European Commission

Science for Environment Policy

FUTURE BRIEF:

The solution is in nature

February 2021
Issue 24

Environment

Science for Environment Policy
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Page 68: Naturvation (H2020, grant no. 730243), Deliverable 1.3 "Characterizing nature-based solutions from a business model and financing perspective"

Acknowledgements
We wish to thank the scientific advisor, Emmanuelle Cohen-Shacham (IUCN Commission on Ecosystem Management), for her useful input to this report. Final responsibility for the content and accuracy of the report, however, lies solely with the authors.

The contents and views included in Science for Environment Policy are based on independent research and do not necessarily reflect the position of the European Commission.

Print ISBN 978-92-76-21354-3 ISSN 2363-2771 doi:10.2779/00625 KH-BB-20-001-EN-C
PDF ISBN 978-92-76-21355-0 ISSN 2363-278X doi:10.2779/656087 KH-BB-20-001-EN-N

Printed by the Publications Office of the European Union in Luxembourg

Luxembourg: Publications Office of the European Union, 2021

This Future Brief is written and edited by the Science Communication Unit, University of the West of England (UWE), Bristol. Email: sfep.editorial@uwe.ac.uk

To cite this publication:
Science for Environment Policy (2021) *The solution is in nature.* Future Brief 24. Brief produced for the European Commission DG Environment. Bristol: Science Communication Unit, UWE Bristol.

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Contents

1. Setting the scene - general introduction on Nature-based Solutions (NbS)

The science is clear: the biodiversity crisis, the climate crisis and the health crisis are interdependent. Political leaders from across the world, representing 80+ countries and the European Union, have also recognised this connection in the Leaders' Pledge for Nature.[1] Climate change accelerates the destruction of the natural world through extreme weather events such as droughts, flooding and wildfires. Biodiversity loss and unsustainable use of nature, driven by intense anthropogenic activities, in turn, reduce resilience to and further drive climate change. But just as the crises are linked, so are the solutions (European Commission, 2020a).

> *Nature-based solutions are our best ally in the fight against climate change and help deliver the EU Biodiversity Strategy for 2030. These solutions bring multiple benefits — they empower people and communities, they increase resilience, and they provide jobs and business opportunities. Scaling up our investments in nature-based solutions and stepping up their implementation is the best insurance policy of all.*

Virginijus Sinkevičius, Commissioner for Environment, Oceans and Fisheries

1. Leaders' Pledge for Nature: https://www.leaderspledgefornature.org/

Nature is a vital ally in the human struggle with climate change. Nature regulates the climate, and **Nature-based Solutions** are essential for addressing global challenges such as reducing carbon emissions. Planting trees and deploying green infrastructure will help to cool urban areas and mitigate the impact of natural disasters (European Commission Biodiversity Strategy 2030, 2020). Figure 1 shows several entry points for the implementation of nature-based solutions.

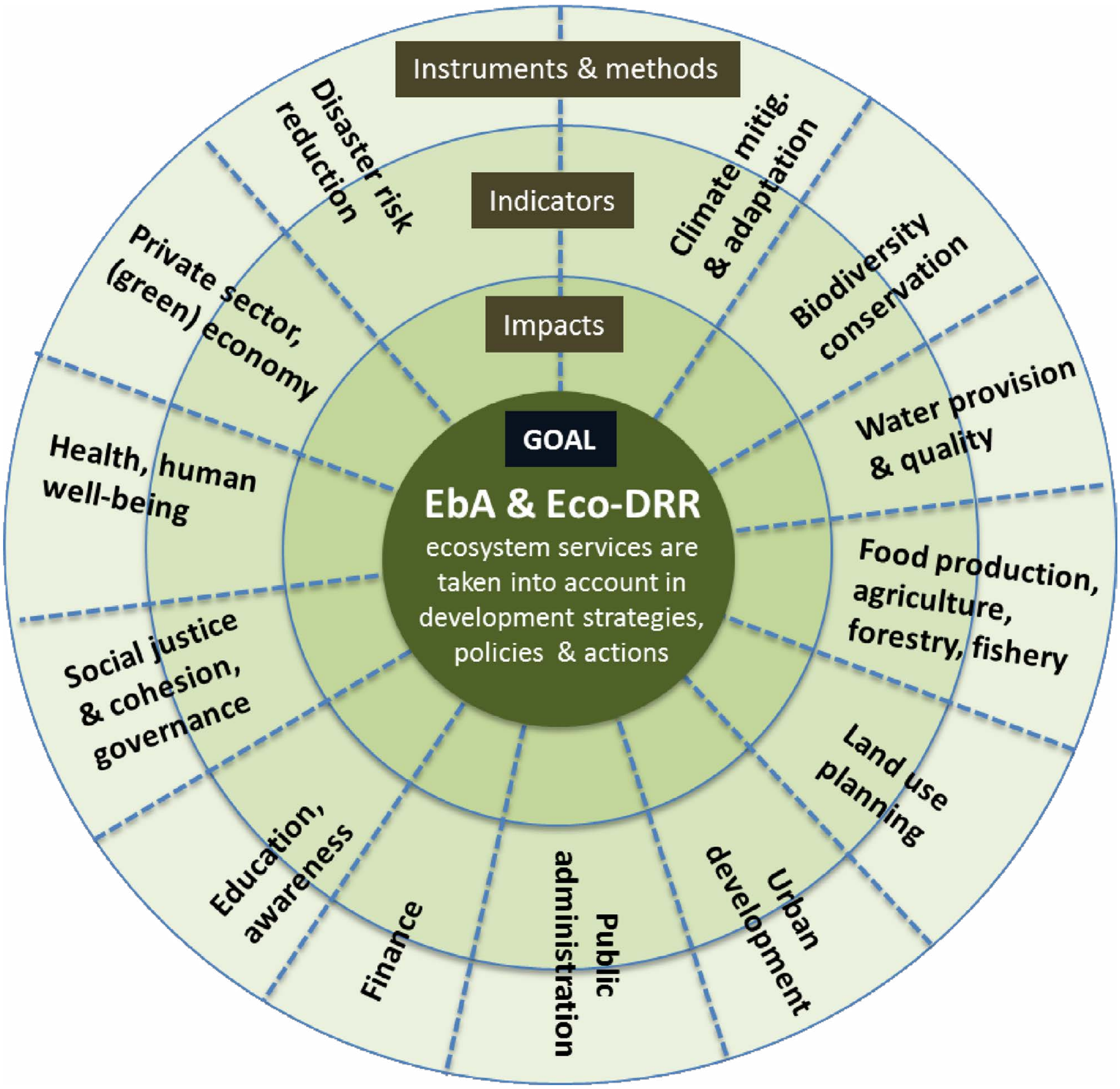


Figure 1. Figure 1. Entry points for mainstreaming EbA (Ecosystem-based Adaptation) and Eco-DRR (Ecosystem-based Disaster Risk Reduction) (see also Figure 2) by embedding ecosystem-based approaches into existing instruments, methods or tools, selecting appropriate indicators for monitoring and evaluation, and ensuring successful impact by developing a theory of change. Source: Convention on Biological Diversity Conference of the Parties (CBD COP), 2018: CBD/ COP/14/5, Annex art. 20.

Time for action is urgent. Globally, ecosystems are being degraded and lost in an unprecedented manner, leading to the loss of the associated services they provide (resources and contributions that either directly or indirectly support human well-being and survival). Drivers include climate change and unsustainable urbanisation. By 2050, over 80% of the European population[2] (and nearly 70% of the global population)[3] is expected to reside in urban areas, increasing the need for sustainable food, housing, employment and care in cities – and increasing the amount of land needed for human activities. All areas of the world, urban and non-urban alike, are facing interlinked and interdependent climate, biodiversity, overexploitation and health crises. Nature provides and points towards viable solutions to such issues. **By working with nature, rather than against it, communities can develop and implement solutions that pave the way towards a resilient, resource-efficient and green economy; Nature-based Solutions (NbS) enhance 'natural capital'[4] rather than deplete it.** (European Commission, 2020b).

NbS work with nature to benefit both natural ecosystems and the people that depend on them. By putting nature at the centre, NbS address a range of societal challenges: protecting, sustainably managing or restoring natural or modified ecosystems and supporting their health, function and biodiversity. In turn, these healthy, well-managed ecosystems "can thereby address economic, social and environmental goals simultaneously" (IEEP, 2020).

NbS can empower people, combat biodiversity loss, mitigate and help adapt to climate change, contribute to disaster risk reduction contribute to human physical and mental health and more. In addition, such solutions can create numerous employment and business opportunities across diverse sectors and are "key to innovation for economic or societal needs that rely on nature" (European Commission, 2020a).

According to the International Union for the Conservation of Nature (IUCN) the key global societal challenges tackled by NbS include Climate Change, Disaster Risk, Food Security, Human Health, Water Security, Economic and Social Development (Cohen-Shacham *et al.*, 2016), as well as ecosystem degradation and biodiversity loss (IUCN, 2020).

In the past few years, many organisations, teams, and projects have developed and implemented NbS, through their work on concepts such as ecosystem-based adaptation, green infrastructure, natural climate solutions and habitat restoration, all of which aim to generate particular ecosystem services[5] or to enhance the benefits and value of nature for people, by addressing societal challenges.

The European Commission promotes NbS via several policy areas (see Chapter 2.2 below). NbS is considered an 'umbrella' framework for a range of ecosystem-based and related concepts, such as the ones referred to in Figure 2. Depending on the specific context, the NbS umbrella covers concepts such as Ecosystem-based Adaptation (EbA), Green Infrastructure (GI), Ecosystem-based Disaster Risk Reduction (EcoDRR), and Natural Water Retention Measures (NWRM). All have in common the assumption that ecosystems in healthy condition deliver multiple benefits and services for human well-being and address economic, social and environmental goals, including climate change adaptation and mitigation as well as biodiversity conservation and restoration.

2. https://ec.europa.eu/research/environment/index.cfm?pg=nbs
3. https://ec.europa.eu/knowledge4policy/foresight/topic/continuing-urbanisation/urbanisation-worldwide_en#:~:text=While%2C%20for%202015%2C%20the%20UN,%25%20(4.6)%20in%202000.
4. Natural capital can be defined as the world's stock of resources, including minerals, soils, water, air and all living organisms.
5. See SfEP in-depth Report on Ecosystem Services and Biodiversity (2015).

NbS-related concepts	Ecosystem-based Adaptation	Ecological Engineering	Ecosystem-based Mitigation
Forest Landscape Restoration	Ecosystem-based Disaster Risk Reduction	Green Infrastructure	Climate Adaptation Services
Natural Infrastructure	Area-based Conservation	Ecosystem-based Management	Ecological Restoration

Figure 2. NbS-related concepts: the NbS framework incorporates a whole range of ecosystem-based and related concepts. Source: Cohen-Shacham *et al.*, 2016.

> *NbS... have in common the assumption that ecosystems in healthy condition deliver multiple benefits and services for human well-being and address economic, social and environmental goals.*

Afforestation of steep slopes (Genova - IT), ©UNaLab

Leisure activities and clean energy on former landfills, community-based urban farms and gardens, aquaponics, accessible green corridors, and pollinator biodiversity (Dortmund, DE), ©PROGIREG, Sabina Leopa

The concept of NbS builds upon a host of well-established practices with varying contexts and perspectives (Nesshöver *et al.*, 2016) – examples being ecological engineering, renaturing or rewilding, green-blue infrastructure, natural climate solutions, and natural capital and infrastructure. The shift in focus represented by these approaches moves away from an anthropogenic view of natural resource management towards a paradigm in which nature provides solutions to global challenges – and turns these challenges into opportunities. The concept provides a new narrative involving biodiversity and ecosystem services aligned with goals of innovation and job creation, and with a potential opening for transformational pathways towards sustainable societal development (*ibid.*).

According to the Naturvation project (EU Horizon 2020-funded), in order to be classified as an NbS, a solution cannot merely involve an existing green area or structure; it must actively alter or enhance the function of the area to address current challenges (whether environmental, societal, economic, or other) (Almassy *et al.* 2018).

Houses with green roofs, ©Getty Images, public domain

Co-design event part of "Making Space for Nature", the Thamesmead specific programme of CLEVER Cities in London project area, ©CLEVER Cities

Some examples of NbS include restoring forest landscapes for food and water security; integrating green infrastructure (such as green roofs and community spaces) into urban planning to improve human health and well-being and to address climate change mitigation (by cooling city areas during periods of hot weather); protecting and restoring coastal ecosystems to simultaneously safeguard human settlements from storm surges, wind or wave erosion risk and create safe nurseries for aquatic species; and sustainably managing agricultural soils to increase ecosystem resilience for climate adaptation.

> *The concept of NbS builds upon a host of well-established practices… examples being ecological engineering, renaturing or rewilding, green-blue infrastructure, natural climate solutions, and natural capital and infrastructure… [It provides]NbS a new narrative involving biodiversity and ecosystem services aligned with goals of innovation for growth and job creation, and with a potential opening for transformational pathways towards sustainable societal development*

(Nesshöver *et al.*, 2016).

1.1. Uptake of NbS in the global arena

The term 'NbS' was first used in the early 2000s, but has since been widely adopted worldwide and included in relevant policy frameworks seeking to "promote synergies between nature, society and the economy" (Somarakis *et al*. 2019). These include the Horizon 2020 EU Research and Innovation Policy agenda, and work by the International Union for the Conservation of Nature (IUCN).

In 2016, at the 13th Conference of the Parties to the Convention on Biological Diversity, the COP recognised that ecosystem-based approaches can be "technically feasible, politically desirable, socially acceptable, economically viable and beneficial and that implementation and investment into these approaches are, in general, increasing at the international and national levels" (CBD COP, 2016: CBD/COP/DEC/XIII/4)

In addition, the umbrella term of NbS has gained significant traction in recent years, notably through the workstream on Nature-based Solutions during the UN Climate Action Summit in 2019, which launched a manifesto on NbS, and gathered an extensive compendium on NbS initiatives.

The higher-level aims of NbS are clear: **to work with nature to develop sustainable pathways that benefit both people and nature.** This Future Brief highlights the increasing convergence around the concept of NbS (Chapter 2); presents several examples of NbS and their policy implications (Chapter 3); collates evidence on different evaluation approaches (Chapter 4); and social implications (Chapter 5); before summarising the findings (Chapter 6).

Vertical ecosystem on a school (Valencia), ©GrowGreen

2. When can I call it a NbS?

The European Commission defines NbS as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits, and help build resilience,"[6] noting that such solutions need to involve *locally adapted, resource-efficient* and *systemic* interventions, which result in bringing more and more diverse, nature and natural features and processes into cities, landscapes and seascapes. Hence, NbS must benefit biodiversity and support the delivery of a range of ecosystem services. As mentioned in Chapter 1, several ecosystem-based concepts fit under the NbS umbrella (see Figure 2 above), all of which can be categorised as protective, restorative (e.g. Forest Landscape Restoration), infrastructure-based (e.g. green infrastructure), management-based (e.g. Integrated Coastal Zone Management) or issue-specific (e.g. Eco-Disaster Risk Reduction) concepts (Cohen-Shacham *et al.*, 2016; see Figure 3, below).

Figure 3. NbS as an umbrella term for ecosystem-related approaches; this graphic, which includes ecosystem degradation and biodiversity loss as a social challenge, was developed by IUCN for the Global Standard. Source: IUCN (2020). ©2020 IUCN.

Somarakis *et al.* (2019) and BiodivERsA (2015) adopt similar approaches to describing NbS, considering the degree of intervention, type of engineering, and number of stakeholders targeted (Eggermont *et al.*, 2015). From the perspective of degrees of intervention, NbS can be divided into three broad categories:

- **Type 1: Minimal or no intervention in ecosystems – or better use of protected/natural ecosystems** (e.g. ecosystem conservation and restoration strategies). Aim of Type 1 solutions: to preserve or improve the delivery of ecosystem services by targeted ecosystems (e.g. protecting and restoring coastal mangroves to sustain protection of human settlements from extreme weather)

- **Type 2: Management approaches that involve some intervention – NbS that support sustainable, multi-functional managed ecosystems** (e.g. sustainable agriculture and forestry, agroforestry). Aim of Type 2 solutions: to improve the delivery of selected ecosystem services by shifting towards sustainable, multi-functional ecosystems (e.g. planning agricultural landscapes to increase functionality, or enhancing the genetic diversity of a forest to increase resilience to extreme events).

- **Type 3: Extensive, intrusive management of ecosystems – or the design and creation of new ones** (e.g. ecosystem creation, urban green spaces, green walls, green roofs). Aim of Type 3 solutions: to connect biodiversity conservation and landscape architecture, and integrate novel approaches such as animal-aided design into efforts to draw benefits from biodiversity and diverse, well-managed ecosystems (e.g. creating new green roof or wall ecosystems to mitigate city warming (help combat the urban heat island effect) or clean polluted air; restoration of heavily degraded areas).

These types are not exhaustive, and initiatives can span multiple 'types' of NbS in space and time.

6. https://ec.europa.eu/info/research-and-innovation/research-area/environment/nature-based-solutions_en

According to the IUCN, Nature-based Solutions:	embrace nature conservation norms (and principles)	can be implemented alone or in an integrated manner with other solutions to societal challenges (e.g. technological and engineering solutions)
are determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge	produce societal benefits in a fair and equitable way, in a manner that promotes transparency and broad participation	maintain biological and cultural diversity and the ability of ecosystems to evolve over time
are applied at a landscape scale	recognise and address the trade-offs between the production of a few immediate economic benefits for development, and future options for the production of the full range of ecosystems services	are an integral part of the overall design of policies, and measures or actions, to address a specific challenge

Figure 4. Eight principles for NbS, to be considered with the IUCN definition. Source: IUCN, 2016.

Reflecting this need to guarantee a measured, multi-benefit approach, the EU 'Connecting Nature' project suggests five questions to define whether an intervention can or cannot be framed as an NbS (although additional local context is also needed):

i) Does it use nature/natural processes?

ii) Does it provide/improve social benefits?

iii) Does it provide/improve economic benefits?

iv) Does it provide/improve environmental benefits?

v) Does it have a net benefit for biodiversity?

"Generally, if you can answer yes to all five questions, there is a good chance it can be considered a nature-based solution. Once it has been recognised as a nature-based solution, a simple first step towards evaluating the benefits of the nature-based solution can be taken by adding HOW in front of each of the 5 principles." (Connecting Nature, 2018). (See also Chapter 4 on evaluating NbS.)

2.1. NbS provide multiple benefits for nature and people

The 'societal challenges' referenced by the IUCN, and more specific challenges defined by the Urban Nature Atlas[7] to meet specific United Nations Sustainable Development Goals (SDGs), are detailed in Figure 5 and Table 1 below.

Figure 5. IUCN's specific social challenges: 'ecosystem degradation and biodiversity loss' also appears under the category of social challenges (IUCN, 2020). ©2020 IUCN.

SDG 13	Climate action for adaptation, resilience and mitigation
SDG 6	Water management
SDG 14	Coastal resilience and marine protection
SDG 15	Green space, habitats and biodiversity Environmental quality, including air quality and waste management Regeneration, land-use and urban development
SDG 16	Inclusive and effective governance
SDG 10	Social justice, cohesion and equity
SDG 3	Health and well-being
SDG 8	Economic development and decent employment Cultural heritage and cultural diversity
SDG 12	Sustainable consumption and production

Table 1. Key Challenges for NbS, and associated SDGs where relevant (Naturvation, 2020)

7. https://naturvation.eu/atlas

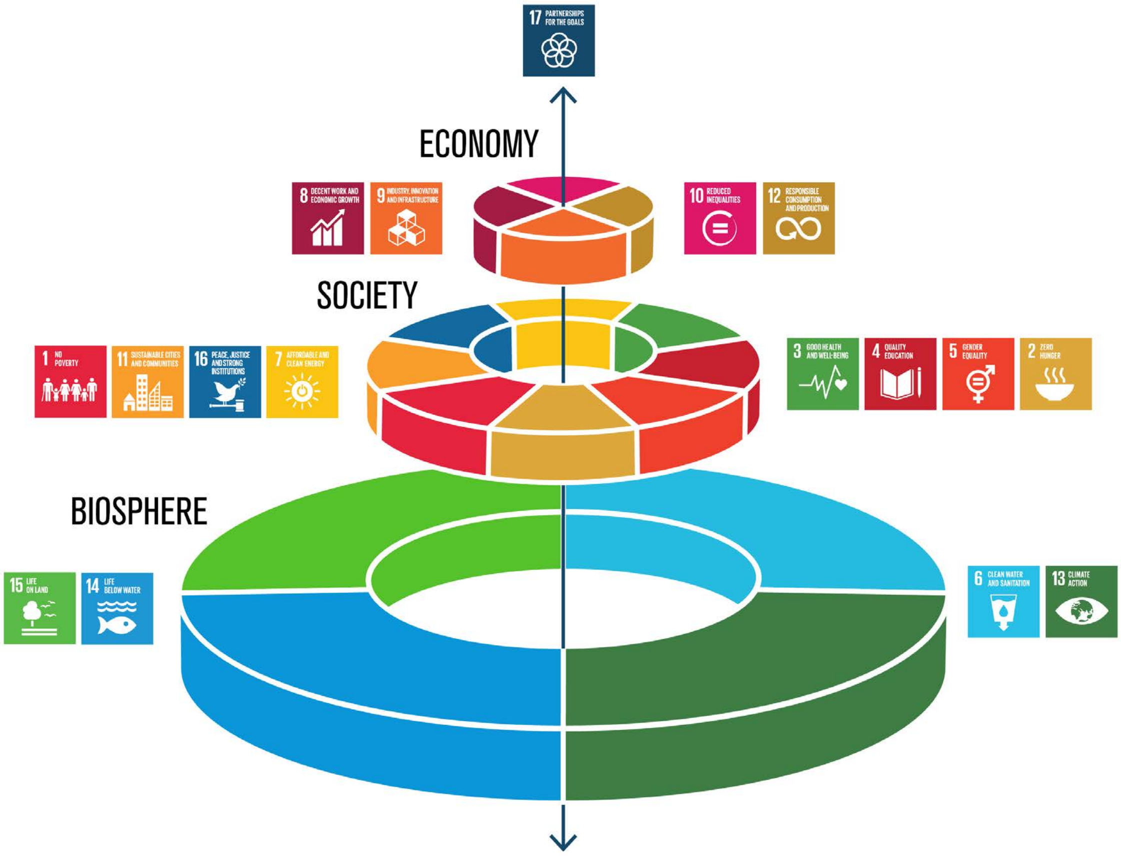


Figure 6. SDGs 6, 13, 14 and 15 are the base of the 'wedding cake'; this figure illustrates how nature connects and is the basis for all the other SDGs. Source: Rockström and Sukhdev, 2016.

Figure 6 shows how the targets for the biosphere – life on land, life below water, clean water and sanitation, climate action – underpin and support all of the societal and economic markers of progress under the SDGs. The relative importance of the biosphere in upholding society and economy is clear – but societal and funding priorities may not be aligned with these relative weights.

The latest Europe Sustainable Development Report (SDSN and IEEP, 2019), which reviews regional progress against the SDGs, found that the EU's Multiannual Financial Framework (MFF) 2021-27 needs to phase out investments and incentives that undermine the objectives of the European Green Deal, and the SDGs more broadly – for example, new investments with significantly negative impacts on biodiversity or other environmental objectives, or those that relate to the production or use of fossil fuels. The same report found that the upcoming MFF needs to mainstream climate action across the entire EU budget (SDSN and IEEP, 2019). The 2020 Eurostat report monitoring the progress of the EU towards the SDGs, found that, for SDG 13 (Climate action), across the EU there had been no significant progress for the past 5 years – and for SDG 6 (Clean water and sanitation) and SDG 14 (Life below water) overall trends could not be calculated due to lack of time-series data for more than 25% of the indicators over the past five years. SDG 15 (Life on land) had made some moderate progress over the past 5 years (Eurostat, 2020).

> *The EU's Multiannual Financial Framework (MFF) 2021-27 needs to phase out investments and incentives that undermine the objectives of the European Green Deal, and the SDGs more broadly – for example, new investments with significantly negative impacts on biodiversity or other environmental objectives, or those that relate to the production or use of fossil fuels.*

(SDSN and IEEP, 2019).

> *NbS are living solutions inspired by, continuously supported by, and using nature. They are designed to address various environmental challenges in a resource efficient and adaptable manner and to provide simultaneously economic, social and environmental benefits.*

(Haase *et al.* 2017).

NbS can bring multiple – and simultaneous – benefits for society, the economy, the environment, and human well-being. As the objectives of various NbS can overlap, it is important to ensure that multi-functional NbS align to meet societal and biodiversity needs while making the best use of resources and limiting trade-offs. Linguistic specifics and socio-political context are of lesser priority than actions that work to aid communities and ecosystems. Acknowledging that NbS are measures that deliver multiple benefits is key to ensuring that interventions under the NbS umbrella bring wide-reaching benefits and do not deliver one-sided results. This distinction is one reason it is important to further improve measurement and monitoring of NbS (see Chapter 4, and the Handbook for Practitioners (Dumitru and Wendling, forthcoming in 2021). By recognising and better understanding the interactions between NbS projects or between the issues they aim to solve – for example, between two NbS targeting the same ecosystem in different ways – policy instruments, incentives and practices can be developed to enhance the success and sustainability of NbS (Busch *et al.*, 2013).

At a practical level, NbS also require robust methods in implementation. At CBD COP 14, Parties to the Convention on Biological Diversity adopted *Voluntary guidelines, for the design and effective implementation of ecosystem-based approaches to climate change adaptation and disaster risk reduction* (Secretariat of the Convention on Biological Diversity, 2019; CBD COP, 2018). The principles and safeguards included in these guidelines (see Box 1 below) are equally valid for NbS.

BOX 1.

Principles for building resilience and enhancing adaptive capacity through EbA and Eco-DRR

1. Consider a full range of ecosystem-based approaches to enhance resilience of social-ecological systems as a part of overall adaptation and disaster risk reduction strategies.
2. Use disaster response as an opportunity to build back better for enhancing adaptive capacity and resilience[8] and integrate ecosystem considerations throughout all stages of disaster management.
3. Apply a precautionary approach[9] in planning and implementing EbA and Eco-DRR interventions.

8. The use of the recovery, rehabilitation and reconstruction phases after a disaster to increase the resilience of nations and communities through integrating disaster risk reduction measures into the restoration of physical infrastructure and societal systems, and into the revitalization of livelihoods, economies and the environment (UNISDR definition of "build back better", 2017, as recommended by the open-ended intergovernmental expert working group on terminology relating to disaster risk reduction (A/71/644 and Corr.1) and endorsed by the United Nations General Assembly (see resolution 71/276)).
9. The precautionary approach is stated in the preamble of the Convention on Biological Diversity: "Where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat."

BOX 1. ***(continued)***

Principles for ensuring inclusivity and equity in planning and implementation

4. Plan and implement EbA and Eco-DRR interventions to prevent and avoid the disproportionate impacts of climate change and disaster risk on ecosystems as well as vulnerable groups, indigenous peoples and local communities, women and girls.

Principles for achieving EbA and Eco-DRR on multiple scales

5. Design EbA and Eco-DRR interventions at the appropriate scales, recognizing that some EbA and Eco-DRR benefits are only apparent at larger temporal and spatial scales.
6. Ensure that EbA and Eco-DRR are sectorally cross-cutting and involve collaboration, coordination, and cooperation of stakeholders and rights holders.

Principles for EbA and Eco-DRR effectiveness and efficiency

7. Ensure that EbA and Eco-DRR interventions are evidence-based, integrate indigenous and traditional knowledge, where available, and are supported by the best available science, research, data, practical experience, and diverse knowledge systems.
8. Incorporate mechanisms that facilitate adaptive management and active learning into EbA and Eco-DRR, including continuous monitoring and evaluation at all stages of planning and implementation.
9. Identify and assess limitations and minimize potential trade-offs of EbA and Eco-DRR interventions.
10. Maximize synergies in achieving multiple benefits, including for biodiversity, conservation, sustainable development, gender equality, health, adaptation, and risk reduction.

BOX 1. ***(continued)***

Safeguards for effective planning and implementation of EbA and Eco-DRR

Applying environmental impact assessments and robust monitoring and evaluation	1.	EbA and Eco-DRR should be subject, as appropriate, to environmental impact assessments including social and cultural assessments (referring to the Akwé: Kon guidelines) at the earliest stage of project design, and subject to robust monitoring and evaluation systems.
Prevention of transfer of risks and impacts	2.	EbA and Eco-DRR should avoid adverse impacts on biodiversity or people, and should not result in the displacement of risks or impacts from one area or group to another.
Prevention of harm to biodiversity, ecosystems, and ecosystem functions and services	3.	EbA and Eco-DRR, including disaster response, recovery and reconstruction measures, should avoid the degradation of natural habitat, loss of biodiversity or the introduction of invasive species, and should not create or exacerbate vulnerabilities to future disasters.
	4.	EbA and Eco-DRR should promote and enhance biodiversity and ecosystem functions and services, including through rehabilitation/restoration and conservation measures, as part of post-disaster needs assessment and recovery and reconstruction plans.
Sustainable resource use	5.	EbA and Eco-DRR should neither result in unsustainable resource use nor enhance the drivers of climate change and disaster risks, and should strive to maximize energy efficiency and minimize material resource use.
Promotion of full, effective and inclusive participation	6.	EbA and Eco-DRR should ensure full and effective participation of the people concerned, including indigenous peoples and local communities, women, minorities and the most vulnerable, including the provisioning of adequate opportunities for informed involvement.
Fair and equitable access to benefits	7.	EbA and Eco-DRR should promote fair and equitable access to benefits and should not exacerbate existing inequities, particularly with respect to marginalized or vulnerable groups. EbA and Eco-DRR interventions should meet national labour standards, protecting participants against exploitative practices, discrimination and work that is hazardous to their well-being.

BOX 1. ***(continued)***

Transparent governance and access to information	8.	EbA and Eco-DRR should promote transparent governance by supporting rights to access to information, providing all stakeholders and rights holders, particularly indigenous peoples and local communities, with information in a timely manner, and supporting the further collection and dissemination of knowledge.
Respecting rights of women and men from indigenous peoples and local communities	9.	EbA and Eco-DRR measures should respect the rights of women and men from indigenous peoples and local communities, including access to and use of physical and cultural heritage.

Source: from the *Voluntary Guidelines for the design and effective implementation of ecosystem-based approaches.*
Source: CBD COP, 2018: CBD/COP/14/5 Annex

2.2. NbS in the EU: strategies and policies

Regardless of the setting, societal challenge, level of intervention or other characteristics, the potential role(s) for NbS to work with nature to overcome societal challenges is huge. According to the EU Biodiversity Strategy for 2030, NbS will be essential for reducing emissions and adapting to our changing climate, and they should also be "systematically integrated into urban planning, including in public spaces, infrastructure, and the design of buildings and their surroundings" (European Commission, 2020a). This goal is supported by the Strategy's objectives and initiatives, with a "significant proportion" (*ibid.*) of the EU budget for climate action promised to investment in biodiversity and NbS. Subtitled 'Bringing nature back into our lives', the Strategy places priority on "making nature healthy again" and "[giving] back more to the planet than [is taken away]", and calls for increasing rollout and upscaling of NbS to make this a reality (European Union, 2020).

The European Commission already promotes nature-based solutions through a wide range of policy areas[10] and has also expressed support for the 'NbS for Climate Manifesto', proposed in August 2019 at the UN Climate Action Summit 2019. NbS are also an important part of the European Green Deal transition, with urban regeneration deemed essential for transformative societal change.

10. Ref: EU contribution NbS 13062019.docx

The EU Biodiversity Strategy to 2030 (2020): Bringing nature back into our lives	Highlights the value and importance of NbS in fighting biodiversity loss, climate change and other pressing challenges. Promises funding for investment in NbS. Restoring degraded ecosystems, establishing protected areas, unlocking funding and becoming a leader in addressing the biodiversity crisis are key factors.
European Green Deal (2019)	Overarching strategy for a climate-neutral Europe, where economic growth is decoupled from resource use. Turning climate and environmental challenges into opportunities in a just and inclusive way.
EU R&I agenda for NbS (2016-present)	Coastal resilience and marine protection Called for enhancement of the framework conditions for NbS and mainstreaming of NbS by building a community of pro-NbS research and innovation policies and projects.
International ocean governance agenda (2016)	Proposed an NbS approach to promoting and developing ocean-related action to implement the Paris Agreement.
The EU Action Plan on the Sendai Framework for Disaster Risk Reduction (2015)	Presented ways that risks can be reduced through working with nature, rather than against it, while also providing human, biodiversity and climate benefits.
Towards a research and innovation policy agenda for Nature-based Solutions and Renaturing Cities (2014)	Proposed NbS as being more effective and efficient solutions than more traditional approaches – turning environmental, social and economic challenges into innovation opportunities.
EU Policy Document on NWRM (2014)	Explains the policy relevance of Natural Water Retention measures, to stimulate the uptake of NWRM as effective tools.
The EU Green Infrastructure Strategy (2013)	Recommends consolidating green infrastructure and EbA to tackle disaster risk, based upon the Natura 2000 protected area network (covering over 18% of EU land area and 10% of EU marine territory)
The EU Adaptation Strategy to climate change (2013)	Commends ecosystem-based approaches (EbA) for delivering cost-effective, accessible multiple benefits in various scenarios
Water Blueprint for Europe (2013)	Natural water retention measures, green infrastructure and ecosystem restoration recognised under the Blueprint as ways to protect and strengthen Europe's water resources while producing co-benefits.
The EU Biodiversity Strategy to 2020 (2011)	Called for mapping of EU ecosystems and services, highlighting their role in mitigating climate change.
Towards better environmental options and flood management (2009)	Called for flood risk management to work with nature, rather than against it, and building up green infrastructure by investing in ecosystems.

Table 2. EU policies and strategies supporting NbS

3. Examples of NbS in practice

In this chapter we present several different NbS projects from across the globe, showing a range of scales: from large-scale initiatives, such as ECCA30, a global project to restore 350 million hectares of the world's deforested and degraded land by 2030, to a more localised project, MARE (Marine Adventures Respecting the Environment), which is focused on conservation activities within Italy's Punta Campanella marine protected area.

The sheer variety of NbS projects means that such projects can contribute towards many different environmental and societal goals and policy areas. For example, the EU's Biodiversity Strategy for 2030 aims to restore Europe's biodiversity over the next decade, to benefit people, the climate and the planet. The strategy has 4 main elements: protect nature, restore nature, enable transformative change, and high ambition and leadership for the post-2020 global biodiversity framework. It promotes NbS as a common thread through all these elements. NbS can contribute to the strategy's policy objectives in a multitude of ways, for example, via: biodiversity protection; emission reduction and climate change mitigation; protecting and restoring wetlands, peatlands and coastal ecosystems; or restoring marine areas, forests, grasslands and agricultural soils. The Biodiversity Strategy will also be supported by NbS such as planting trees and vegetation (which can also prevent erosion and mitigate the effects of natural disasters) or building green infrastructure (which can also cool urban areas), illustrating the multiple benefits that can be achieved.

Close-up of volunteers child and woman planting tree in city park, ©Getty Images, public domain

New Strategy for Renaturing Cities through Nature-Based Solutions, ©URBAN GreenUP

Table 3. In Table 3 and Box 2 below, we include a small selection of European and global NbS projects, which have multiple benefits for ecosystems and people, and therefore contribute towards a wide variety of policy areas.

Project Name	Dates	Geographical region	Project description	Relevant policies
One Trillion Trees	2020	Global (World Economic Forum)	Aims to end deforestation and restore one trillion trees to the planet by 2050. There are three strands: 1) Ending deforestation; 2) improving forest protection; 3) Advancing restoration – i.e. getting the right trees in the most effective places.	Paris Agreement; New EU Forest Strategy; Aichi Biodiversity Targets; Communication on Deforestation
Initiative 20x20	2020	Latin America and Caribbean	This initiative supports the Bonn Challenge: these 3 regional programmes in 17 countries are committed to restore over 150 million hectares of degraded land by 2020. As well as reforestation, the initiative has supported soil conservation and recovery and biodiversity conservation via agroforestry and sustainable land-use schemes.	Aichi Biodiversity Targets; Paris Agreement; New EU Forest Strategy
Compendium of contributions nature-based solutions – from the 2019 UN Climate Action Summit	2019	Global	The purpose of this compendium is to share a summary of initiatives and best practices received from the global call for initiatives on how NbS can be enhanced and scaled-up.	Paris Agreement.
ECCA30	2019-2030	Europe, the Caucasus and Central Asia	This is a regional project implementing the Bonn Challenge (a global project to restore 350 million hectares of the world's deforested and degraded land by 2030). The ECCA 30 project aims to restore 30 million hectares of the degraded and deforested landscapes of Europe and central Asia over the next 30 years.	Aichi Biodiversity Targets; Paris Agreement; Biodiversity Strategy for 2030; New EU Forest Strategy
Great Green Wall	2007-	Africa's Sahel region – from Senegal to Djibouti	The Sahel is on the frontline of climate change, with consequences including persistent droughts, lack of food, conflicts over dwindling natural resources and mass migration to Europe. The Great Green Wall is an African-led solution aiming to grow an 8,000km natural barrier to desertification stretching the entire width of Africa. Once complete, the Great Green Wall will be the largest living structure on the planet, 3 times the size of the Great Barrier Reef, providing food security, jobs and livelihoods for the millions who live along its path.	Land Degradation Neutrality, UN Decade on Ecosystem Restoration, Aichi Biodiversity Targets

Resilient Asian Deltas (FAD)	2019-	Asia	Asian deltas, such as the Indus River Delta in southern Pakistan, are shrinking due to erosion and sinking because of land subsidence. This is threatening human livelihoods in delta areas. This project aims to enforce long term resilience of the delta systems by protecting and restoring the river and coastal processes that replenish deltas.	SDGs 2, 8, 12, 13, 14; Paris Agreement; Action Plan on the Sendai Framework for Disaster Risk Reduction
Blue Lifelines for a Secure Sahel (BLiSS)	2019-	Africa's Sahel region	This project aims to revive and safeguard the Sahel region's rivers, floodplains, lakes, deltas and ponds — improving water and food security for local communities. By the end of 2030, the project aims to have restored and safeguarded 20 million hectares of wetlands in at least six major systems, building resilience for 10 million people across the Sahel.	EU Action Plan on Sendai; Aichi Biodiversity Targets
Productive Green Infrastructure for post industrial urban regeneration (proGIreg)	2018-2023	Dortmund (Germany), Turin (Italy), Zagreb (Croatia), Ningbo (China)	proGIreg (one of many H2020-funded NbS projects) aims to create a green infrastructure to improve quality of life and provide economic benefits to urban citizens. Nature based solutions are designed and put into practice by citizens, governments, business, NGOs and universities.	European Green Deal; Biodiversity Strategy for 2030; Urban Agenda for the EU; Aichi Biodiversity Targets Strategic Goal D. Green Infrastructure Strategy
BLUE SMART: Blue Education for Sustainable Management of Aquatic Resources	Jan 2017-Dec 2018	Croatia	The purpose of this project is to educate future experts in reducing the impact of the blue sector on aquatic ecosystems, and to increasing its sustainability.	Biodiversity Strategy for 2030; Integrated maritime policy; Aichi Biodiversity Targets: Strategic Goal A and Strategic Goal E; European Green Deal
Promoting transboundary co-existence of large carnivores	2017-2026	Italy & Slovenia	The project used a participatory decision-making process to develop a transboundary bear management plan for a nature park in Italy (Prealpi Giulie) and an adjacent national park in Slovenia (Triglav). The project set up a joint agreement for allocation of money and staff time to satisfy stakeholders concerned about brown bears in the Transboundary Julian Alps Ecoregion.	Biodiversity Strategy for 2030; Aichi Biodiversity Targets: Strategic Goal C

Global Peatlands Initiative	2016	Indonesia, Peru, Democratic Republic of Congo; Republic of Congo	Initially a global assessment of peatlands as an essential asset in efforts to mitigate climate change. Pilot projects in the four initial countries are changing management practices to inclusive and sustainable approaches to use peatlands management in addressing climate change and natural resource use, while working to transition to a green economy.	Paris Agreement; EU Action Plan on Sendai; SDGs 1, 7, 8, 12, 13, 15.
Green Deal Green Roof	2016-	The Netherlands, Central Europe	A cross-sectoral initiative which aims to increase the implementation of green roofs, whilst removing barriers that inhibit their implementation. This initiative aims to develop new revenue models and apply them around roof greening. Benefits include improving sustainable urbanisation, creating green jobs relating to construction and maintenance of NbS and increasing awareness of NbS solutions.	European Green Deal; Renovation Wave;
OPPLA NbS Case Studies	2016	60 universities, research institutes, agencies and enterprises, funded by European Commission FP7 Programme	An EU Repository of Nature-Based Solutions. It provides a knowledge marketplace, where the latest thinking on natural capital, ecosystem services and nature-based solutions is brought together.	Potentially all NbS-relevant policies.
Central African Forest Initiative	Sept 2015 -	Cameroon, Central African Republic, Republic of Congo, the Democratic Republic of Congo, and Equatorial Guinea Donors: EU, France, Norway, Germany, UK, The Netherlands, South Korea	This coalition of central African countries, Republic of Congo, and Equatorial Guinea are working to maintain their rainforest cover which is currently under extreme pressure from expanding agriculture – and thereby mitigate climate change, reduce poverty and work towards sustainable development.	Paris Agreement; Aichi Biodiversity Targets; New EU Forest Strategy
MARE: Marine Adventures Respecting the Environment	2013-	Western and Southern Europe	Supports the conservation activities of Italy's Punta Campanella marine protected area. Volunteer activists work on defining and practising sustainable initiatives, such as environmental monitoring, cleaning beaches and ecotourism promotion.	Biodiversity Strategy for 2030; Marine Strategy Framework Directive; European Green Deal

Table 3: Illustrative selection of NbS projects

BOX 2.

Three spatial scales of NbS in practice and their contribution to international policy aims

Urban garden (Turin, Italy), ©PROGIREG

ProGIreg's Living Labs (2018-2023): Using nature for urban regeneration in Europe and China

ProGIreg (Productive Green Infrastructure for post-industrial urban regeneration) is supporting nature-based innovation in the post-industrial districts of eight cities: four of which host Living Labs (Dortmund, Ningbo, Turin, and Zagreb), and four of which collaborate in city-to-city exchange of NbS (Cascais, Piraeus, Cluj Napoca and Zenica). The initiative implements eight different types of NbS: community-based urban gardens and farms, reusing former landfill sites for leisure activities and clean energy production, sustainable aquaponics, accessible green corridors, soil regeneration, local environmental compensation processes, green walls and roofs, and measures to promote pollinator biodiversity. This project, therefore, contributes to policy areas including the European Green Deal; Biodiversity Strategy for 2030; Urban Agenda for the EU; Aichi Biodiversity Targets Strategic Goal D and the Green Infrastructure Strategy. (Funded by the European Commission under Horizon 2020.)

BOX 2. ***(continued)***

Food Forest (Dortmund, Germany), ©PROGIREG

Natural Water Retention Measures (2009-2010): Draining basin of the Venice Lagoon, Italy

A project aimed to re-structure the draining channels of the Dese River to reduce the amount of nitrogen and phosphorous reaching the Venice lagoon, in order to improve water quality and reduce flooding issues. This project aimed to address the sustainability challenges of water management, green space, habitat, and biodiversity protection, and coastal resilience and marine protection (SDGs 3, 11, 16). Implemented by the Consorzio Acque Risorgive and funded by the Veneto Region.

Green space regeneration for social cohesion (2013-2014): Teleki Square community park in Budapest, Hungary

A project aimed to support socially sensitive urban regeneration of a stigmatised part of Budapest, involving local people in renovating the neighbourhood green space of the park to strengthen social cohesion. This project aimed to address the sustainability challenges of regeneration, land use and urban development, inclusive and effective governance, and health and well-being (SDGs 3, 16, 11). The local participants later established an association that provides them with a legal frame for taking care of the park, helping to ensure sustainability. Implemented by local people, as part of the Magdolna Quarter Programme III, and funded by European Regional Development Funds.

4. Evaluating NbS

This Chapter will discuss the key contributing factors for assessing and evaluating the impacts of NbS, including using indicators for monitoring, the use of integrated assessment frameworks, economic valuations, and some real-world examples of key challenge areas that NbS can address, including climate change, health and flood/drought management. The examples within this chapter, such as the use of wetlands to mitigate sewerage overflow, or the use of saltmarshes for ameliorating flood risk, show that nature itself can inspire ideas and solutions for mitigating some of the risks caused by environmental degradation and a changing climate. NbS based on nature's designs are often elegant, effective and frugal, as is the case with urban green spaces – aiding human well-being whilst also lowering the impacts of the urban heat island effect. Utilising NbS, including hybrid green/blue/grey infrastructure, can provide ecological, social and economic resilience for society.

4.1. Why is evaluating NbS important?

Gathering evidence of the effectiveness of NbS, compared to other alternative, technical solutions for addressing societal challenges – challenges such as flooding, water shortage, water pollution, pollinator decline, urban heat island and carbon emissions (Albert *et al.*, 2019) – will encourage appropriate uptake and implementation. The Horizon 2020 Expert Group, stressed in their 2015 Report the importance of creating an evidence base for NbS, to promote uptake (EC, 2015). Towards meeting this goal, an evidence base for NbS is now hosted in two online repositories by Oppla and the new Network Nature Platform,[11] launching in 2020. The EKLIPSE NbS Integrated Evaluation Framework, and the IUCN Global Standard for NbS, are two examples of protocols and standards for evaluating NbS that enable development of robust evidence in support of NbS (Raymond *et al.*, 2017a; Raymond *et al.*, 2017b; IUCN, 2020; Somarakis, Stagakis and Chrysoulakis, 2019).

BOX 3.

Key Indicators for NbS

Each societal challenge has a range of qualitative and quantitative indicators, which enable evaluation of the impact of a proposed NbS. Indicators can include both modelled and measured data, and, in a mixed approach, would be selected from a range of categories. A list of recommended core indicators for assessing a range of societal challenges have been proposed by the impact evaluation taskforce. Some examples are given below (Dumitru and Wendling, forthcoming in 2021):

1. Climate resilience:
    - Total carbon removed or stored in vegetation and soil per unit area per unit time
    - Avoided greenhouse gas emissions from reduced building energy consumption
    - Monthly mean value of daily maximum temperature
    - Monthly mean value of daily minimum temperature
    - Heatwave incidence: Days with temperature>90th percentile

11. Network Nature is created by ICLEI Europe, IUCN, BiodivERsA, Oppla and Steinbeis 2i, in close collaboration with the European Commission Directorate-General for Research and Innovation and Executive Agency for SMEs.

BOX 3. ***(continued)***

2. Water management:
   - Surface runoff in relation to precipitation quantity (mm/%)
     Water quality: general urban; total suspended solids (TSS) content, nitrogen and phosphorus concentration or load; metal concentration or load; total faecal coliform bacteria content of NbS effluents
3. Natural and climate hazards:
   - Disaster resilience (as per United Nations office for Disaster Risk Reduction (UNDRR) Disaster Resilience Scorecard for Cities)
   - Mean annual direct and indirect losses due to natural and climate hazards (€)
   - Risk to critical urban infrastructure
   - Number of people adversely affected by natural disasters each year
   - Multi-hazard early warning system utilisation
4. Green space management:
   - Green space accessibility
   - Share of green urban areas
   - Soil organic matter content
   - Soil organic matter index
5. Biodiversity enhancement:
   - Structural and functional connectivity of green infrastructure
   - Number of non-native plant and animal species introduced
   - Number of invasive alien species
   - Species diversity within defined area as per Shannon Diversity Index
   - Number of species within defined area as per Shannon Evenness Index

BOX 3. ***(continued)***

6. Air quality:

   - Number of days during which ambient air pollution concentrations in the proximity of the NbS (PM2.5, PM10, O3, NO2, SO2, CO and/or PAHs expressed as concentration of benzo[a]pyrene) exceeded threshold values during the preceding 12 months
   - Proportion of population exposed to ambient air pollution (PM2.5, PM10, O3, NO2, SO2, CO and/or polycyclic aromatic hydrocarbons (PAHs) expressed as concentration of benzo[a]pyrene) in excess of threshold values during the preceding 12 months
   - European Air Quality Index

7. Place regeneration:

   - Derelict land reclaimed for NbS
   - Quantity of green/blue space (as a ratio to built form)
   - Perceived quality of urban blue-green spaces (accessibility, amenities, natural features, incivilities & recreational facilities)
   - Place attachment: place identity or "sense of place"
   - Recreational value of public green space
   - NbS incorporated in building design/incorporation of environmental design in buildings
   - Cultural heritage protection

8. Knowledge and social capacity building for sustainable urban transformation:

   - Citizen involvement in environmental education activities
   - Social learning regarding ecosystems and their functions
   - Pro-environmental identity and behaviour

9. Participatory planning and governance:

   - Openness of participatory processes
   - Proportion of citizens involved in participatory processes
   - Sense of empowerment: perceived control and influence over decision-making
   - Adoption of new forms of participatory governance: PPPs activated
   - Policy learning for mainstreaming NbS: number of new policies instituted
   - Trust in decision-making procedure and decision-makers

BOX 3. ***(continued)***

10. Social justice and social cohesion:
    - Bridging – quality of interactions within and between social groups
    - Bonding – quality of interactions within and between social groups
    - Inclusion of different social groups in NbS co-co-co processes
    - Trust within the community
    - Solidarity among neighbours
    - Tolerance and respect
    - Availability and equitable distribution of blue-green space

11. Health and well-being:
    - Level of outdoor physical activity (min/week)
    - Level of chronic stress (perceived stress)
    - General wellbeing and happiness
    - Self-reported mental health and wellbeing
    - Prevalence of cardiovascular disease
    - Incidence of cardiovascular disease
    - Quality of life

12. New economic opportunities and green jobs:
    - Valuation of NbS: value of NbS calculated using GI-Val
    - Economic value of urban nature
    - Mean land and/or property value in proximity to green space
    - Change in mean house prices/rental markets
    - Average land productivity and profitability
    - Property betterment and visual amenity enhancement
    - Direct economic activity: number of new jobs created
    - Direct economic activity: retail and commercial activity in proximity to green space
    - Direct economic activity: gross value added to local economy from new business creation
    - Recreational monetary value
    - Overall economic, social and health well-being

4.2. Monitoring: data collection on key indicators

Monitoring across all the stages of the NbS process provides the information needed to form and improve longer-term plans for NbS projects (Kabisch *et al.*, 2016). Long-term monitoring of NbS enables active learning about what constitutes successful functioning in order to improve future implementation (Raymond *et al.*, 2017a).

NbS are multifunctional, and they provide multiple benefits and a range of direct and indirect services compared with traditional infrastructure solutions (Engström *et al.*, 2018). Assessing the multiple benefits that NbS provide can be achieved using multi-metric indicators such as recreation potentials, water retention, temperature, humidity and biodiversity, integrated environmental performance and civil participation – including multiple value dimensions (Kabisch *et al.*, 2016; Raymond *et al.*, 2017a; Albert *et al.*, 2019). Indicators may be related to budgetary considerations: for example, the cost of personnel needed to monitor the project, or the financial return on the initial investment. A variety of descriptive and quantitative or mixed methods can assess the direct benefits or costs of NbS actions (Raymond *et al.*, 2017b). For example, ecosystem service stocks and flows associated with an NbS can be examined via quantitative models, whilst air pollution can be modelled using the iTree suite of tools. Social impacts of NbS can be assessed using fuzzy cognitive maps, narrative analysis, Q-methodology and interpretative analysis. Direct economic benefits can be assessed using a number of methods: cost-effectiveness assessments (CEA), for example, assess the performance (non-monetary, single outcome) of the measures against their costs. Another assessment method for NbS is multi-criteria analysis (MCA), which assesses the performance (non-monetary, multiple outcomes) of the measures through public or expert opinion, whereas the social costs and benefits approach (SCBA), analyses the monetised costs and benefits from the effects of the measures discounted over time (Raymond *et al.*, 2017a).

Data on effective NbS governance found in city NbS projects are shared with wider city networks via projects like REGREEN. Using pilot NbS demonstration projects aids in evaluating and scaling up of NbS (REGREEN, 2020; Raymond *et al.*, 2017a; Raymond *et al.*, 2017b). Approaches for governing NbS need to be developed in a way that would ensure a fair distribution of benefits and costs, i.e. through multi-criteria analysis and a weighting process between competing interests (Albert *et al.*, 2019; Rutt and Gulsrud, 2016).

Demonstration projects can show, for instance, the additional benefit of NbS in addressing energy efficiency and providing climate change resilience to the urban-heat-island effect, whilst also improving air quality, reducing noise and improving human health (European Commission, 2015). During the COVID-19 pandemic, many city dwellers have recognised the importance of urban green spaces to their well-being (Derks, Gissen and Winkel, 2020).

IUCN has contributed to several global NbS initiatives that have been operating for a number of years, including the Bonn Challenge, which addresses Forest Land Restoration (FLR). To aid with evaluating the success of this international NbS initiative, the IUCN has developed a barometer – an online platform whereby countries who have made pledges to implement FLR can provide data on their progress. The Bonn Challenge Barometer was developed to minimise reporting effort and to aid with countries' existing national and international commitments to gather data on restoration (Dave *et al.*, 2019).

The Bonn Challenge Barometer protocol has two main categories: 'success factors,' and 'results and benefits.' The success factors category is further divided into policies, financial flows and technical underpinning (see Figure 7). Under technical underpinning, a broad 'restoration planning' indicator includes a description of formal restoration planning exercises and approaches. Feedback on capacity issues from the data providers helped refine this indicator – removing the requirement for specific detailed reports (Dave *et al.*, 2019).

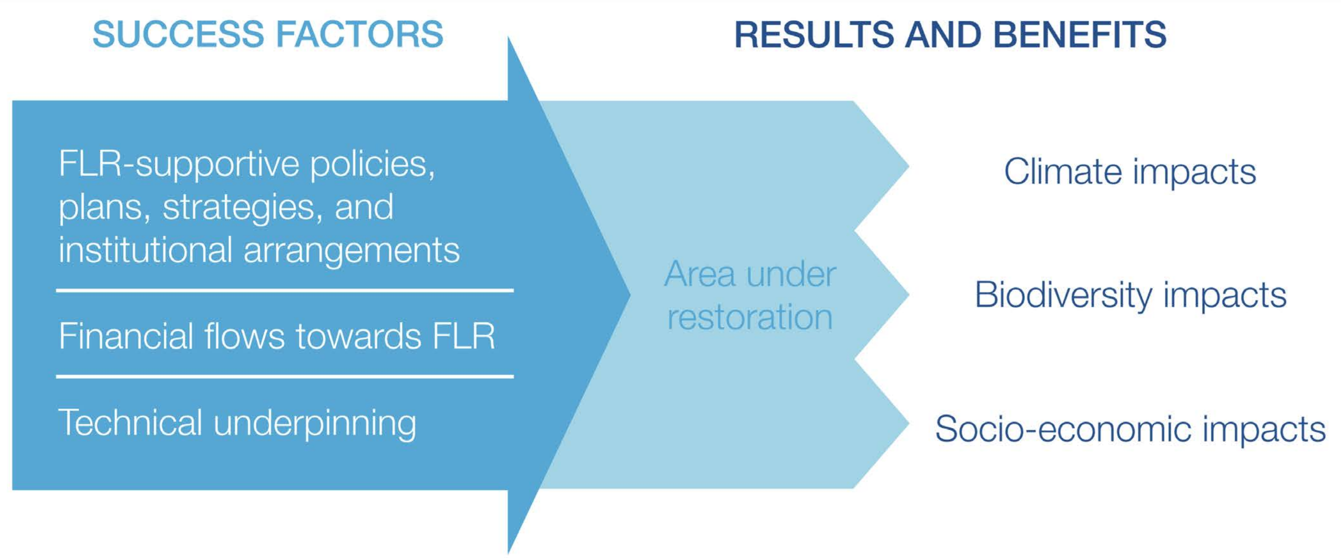


Figure 7. The two dimensions of the Barometer and their constituent indicators (Dave *et al.*, 2019). ©2019 IUCN.

For the Bonn Challenge Barometer protocol for forest land restoration (FLR), the central indicator "under restoration", is a set of measures put in place that slow, and then reverse, the degradation status of key ecological, social and economic indicators. In addition to the central indicator, other indicators in this category are climate impacts, biodiversity impacts and socio-economic impacts. Data collection for these indicators overlaps with other reporting commitments, and explicit guidance is provided on this so data providers do not have to duplicate work, and can use this tool to aid with reporting under other international commitments and frameworks (e.g. climate change and UNFCCC reporting on mitigation outcomes from the land and forest sector, biodiversity impacts and the CBD Aichi Biodiversity Targets).

BOX 4.

Copenhagen: An urban NbS strategy – monitoring with indicators of quality

To identify the multiple definitions of quality for NbS in a city, residents, urban planners and other stakeholders also need to have a chance to define their indicators of quality for different types of NbS. Authorities in Berlin and Copenhagen are focusing on expanding the indicators of quality and citizen preference in their NbS strategies (Rutt and Gulsrud, 2016).

Copenhagen's Urban Nature Strategy 2015-2025, has ambitious, sustainable development objectives including urban development of reclaimed land and former industrial areas. The city developer, By & Havn, with partner Arup, use a bespoke data-monitoring dashboard for assessment of the impact of the urban NbS projects they have implemented. Furthermore, the dashboard enables the developer to check if the NbS outcomes align with the UN's Sustainable Development Goals, and the city's sustainability priorities. There were 16 Key Performance Indicators used, including the proportion of natural areas within walking distance, as well as the total annual water consumption per resident (By & Havn, 2020). Moreover, Copenhagen has invested in improving its urban parks and forests for rainfall retention during more frequent heavy rainfall events. The amount of green space in a city is important, with a high percentage of green space, high edge-density and high patch-density (two fundamental aspects of landscape pattern) providing connectedness and resilience to heat waves and heavy rainfall. Some of these indicators can be easily monitored and measured by city authorities, using remote data gathering techniques, such as satellite sensors providing high-quality imagery (Lafortezza *et al.*, 2018).

4.3. Assessing NbS

An NbS framework or protocol can be used by multi-stakeholder and multi-disciplinary teams to guide monitoring and evaluation of NbS during the various stages of NbS action plans (Raymond *et al.*, 2017a). These frameworks can be applied to NbS across a range of city, rural, and semi-rural environments. However, in a world where urban areas are growing, it is vital to incorporate NbS in city planning and design, to be able to achieve global sustainability. This will often allow the provision of multiple services such as mitigating floodwater and carbon emissions, and improving energy efficiency (Engström *et al.*, 2018), as well as benefiting human health through air filtering and reducing urban heat island effects. However, choosing the right type of NbS to sustainably address urban challenges, requires a robust approach to evaluate the quality and effectiveness of each intervention. Assessing NbS requires a multi-criteria decision-making approach, to account for the direct and indirect benefits that the different interventions may provide, and the possible trade-offs between them. Not all green infrastructure interventions will be of equal quality, and more than one type of NbS intervention may be available to solve a particular challenge, which requires a rigorous comparison protocol. Furthermore, to continue the example of urban challenges, several NbS could be considered alongside an existing, in-situ grey infrastructure solution, or as part of a grey-green hybrid solution. Assessment provides a clear picture of which solution will work best in a particular setting. (Rutt and Gulsrud, 2016; Albert *et al.*, 2019). The IUCN Global Standard for NbS, and the EKLIPSE NbS Integrated Evaluation Framework (which led to the forthcoming *Practical Handbook* on evaluating NbS, and which will provide a comprehensive set of indicators and methodologies for evaluating NbS; Dumitru and Wendling, forthcoming in 2021) are two examples of systematic frameworks for assessing ecosystem services and co-benefits of NbS, which can aid in creating and using NbS action plans' for a particular societal challenge.

4.3.1. IUCN Global Standard for NbS

In order to ensure that NbS reach their potential to address societal challenges, the IUCN have developed the Global Standard for NbS, to be used by different types of stakeholders, such as governments, businesses, investors, communities and NGOs (IUCN, 2020). The IUCN and its partner organisations have, over the past few decades, developed a number of well-established approaches – such as FLR (Forest Landscape Restoration – see Bonn Challenge), EbA, and EcoDRR that have been used around the world and constitute the foundation of many NbS (IUCN, 2020). The Global Standard was launched by the IUCN in July 2020, with a large support from governments and organisations from different parts of the globe. In addition, it can help users assess and improve the efficiency of their interventions and transform them into strong NbS, addressing societal challenges, while providing benefits to people and biodiversity (IUCN, 2020). The Global Standard has eight criteria with associated indicators (28 indicators in total), based on best-practice principles adopted by the IUCN, in addition to the definition for NbS (IUCN, 2016) (see Figure 8). The Standard includes guidance to users on how to conduct a self-assessment, to help with designing new NbS, up-scaling pilot projects, identifying gaps, and improving and verifying past and ongoing projects. The output – in the form of traffic-light descriptors for each indicator, within each of the eight criteria – helps assess adherence to the Global Standard for NbS, and can identify areas for further work (IUCN, 2020).

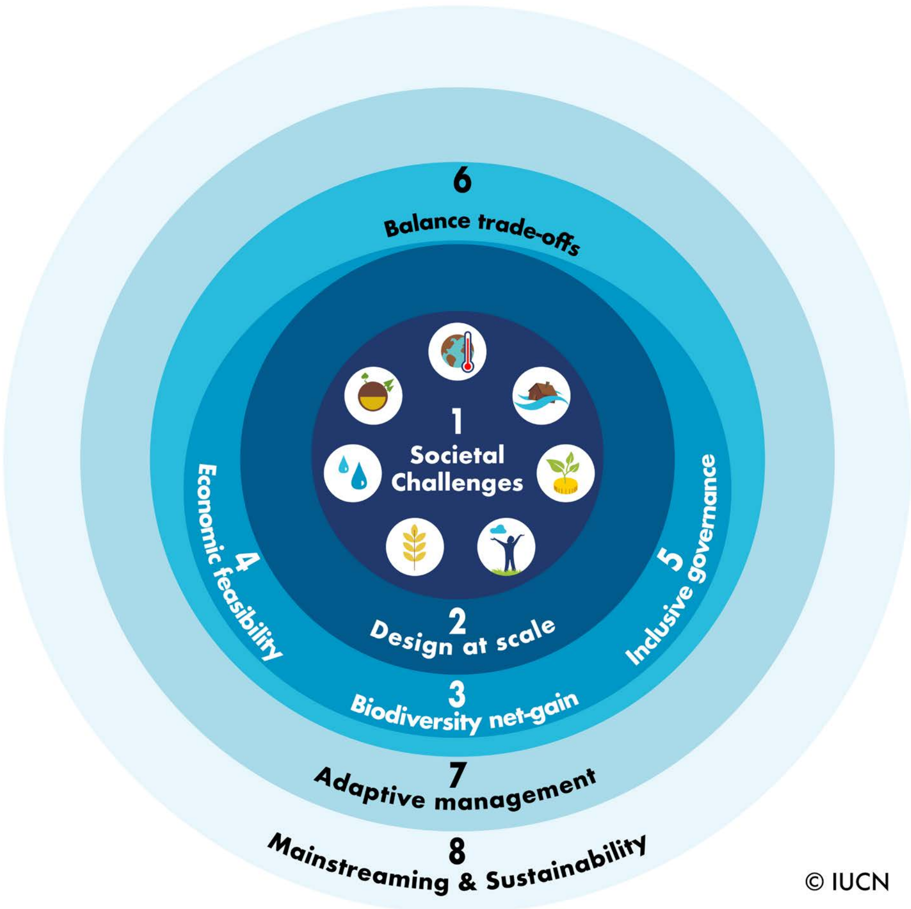


Figure 8. Eight interconnected criteria of the IUCN Global Standard for NbS (IUCN, 2020). ©2020 IUCN.

4.3.2. EKLIPSE NbS Integrated Evaluation Framework and the *Handbook for Practitioners*

Raymond *et al.* (2017b) developed the holistic EKLIPSE NbS Integrated Evaluation Framework (funded by Horizon 2020) to aid in assessing the impact of NbS, within and across different societal challenges (Raymond *et al.*, 2017b). NbS in urban settings can simultaneously provide co-benefits for human health and biodiversity (Cohen-Shacham *et al.*, 2016), but prior research into assessing NbS had focussed on a more constrained set of impacts and single indicators (Raymond *et al.*, 2017b). The EKLIPSE Integrated Evaluation Framework sought to fully represent the complexity of NbS in a framework that systematically identifies how they provide synergies across ecosystem services, but also co-benefits (or costs) in other different elements (socio-cultural, socio-economic system, environment, biodiversity, ecosystems, and climate), particularly in urban settings (Raymond *et al.*, 2017b).

The EKLIPSE framework consists of 4 aspects that can appear when implementing NbS: 1) co benefits for human health and well-being; 2) integrated environmental performance; 3) trade-offs and synergies with biodiversity, health or economy; and 4) potential for citizen's involvement in governance and monitoring. The EKLIPSE framework differs from prior attempts, by addressing the complexity of not only benefits and costs of each of these aspects, but also the benefits and costs of interactions between these factors, for example across socio-cultural, or economic systems. The framework examined 10 key societal challenges (see Figure 12, page 44) faced by cities, and noted potential actions for each challenge and expected impacts of specific NbS objectives; indicators of impact; and potential methods for assessing impact. The final EKLIPSE framework is a guide which requires tailoring to city-specific circumstances to enable a successful implementation of NbS action plans.

Expanding upon the pioneering work of the EKLIPSE framework, the NbS Impact Evaluation Taskforce, comprised of representatives from 17 individual EU-funded projects on NbS and collaborating institutions such as the EEA and JRC – as well as more than 150 European researchers and over 60 European cities and regions – has created an integrated NbS assessment framework. This framework aims not only to serve as a reference for relevant EU policies and activities, but also to orient urban practitioners in developing robust impact evaluation for NbS at different scales. It intends to provide a comprehensive set of indicators and methodologies for NbS in transforming the urban environment (see *Evaluating the Impact of Nature-based Solutions: A Handbook for Practitioners*, Dumitru and Wendling, forthcoming in 2021)

4.3.3. Are you living in the greenest city in Europe?

There are other ways that NbS can be evaluated and recognised. Each year, the European Commission awards the title of European Green Capital or European Green Leaf to cities for their commitment in achieving high environmental standards and sustainable development and thus in improving the quality of life of their citizens. May 2020 saw the competition launch for the 2023 European Green Capital Award (EGCA 2023) for cities with over 100,000 people and the 2022 European Green Leaf Award (EGLA 2022) for towns/cities with 20000 to 99999 residents. The combined cash prize total is 1 million Euros and is awarded to cities to support them in further implementing measures to contribute to meeting the objectives of the European Green Deal (such as those contained in the Biodiversity Strategy 2030).

Winning the awards brings many benefits: increased international media coverage, a boost in local pride, a greater focus on environmental projects, and increased foreign investment. Finalist and winning cities also gain entry to a network of previous finalists and winning cities to share knowledge on urban sustainability issues, including on how to overcome key urban challenges. The main aim is to share their expertise with other, less-advanced cities, and to demonstrate that any city can 'go green'.

More information on how to apply for EGCA and EGLA awards can be found online.

4.4. Economic valuation of NbS

Wild, Henneberry and Gill (2017) consider the valuation of a range of blue/green urban water management strategies within a range of scales (from individual properties to city regions) and valuation approaches (using a single value or multiple criteria). Total economic valuations of NbS schemes usually total the private and public costs and benefits to come up with an overall figure. For example, willingness to pay (WTP) values, where urban residents are asked for their WTP (via higher rents, mortgages and taxes), could be assessed for a range of different green infrastructure investments nearby (Wild, Henneberry and Gill, 2017). These results can then be extrapolated to calculate the consequent uplift in house prices in the area arising from the green infrastructure development. A similar technique was applied in another study, which used the benefits transfer method, to apply a 4% uplift in house prices to houses built near to the parks of Sheffield (Wild, Henneberry and Gill, 2017). However, consideration of who bears the costs, and who gains the benefits in these situations is important, as it is fundamental to decisions about green infrastructure investment. Private developers are among the key groups of people that develop land, buildings and spaces for economic gain. So, from a private investment standpoint, developers are central in being able to successfully deliver NbS as they can often decide if it gets built or not. Wild, Henneberry and Gill (2017) used two property development scenarios for the same riverside site in Sheffield – one with access to views of green infrastructure and one without – to analyse the financial costs and benefits of each with the resulting profit or loss to the developer. The results showed that, despite WTP for green infrastructure and the co-benefits of biodiversity and improved flood management, the increased costs associated with the NbS outweighed the additional income to the private developer. In this example there is little chance of using market mechanisms – such as private development schemes – to deliver NbS in the form of green infrastructure. In such examples, government funding to support local authorities, non-governmental organisations and communities in creation of the common goods of green infrastructure and NbS becomes vital (Wild, Henneberry and Gill, 2017).

The recovery from COVID-19 could be game-changing for valuations of NbS. During and after country lockdowns, the importance and values of urban green spaces notably for human health has been clearly demonstrated. A resilient recovery could lead to increased investment to scale-up and raise the profile of NbS in urban environments, providing new job and business opportunities.

Natural capital allows valuation of the flow of goods and benefits of natural resources, with 'natural capital asset' checks enabling decision makers to understand how changes in ecosystems could impact upon human health and well-being and the economy. Natural capital approaches to assess natural capital assets can be used to help evaluate and encourage uptake of NbS. The interconnectedness of NbS, natural capital and ecosystem services has led the EU to fund the Oppla project, which is an online platform bringing together all of these elements into a knowledge marketplace.

The 'Natural Capital Coalition' a non-governmental organisation in the UK promoting the uptake of the concept of natural capital, has now amalgamated with two other organisations – covering social and human capital – to form the newly entitled 'Capitals Coalition'. This name change is in recognition of the need for an integrated systems approach showing the interconnections of these different types of capital, and the Coalition now unites over 350 organisations (Capitals Coalition, 2020). There has been a lot of uptake from countries with 95% of all countries represented within the Capitals Coalition organisations. These public and private sector organisations wish to incorporate natural, social and human capitals into their accounting frameworks which requires integration of independently developed natural capital approaches.

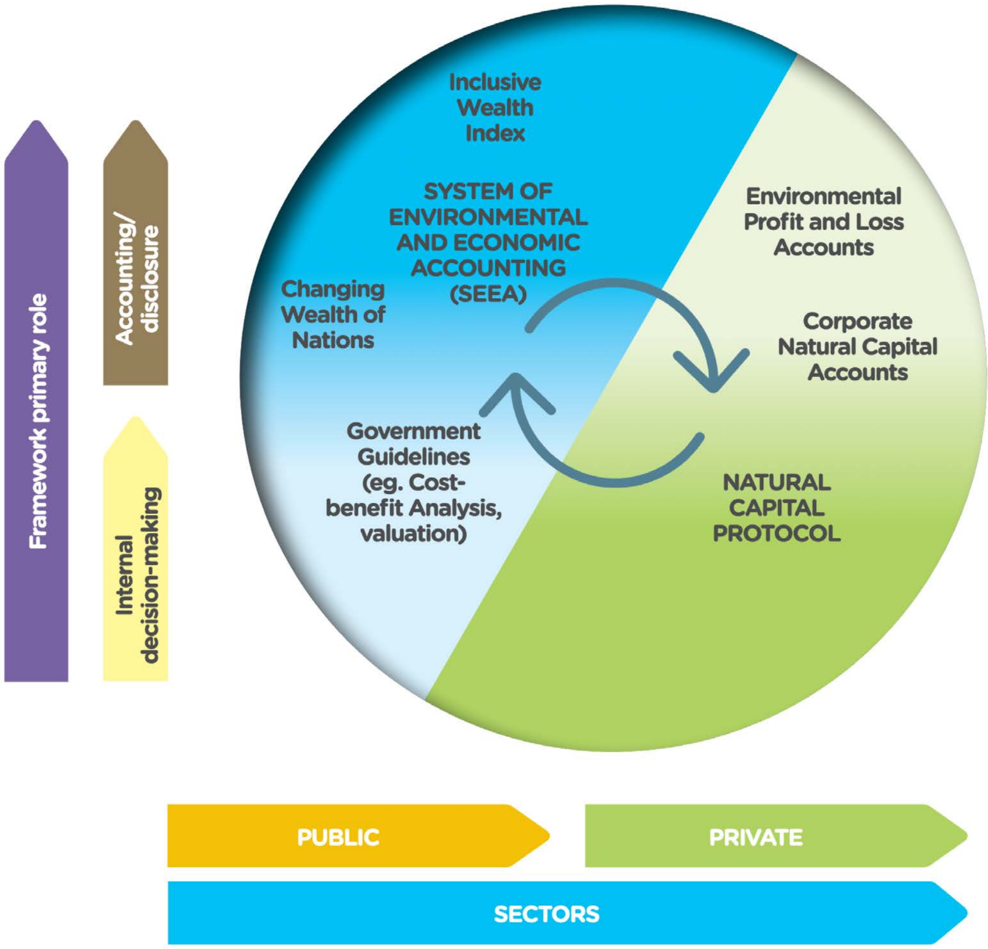


Figure 9. Inter-relationships between natural capital approaches (Spurgeon *et al.*, 2018). This Is Natural Capital 2018, Capitals Coalition'.

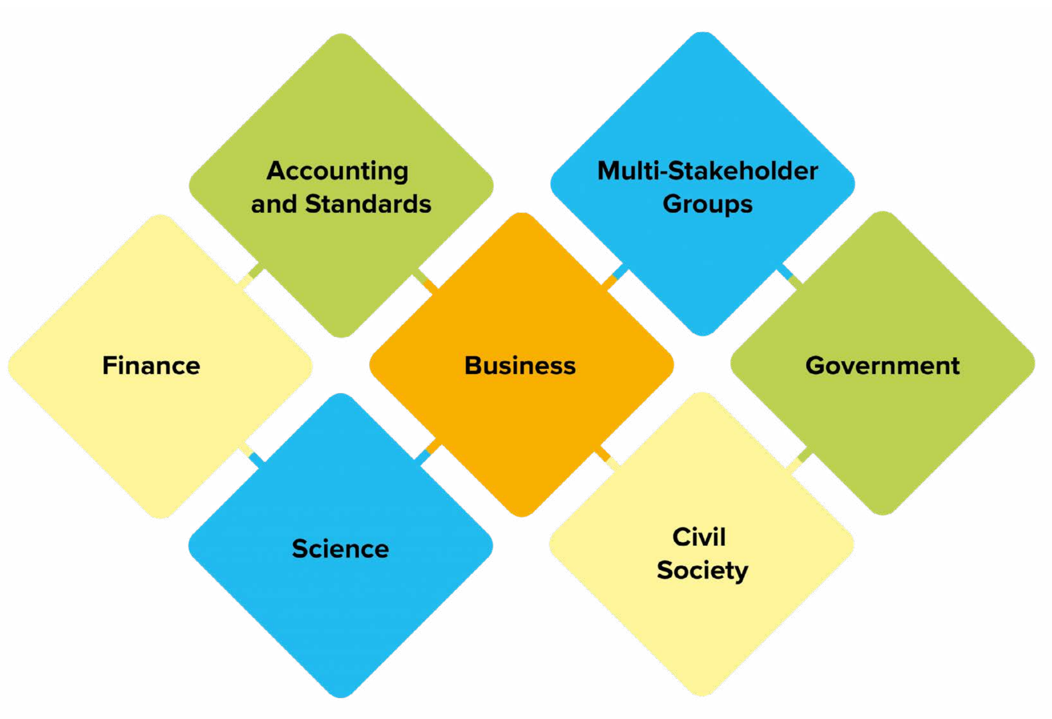


Figure 10. A schematic of the key stakeholders and interests covered by the Capitals Coalition. Both Coalitions brought together broad global communities, in programmes aimed at ensuring the value of nature and people were considered by decision makers. The natural, social, human and economic issues are fundamentally interconnected hence the merging of the coalitions into one organisation (Capitals Coalition, 2020)

BOX 5.

Valuation of NbS and alternative solutions to treat combined sewer overflows (EU OpenNESS project case study)

A set of constructed wetlands was built to treat combined sewer overflows (CSO) (containing human and industrial wastes) in Gorla Maggiore, northern Italy, funded by the regional government and a private foundation in Lombardy (Liquete *et al.*, 2016). Prior to this NbS intervention, 70 CSO events were recorded during heavy rain events for a 6-month period in 2014. Researchers applied a multi-criteria analysis (MCA) – an integrated valuation of the alternatives with economic, social and ecological aspects included. Using explicit objectives for a given NbS scenario, MCA – which ranks qualitative and quantitative data – can be used to identify the preferred solution to a challenge.

Stakeholders from the region were involved in this MCA analysis of the NbS, and alternative solutions, including water managers, grey and green infrastructure experts and social groups from the area of the project. Alongside the constructed wetland CSO solution, alternatives to the business-as-usual (BAU) poplar plantation, and the traditional grey infrastructure option, were considered. The grey infrastructure considered consisted of a first-flush storage tank for moderate rainfall and a buffer tank where heavy rainfall could be stored until naturally drained. Data gathering via monitoring of the site took place in 2014, including biodiversity surveys and water measurements of flow, dissolved carbon and nitrogen.

Calculations were produced for costs of construction and maintenance for the different options. The green infrastructure solution – the constructed wetlands, wet retention pond and riparian park – was identified consistently as the best option via the MCA approach. An ecosystems-service approach also showed the wetlands' multiple benefits with regards to water purification, flood regulation, natural habitat and recreation.

4.5. Examples of challenge areas NbS can address

NbS can be applied to a range of environmental and societal challenges with multiple benefits, and co-benefits, as discussed by the developers of the IUCN Global Standard for NbS and the EKLIPSE NbS Integrated Framework.

A few of the predominant challenge areas NbS can address are climate – including flood and drought management – and health. Considering these challenge areas can benefit from the use of a few successful examples, alongside a consideration of some of the complexities around data collection and implementation posed by these challenge areas. In addition, understanding the views of local people and institutions about the risks related to the societal challenges addressed by an NbS, can help lower trade-offs, resulting in a more acceptable and more successful NbS. Stakeholder involvement at all stages of the NbS process is both recommended by most contemporary NbS frameworks found in the literature, but also occurs in real-world project case studies offering best-practice consensus.

4.5.1. Climate-related challenges

When assessing NbS projects it is important to consider the changing nature of ecosystems, in the context of climate change. Climate impacts may alter ecosystems and affect the services they provide, undermining green solutions that would potentially rely on these. Calliari *et al.* (2019) propose a combined framework with a dynamic approach using systems analysis to account for ecosystem changes, alongside back-casting techniques that can capture breakthrough leaps of transformative change – a potential outcome of innovative NbS. The framework incorporates assessment of both indirect and direct costs and benefits and the researchers say it should be applied up-front to compare NbS to alternative traditional solutions.

The EU-funded PHUSICOS project has developed a guiding framework for creators of NbS. The PHUSICOS approach centres on tailored living labs, utilising a co-design, co-implementation protocol at demonstrator sites in Europe. The main objective of PHUSICOS, is to show that NbS that reduce extreme-weather-related natural hazards are viable, cost effective, and implementable at a regional scale. The Isar River Basin in Germany was one of 2 small-scale concept cases for the PHUSICOS project with focus on selected innovation actions.

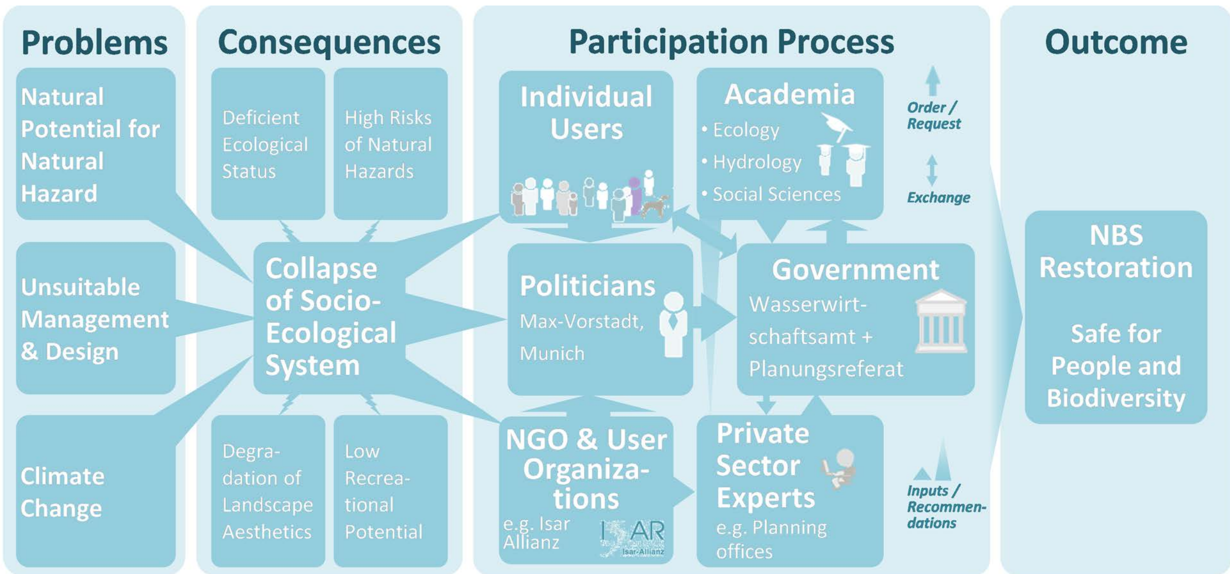


Figure 11. Composition of the Isar Living Lab and relations between its key components. Source: Fohlmeister *et al.* (2018: 38); Courtesy: Technische Universität München & C. Smida.

The challenges to be addressed at the Isar River Basin site, as shown in Figure 11, were climate change, unsuitable management and design, and potential for natural hazards. The natural course of the River Isar had been changed and hydroelectric power plants built, with water diverted for use in these plants and in cooling nuclear power plants. A dam had also been erected with insufficient protection for cities in the flood plain below (for example, Munich). These changes led to a number of consequences including the river water quality degrading, a lowering of biodiversity and overall a collapse of the socio-ecological system (Fohlmeister *et al.*, 2018).

The challenges with this river catchment resulted in the set-up of an 11-year participatory process leading to the design of the "Isar Plan" project (1999-2011), with a budget of 35 million euros for the restoration of 8 kilometres of the Isar. The participatory process overcame challenges of conflict of interests of stakeholders, a lack of prototypes of NbS (in the late 1990s), and the River Isar itself being an ever-changing entity (Fohlmeister *et al.*, 2018). By applying a 'Living Lab' approach the project achieved its goals: assuring flood protection, improving the Isar River's ecological status and water quality. Downstream a larger major 'Living Lab' project has been initiated based on the experiences from the Isar River plan project.

In another climate-related example, Vieira *et al.* (2018) sought to evaluate the relative success of particular NbS at regulating climate and air purification in urban areas, beyond the overarching trend that green infrastructure aids these climate-adaptive ecosystem services (Vieira *et al.*, 2018). The indicators they identified to assess which vegetation types performed these ecosystem services most effectively were lichen diversity and pollutant accumulation in lichens. The researchers found that vegetation with a more complex structure i.e. woodland with a shrub and herb layer – an example of an NbS – was better than a monoculture tree plantation, with both performing better than lawn. Less management intervention applied to the vegetation types increased the capacity to filter air and regulate climate. This highlights a common misconception that any type of 'green' intervention is sustainable, and shows that monoculture planting is damaging to ecosystem services, and therefore cannot be considered an NbS.

BOX 6.

NbS flood management case study

There is a worldwide need for effective systemic strategies to deal with flood risk management whilst also addressing other challenges such as quality of life, health and well-being, and climate resilience. Providing a solution to these multiple challenges and lowering flood risk is often better addressed using a nature-based solution than a grey infrastructure solution (Santoro *et al.*, 2019).

The Glinščica river basin in (Slovenia) is within the borders of the city of Ljubljana (Santoro *et al.*, 2019). The expansion of Ljubljana in the lowlands of the Glinščica river basin has increased the amount of impervious surface, which, coupled with a rise in groundwater level and more torrential rain, has resulted in regular flooding in parts of the city. To develop an NbS that would be effective at lowering the flood risk whilst addressing other societal challenges, a participatory design process was instigated to gather the risk perception of individuals and institutions from the area (Pagano *et al.*, 2019; Santoro *et al.*, 2019). This was done through a couple of workshops in which the risk perceptions of individuals were recorded as 'fuzzy cognitive maps (FCM)'. These were then brought together and areas of commonality of risk perception were noted from across the stakeholders involved in this exercise to prompt the acceptance of an NbS rather than a traditional grey infrastructure approach (Santoro *et al.*, 2019). The stakeholders were then involved in co-designing and assessing a system dynamic model capable of measuring the effectiveness of NbS to deal with floods under a business-as-usual scenario, but also to enable participants in the workshop to look at the potential effects of specific measures on both flood risk reduction and co-benefits.

This raised awareness of the benefits of NbS and hybrid measures – incorporating NbS and socio-institutional measures. A similar study by Giordano *et al.* (2020), also used FCM with stakeholders, engaging them with the implementation of an NbS to enhance acceptance of an NbS on the lower Danube.

BOX 6. ***(continued)***

The identification and involvement of local stakeholders that will be impacted by an NbS project, is outlined in Criteria 5 of the IUCN Global Standard framework to ensure inclusive, transparent and empowering governance processes (IUCN, 2020). The costs and benefits trade-off analysis among stakeholders showed most conflicts occurred around agricultural factors in the long term. The authors suggest that recognising the different perceptions of stakeholders is key to reducing the trade-offs and thus enhancing acceptability of NbS (Giordano *et al.*, 2020).

Vanuatu is a small Pacific island, developing nation that is particularly prone to the detrimental impacts of climate change. An urban ecosystem-based adaptation (EbA) was utilised for the capital of Vanuatu, Port Villa. Data was gathered for the island, to facilitate the creation of baseline geospatial maps including the state of ecosystems from ridge to reef. Future climate change scenario data were prepared, and the understanding, and use of local ecosystem services gathered. Collaborative stakeholder workshops, including community participation in the design process, were important in data gathering and selection of the final five EbA projects developed into full implementation plans.

Vanuatu has pre-existing government and international aid financed projects in place, so when developing EbA projects, these should be factored in when considering costs and benefits, to create a design that works well alongside existing provision. The researchers also identified that ensuring that EbA projects work in Vanuatu would require a dynamic approach with ongoing readiness to adapt to changing, on-the-ground realities (Pedersen Zari *et al.*, 2020). Assessing the perceptions and opinions of local stakeholders when planning an NbS is useful in ensuring long-term acceptance and success when a project is implemented. Community involvement in NbS, is the focus of a criterion within the IUCN Global Standard – addressing the importance of acknowledging, involving and responding to the concerns of a variety of stakeholders, especially rights holders (IUCN, 2020).

4.5.2. Health-related challenges

Human health depends on ecosystem services that in turn rely on biodiversity. The inter-linkages between biodiversity, health and ecosystem services are complex but interdisciplinary research is aiming to develop a more thorough understanding. It is accepted that maintenance of watersheds, for example, can mitigate natural disaster risks, and minimising habitat conversion can minimise disease emergence and spread (CBD, 2020; Romanelli *et al.*, 2015).

Expanding river habitats by creating wetlands and green spaces, Lledoner park in the north of Granollers, ©Granollers City Council, source: INTERLACE

NbS and the ecosystem services they provide, are known to have multiple positive impacts on people's health, through ameliorating the detrimental effects of the 'urban heat island', but also providing a space for increased physical activity and relaxation with positive impacts on mental health. However, despite widespread acceptance of the multiple health benefits of NbS, van den Bosch and Ode Sang (2017) note in their systematic review of NbS and health that further research into expanding the evidence base of measurable indicators linking NbS and health would be beneficial (van den Bosch and Ode Sang, 2017). To increase the research effort into quantitatively measuring the health impacts of NbS, the researchers, call for human health to be incorporated into the definition of NbS alongside environmental, social and economic benefits to encourage collaborations across sectors – including health – to meet the increasing challenges of urban living. The present IUCN definition of NbS, for example, states human well-being as a benefit derived from NbS – clearly making the link with human health (IUCN, 2020).

A review of health-related effects from green and blue spaces in urban areas, for children and elderly people, noted that there was a trend that showed a positive association between health and green spaces. However, the authors also noted that socio economic factors and other contextual elements prevented a categorical conclusion regarding the health-NbS relationship to be made (Kabisch, N. *et al.*, 2017). A review study published in 2020 examined the association between green space and prosocial behaviour in children and adolescents (Putra *et al.*, 2020). The authors found a positive association between exposure to green space and prosocial behaviour but there was not enough data to note a definite cause and effect relationship. However, a recent systematic review from the EKLIPSE project (Beute *et al.*, 2020) found that, across 134 papers, most urban green space types - parks, forests, grassland, and other urban green spaces (such as green community squares, or greenways) – can independently improve mental health. Direct comparisons between different green space types rendered very mixed results, which could signal a need for variety in green spaces to capture all potential users, activities and locations. Street greenery, trees, and urban green space also appeared to have a positive relation with mental health; the authors recommend valuing and considering "daily and often unintentional micro-restorative experiences". They also suggest that studies looking at exposure, experience and longitudinal studies are necessary to further explore the relation between green spaces and mental health. NbS combining green and blue spaces together have been shown to favour cognitive and social development in children, affecting factors related to behavioural development and symptoms of attention deficit/hyperactivity disorder (ADHD) (Amoly et al., 2014). Most research on the benefits of Cultural Ecosystem Services (CES) for health and well-being is cross sectional and focussed on access. Chen *et al.* (2019) propose longitudinal and natural experiments to be conducted to provide firm evidence of NbS and positive health impacts.

Long-term health research data exist, but often omit CES data to allow analysis of the impact of NbS on health of the participants (Chen *et al.*, 2019). Ongoing or new health data collection can be adapted to include data on CES or CES data collection can be adapted to include health data. Another approach to obtain high-value CES/health data is to collect them before and after a significant NbS implementation occurs, which dramatically changes CES provision for the local population. Chen *et al.* (2019) suggest a significant increase in CES from introduction of a new NbS, is more likely to result in a notable health impact on local residents than smaller NbS interventions but requires flexible research funding.

The CBD established a joint working relationship with the World Health Organisation (WHO) in 2012, in recognition of the linkages between human health and ecosystem health. This partnership reflected the recognition of a need to strengthen collaboration with the health sector in order to mainstream biodiversity and health linkages into national strategy policies (CBD, 2020). Integrating biodiversity and human health concerns would benefit from the use of a common framework, which included human well-being indicators, to enable quantifiable evaluation. Utilising a broad framework, that aims to maximise both the health of ecosystems and humans, could help the sectors collaborate more effectively. Romanelli, *et al.* (2015) highlight in their review for the WHO/CBD, that the conceptual framework of the IPBES is a framework that links biodiversity to human health and well-being, with a consideration of drivers of change. There is certainly growing consensus that research to establish the cause and effect links between ecosystems, biodiversity and health is warranted and this would also aid in the evaluation of NbS in this respect (Romanelli *et al.*, 2015)

BOX 7.

Emerging Infectious Diseases and land use change – how NbS can help

The spread of the COVID-19 virus in 2020 caused the world to question: how did this pandemic emerge, and how this might be prevented from happening again? Pandemics are becoming more frequent, as the key drivers – land use change and wildlife trade – are increasing pandemic emergence (IPBES, 2020).

Covid 19 is thought to have originated at an animal market in Wuhan, China. The exact species that transmitted the virus to humans is still unknown; however, horseshoe bats are known wildlife reservoirs of coronaviruses and can pass the virus to other species traded at wildlife markets (IPBES, 2020; World Health Organisation, 2020). This has triggered global debate about land-use change, ecosystem degradation and the convergence of human/livestock/wildlife – in areas of high microbial biodiversity – where novel pathogens can transmit from animals to humans.

NbS projects to conserve intact habitat, reduce land use change by sustainably managing land, and reverse ecosystem degradation by restoring forest and other intact habitats may also affect disease transmission dynamics by altering wildlife-livestock-human contact. Where planning shows NbS can reduce disease transmission – especially, emerging infectious diseases (EID) – the link to human health could be used to identify added societal and economic value to the NbS policy. Reducing the frequency and impact of pandemics will is expected to require worldwide transformative change, like those offered by NbS for conservation and restoration of nature (biodiversity and ecosystem processes) and its benefits to people (IPBES, 2020).

Future NbS schemes in high EID risk areas should be designed to incorporate monitoring and surveillance for potential for emergence of novel pathogens, due to human/livestock/wildlife contact changing. This is of particular import in policies that promote mosaic strategies, incorporating wildlife corridors next to agricultural areas within conservation zones. Whilst NbS incur costs, when the cost of emerging diseases (including COVID-19) is likely to exceed $1 trillion dollars a year, it can be assumed the costs are outweighed by the monetary and global health benefits NbS confer in preventing EID (IPBES, 2020).

4.6. Integrating NbS with grey infrastructure

The benefits of NbS have been shown to exceed the costs of implementation and maintenance in a number of contexts, including disaster risk reduction (largely from flooding) along coasts and in in river catchments (Seddon *et al.*, 2020). There is also growing evidence that NbS (and hybrid NbS) can be more cost-effective than engineered solutions for some less-extreme hazards as shown in some coastal defence projects in the US (Reguero *et.al.*, 2020). Similarly, in the UK, woodland catchments and leaky dams ameliorate risks from small floods – however they may not be as effective with more extreme events, but they will always buffer (Seddon *et al.*, 2020). Whereas a grey infrastructure such as a dam which has underestimated the impact could aggravate the destructive effect when it fails, damaging property and potentially leading to human fatalities (Sutton-Grier *et al.*, 2018).

Engineered solutions have more known costs than NbS, often with predictable timescales – which is not always the case with NbS. The timescales of return versus costs of NbS may exceed political timescales making the scheme seem less attractive (Seddon *et al.*, 2020). Progress has been made in modelling the return and impacts of landforms as natural solutions to challenges, as well as valuing the many indirect benefits of NbS, as discussed. However, many ecologists, engineers and managers are acknowledging that in some situations the best solution to dealing with climate-change impacts would be a combination of green and grey infrastructure (Raymond *et al.*, 2017b; Seddon *et al.*, 2020).

The OPERAs project – an EU-funded ecosystem and natural capital sustainable ecosystem implementation project – combined traditional engineering with NbS in the stabilisation of the Barcelona sand dunes (Somarakis, Stagakis, and Chrysoulakis, 2019). The loss of sand dunes and the associated flora and fauna from Catalan beaches was of concern, not only because of their biodiversity value, but also the role they play in protecting the beaches from sea level rise and flood. Through collaboration with stakeholders, including local citizens, the project aimed to learn to construct and maintain semi-fixed sand dunes on heavily used urban beaches to maximise the flows of ecosystem services. (OPERAs, 2015).

Stakeholder mapping, social valuation, economic valuation and analysis of the ecosystem services of the urban coastal sand dunes were undertaken. An engineered construction project created a semi-fixed sand dune habitat planted with *Ammophila arenaria* (OPERAs, 2015). The dunes were constructed in 2015 and maintained since whilst still having beaches with a high degree of recreational use. The project managers noted that in this instance the 'no dunes, no beach' approach was more effective in convincing locals of the value of preserving the sand dunes than the biodiversity or flooding benefits. The project managers also noted cost-benefit and economic valuations as key determinants in success, alongside media interest and citizen science (OPERAs, 2015).

The effectiveness of saltmarshes for flood risk reduction – an NbS – can be increased by combining them with engineered breakwaters or artificially raising them. This mix of interventions can also help address diverging stakeholder needs. Identifying integrated solutions incorporating both grey and green/blue infrastructure can in some contexts address a range of climate impacts, provide additional ecosystem services and be feasibly managed over the longer term.

So in some instances, rather than framing NbS as alternatives to engineered solutions and exclusive of grey infrastructure, instead focus should be placed on finding synergies between traditional and nature-based solutions (Seddon *et al.*, 2020).

People chilling and relaxing in an outdoor public park, ©Getty Images, public domain

5. Social and economic opportunities through implementing NbS

The accelerating pace of global change is putting societies under pressure to adapt in order to sustain peoples' livelihoods. Societal challenges – such as increasing urbanisation, economic inequality, social disorder and climate change – are high on the agenda of policymakers both in Europe and worldwide (European Commission, 2015). The COVID-19 pandemic of 2020 has reinforced global social and health inequalities, and has highlighted the importance of equitable and inclusive access to green spaces. The group BlackAFinSTEM, formed in May 2020 – following a racist incident towards a black birder in a city park – aims to change the narrative around natural spaces to a more inclusive one, organizing a 'Black Birders Week' and sharing experiences on social media (Thompson, 2020). Nature-based solutions are able to help solve a number of societal challenges, including improved livelihood opportunities and living conditions for people living in urban poverty, better urban health and well-being, and increased social cohesion (Haase *et al.*, 2017). Furthermore, ecosystems can support social adaptation by regulating the risks of climate change and natural hazards, and provide both material and non-material benefits. There will inevitably be challenges to using NbS to address such complex social and environmental issues, but these are surmountable and dwarfed by the multiple benefits provided by these solutions (Lavorel *et al.*, 2020).

To offer opportunities for social cohesion in modern multicultural cities, all sectors of society must be catered for in the design of NbS, across all ages, belief systems, abilities, ethnicities and socio-economic backgrounds. At present, many sectors do not access or use the green spaces available to them, and so actions to activate and educate underrepresented sectors of society to take advantage of existing and future NbS should be considered (Zwierzchowska *et al.*, 2019; Thompson, 2020). In urban settings, NbS can foster social cohesion and form socially inclusive solutions to modern societal challenges (European Commission, 2015). To create a green and sustainable future for human society requires fundamental, system-wide reorganisation across technological, economic and social factors. This transformative change must have local communities and indigenous people – vital for tackling the biodiversity and climate crises – at its centre (Lavorel *et al.*, 2020). IUCN also asserts that successful NbS are created through the partnership of diverse stakeholders, such as local communities, indigenous groups, businesses, NGOs, and government, to offer a comprehensive and inclusive solution (Fritz, 2017). NbS aim to address broad societal goals, such as human well-being and poverty alleviation, and in doing so differ from traditional conservation approaches. However, to be resilient, NbS must be structured to support both biodiversity and people (Seddon *et al.*, 2020).

The EKLIPSE Expert Working Group on Nature-based Solutions to Promote Climate Resilience in Urban Areas, (see Chapter 4.3.2 above), identified 10 challenge areas, all of which interlink with co-benefits to biodiversity, ecosystems, climate and physical systems and society (economic and cultural) as shown in Figure 12. Five of the challenges in the EKLIPSE framework are considered societal challenges: urban regeneration, participatory planning and governance, social justice and social cohesion, public health and well-being, and economic opportunities and green jobs (Raymond *et al.*, 2017b).

Expanding on the original EKLIPSE framework, a further two challenges have been added to the existing 10, and the descriptors of several of the EKLIPSE challenges are now broadened. An up-to-date list of societal challenge areas addressed by NbS is presented in the *Handbook for practitioners* (Dumitru and Wendling, forthcoming in 2021).

This chapter will present the social aspects of NbS through the lens of a number of discrete social challenge areas, including the health and wellbeing of urban residents, the economy, equity, citizen-led participatory planning, food security and financing

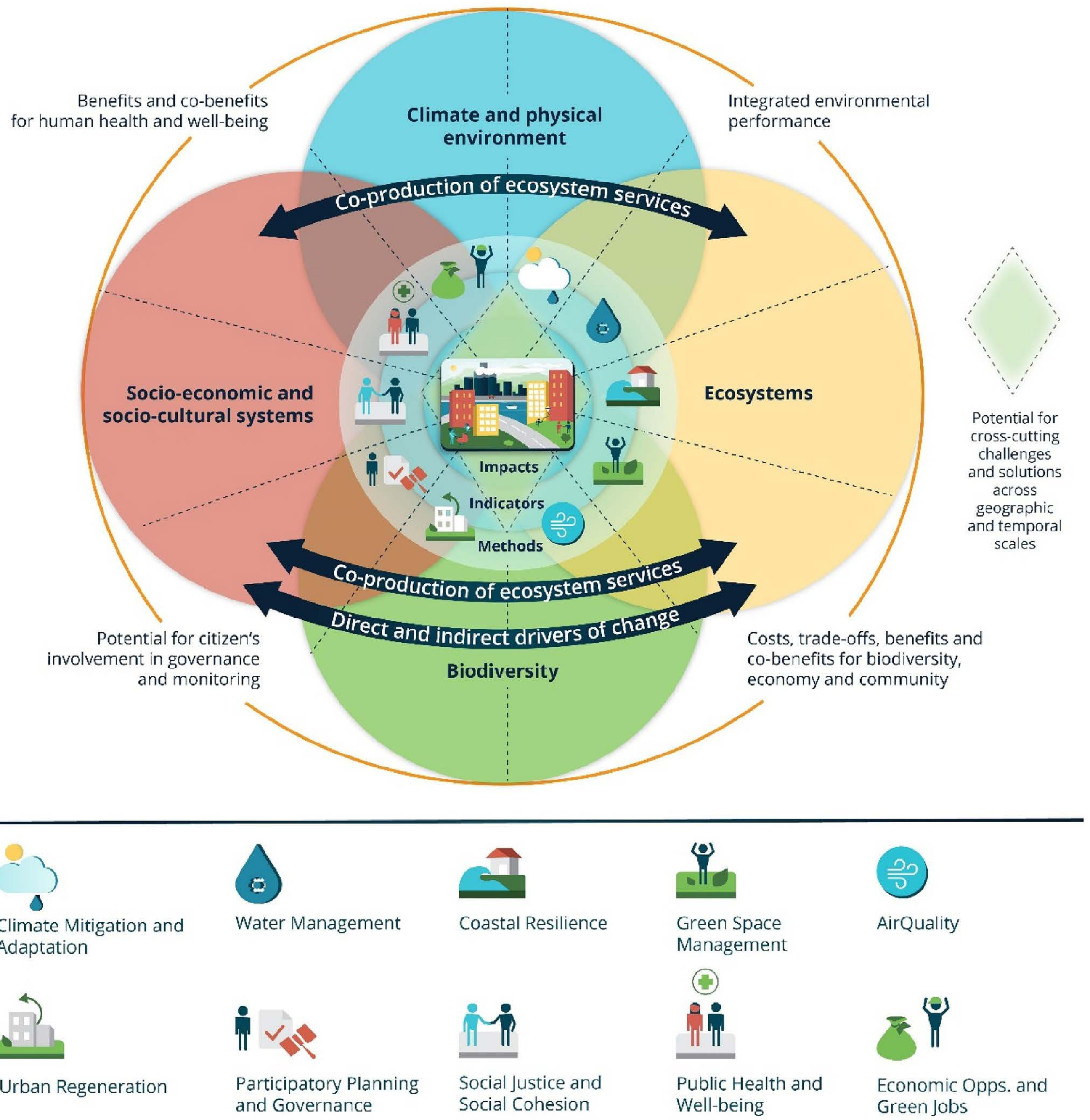


Figure 12. The EKLIPSE NbS assessment framework. This considers different elements of the system, the 10 challenge areas and indicators and methods for assessing NbS impacts within and across challenge areas reproduced from Raymond et al. (2017a).

5.1. Health and well-being for urban residents

NbS, and the ecosystem services they provide, are known to positively impact people's health. This is true both generally and in the specific scenario of the urban environment, which affects the health and well-being of the people within it, with the fast pace of life, overcrowded conditions and long working hours contributing to stress and mental health problems for some city residents (Barton and Grant 2006). As urbanisation increases, disease scenarios shift, levels of air pollution rise and climate change impacts are predicted with greater certainty, we require innovative strategies for supporting healthy, sustainable cities – both now and into the future (van den Bosch and Ode Sang, 2017). Heatwaves, for example, are becoming more frequent, with the 2018 report from the Intergovernmental Panel on Climate Change (IPCC) suggesting that we have just 12 years (now 9) to avert catastrophic temperature rise and cascading tipping points (Lenton *et al.* 2019; IPCC, 2018). This is likely to result in more heat-related deaths in the future (a rise of 250% by the 2050s, predicts a UK report; Bartlett, 2020), particularly in urban areas where the 'urban heat island' (UHI) effect raises temperatures further. The conventional materials used in grey infrastructure, such as concrete, cause UHI effects by absorbing heat from the sun, alongside detrimental effects on energy consumption, air quality, outdoor thermal comfort and health conditions. These impacts position NbS as the better choice for urban planners (Qi *et al.*, 2019).

5.1.1. NbS reducing human heat stress

NbS related to blue spaces (fountains, rivers, lakes, coastal areas) in urban areas, could help cities adapt to climate change by reducing heat stress. To fully assess the effect of urban heat islands, heat monitoring must include both air temperature and relative humidity to provide a measure of impact on human health – one such measure of impact is known as the Wet Bulb Globe Temperature (WBGT) (van den Bosch and Ode Sang, 2017), which combines the effects of temperature, humidity, wind speed, and radiation (sun angle and cloud cover) on the human body (see Figure 13).

Relative humidity (%)	Temperature (°F)															
	68.0	71.6	75.2	78.8	82.4	86.0	89.6	93.2	96.8	100.4	104.0	107.6	111.2	114.8	118.4	122.0
0	58.6	60.9	64.3	65.5	67.7	69.9	72.1	74.3	76.4	78.5	80.6	82.6	84.7	86.6	88.6	90.5
5	59.6	62.1	65.6	67.0	69.3	71.7	74.0	76.4	78.6	80.9	83.1	85.3	87.5	89.9	92.1	94.2
10	60.7	63.3	66.9	68.4	70.8	73.3	75.8	78.2	80.7	83.0	85.5	88.0	90.3	92.8	95.1	97.6
15	61.7	64.5	68.1	69.6	72.2	74.8	77.4	80.0	82.6	85.2	87.8	90.2	92.8	95.4	98.0	
20	62.7	65.6	69.4	70.9	73.6	76.3	79.2	81.8	84.5	87.1	89.8	92.5	95.2	97.8		
25	63.8	66.7	70.5	72.2	75.1	77.8	80.6	83.4	86.2	89.0	91.8	94.6	97.4			
30	64.8	67.6	71.7	73.4	76.3	79.2	82.1	84.9	87.8	90.8	93.6	96.6	99.4			
35	65.6	68.6	72.7	74.6	77.5	80.5	83.5	86.4	89.4	92.4	95.3	98.3				
40	66.7	69.6	73.8	75.7	78.8	81.8	84.8	87.8	90.9	94.0	97.0					
45	67.5	70.6	74.8	76.8	79.9	83.0	86.1	89.2	92.3	95.4	98.6					
50	68.4	71.5	75.8	77.8	81.1	84.1	87.4	90.5	93.7	96.9						
55	69.3	72.4	76.7	78.8	82.1	85.3	88.5	91.9	95.1	98.3						
60	70.1	73.3	77.7	79.8	83.2	86.4	89.8	93.1	96.3	99.6						
65	70.9	73.8	78.6	80.9	84.2	87.5	90.8	94.1	97.5							
70	71.7	75.0	79.5	81.7	84.9	88.6	91.9	95.3	98.6							
75	72.4	75.9	80.3	82.7	86.1	89.6	92.9	96.4								
80	73.2	76.7	81.2	83.6	87.1	90.4	93.9	97.4								
85	74.0	77.4	82.0	84.5	88.0	91.5	94.9	98.5								
90	74.7	78.2	82.9	85.3	88.9	92.3	95.9	99.4								
95	75.5	78.9	83.6	86.1	89.6	93.2	96.8									
100	76.1	79.7	84.4	86.9	90.5	94.1	97.7									

	Temperature	Category	Risk level
(green)	77° to 81.9°F (25° to 27.7°C)	Caution	Possible fatigue with prolonged exposure
(yellow)	82° to 84.9°F (27.8° to 29.4°C)	Extreme caution	Heat-related illness possible with long exposure
(red)	85° to 88.9°F (29.5° to 31.6°C)	Danger	Heat stroke possible, heat-related illness likely
(black)	≥ 89°F (≥ 31.7°C)	Extreme danger	High risk of heat stroke

Figure 13. Wet bulb globe temperature, based on temperature and humidity, assuming a clear sky (maximum solar load) and atmospheric pressure of 1 ATA (760 mm Hg). Source: Grauer and Meyers (2019), adapted with permission from Ariel's checklist. WBGT chart, developed by Professor Yoram Epstein available at *https://arielschecklist.com/wbgt-chart*

There is an upper limit to humans' capacity to adapt to rising temperatures. That limit is expressed as a WBGT, which measures the combination of heat and humidity for an index of physical human misery. When the WBGT exceeds 35 degrees Celsius, the body cannot cool itself and humans are at risk of death in just a few hours (with the exact length of survival time determined by individual physiology).

The Physiological Equivalent Temperature (PET) index has been used in a number of projects aimed at evaluating the role of NbS in ameliorating urban heat stress (Calfapietra, 2020). Acero and Herranz-Pascual (2015) used the thermal comfort index model ENVI-Met to model NbS benefits for the city of Bilbao, and to compare different greening scenarios to improve outdoor thermal comfort. They demonstrated the importance of considering different vegetation systems, concluding that using trees and grass in the selected street canyons could allow a PET reduction of up to 10°C. Amorim *et al.* (2017) also point out that trees in urban areas could have implications for thermal comfort (and air pollution dispersal) via altering air flows.

Some of the regions that are most susceptible to dangerous heat and humidity are also densely populated, meaning there is potential for widespread exposure to wet bulb temperatures to approach, and in some cases exceed, postulated theoretical limits of human tolerance by mid- to late-century (Coffel, Horton and De Sherbinin, 2018). Population exposure to WBGTs that exceed recent deadly heatwaves may increase by a factor of up to ten, with 150–750 million person-days of exposure to WBGTs above those seen in today's most severe heat waves by 2070–2080 (Coffel, Horton and De Sherbinin, 2018). The consequent fall in human productivity caused by heat stress also has an economic impact, with scientists predicting that a warm year in the far future (2081) could cause London alone to lose 1.9 billion Euros (Costa, 2016). This further reinforces the need to change the narrow economic growth paradigm (IPBES, 2019).

The impacts of heatwaves upon city-dwellers particularly affected by the UHI effect can be mitigated by the climate regulatory services offered by NbS (Alexandri and Jones, 2008; Bowler *et al.*, 2010). Urban green spaces with trees and plants offer cooling via evapotranspiration and shading, lowering illness and death related to heat in densely populated cities (Raymond *et al.*, 2017b; Chen *et al.*, 2014). Increasing the provision of green space can lower the temperature of urban areas, thus reducing heat stress. Urban parks have been found to reduce ambient daytime temperatures by an average of 0.94°C; with an average night-time reduction of 1.15°C. Models have shown that a 10% increase in green areas in the dense urban areas of Greater Manchester could retain maximum surface temperatures at, or below, the 1961–1990 baseline until the 2080s for all emissions scenarios, thus mitigating the effects of climate change (European Commission, 2015). The use of NbS to lower the vulnerability of European citizens to heat-related health problems becomes more pertinent when considering the tens of thousands of deaths from the 2003 summer heatwave – back then, an event that would happen twice a century, but now an event that happens twice a decade or more (Christidis, Jones and Stott, 2015).

5.1.2. NbS improving air quality

The global COVID-19 pandemic of 2020 has consolidated the detrimental health impacts that polluted, overcrowded cities can have on local residents – in terms of the higher death rates found in more polluted cities. Preliminary research in Italy and the United States, may indicate an association between cities with high levels of air pollution in the years preceding COVID-19, low wind levels, and higher numbers of COVID-19 deaths (Coccia, 2020). Breathing in polluted air over prolonged periods can cause cardiovascular disease, in turn predisposing people to become more unwell from infections such as the COVID-19 virus. City residents have also displayed a clear desire to spend time in urban green spaces, throughout the disruption of the 2020 pandemic, with early survey results from the EU Horizon 2020-funded project CLEARING HOUSE reporting that residents of Brussels, Belgium, spent far more time in green spaces during the pandemic and associated quarantine period than before (from 37% of respondents visiting a neighbourhood green space several times a week to 80%). Enjoyment of nature remained the primary motivation for this behaviour change (Vrije Universiteit Brussel, 2020).

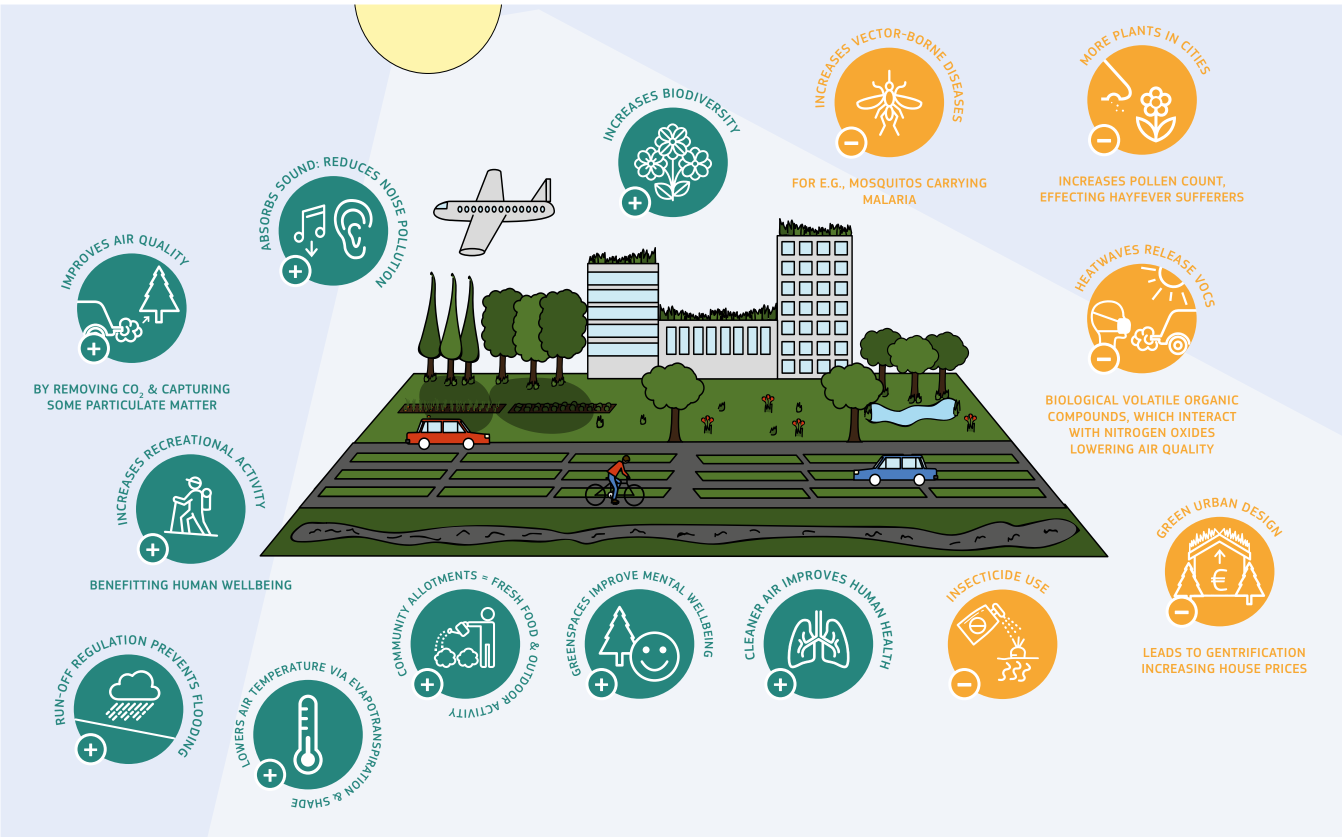


Figure 14. Infographic showing the benefits and risks of green urban design. Source: European Commission, 2018.

NbS can help reduce air pollution (Baró *et al.*, 2015) as plants use carbon dioxide, produce oxygen, regulate humidity and trap particulate matter on leaves (Tallis *et al.*, 2011; Chen *et al.*, 2017). Vegetation and landscaping can absorb sound, buffering urban areas against noise pollution as shown in Figure 14. (European Commission, 2018; Madureira *et al.*, 2015). Technology and NbS are coming together to provide innovative ways to clean the air in polluted urban areas and near busy roads, one example being 'City Trees' – vertical panels that contain hardy pollution-processing plants such as moss and lichen, and that can be attached to a park bench or highway partitions. The European creators of City Trees suggest that each unit can clean as much air as a forest of 275 trees, at a fraction of the space and cost (Green City Solutions, 2020). That particular solution is being trialled in a few European cities including Modena, Italy, where it is sited in a 'city canyon' – a narrow busy road through high buildings, with low wind, causing pollution to sit in the 'canyon' above it. Scientists monitoring its effectiveness locally have suggested that the panels may be most useful for air pollution mitigation in areas with little space – where trees are less viable, and that are enclosed – such as in a city canyon. The startup that created City Trees was co-funded by the European Horizon 2020 scheme, and is one example of novel NbS becoming more widespread.

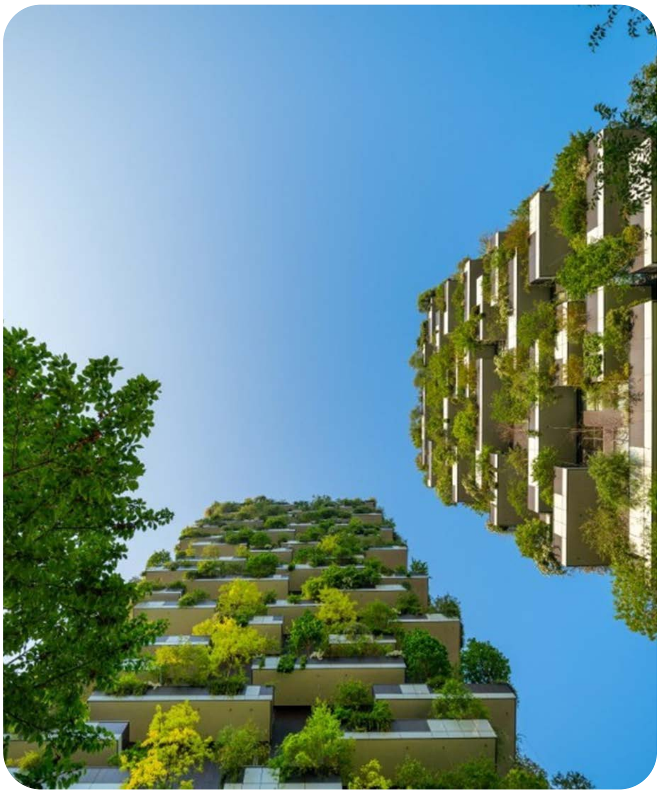


Figure 15. Photographs of vertical forests in Milan by Stefano Boeri Architetti. Source: Stefano Boeri Architetti, 2020

Vertical forests use plants on buildings to clean the air and bring natural beauty to manmade structures. An example of an award-winning vertical forest was conceived of by architect Stefano Boeri, who created a vertical forest in Milan, Italy, as a prototype building for a new type of architectural biodiversity – to bring people and other species together. Boeri's development (Figure 15) comprised two towers housing a total of 800 trees, 15,000 perennials and 5,000 shrubs – an amount of vegetation equivalent to 30,000 square metres of woodland and undergrowth in an urban area of 3,000 square metres. The towers' vegetation filters the Sun's rays, thus not reflecting them into the city as a mineral façade would. The greenery regulates humidity, lowers air pollution (Stefano Boeri Architetti, 2020), increases biodiversity, and helps mitigate heat, noise and air pollution impacts for residents, while the development reduces urban sprawl (Oppla, 2020). The green façade keeps the building interior up to 3 degrees cooler than external temperatures in the summer; one study found that this feature alone resulted in annual energy savings of 7.5%, and significantly lower energy consumption than a typical building in Milan (Giacomello and Valagussa, 2015). The success of the 'vertical forest' has led to them being used as a prototype for similar schemes in countries around the world, including the Netherlands, Switzerland, China and France. There are now efforts to improve the full lifecycle of the building and the upfront carbon costs associated with its cantilevered concrete balcony design, to maintain the operational benefits of the forest while reducing embodied carbon emissions. An example of this is Boeri's 'La Forêt Blanche' in Paris (Figure 16), an entirely wooden structure that supports 400 trees. This uses lower upfront carbon materials in the form of sustainably sourced timber (Burrows, 2019). The creator of vertical forests also launched the 'global campaign on urban forestry' at the first World Forum on Urban Forests, held in Italy in 2018 (Lafortezza and Sanesi, 2019).

Figure 16. La Forêt Blanche, 'The White Forest', in Paris, France. (Stefano Boeri Architetti, 2020).

5.1.3. NbS: beneficial for people's body and mind

NbS are known to have positive psychological and physiological outcomes for the people living near them (Tsunetsugu *et al.*, 2013). Urban green spaces help residents to relax by providing stress relief (Ward Thompson *et al.*, 2012), with roadside vegetation having a similar relaxing effect on drivers (Parsons *et al.*, 1998). People working long hours in front of computers can suffer from directed attention fatigue. Being in a green space or 'nature bathing' can help restore people's ability to think clearly, as it provides a fascinating immersive environment that requires little cognitive effort and alleviates directed attention fatigue (Marselle *et al.*, 2019). Urban green spaces such as parks, urban forests and community gardens provide an opportunity for urban residents to undertake more physical activity – such as walking, cycling or gardening (Sugiyama and Ward Thompson, 2007). Urban green space also provides opportunities for exploratory behaviour in children, whether it be tree climbing, pond dipping, den making or splashing in streams (Kuo, 2015). Unstructured and exploratory outdoor play provides children with cognitive, social and health benefits, and aids children's development by teaching them how to analyse risk and accomplish tasks through practice and perseverance (Powers and Williams Ridge, 2018) – skills that aid risk assessment into adulthood.

NbS improve the health of city-dwellers via the services provided by ecosystems in urban green and blue spaces, including temperature regulation, increased opportunities for recreation and to exercise, water storage and cycling, improved air quality and provision of nutritious fresh food grown in these areas (Keniger *et al.*, 2013). The resulting positive health outcomes NbS bring to urban residents (Qin *et al.*, 2013) include better mental health through improved mood and reduced depression, enhanced immune system functioning, reduced cardiovascular illness and death (van den Bosch and Ode Sang, 2017), positive impacts on pregnant women and a reduction in obesity and diabetes (Raymond *et al.*, 2017b). These improvements in health and well-being increase with urban green spaces with higher biodiversity and more natural features, as they are perceived as being more restorative, resulting in longer visits and of greater benefit to individuals (Carrus *et al.*, 2015; Marselle et al., 2019).

BOX 8.

Avoiding the downsides of NbS with thoughtful design

From allergic reactions due to higher pollen levels to the increased spread of vector-borne diseases as biting insect populations flourish, urban green spaces and NbS can also bring negative health outcomes (Marselle *et al.*, 2019; Raymond *et al.*, 2017b). During a heatwave, the interaction between volatile organic compounds from trees and anthropogenic air pollutants may decrease air quality. Play or physical activity in green spaces can increase the risk of injuries, particularly for children (Kendrick *et al.*, 2005), although some studies have demonstrated that most injuries in outdoor spaces come from built structures rather than the natural environment itself (Powers and Williams Ridge, 2018). Despite the potential for negative outcomes, most of the negative impacts of NbS can be reduced by good design – for example, ensuring areas of stagnant water are avoided to minimise mosquitoes, or planting species that are less commonly associated with hayfever. Moreover, exposure to plants and soil – as commonly found in NbS – has been shown to increase serotonin, improving mood, and may also improve gut microbiota (Nurminen *et al.* 2018; Malan-Muller *et al.*, 2018). Similarly, urban farms can be designed to minimise potential negative impacts to local residents and the environment, for example by avoiding the use of chemicals and instead using organic production methods. Through thoughtful design that pre-emptively considers potential downsides, maintaining and managing any negative impacts can be overcome (Lõhmus and Balbus, 2015).

5.2. Economic benefits of NbS

The COVID-19 pandemic of 2020 has led to a global recession, causing unemployment and affecting the health and wealth of most nations worldwide. The COVID-19 virus and will remain a concern for a number of years until a vaccine is developed and herd immunity is achieved (Lo *et al.*, 2020). The societal impacts of the pandemic are widespread and diverse; for example, the 2020 pandemic lockdown that occurred in most countries led many companies to accelerate the adoption of artificial intelligence (AI) and robotics, in turn contributing to technology-induced unemployment. Technology-induced unemployment is a longer-term concern of policy makers and governments, as rising unemployment brings financial hardship, which is linked to a rise in suicide rates and domestic abuse. Suicide rates in Europe and the US rise in line with unemployment – so a 1% rise in unemployment will see a 1% rise in suicide rates (WEF, 2020).

However, ahead of a full solution to COVID-19, cities are opening up to enable people to work and to prevent social unrest and spiralling unemployment. Emerging from a societal crisis of this scale in a sustainable manner requires multiple disciplines to work together in an agile manner, for a safe transition to a new socially distanced regimen (European Council, 2020). The rapid transmission of the COVID-19 virus and higher death rate in some urban areas – with higher levels of air pollution, for example, as discussed in Chapter

5.2 – has led some city planners to accelerate plans to pedestrianise city centres and increase the amount of green open spaces (Coccia, 2020; Wu et al., 2020). Large, built-up areas will likely give way to fewer retail stores, more open green spaces, and more flexible work options (Report, 2020). In its 'roadmap for recovery' from the COVID-19 pandemic, the European Council indicates that the green transition is one of three key strategic action areas requiring investment to build a more resilient, sustainable and fair Europe (European Council, 2020; WEF, 2020).

Figure 17. The various elements of the European Green Deal (European Commission, 2019).

NbS are open innovations requiring the involvement of multiple actors, providing benefits to both social and economic interests, and stimulating new green economies and green jobs (Kabisch *et al.*, 2017; Raymond *et al.*, 2017a). When NbS were first introduced in the early 2000s, they aimed to create sustainable livelihoods alongside climate- and biodiversity-related goals, and the ability of NbS to create green-collar jobs is now well recognised (Escobedo *et al.*, 2019). The high unemployment rates resulting from the 2020 pandemic, and prior high levels of youth unemployment, could be eased investing in NbS to create green jobs in sustainable professions such as landscape architecture, ground maintenance, construction, horticulture, wildlife officers, agroforestry, outdoor educators, urban farming and more (European Commission, 2015; Raymond *et al.*, 2017b). These green jobs include low-skill entry-level positions to high-skill higher-paid jobs, with opportunities across a wide array of terrestrial and aquatic NbS (Apollo Alliance and Green for All, 2008; Raymond et al., 2017b).

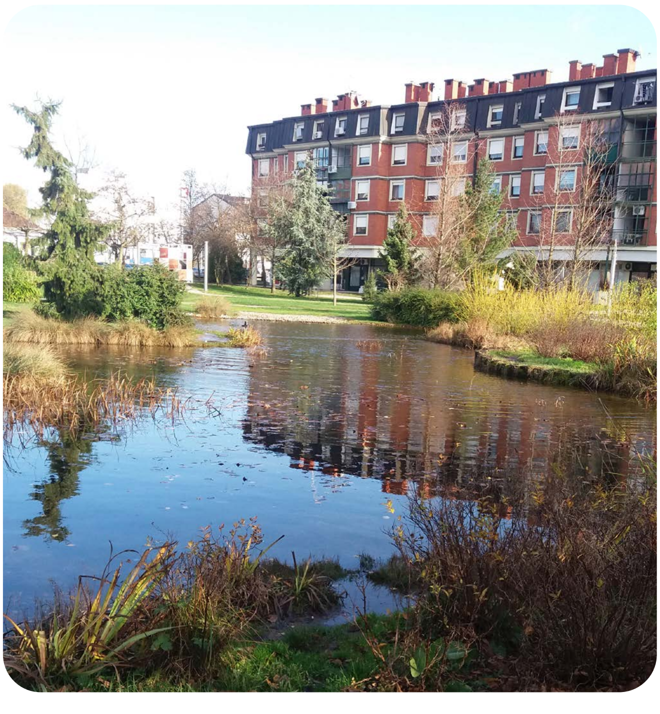
Raymond et al. (2017b) suggest that additional vocational training on the skills needed to design and deliver NbS should be made available, to drive an uplift in earnings for local employees working on these projects (Raymond *et al.* 2017b). The European Green Deal is highlighted as the strategy to guide investment in the roadmap for recovery, with the 'just transition mechanism' providing reskilling programmes for people whose livelihoods are affected by the transition away from fossil fuels and carbon-intensive processes (European Commission, 2019; Allan *et al.*, 2020; European Council, 2020). Furthermore, Allan *et al.* (2020) suggest digital further education as a means of delivering retraining initiatives – in a post-COVID-19 economic recovery plan – to address unemployment arising from decarbonisation measures (Allan et al., 2020).

Additionally, the Horizon 2020-funded initiative Connecting Nature promotes the use of nature-based enterprises – independent entities engaged in an economic activity i.e. the sale of products or services at a given price, on a given/direct market, using nature as a core element of their product or service offering – in meeting the challenge of NbS complexity and lack of experience or relevant skills (Connecting Nature, 2020). The Connecting Nature platform has found that the number of such enterprises is increasing year on year, with value in the form of economic (skills development, innovation, job creation), environmental (biodiversity, green/blue space, water/air quality) and social (environmental attitudes, community empowerment, health and well-being) indicators.

Combining biodiversity & adaptation in urban park (Aarhus, Denmark), ©REGREEN

Increasing urban NbS has a number of co-benefits other than addressing direct environmental challenges: positive health impacts, for example, or improved water management or recreational services – all of which can help save money at household and governmental levels and create economic opportunities for 'green businesses' (Raymond *et al.*, 2017b). The renaturing of landfill sites, for example, provides multiple benefits, including space for leisure but also an economic opportunity to harness clean energy (proGIreg, 2020).

NbS pilot projects with strong replication and up-scaling capacity can use existing city networks to deliver a successful template for other cities and regions to then enact. This can lead to job generation and green growth on a larger spatial scale (European Commission, 2015). The REGREEN project, started in 2019 and funded by the EU's Horizon 2020, has trained over 100 technicians to work on a range of NbS projects in their 'urban living labs' (ULL). The REGREEN project also has an outreach component, targeting business and urban planners with a strong knowledge-sharing ethos to provide best practice from different successfully implemented NbS found in ULL across a number of cities. The REGREEN project connects NbS with the business and start-up communities, and organises accelerator programmes to build the future NbS market (REGREEN, 2020) (see also Chapter 5.4 for more about the REGREEN project).



NbS can transform historic city districts, neglected industrial sites and run-down urban areas, enhancing their attractiveness and converting their use (European Commission, 2015). Green spaces attract visitors and improve the aesthetics of the urban locale, leading to more businesses (cafés, shops) being attracted to the area (Raymond *et al.*, 2017b). As an example, investment in retrofitting sustainable urban drainage systems (SUDS) in an urban regeneration area in Augustenborg, Sweden, had multiple co-benefits aside from decreasing rainwater run off – biodiversity increased by 50%, unemployment in the area fell from 30% to 6%, and tenancy turnover decreased by 50% (Kazmierczak and Carter, 2010; European Commission, 2015).

Use of NbS in cities can cut energy and resource costs while also mitigating the risks of climate change (European Commission, 2015). Roof gardens, green school grounds and large urban parks can generate economic value due to the cooling energy they save, which would otherwise have to be artificially produced via air conditioning units (Lafortezza and Sanesi, 2019). In the Mediterranean region, for example, a green roof led to a 12% reduction in energy demand, and, more broadly, energy savings of between 10-15% have been found for green roofs. In Athens, green roofs have lowered buildings' cooling demands by 66% (European Commission, 2015).

The promotion of NbS across funding schemes and projects (e.g., European Commission, 2015), and the advent of the European Green Deal is encouraging EU Member States to adopt this approach at the outset of any urban strategy (European Commission, 2015). NbS projects have already been undertaken across Europe and, as a result, a plethora of green jobs will be created as the green economy grows (Raymond *et al.*, 2017b). When considering current global priorities, scaling and stepping up the implementation of NbS could significantly contribute to a resilient recovery from COVID-19.

Urban green-blue area (Velika Gorika, HR), ©REGREEN

5.3. Equity

A number of European countries are experiencing growing income disparity as urban gentrification spreads across the continent, exacerbating the problems associated with social inequality (Marcińczak *et al.*, 2015; Rutt and Gulsrud, 2016). Immigration has also increased, with some European countries, such as Sweden and Germany, having as much as 40% of the population made up of foreign-born residents or residents with an 'immigrant background' (Rutt and Gulsrud, 2016). In recent decades, European countries have received the vast majority of asylum seekers from industrialised nations, with 714,300 claims made in Europe in 2014 alone (UNHCR, 2015). Immigrant-background residents are more likely to struggle with finding a job or be on low incomes (Schraad-Tischler, 2015; Rutt and Gulsrud, 2016). The rapidly growing cultural heterogeneity in Europe has provided a socioeconomic context that has amplified marginalisation in society, and highlighted how unequally public green spaces and NbS are experienced (Rutt and Gulsrud, 2016). Green infrastructure and NbS in cities are indicators of a high quality of life, but they also often indicate privilege and inequality – with most urban green spaces being in wealthier areas and designed to the preferences of wealthier residents (Wolch *et al.*, 2014). Privately developed urban green spaces, with controlled access and high entry fees, are now becoming commonplace. Vulnerable and marginalised people are those in greatest need of the health benefits such spaces can offer, but are much less likely to have their voices heard in the decision-making process – or to possess the resources needed to claim or access green areas (Seddon *et al.*, 2020).

BOX 9.

Inner-city areas

Inner-city areas often host economically marginalised populations, who often belong to ethnic minority groups, and who often have limited local resources for parks. This can lead to inadequate parks that are crowded and poorly maintained, with local residents viewing them as unsafe or even dangerous – a perception that prevents them from accessing the space (Sister, Wolch and Wilson, 2010; Zavadskas, Bausys and Mazonaviciute, 2019). The safety of urban public parks can be enhanced through environmental design features, but urban parks in need of a redesign must be identified and prioritised (Zavadskas, Bausys and Mazonaviciute, 2019). The inequality in the distribution and access to urban green spaces undermines the social sustainability of these NbS, and affects the economic and environmental feasibility of urban developments (Harris, 2003).

To achieve social justice, NbS design must recognise that all of society needs to be supported and accepted. Equitable co-design therefore requires typically excluded groups to be actively engaged in the process (Raymond *et al.*, 2017b). Environmental justice in green infrastructure design includes elements of several types of justice, including recognition justice whereby people often excluded – for example the elderly, migrants, women and people with disabilities – are acknowledged and included (Fraser, 2009). Distributional justice refers to the unequal allocation of environmental qualities across cities and between different social strata. Procedural justice relates to inclusiveness and fairness in processes and enforcement of rules (Rutt *et al.* Gulsrud, 2016). Ensuring environmental justice is at the forefront of NbS co-design. Including all of the aforementioned types of justice also aids social cohesion, and narrows the gaps between different social groups. For example, supporting processes that enable immigrants to feel comfortable in their living environment helps develop intercultural understanding in that community, enhancing social cohesion (De Vries *et al.*, 2013).

Skawina Park, ©Januszk57, CC BY-SA 3.0

NbS, however, do not always benefit all sectors of society, and often an increased presence of green spaces and trees in an area that lacked them previously contributes to 'ecological gentrification', altering housing opportunities and the commercial and retail infrastructure that supports lower-income communities (European Commission, 2018; Haase *et al.*, 2017; Raymond *et al.*, 2017b). Improving environmental qualities in an area also improves living conditions, consequently increasing property prices and negatively affecting social justice and cohesion by contributing to gentrification (Rutt and Gulsrud, 2016; Haase *et al.*, 2017). While well-intentioned, green infrastructure projects can inadvertently cause such gentrification and force out lower-income and elderly people, as was the case in the redevelopment of a former railway station into a green park in a formerly lower-income area in Leipzig, Germany, in 2001. The 10-hectare Lene-Voigt-Park became popular and instigated change in local residential areas, with new cafés and shops opening. New residents with higher incomes were attracted to the area, and rents rose from 4.5 to 7 euros per square metre by 2017 (Haase *et al.*, 2017).

Some NbS are positioned as greening strategies for urban renewal and revitalisation, whereas in reality they are primarily market-driven endeavours to cater to high-income residents and increase house prices (Anguelovski, 2015). Lower-income and homeless people in these instances are threatened by displacement. Typical examples of these inequitable strategies can be found in waterfront developments in former harbour or industrial areas in many European cities, such as Liverpool, London, Hamburg, Bristol, Amsterdam, Copenhagen and Barcelona, and US cities, such as New York City, Chicago, Pittsburgh and Baltimore. These NbS do not have inclusiveness as a core component (Haase *et al.*, 2017).

BOX 10.

Pocket parks and urban gardens

One example of an NbS that seeks to provide social cohesion and accessibility to green spaces is **the 'Pocket Park' programme,** run by the Greater London Authority, UK, with a similar initiative in Barcelona (Raymond *et al.*, 2017b). The 'Pocket Park' aims to improve streets, squares, local parks, and canal and riverside areas across the city by delivering 100 new or improved areas of greenery within London's urban environment. These are delivered through collaboration between public bodies and local organisations, supporting volunteering, public participation and social cohesion (Raymond *et al.*, 2017b). As these pocket parks are distributed in small spaces at a local scale, this increases community engagement as well as improving biodiversity (Raymond *et al.*, 2017b).

BOX 10. ***(continued)***

In 2016, **urban gardens across Barcelona** were examined by Camps-Calvet et al. (2016) to identify how they contribute to the quality of life of their urban users. Spain has been suffering from an economic crisis with high rates of unemployment and poverty – in 2014 unemployment rates were generally at 26% and 55% amongst young people (Camps-Calvet *et al.*, 2016). Like many European cities, Barcelona has been subject to gentrification and the commodification of urban green spaces – in contrast, urban gardens offer a non-consumptive space where purchasing power does not prohibit access (Anguelovski, 2013). Users of 27 gardens across Barcelona were interviewed and a number of ecosystem services identified, including social cohesion, food production, and environmental learning, with the most highly valued being cultural non-material benefits derived by people's interactions with nature. The main people to benefit from the ecosystem services of the gardens were elderly low- to middle-income users and migrant people. The study indicates that NbS such as urban gardens can promote social cohesion and improve people's quality of life, particularly when their benefits are opened up to all of society (Camps-Calvet *et al.*, 2016).

When designing and implementing NbS, it is important to consider the wider ramifications that policies may engender. For example, policies offering financial incentives to scale-up NbS for the purpose of mitigating greenhouse gas emissions risked compromising the local land rights of indigenous peoples, with land grabs by private investors and governments (Seddon *et al.*, 2020). This was due to the wording of some NbS actions being too vague regarding indigenous people and local communities – as was the case with the 2007 Reduced Emissions from Deforestation and Land Degradation (REDD) forest monitoring metric. REDD's Monitor, Report and Verify (MRV) metric had potential to lead to unintended outcomes, for example contravening land rights, and so the concept of 'safeguards' was introduced (in Bonn, 2009) and the framework widened to incorporate non-carbon benefits of the activities of REDD+ (Seddon *et al.*, 2019).

5.4. Citizen-led participatory planning

The global population has grown rapidly over the last 50 years. The value of nature and its wide range of benefits to society are now well recognised, and as a result there are a number of local, national and international policy initiatives for the use of NbS in populated areas (Lafortezza and Sanesi, 2019). The planning of NbS has been shown to benefit from an integrated approach that incorporates knowledge from multiple actors, including the interests and perceptions of citizens living locally to a particular NbS (Buchel and Frantzeskaki, 2015). The European Green Deal recognises that the public and all stakeholders must be fully involved in all the aspects of the design and implementation of the green transition in order for it to deliver lasting change (European Commission, 2019).

NbS policy initiatives have resulted in a plethora of bottom-up projects, particularly community-led, using NbS to bring nature back into urban areas (European Commission, 2015). A foundation in the blossoming of numerous urban European NbS was the activation of EU funding instruments for NbS such as Horizon 2020 (H2020), which supports knowledge transfer and practices between businesses, researchers, policy makers and public entities (Lafortezza *et al.*, 2018; Lafortezza and Sanesi, 2019). Civic communities are focusing on 'people and nature' and creating knowledge for the co-design of NbS (Fritz, 2017). While prior studies focused largely on climate change mitigation and adaptation, it is now recognised that nature has an equally important restorative impact on local populations and increases social cohesion (Carrus *et al.*, 2015; Fritz, 2017)

Urban rain garden, West Gorton, Manchester, ©GrowGreen

NbS must be aesthetically appealing for citizens to appreciate and protect them, as shown by co-design projects such as the rain gardens in Rotterdam, Netherlands, which meanders through sidewalk greenery. The rain gardens were co-designed by citizens, artists and architects in a common process (Frantzeskaki, 2019). Similarly, the courtyard renovation 'Plac na glanc' in Katowice, Poland, had pocket parks in the courtyards as part of the architectural design that were co-created with citizens. The aesthetic look of the courtyard was flagged to the architects by the citizens as important to them for the recreational use of the place in the future (Frantzeskaki, 2019).

Involving citizens in the co-creation of NbS creates new green commons, with benefits shown by a change in perception from 'back yard' or 'abandoned places' to 'welcoming places' and 'community spaces'. Where city budgets cannot afford to maintain green spaces, citizen groups are stepping in, as they recognise their importance for urban life. An example is the Montreale Park in Potenza, Italy, where a citizen group named 'hoes armed citizens' stepped in to maintain the park when the city no longer did. In Burgas, Bulgaria, an urban site was renatured with replanting of willow trees, and city officers displayed an openness to collaborate with citizens of all ages. This created a pocket greening solution – and is the start of a new urban green common movement in the area (Frantzeskaki, 2019).

The REGREEN project, uses co-creation of knowledge involving local citizens, schools, businesses, organisations and public administrations to create new forms of innovative urban NbS. 'Urban Living Labs' is a central element of the project, where scientific research is tested in real-world settings to see what works. The project spans cities across Europe and China, with knowledge-sharing as a key aspect of the network. The project relies on citizen input and has a particular focus on meeting the needs of vulnerable groups such as young children, different gender identities, and the socially deprived (REGREEN, 2020). REGREEN has yet to produce data reports on outcomes, but in Aarhus, Netherlands, it aims to enhance the cultural ecosystem services of NbS flood interventions by engaging local inhabitants. Aarhus' water supply company plans to invest 19 million Euros over the next 65 years to fully separate rain and waste-water using NbS and NbS hybrids (REGREEN, 2020).

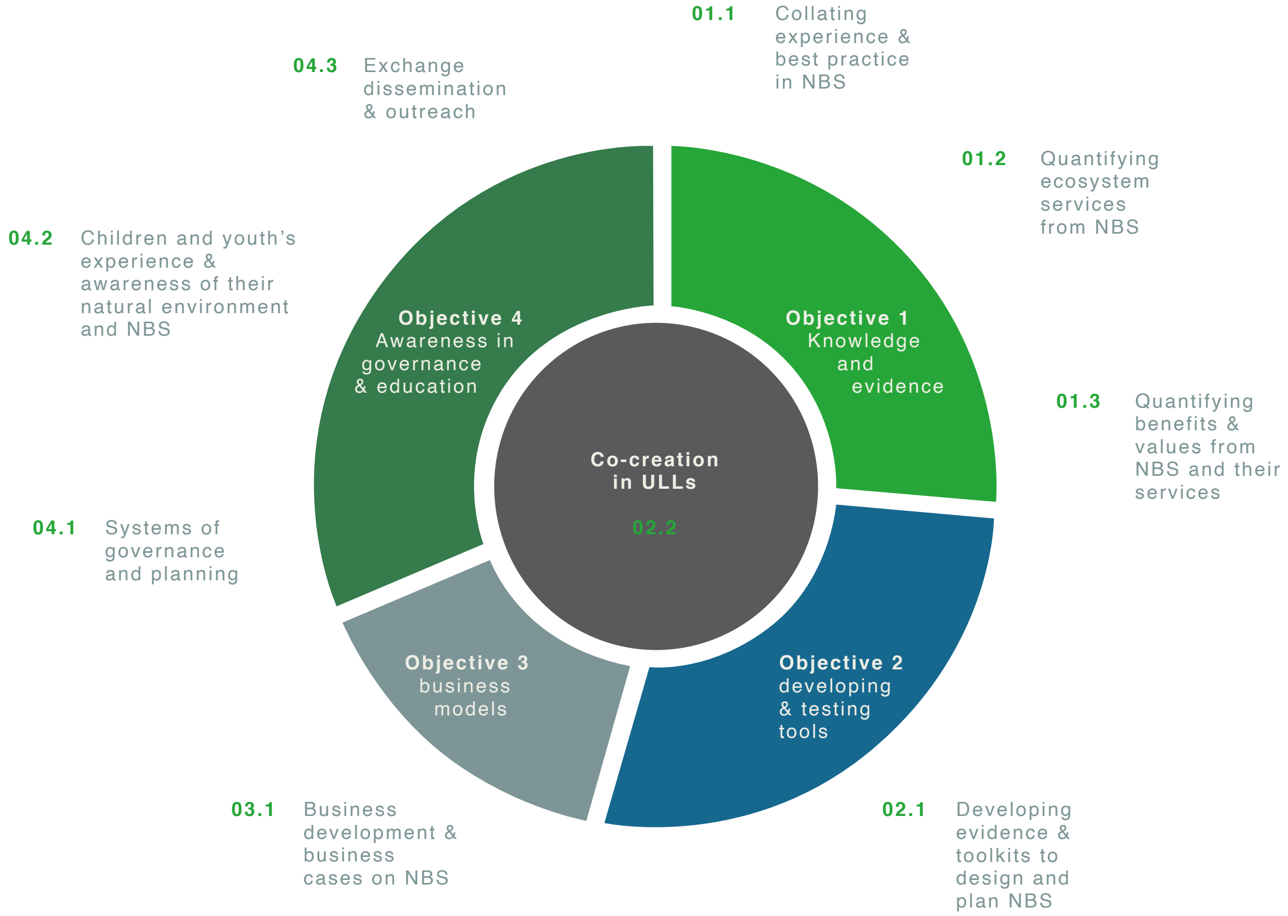


Figure 18. Workflow for co creation in Urban Living Labs developed by the REGREEN project. Source: REGREEN, 2020.

Supporting community-based projects that account for people's perceptions of urban nature ensures that different socio-cultural values relating to NbS are incorporated into the design, so that the result meets everyone's expectations (Raymond *et al.*, 2017b). Incorporating local communities into an inclusive dialogue about the design of local nature-based spaces is important to engender a greater level of ownership of NbS (Frantzeskaki, 2019). Involving the community enables accessibility and encourages stewardship amongst local populations (Dennis and James, 2016).

An example of citizen voices being used to manage nature-based areas is found in the city planning department in Helsinki, Finland, who in 2014 engaged with 300,000 15- to 75-year-old residents about the management of the city's shoreline for recreation (Raymond *et al.*, 2017b). An interactive map enabled the residents to mark which areas of blue space they enjoyed in the metropolitan area. The results were shared with the environment and sports departments who manage these areas, and the data were made available for future planning projects to ensure wider knowledge-sharing (Raymond *et al.*, 2017b)

Digital methods of gathering citizen voices – such as mobile phone applications – enable a better understanding of widespread perceptions of NbS and the different needs of various social groups, potentially enabling social and spatial justice to be better addressed (European Commission, 2018). However, a digital, data-driven approach may be biased towards only those certain groups engaging in the dialogue (*ibid*).

Researchers assert the importance of building capacity for typically excluded groups – such as homeless people – to engage in the co-design of NbS (Raymond *et al.*, 2017b; Rutt and Gulsrud, 2016). This could be via number of pathways to increase literacy, numeracy, physical security, provide employment, information, and recognition as a citizen (Rutt and Gulsrud, 2016).

NbS are now mainstream, and being delivered at different scales in all shapes and sizes. Engaging communities by introducing the promise of the NbS concept can instigate rapid uptake and integration into existing knowledge, in turn inspiring engagement with multiple stakeholders (Lafortezza and Sanesi, 2019).

5.5. Food Security

Urban agriculture – whether indoor, garden plots on walls and rooftops, or city farms – provides social and cultural benefits to the communities surrounding them by offering opportunities for nature-based recreation, and bridging the gap between producer and consumer (Engström *et al.*, 2018). During COVID-19 and associated lockdowns, the mindset of supporting local networks and opting for shorter supply chains has gained increased in popularity. Importantly, such spaces improve the diet of city-dwellers, providing fresh food – and, potentially, an important boost to household budgets (Engström *et al.*, 2018). City farms and community growing spaces offer chances for social interaction and learning, as well as opportunities for different groups to engage in physical activity (including elderly and disabled people; European Commission, 2018). City farms are therefore an NbS offering multiple benefits and social opportunities for their communities, including accessible education and physical recreation for all ages. By offering locally produced fresh food, urban farms are easing the pressure on rural farming and improving the nutrition and health of urban populations. This has a direct economic benefit to the urban producers but also aids the economy by improving people's mental and physical well-being.

Barcelona has a number of NbS programmes aimed at promoting inclusivity within urban allotments and community gardens, targeted at elderly, low-to-middle income and immigrant people (Camps-Calvet *et al.*, 2016). Barcelona also recently developed the Pla Buits (Empty Spaces Plan), designating some city allotments for people at risk of social exclusion (Langemeyer and Connolly, 2020). Community growing spaces provide nutritious food to those who need it, whilst aiding social cohesion and mental health.

The world's largest rooftop farm will open in Paris in 2020, and green roofs are becoming increasingly popular in cities worldwide (Hardman and Davies, 2019). A variety of terms are used to describe forms of urban agriculture, including 'vertical farming', 'zero-acreage farming', 'plant factory' and 'continuous productive urban landscapes' (Engström *et al.*, 2018). Locally produced food in cities is often distributed to low-income citizens via food banks, and this can aid estimates of the food security benefits related to urban agriculture. There are commercial benefits to urban farming too – for example growing herbs on the 195-square-metre rooftop garden of a hotel in Vancouver saved an estimated $25,000 to $30,000 (21,110 to 25,350 Euro) in food costs for the hotel restaurant (Engström et al., 2018).

Green roofs are expanding worldwide, with Stuttgart, Germany, considered the green roof capital of Europe. In the UK, they are expanding at a rate of 17% each year (Hardman and Davies, 2019). Green roofs provide valuable ecosystem services related to production, including pollination and bee conservation. Urban honey can provide another income stream for households and adds another local supply of food. Bee-keeping is another opportunity for people to interact with nature, and the honey produced has benefits such as antibacterial properties (Engström *et al.*, 2018; Klein *et al.*, 2018).

Initiatives exist to promote the use of urban landscapes for food production – including the Edible Cities Network, a H2020-funded project aiming to implement Edible City Solutions to create liveable, healthier cities (Edible Cities Network, 2020). Edible Cities Network aims to leverage the substantial benefits of such solutions at a local level, and catalyse their replication on both EU- and world-wide scales by creating an open, participatory city network. Another H2020-funded project, the ProGIreg NbS project, also pushes for NbS innovation in achieving urban regeneration, and has 3 of its 8 types of NbS focused on food production in post-industrial urban areas in cities:

1. new, regenerated soil from biotic compounds for urban forestry and farming;
2. community-based urban farms and gardens on post-industrial sites;
3. aquaponics as soilless agriculture for polluted sites.

The ProGIreg project asserts that such NbS help improve living conditions, reduce vulnerability to climate change, and provide measurable economic benefits to citizens and entrepreneurs in urban districts (European Commission, 2020).

The Angel Community Garden in London, UK, is a Pocket Park initiative aiming to develop a community food growing space where local people from multiple ethnicities come together and help run the space as a productive fruit and vegetable garden (Semble, 2020). The site, formerly a disused railway, was transformed in 2013 by Enfield council into a 1.5-acre green space. The Pocket Park initiative consulted on the design of this space with local residents, who requested the inclusion of a community food-growing space (Raymond *et al.*, 2017b). A similar growing space was set up in Berlin, Germany, but this time by a bottom-up initiative: 'Prinzessinnengarten' (Princess Gardens) was launched in 2009 at a site that had been a wasteland for more than half a century. A group of friends, activists and neighbours, called 'Nomadic Green', obtained a temporary permit to use the vacant urban area, cleared away the rubbish, and built transportable organic vegetable plots. Nomadic Green is a not-for-profit organisation and the garden is maintained by volunteers and funded by the selling of food at the site (prepared from vegetables grown on site). Informal learning occurs for volunteers through the practical day-to-day tending of the gardens (Shaw, 2020).

Urban agriculture provides more than just food security to local people. It also provides social goods such as education (culinary, nutrition and education), connection to nature, and community. It can form part of the portfolio of solutions to address food security, but must be reinforced by other policy and civic efforts to provide affordable, healthy food in neighbourhoods such as food hubs and neighbourhood markets, and to address the structural causes of food insecurity such as job access (Siegner, Sowerwine and Acey, 2018).

BOX 11.

Overseas inspiration

New Zealand: Lavorel et al. (2020) say that rural farming in New Zealand benefits from NbS in the form of pasture diversification and regenerative agricultural approaches (to aid resilience to climate change). Planting drought-resilient grasslands for fodder requires consideration of plant functional diversity and the use of native plants such as tussocks, as their leaf and root traits aid grassland soil biota. Other co-benefits to this NbS approach include soil erosion reduction, carbon sequestration and water quality regulation. Additionally, the restoration of native vegetation on riparian margins alongside native forest fragments and wetlands helps mitigate the risk of flooding due to more intense rainfall, and aids water purity. Variations of this NbS approach can be used in countries with a similar climate to New Zealand to aid food security, by providing farmers with more resilient grassland fodder and land management that lowers the risk of flooding (Lavorel *et al.*, 2020).

Mangrove forest planting, ©Getty Images, public domain

Cameroon: Cecile Ndjebet, founder of the African Women's Network for Community Management of Forests (REFACOF), organised local women in Cameroon to map and restore local mangrove forests (Ndjebet, 2020). Local women living near the coast where mangroves were degraded were worried about the loss of the mangroves, which provide food, timber and medicine. As sea levels are rising, the mangroves also protected them from the effects of tsunamis and stopped soil quality from degrading. Working with the women and village leaders, Ndjebet and those involved in the project have restored 46% of the degraded mangroves and improved fishing productivity. The NbS project also improved the livelihoods of the women involved. Further work is needed to ensure that the women who restored the mangroves have the rights to use these mangroves to make a living, as they do not have any land-ownership rights at present (Ndjebet, 2020).

BOX 11. ***(continued)***

USA: The U.S. city of Detroit suffered economic decline and bankruptcy in 2013, fuelled by the demise of the local automobile industry and the subprime mortgage crash of 2007. This led to poverty and abandonment of houses in Detroit due to 'white flight' – where white residents moved away, meaning that remaining residents were largely African-American (83%). Due to the lack of federal support, most help came from local initiatives and policies. Food poverty was a big problem in Detroit, with 48% of residents in 2017 designated as 'food insecure' (Hill and Kuras, 2017). Food security in the city was partly alleviated by local urban farming initiatives which turned vacant lots and gardens into huge urban farms. In 2015 there were approximately 1,400 active urban gardens and farms in Detroit.

Benefits for nature are inherent in the Detroit 'good food purchasing' policy, which has 5 core values including 'environmental sustainability': within this, protecting and enhancing wildlife habitats and biodiversity is explicit (Hill and Kuras, 2017). The biggest impact on food security was by assistance programmes such as SNAP (supplemental nutrition assistance programme), with 60% of food-insecure households accessing such national food assistance programs (Hill and Kuras, 2017). There is an effort to encourage local food production through the good food purchasing standards, whereby locally grown, nutritious produce is produced by workers paid a fair wage. Within Detroit, 5% of food consumed is grown locally, with locally-grown produce having a market value each season estimated at 1.5 million US$ (1.25 million Euro; Hill and Kuras, 2017).

6. Financing of NbS

Scaling and stepping up the implementation of myriad NbS – some of which have been described in this brief – will provide a range of valuable environmental and social benefits with ecosystem services for Europe (regulating, market and non-market economic values). Such benefits include food production, habitat maintenance, freshwater and air quality, climate change mitigation and adaptation, disaster risk reduction, and tourism and recreation (Cherlet *et al.*, 2018; Rounsevell *et al.*, 2018). For example, ecosystem-based adaptation to prevent climate-associated flooding events prevents damage to infrastructure, in turn saving private companies and insurers lost revenue (Gómez Martín, Máñez Costa and Schwerdtner Máñez, 2020; Reguero *et al.*, 2020). The European Nature Insurance Value: Assessment and Demonstration (NAIAD) project provides a robust framework for assessing the insurance value of ecosystem services (NAIAD, 2020). The value of these benefits is in excess of the cost of most NbS; the cumulative cost of inaction to address land degradation in Europe over the next 30 years, for instance, would be over 5,738 billion US dollars (4,850 billion Euro) – but restoration would cost far less at just under 950 billion (810 billion Euro; Cherlet *et al.*, 2018).

However, planning, delivering and maintaining NbS requires financial investment. Where can this money come from?

6.1. Financing strategy for NbS

The European Councils' (EC) 2020 COVID-19 recovery plan highlights the need for unprecedented financial investment, drawing on public investment at European and national levels as well as mobilising private investment (European Council, 2020). The EC suggests that large-scale investment in the green transition – alongside several other key areas – is required, and should be guided by the European Green Deal (European Commission, 2019). NbS are key elements of a green transition and, as proposed by the EC, financing should come from both governmental and private investment.

Securing finance is vital to implementing NbS. An array of NbS financing strategies are used, with some being more applicable in certain ecological domains than others. The extent to which private value can be captured from an NbS approach, as well as the scale of the investment (amount and timescale), also influences the most appropriate financing strategy (Toxopeus and Friedemann, 2017). A number of tools have been developed within H2020 projects to assist decision-makers and planners in identifying and considering alternative business models for NbS. For example, the H2020 project GrowGreen produced a catalogue of NbS financing approaches (Trinomics and IUCN, 2019) which provides details on a range of financing mechanisms that have been used to finance NbS investments by public sector entities within Europe and beyond.

Financing for NbS can be obtained by governments, via global funds such as the World Bank and German Government's multi-donor trust fund PROGREEN, which supports efforts to improve livelihoods whilst tackling loss of forests and biodiversity (Shelest, 2019). Accessing funding from PROGREEN can be aided by European Member States committing to global NbS initiatives such as the Bonn Challenge. Specifically for Europe, the regional ECCA30 initiative can facilitate access to technical and financial support to EU members that commit to forest landscape restoration (FLR). The ECCA30 can help mobilise financial support from multilateral banks and bilateral donors as well as private impact investors to implement country-led restoration efforts (IUCN, 2018). With desertification affecting 8% of southern, eastern and central Europe (around 14 million hectares), investing in addressing this challenge will aid the national economies of affected countries (Cherlet *et al.*, 2018; Shelest, 2019).

6.2. Incentives for the uptake of NbS

Raymond *et al.* (2017b) propose incentives such as tax reductions and subsidies to co-creators of NbS to encourage green investment and create more green jobs (Raymond *et al.*, 2017b). Investment in NbS can be encouraged in national post-COVID-19 recovery plans by creating recovery plan savings accounts that direct capital towards green projects; furthermore, governments could issue green recovery bonds to focus funding on sustainable investment such as in NbS (Allan *et al.*, 2020). In Massachusetts, USA, green bonds can already be used to purchase and conserve land, and these can also be utilised to fund NbS (Sutton-Grier *et al.*, 2018).

Another approach to encourage businesses to utilise NbS is for companies that adopt sustainable features to be charged less for utilities. An example of this is United Utilities in the north-west UK, who charge companies for water based on the amount of hard standing (impermeable surface) on the premises. This is to encourage businesses to adopt permeable surfaces — sustainable urban drainage systems (SUDS) — which have a number of benefits, including flood mitigation and lower water processing costs. Similarly, domestic customers of United Utilities can save money on their water bill if rain is gathered into a local stream or channelled into a soak-away rather than entering United Utilities pipes (United Utilities, 2020).

Mandating NbS within new urban design and retrofit projects is another approach to encourage investment and uptake — as recently utilised by the Mayor of New York City (NYC), USA, with a bill that makes green roofs, solar panels or a combination of the two compulsory for new buildings in the city (New York City, 2019).

Additionally, after Superstorm Sandy ravaged New York in 2012, former US President Barack Obama requested the prioritisation of natural infrastructure in restoration activities via Executive Order. Benefits to real estate developers include the money saved and the 'natural capital' that green roofs provide in terms of flood mitigation, heat reduction, increase in biodiversity and improvement of air quality (Hardman and Davies, 2019). In addition, NYC provides tax relief for green roofs and solar panels, as well as access to additional financing to aid construction and installation through the New York City Energy Efficiency Corporation (NYCEEC) and the Green Housing Preservation Program (New York City, 2020). Municipal subsidies like those offered in New York can be very effective in increasing the returns on green roof investment and triggering larger-scale green roof adoption (Claus & Rousseau, 2012). Private benefits, such as doubling of the lifetime of the roof by installing a green roof system, are also important but require investors to have a long-term vision (Toxopeus and Friedemann, 2017).

Economic arguments (such as public subsidies and tax relief) have shown to be the most important way to convince investors and developers to install green roofs – such as the storm-water tax cuts offered in Germany (Hardman and Davies, 2019; Toxopeus and Friedemann, 2017). This can be in the form of tax relief and grants, but also in highlighting the money saved by installing a green roof and preventing flooding, lowering energy costs, and improving the mental and physical health of people using the space (Hardman and Davies, 2019). For instance, 'The Edge' in Amsterdam is one of the greenest buildings in the world; it uses 70% less energy than the average office building, saving the building owners money (Randall, 2015).

Photograph of a green roof in Denver, ©Wikipedia Commons CC BY-SA 3.0

6.3. NbS investment for adaptation in urban environments

Urban populations have been growing rapidly over the last 50 years. Significant amounts of money are earmarked for investment in cities around the world – and in a post COVID-19 world, it is ever more important to ensure that this money is spent on infrastructure projects that utilise NbS. Population growth and the need for housing in cities is an opportunity to mobilise finance for adaptation using NbS, such as by minimising urban sprawl and habitat destruction by regenerating unused post-industrial inner-city areas and deploying green walls and green roofs.

Green façade on the NRE terrain (Eindhoven, Netherlands), ©UNaLab

Mobilising investment for NbS adaptation in cities involves garnering support from city governments, as in the NYC case presented earlier, but also bringing private investors onboard. Public-private partnerships can leverage public spending to implement NbS where infrastructure projects also benefit industry (Sutton-Grier *et al.*, 2018). Investments are at risk in cities as extreme weather and climate-related events — flooding, for example — become more commonplace due to climate change. The insurance industry has a vested interest in financing NbS, with models estimating wetlands to have saved more than US$635 million (490 million Euro) in avoiding flooding damages, and 20% of the communities located behind marshes experiencing property loss during Hurricane Sandy (Sutton-Grier *et al.*, 2018). In the US, insurance discounts of 5-45% are available for communities in high flood-risk areas, who can demonstrate risk reduction measures such as preservation of natural areas — as measured by a community rating system (*ibid*).

The European Nature Insurance Value can be applied through co-developing and co-testing – with key insurers and governing authorities – the NbS concepts, tools, applications, and instruments (business models) applicable, and ensuring that they can be used Europe-wide (Faivre *et al.*, 2017; Somarakis, Stagakis and Chrysoulakis, 2019). Implementing the nature insurance value of ecosystems will reduce human and economic costs of risk associated with water (floods and drought) (NAIAD, 2020).

Coastal NbS also have a range of co-benefits - including habitats for valuable fish stocks, biodiversity, improved aesthetics and access to nature, increased tourism and improved water quality - with estimated natural capital benefits of over $100 billion (85 billion Euro) annually (Sutton-Grier *et al.*, 2018). Reguero et al. (2020) investigated a resilience insurance that combined risk transfer (insurance) with risk reduction (hazard mitigation). The authors assessed this type of insurance for coral reef restoration and found that 44% of the initial restoration costs would be covered by insurance premiums in the first five years, with benefits amounting to more than six times the total cost over a period of 25 years. This mechanism could help align environmental and risk management goals, creating opportunities for public and private investment in NbS for adaptation (Reguero *et al.*, 2020).

In 2010, New York City instigated a storm water management plan that decentralised green infrastructure and aimed to capture an additional billion gallons of water. This was through a variety of nature-based and hybrid measures such as green roofs, blue roofs, engineered wetlands, rainwater harvesting, tree planting, permeable pavements, and enabling measures including economic incentives, design guidelines, zoning, and performance measures. In meeting just this challenge, billions of dollars were saved – and similar measures are being implemented in cities around the world (USEPA, 2013).

6.4. Public and private sector procurement

The public and private sectors are the main procurers of infrastructure, and can make a direct impact on increasing NbS implementation through their spending decisions. Policymakers can encourage business and finance models using NbS innovations, by changing accounting frameworks, adjusting procurement rules and providing risk guarantees (Toxopeus and Friedemann, 2017; Davies and Lafortezza, 2019). Accounting rules should incorporate non-monetary values related to nature and procurement rules, adjusted to include NbS benefits such as improved air quality (Toxopeus and Friedemann, 2017).

Despite the evident social and environmental value of NbS, many public authorities report difficulties in using public procurement to implement NbS projects. As part of the research undertaken within the H2020 Task Force 3 Governance, Business Models, and Financial Mechanisms,[12] a report on *Public Procurement of Nature-based Solutions* (Mačiulytė and Durieux, 2020) aims to address this issue by providing cities with a better understanding of the topic and presenting challenges and opportunities of NbS procurement – including several case studies and experiences from European cities.

Assessing citizen willingness to pay (WTP) for NbS such as urban forests, can help encourage private investment in urban forest construction and maintenance, as well as preventing loss of existing urban forests. Added values of forests – such as rainwater capture, or making trees a fixed asset – can help quantify the natural capital urban forests offer (Davies and Lafortezza, 2019). Poudyal et al. (2015) found that some carbon-offset buyers are willing to pay a price premium for carbon credits sourced specifically from urban forests, due to the importance they place on the additional community, economic and environmental benefits due to their urban location. Targeting urban carbon credit sales to these specific buyers could provide additional financing for urban tree cover. Urban forests can increase property prices, motivating residents to contribute, but also can help cities recover some of their investment in trees via property taxation and ground sales (Davies and Lafortezza, 2019).

12. The H2020 Taskforce on Governance, Business Models and Financial Mechanisms (Task Force 3) collaborates in the areas of business, finance and governance models, within the overriding objective of advancing the development, uptake and upscale of NbS. It was created as a collaborative space and clustering channel for all relevant Horizon 2020-funded NbS projects.

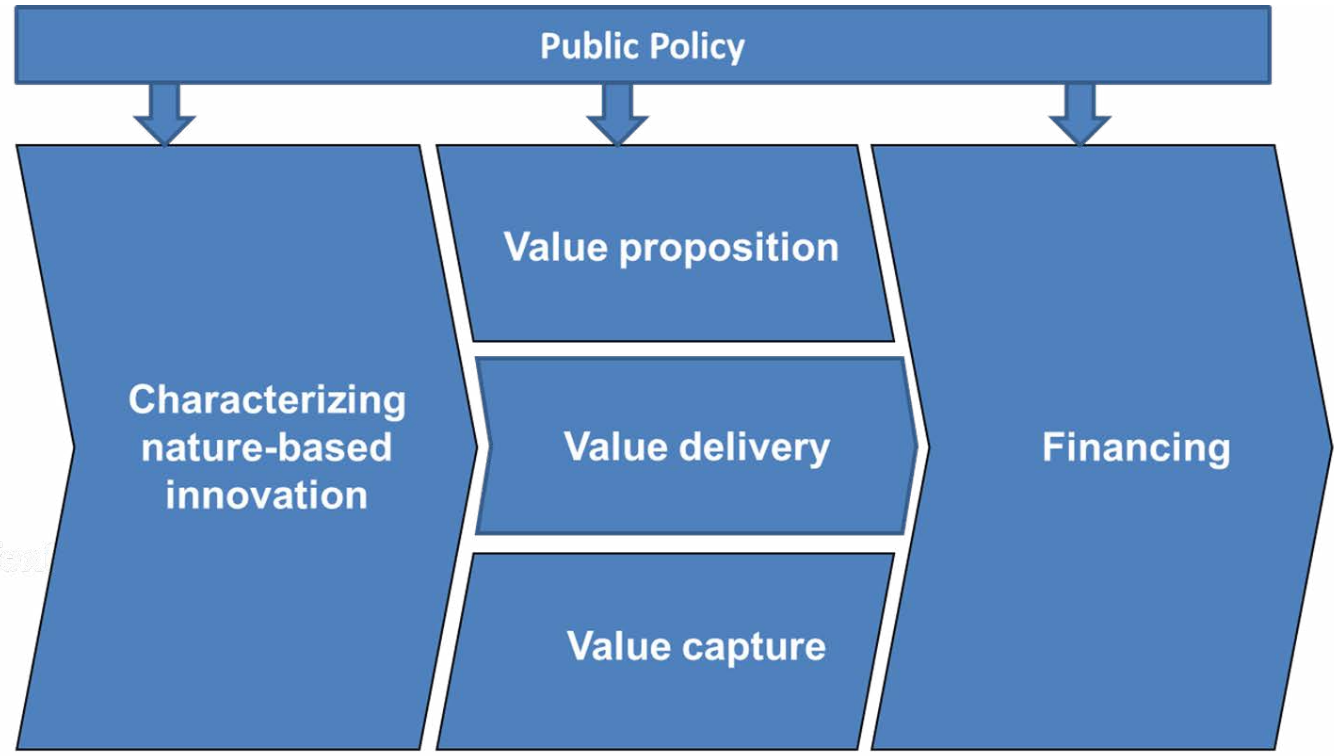


Figure 19. Proposed process by which NbS value can be created, delivered and privately captured (Toxopeus and Friedemann, 2017).

6.5. NbS financing: summary

The financing of NbS requires careful consideration tailored to the particular circumstances and sources of funding (public or private financiers). Such an approach can maximise incentives and improve the ability to value different types of NbS ecosystem service payoffs (Toxopeus and Friedemann, 2017). Alongside this, innovative accounting and valuation methodology (such as natural capital accounting) for NbS is needed to capture all the direct and indirect benefits in the decision-making processes of businesses, governments, investors and the public. Citizen WTP can be gathered using innovative business models and financing arrangements (Toxopeus and Friedemann, 2017). Despite lack of funds, some bottom-up NbS – such as community agriculture – can be sustainable (Hill and Kuras, 2017; Čamprag, 2018). Innovative financial instruments can be used to offer public–private funding, such as different forms of taxation to capture uplift in land value from urban NbS but also in charges passed on to businesses to encourage uptake of NbS. Alternative financing schemes, such as Green Bonds and savings accounts or Social Impact Bond schemes, shift the risk of achieving environmental milestones from the taxpayer to private bond holders (Toxopeus and Friedemann, 2017; Allan *et al.*, 2020). At national and supranational policy levels, the carbon sinks provided by NbS should be incorporated into emissions accounting and trading systems, and national procurement rules must be adjusted to capture the indirect benefits of NbS to nature and human health – such as increased biodiversity and improved air quality (Toxopeus and Friedemann, 2017; Davies and Lafortezza, 2019). It is noteworthy that although NbS have the potential to deliver over a third of the mitigation effort needed until 2030 to keep global warming well below 2°C (IPBES, 2019), only 3% of climate funding is invested in NbS.

7. Conclusion

The research collated in this Future Brief demonstrates that Nature-based Solutions are as diverse in their benefits as they are in the myriad ways they could be implemented. NbS are currently at the forefront of global environmental change solutions, highlighted by their increasingly mainstream position in global conversations (for example, in the 2019 UN Climate Action Summit Nature-based Solutions workstream).

NbS are integral to the EU's Biodiversity Strategy for 2030, as well as being an important enabling factor for the European Green Deal transition to a sustainable Europe. But the diversity of NbS projects worldwide – a very small selection of which are presented in Chapter 3 – demonstrate the wide-reaching societal and environmental benefits that NbS confer across many policy areas. Furthermore, this Brief demonstrates that policy frameworks since 2009 have built complementarity, and have contributed to the genesis of a plethora of pathbreaking NbS projects. Nonetheless, there appears to be great potential for this complementarity to increase further, and to ensure that a global wave of nature-based innovation and practice starts to make real steps towards crisis mitigation and adaptation to climate change.

NbS have multiple benefits to society and biodiversity though their capacity to address multiple challenges simultaneously, benefitting health and wealth whilst creating, maintaining and improving natural spaces. Chapter 2 discussed the types and functions of NbS, highlighting the need to recognise the multiple benefits and trade-offs inherent in NbS and ensure that these are recognised. NbS can address deep societal and environmental challenges, but appropriate monitoring and assessment approaches are required to evaluate the impacts of NbS and to investigate their effectiveness (Chapter 4), particularly in addressing multiple challenges simultaneously. Measuring and valuing NbS including both monetary and non-monetary benefits, enables development of robust NbS business models attracting financial investment.

Some of the many social and economic aspects of NbS are collated in Chapter 5, where the science highlights the physiological and psychological benefits to people, for example, through cleaner air, reducing noise, improving urban heat, and providing healthy food, as well as by providing places to relax and develop social bonds with others. It is clear that direct economic benefits of NbS arrive through the creation of more green jobs, but indirect benefits also occur: for example, through businesses being attracted to previously derelict urban areas, via regeneration schemes. These social and economic benefits are often framed within the context of social participation of all sectors of the community and by emphasising the importance of co-governance structures.

The research in this Brief clearly indicates the wide-ranging beneficial impacts of scaling up the implementation of NbS in Europe; however, to do so requires financial investment. Chapter 6 presents research into a range of financial and investment instruments and options for gaining funding for NbS. The approaches discussed included government funding schemes, mandating NbS in global cities (such as green roofs in New York), public and private sector procurement of NbS, public subsidies and tax relief to incentivise investment and insurance premium reduction for areas using NbS to reduce risk (of flooding, for example).

Nature-based Solutions do not need to be viewed as alternatives to engineered grey infrastructure or other solutions, but are rather highly complementary. Indeed, synergies can sometimes be the best solution, combining multiple NbS approaches with, where appropriate, existing or new grey infrastructure (Seddon *et al.*, 2020; Cohen-Shacham *et al.*, 2019). At this crucial crossroads, the spheres of science and policy seem aligned. Shifting the global emphasis – and funding – towards high-potential, multi-benefit solutions, based in nature, will be absolutely pivotal to address the interdependent crises of our age: biodiversity loss, health, overexploitation of nature and climate change.

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ISBN 978-92-76-21355-0