A1). These placements served to observe day-to-day decision-making and practices that sustain existing conditions and give rise to new opportunities for nature-based solutions.¹⁹

Table A1. Overview of placements carried out as part of the data collection

| No. | PLACEMENT ORGANISATION | DESCRIPTION | CASE | FUNCTIONAL DOMAIN(S) | PLACEMENT PERIOD | MAIN ACTIVITIES |
|-----|---|---|-----------------|-------------------------------|---|---|
| 1 | City Deal "The Values of Green and Blue in the City" (<i>City Deal "De waarde van groen en blauw in de stad"</i>) | A public-private partnership to co-develop the Natural Capital Atlas (Atlas Natuurlijk Kapitaal – ANK) and TEEB city (TEEB stad) instruments to quantify and visualise the benefits of nature-based initiatives | The Netherlands | Regulatory | 3 meetings: 6 Jun 2018; 21 Mar 2019; 9 May 2019 | Observation, participation in discussion and workshop activities |
| 2 | Tyne Estuary Partnership | A catchment partnership, initiated by The Environment Agency and involving ca. 20 organisations, to enhance ecological and economic values of the river Tyne in Newcastle | United Kingdom | Regulatory | Various events: Jan - Jun 2019 | Observation of events, meetings with organisers, informal discussions |
| 3 | IUCN European Regional Office | An international organisation that is a frontrunner in knowledge development and dissemination on nature based solutions, as well as the development of new tools and metrics. | European Union | Regulatory | 19-21 Feb 2019 | Delivering a talk; participation in relevant events; exchange with IUCN staff; observation of IUCN internal meeting |
| 4 | Urban Ecology Agency of Barcelona (AEUB: <i>Agencia de Ecologia Urbana de Barcelona</i>) | A public-private agency providing consultancy services to public institutions, foundations, organisations and firms on sustainable urbanism, including aspects such as mobility, energy, waste, water, biodiversity and social cohesion | Spain | Regulatory, Urban development | 27-30 May 2019 | Participation in staff and external meetings about current projects and adopted technologies; delivering a presentation; field visits of superblocks initiative |
| 5 | Building Agenda (<i>Bouwagenda</i>) | A 4-year program by a coalition of urban development industry professionals, setting an agenda to achieve sustainability objectives | The Netherlands | Urban development | 3 meetings: 29 Oct 2018; 25 Jan 2019; 11 Apr 2019 | Attendance of conferences and dedicated conference sessions organised by the Bouwagenda |
| 6 | Cologne Green System & Office for Landscape Management and Green Areas, Cologne municipality (<i>Grünsystem Köln & Amt für Landschaftspflege und Grünflächen, Stadt Köln</i>) | Cologne Green System is a citizen initiative to raise awareness about and lobby for the green belt system in Cologne, the 4 th biggest city in Germany. They are supported by the municipality's Office for Landscape Management and Green Areas | Germany | Urban development, Regulatory | 3 Oct 2018 | Participation in guided cycling tour of Cologne's green belt, followed by an interview with municipal officials and members of the Grünsystem Köln NGO |
| 7 | Sustainable Use of Land and Nature Based Solutions (SUL-NBS) Partnership | The SUL-NBS Partnership is the 12 th Partnership of the EU Urban Agenda involving DGs, knowledge institutions, Member States and cities interested in supporting NBS uptake | European Union | Urban development, Regulatory | Three 2-day meetings: 17-18 Jan 2019; 10-11 Jul 2019; 2-3 Oct 2019 | Taking part in the discussions, development and implementation of some of the NBS Partnership Action(s) defined in the Draft Action Plan |
| 8 | White Architects (<i>White Arkitekter</i>) | An interdisciplinary firm for architecture, urban design, landscape architecture and interior design, with a commitment to sustainability | Sweden | Urban development | 5 Feb 2019; 30 Apr – 2 May 2019 | In-office observation and informal discussions |

¹⁹ See van der Jagt et al. (2020) for a more detailed explanation of the placements carried out in the research.

| No. | PLACEMENT ORGANISATION | DESCRIPTION | CASE | FUNCTIONAL DOMAIN(S) | PLACEMENT PERIOD | MAIN ACTIVITIES |
|-----|--|---|-----------------|--|------------------|--|
| 9 | European Conference on Innovative Financing for Green Cities | This conference, organised by the H2020 project Grow Green, brought together city representatives, investors and businesses to find joint solutions for financing urban greening | United Kingdom | Finance | 26-27 March 2019 | Organising a conference session, delivering a talk, observing, 'catalysing' follow up action |
| 10 | The 4 th Climate Finance Day and the UN Environment Finance Initiative's (UNEP FI) biennial Global Roundtable | Two flagship events co-organised by EUROPLACE and UNEP FI aimed at mobilising the financial sector to deliver a sustainable financial system | European Union | Finance, Regulatory | 26-28 Nov 2018 | Participating in plenary and break-out sessions, networking with delegates and collecting printed information |
| 11 | Budapest City Planning Ltd., Nature planning office (Budapest Főváros Városcépzési Tervező Kft., Környezettervezési iroda) | A municipality-owned organisation responsible for environmental planning | Hungary | Finance, Regulatory, Urban development | 23-26 Apr 2019 | Taking part in meetings and a focus group |
| 12 | Green Deal Green Roofs, later National Roof Plan | A national network set up to speed up the uptake of green roofs in The Netherlands involving green roof firms, water boards, municipalities and sector organisations / consultants. After 2019 this network was rebranded the National Roof Plan. | The Netherlands | Finance | 2017 – 2020 | Participating in conferences, working groups, presenting findings from NATURVATION work and receiving feedback, co-developing strategies for finance and business models for green roofs |

APPENDIX 2: CONCEPTUAL FRAMEWORK

The research which underpins this report focused on three domains of the urban infrastructure regimes that shape the uptake of nature-based solutions, namely the regulatory domain, the financial domain and the urban development domain. Each of these three domains have been clearly demarcated in Dorst et al. (2018), also see Table A2.

Table A2. Domain demarcation of the urban infrastructure regime

| | URBAN DEVELOPMENT DOMAIN | URBAN DEVELOPMENT DOMAIN | FINANCIAL DOMAIN |
|--|--|---|--|
| General description | The interests, practices, institutions and technologies of the urban development and construction industry, which is engaged in the design and provision of infrastructure and housing in cities | The interests, practices, institutions and technologies of regulatory actors involved in the governance of mainstream urban planning, as well as the wider policy paradigms and political power structures in which they are embedded | The interest, practices, institutions and technologies of organisations – notably financial players but potentially more broadly defined depending on the case, such as real estate agglomerates – involved in the provision of capital funding for investing in urban infrastructures |
| Function in urban infrastructure provision | Development of built environment – design, construction, maintenance, renovation, etc. | Regulation, policy-making, strategising, agenda-setting, political decision-making and planning – e.g. environmental limits, land use planning, etc. | Funding, investment, insurance – e.g. provision of loans to finance construction, cost recovery exploitation, financial risk-sharing, etc. |

Each of the three domains has a different set of associated stakeholders and actor groups, providing different views and knowledge to understand the infrastructure regimes (see Table A3). It is to be noted that there are some overlaps in the types of stakeholders included across the three domains during the interviews. For example, some government stakeholders were also interviewed by researchers of the finance domain to understand the specific role of policy and regulation on actors in this domain and nature conservation NGOs were interviewed as part of the urban development domain if these actively

engaged with design and construction activities.²⁰

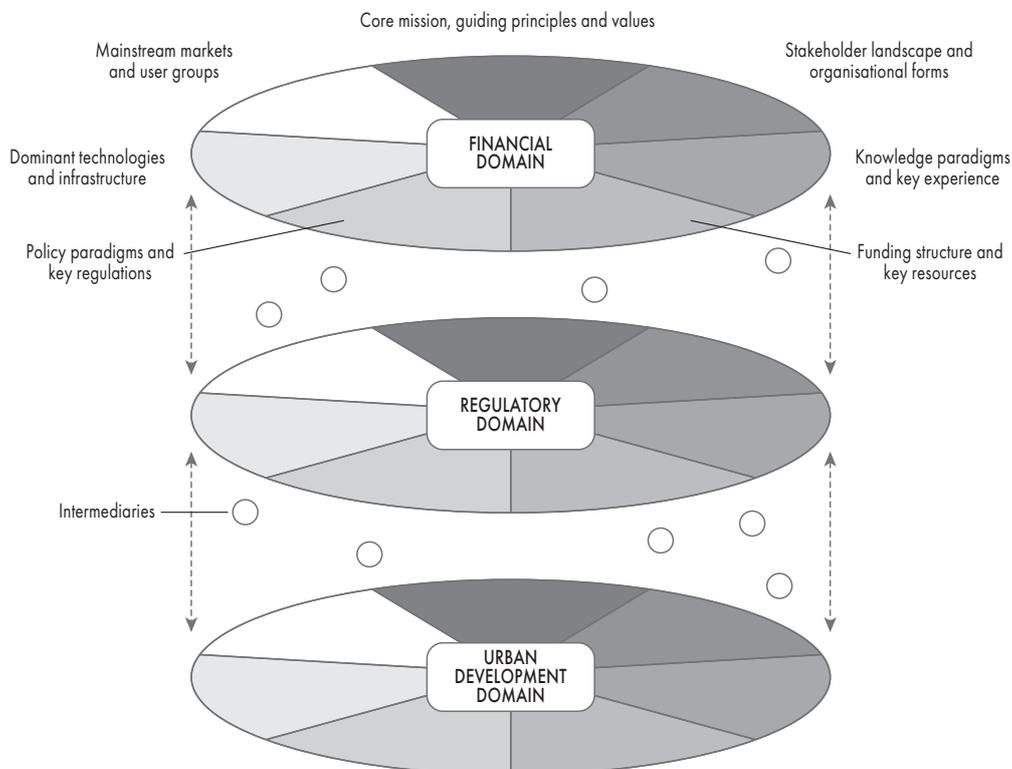
As outlined in Dorst et al. (2019), seven general dimensions were identified in NATURVATION that serve as conceptual categories for identifying structural barriers and enablers in each domain that are likely to influence nature-based solutions uptake. They enable the understanding and comparative study of the dynamics of each of the three domains in different national contexts and at the EU level, as well as between these different domains (see Figure A1). Table A4 provides general description of each of the seven dimensions.²¹

By analysing how each of these dimensions influences urban nature-based solutions uptake (i.e. conditions), the barriers they create, the opportunities that are emerging to facilitate the uptake, researchers identified the key actions that could be taken to overcome challenges or seize opportunities. The data generated from the analysis formed the basis of the research underpinning this report.

Table A3. The stakeholder groups making up each of the functional domains

| REGULATORY DOMAIN | URBAN DEVELOPMENT DOMAIN | FINANCIAL DOMAIN |
|--|--|---|
| <ul style="list-style-type: none"> • Supra-national government • National government • Sub-national government (regional, urban) • Government agencies (e.g. water dept.) • Lobby groups/Trusts/Charities • Politicians • Policy advisory organisations (e.g. knowledge institutes) | <ul style="list-style-type: none"> • Development companies • Architects and landscape designers • Utilities • Transport infrastructure providers • Housing providers (e.g. housing corporations) • Urban development consultancies • Large landowners | <ul style="list-style-type: none"> • Banks • (Re-)Insurance companies • Institutional and other investors • Financial consultants • Foundations • Networks of financial actors • Rating agencies |

Figure A1. A conceptualisation of the urban infrastructure regime structure



²⁰ See van der Jagt et al. (2020) for a more detailed explanation of the data collection through interviews.

²¹ See Dorst et al. (2019) for a more detailed description of the regime dimensions for each domain.

Table A4. Categorisation and description of regime dimensions

| REGIME DIMENSIONS | GENERAL DESCRIPTION |
|--|---|
| Core mission, guiding principles and values | Main sustainability targets, objectives, priorities articulated in the domain, as well as underlying values, rationales and principles of regime actors that shape their strategies in relation to urban sustainability. |
| Stakeholder landscape and organisational forms | Roles and responsibilities of regime actors, and the formal and informal rules that shape their interaction. Included in stakeholder landscapes are key advocates or events pushing or preventing processes of urban sustainability transitions. |
| Knowledge paradigms and key expertise | (Expert) knowledge that informs the regime’s functioning and decision-making processes of regime actors. |
| Funding structure and key resources | Availability and types of funding and resources influencing regime practices, as well as the instruments to raise funding or collect and control necessary resources to promote urban sustainability (and the types of urban sustainability that are promoted). |
| Policy paradigms and key regulations | Influential policies and regulations relevant to the regime and their role in shaping sustainable urban development. |
| Dominant technologies | Technologies (e.g. tools, procedures and models), material features and physical |



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