



Network  
Nature



**European Roadmap to 2030**

**for Research and Innovation  
on Nature-based Solutions**

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## Authors

Mariem El Harrak & Frédéric Lemaitre (Biodiversa+)

## Main contributors

Kris Declerck, Robert McDonald, Siobhan McQuaid, Ignacio Palomo, Christopher M. Raymond, Laura Wendling

## Additional contributions from

Bettina Wilk, Alice Reil, Pam Berry, Sandra Naumann, Tadhg MacIntyre, Harriet Bulkeley, Fabrice Declerck, Julie Delcroix, Silvia Donato, Hilde Eggermont, Tiago Freitas, Kris Verheyen, Rik de Vreese, Tom Wild.

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## Figure layout

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<b>ABOUT NETWORKNATURE</b>	<b>5</b>
<b>EXECUTIVE SUMMARY</b>	<b>5</b>
<b>INTRODUCTION</b>	<b>9</b>
<b>METHODOLOGICAL APPROACH</b>	<b>12</b>
<b>TAKING STOCK</b>	<b>14</b>
1. Mapping of EU R&I and Implementation projects landscape	15
2. Overview of progress on the EU's 2017 research policy goals on NBS	17
<b>ROADMAP TO 2030</b>	<b>22</b>
Action area 1 – Advancing NBS Knowledge and Data	23
1a. Advancing knowledge for sustainable and effective NBS design and implementation	23
1b. Improved evidence-base on NBS effectiveness	25
1c. Further developing non-monetary and monetary valuation of NBS benefits and cost	26
Action Area 2 – Closing the NBS research-implementation gap	27
2a. Better integrating research and demonstration	27
2b. Operationalising NBS in business contexts	27
2c. Developing and testing tools to help close the research-implementation gap.	29
Action Area 3 – Mainstreaming the role of R&I in NBS policy	30
3a. Advancing policy implementation across EU sectors and scales	30
3b. Enabling supportive conditions and legal frameworks for NBS through R&I	31
3c. EU R&I supporting an ambitious NBS international agenda	32
Action Area 4 – Exchange, capacity building and awareness	33
4a. Raising awareness of and empowering society on NBS	33
4b. Enabling transdisciplinary dialogue and local knowledge integration	33
4c. Developing skills and investment capacities for NBS implementation	34
<b>IMPLEMENTATION</b>	<b>35</b>
<b>BIBLIOGRAPHY</b>	<b>37</b>
<b>ANNEX</b>	<b>42</b>
Annex 1: Methodology	42
1. Mapping the EU Research, Innovation, and Implementation landscape on NBS	43
2. Collecting and synthesising knowledge gaps on NBS	46
3. Developing strategic objectives for NBS R&I	47
4. Public Consultation and Finalisation of the Roadmap	47
Annex 2: Detailed Graphs of the mapping NBS projects	48
Annex 3: List keywords for “Biodiversity”	50
Annex 4: List keywords for “Services and approaches”	51
Annex 5: List of publications used in the Knowledge gaps desk Study	52

# About Network Nature

NetworkNature is a resource for the nature-based solutions community, creating opportunities for local, regional, and international cooperation to maximise the impact and spread of nature-based solutions. The project is funded by the EC under the Horizon 2020 programme.

NetworkNature's activities:

- Synthesise and strengthen the NBS evidence base by gathering experiences, knowledge, tools, and services from more than 50 Horizon 2020 and Horizon Europe projects.
- Engage existing stakeholders and expand the NBS community to new sectors and target audiences, by creating new partnerships and identifying sectoral champions, sharing knowledge in dedicated events, educating young generations, and communicating the latest findings in the field.
- Ensure NBS science informs the policy agenda and vice versa. As an interface between NBS innovators and knowledge generators as well as business and policy makers, NetworkNature is a bridge between the European policy landscape and the NBS community.
- Accelerate the uptake of NBS across science, business, policy and practice by providing guidance and building capacity, creating and operating new European NBS national and regional hubs, coordinating the EU Nature-based Solutions Task Forces and networking with practitioners, business, investors and policymakers.

# **Executive summary**

This Roadmap to 2030 identifies **core action areas for European research and innovation on Nature-based solutions** (NBS) that are essential to achieve EU goals for NBS development and deployment.

It provides an overview of efforts implemented so far, major knowledge needs and knowledge implementation gaps, and helps lay out and facilitate synergies and complementarities between the past, on-going, and forthcoming activities of European R&I on NBS.

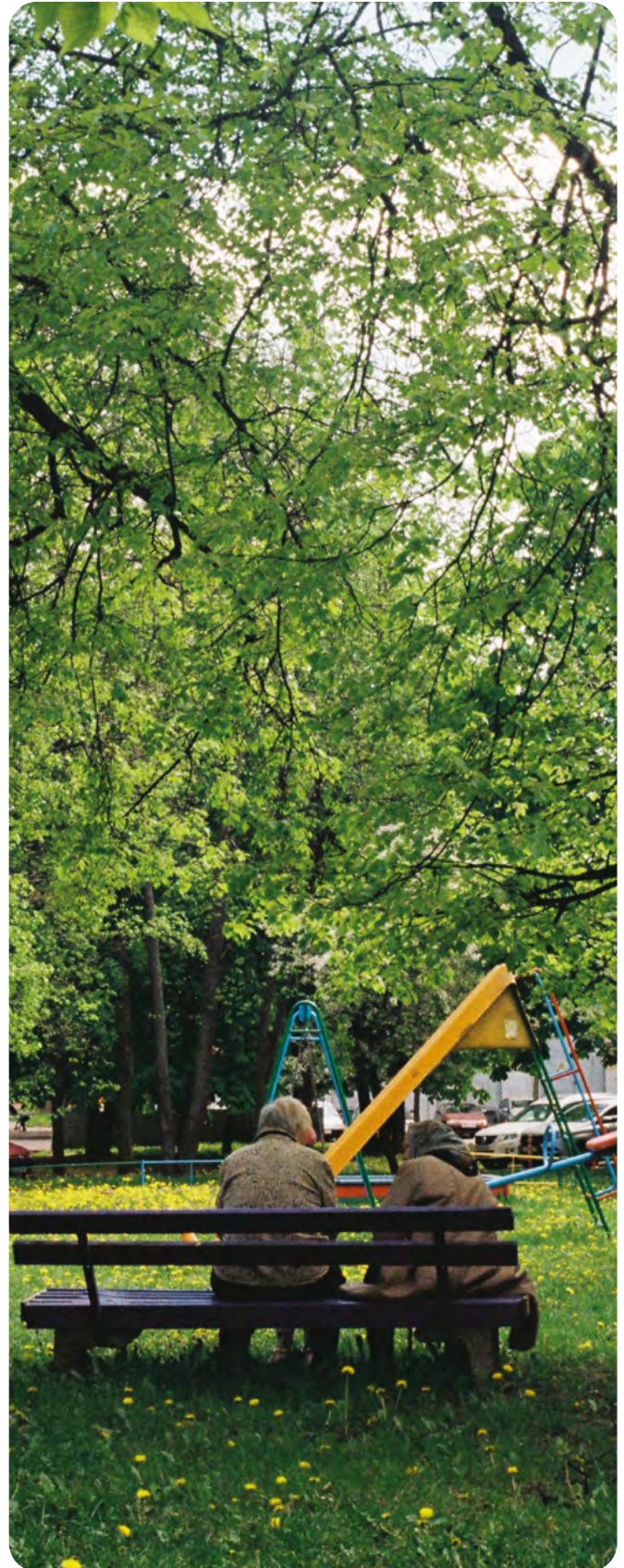
This roadmap is grounded in the **co-development, implementation and dissemination of knowledge** and its timeframe is aligned with key EU and global policy processes related to NBS and R&I, such as the EU Biodiversity Strategy to 2030 and the EU Missions on adaptation to climate change, on the restoration of ocean and waters by 2030, on climate-neutral and smart cities, as well as the IP-BES, IPCC and the CBD Global Biodiversity Framework.

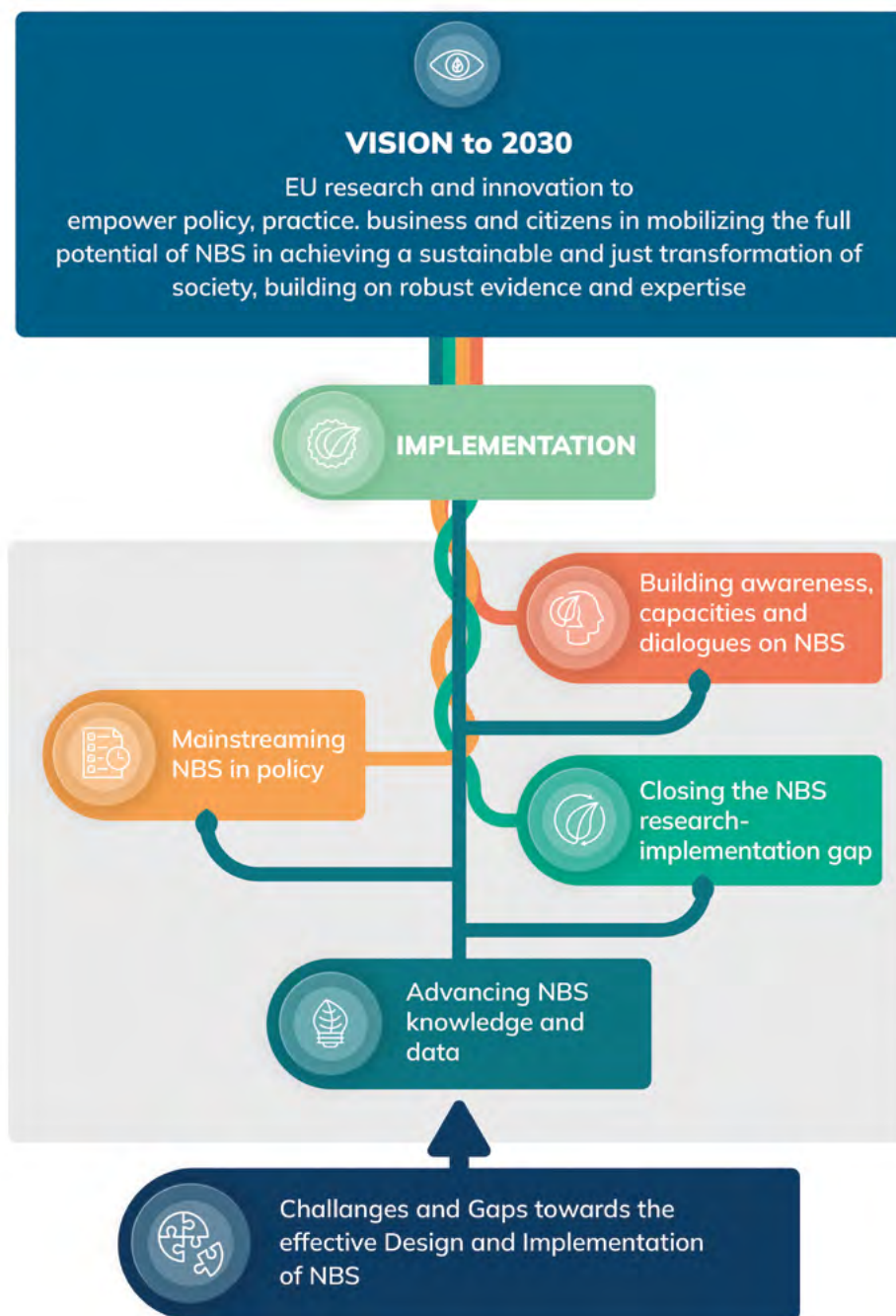
**The overarching vision of the roadmap is for EU research and innovation to empower policy, practice, businesses, and citizens in mobilizing the full potential of NBS in achieving a sustainable and just transformation of society, building on robust evidence and expertise.**

To support the deployment of evidence-based NBS in Europe and globally (see [Figure 1](#)), and achieve the vision depicted above, four strategic action areas were identified for transdisciplinary R&I to:

1. Advancing NBS knowledge and data on NBS
2. Closing the NBS research-implementation gap
3. Mainstreaming NBS in policy
4. Building awareness, capacities, and dialogues on NBS

The findings of this Roadmap suggest there is a need for further advance R&I actions and programs to address these four strategic action areas. R&I on NBS will require even stronger inter- and trans-disciplinary science as well as integrative partnerships with academic and non-academic actors to fully play its role. This is needed to enable NBS delivery and the structural changes across EU R&I, academic institutions, governmental bodies, and civil society to fully achieve a sustainable and just transformation of society.

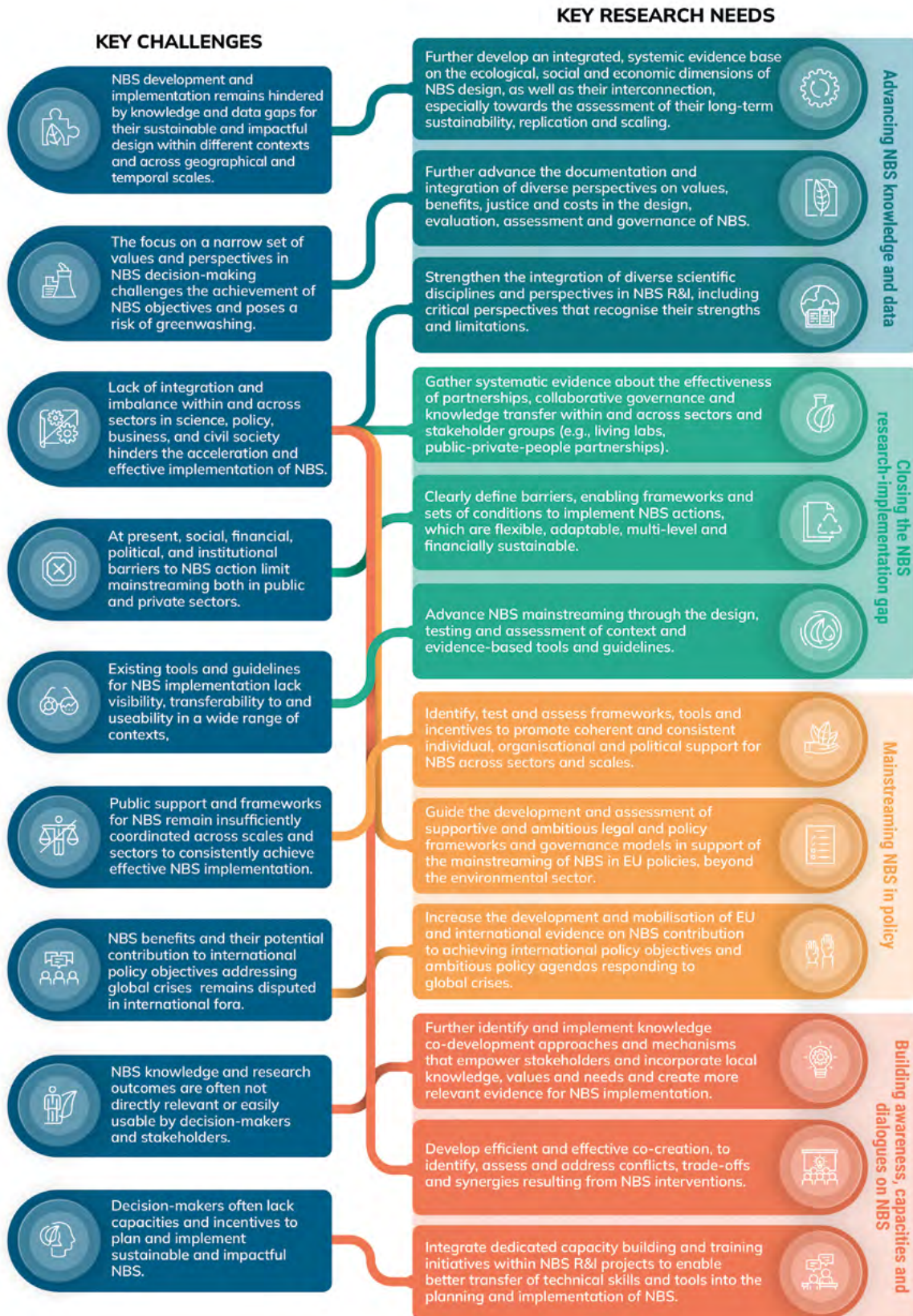




**Figure 1: Approach of the EU Roadmap to 2030 for R&I on NBS**

Figure 1 presents an overview of the four strategic action areas of the roadmap. It shows the interdependence between the different areas for addressing challenges in the design and implementation of NBS and highlights the co-development of robust transdisciplinary knowledge as a foundation for the successful and inclusive development and implementation of NBS.

The roadmap outlines key challenges and knowledge needs in each action area for R&I to support the successful and inclusive development and implementation of NBS. These challenges and messages are briefly summarised below (Figure 2) and presented further in the full sections of the roadmap, including key levers behind these action areas, and corresponding knowledge, implementation, and capacity needs.



**Figure 2 – Highlight of key challenges and action areas for R&I to support the successful and inclusive development and implementation of NBS**



# Introduction

This European Research & Innovation Roadmap to 2030 on Nature-based Solutions (NBS) aims to identify core Research & Innovation (R&I) activities that are essential to achieve EU goals for NBS development and deployment. It provides an overview of knowledge needs and knowledge implementation gaps, and helps facilitate synergies and complementarities between the past, on-going, and forthcoming activities and support of European R&I on NBS.

This roadmap was co-developed with multiple researchers and stakeholders, contributing to identifying and organising the action areas. It also builds on the first NBS R&I roadmap (2017)<sup>1</sup> as well as the R&I work performed by EU-funded NBS projects. This new roadmap is organised around four main action areas for R&I to support the further development and implementation of NBS in Europe.

- 5. Advancing NBS knowledge and data on NBS
- 6. Closing the NBS research-implementation gap
- 7. Mainstreaming NBS in policy
- 8. Building awareness, capacities, and dialogues on NBS

## What are NBS?

The term nature-based solutions (NBS) emerged in the late 2000s as a new concept to address and mitigate societal, economic, and ecological challenges simultaneously. This conceptualisation was initiated by the World Bank and supported by the International Union for Conservation of Nature (IUCN) and by the European Commission (EC)<sup>2</sup>. Nature-based solutions are defined by the EC as solutions that are “*inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient, and systemic interventions. Nature-based solutions must therefore benefit biodiversity and support the delivery of a range of ecosystem services.*” More so, in March 2022, the Fifth Session of the United Nations Environment Assembly (UNEA-5.2) adopted a resolution on NBS (UNEA/EA.5/Res.5), which included a multilaterally agreed definition of NBS recognising the important role these play in the global response



to climate change and its social, economic, and environmental effects. Under the resolution, NBS are defined as ‘actions to protect, conserve, restore, sustainably use, and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic, and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits. This definition is currently used by UN conventions such as the CBD and UNFCCC.’ The EC definition is aligned with the UNEA definition, as each highlight the critical importance of NBS in providing human well-being, ecosystem service and biodiversity benefits<sup>3-5</sup>.

The concept of NBS draws from a variety of previously conceptualised approaches including, for example, Green Infrastructure, Ecosystem-based approaches or ecological engineering<sup>6,7</sup>. Conceptually, NBS differ due to the importance of transdisciplinary and holistic approaches in their design and implementation as well as its objectives to tackle multiple challenges at the same time.

## Wider socio-political context

Since its emergence, the NBS concept, components and aims evolved quickly, as NBS were increasingly explored and implemented for different purposes, such as climate mitigation and adaptation, urban resilience, or disaster risk reduction (Cassin & Matthews 2021) and examined as a response to the emergence of new environmental and social challenges such as Covid-19 (Davies *et al.* 2021). This growth in the use of and research around NBS has occurred in parallel with an increased reference to NBS by political bodies, as well as in policy instruments<sup>8</sup>. For example, the rate of growth in relevant publications has increased considerably over the last five years<sup>9</sup>.

In Europe, policymakers have integrated NBS into the new European Green Deal and its associated Biodiversity Strategy to 2030, and the Climate Adaptation strategy as an innovative approach to support achievement of multiple goals. NBS are also integrated within the EC Framework Programme for Research and Innovation, Horizon 2020, and Horizon Europe. It is important to state that while NBS are increasingly mainstreamed in environmental and research policy, recognition of NBS co-benefits and uptake of the concept appears significantly lower in other policy fields.

Nature-based solutions have also gathered interest from international bodies, technical international organisations (e.g., The Organisation for Economic Co-operation and Development, OECD), United Nations science-policy fora (e.g., the Intergovernmental Panel on Climate Change, IPCC), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), but also directly from UN institutions and conventions. At the end of 2022, at COP27 in Sharm el-Sheikh and COP15 in Montreal, the term “Nature-based

solution” has been included in both the Sharm el-Sheikh Implementation Plan and in the Kunming-Montreal Global Biodiversity Framework where NBS are seen to minimise the impact of climate change on biodiversity and to restore, maintain and enhance nature’s contributions to people (GBF Targets 8, 11). NBS were also mentioned during RAMSAR COP14, and a resolution was adopted to recognize wetlands’ potential as nature-based solutions for climate mitigation and adaptation.

Lastly, NBS are being increasingly used or referenced in the private sector, by specialised actors such as consulting firms in sustainable development, climate resilience or biodiversity, ecological engineering, financial institutions and landscape and architecture firms, as well as by larger or multinational companies. Research has further identified the importance of ‘nature-based enterprises’ to respond to the increasing demand for NBS from the public and private sectors<sup>10</sup>.

Despite an increasing attention to and use of NBS, the concept has limits and still faces criticism, often related to potential risks of greenwashing or to the unequal distribution of NBS benefits<sup>11</sup>. For example, it has been shown that superficially planned NBS can increase housing and land costs and displace vulnerable groups<sup>12</sup> or result in ecological injustice<sup>13–15</sup>. Also, there is no consensus yet on the transformational capacity of NBS. Some studies find that NBS provide incremental changes to adapt to climate change such as in urban spaces<sup>16</sup> while others identify transformative changes linked to the implementation of NBS, building on stakeholder empowerment, knowledge, diverse values of nature and several governance and management mechanisms<sup>17</sup>.

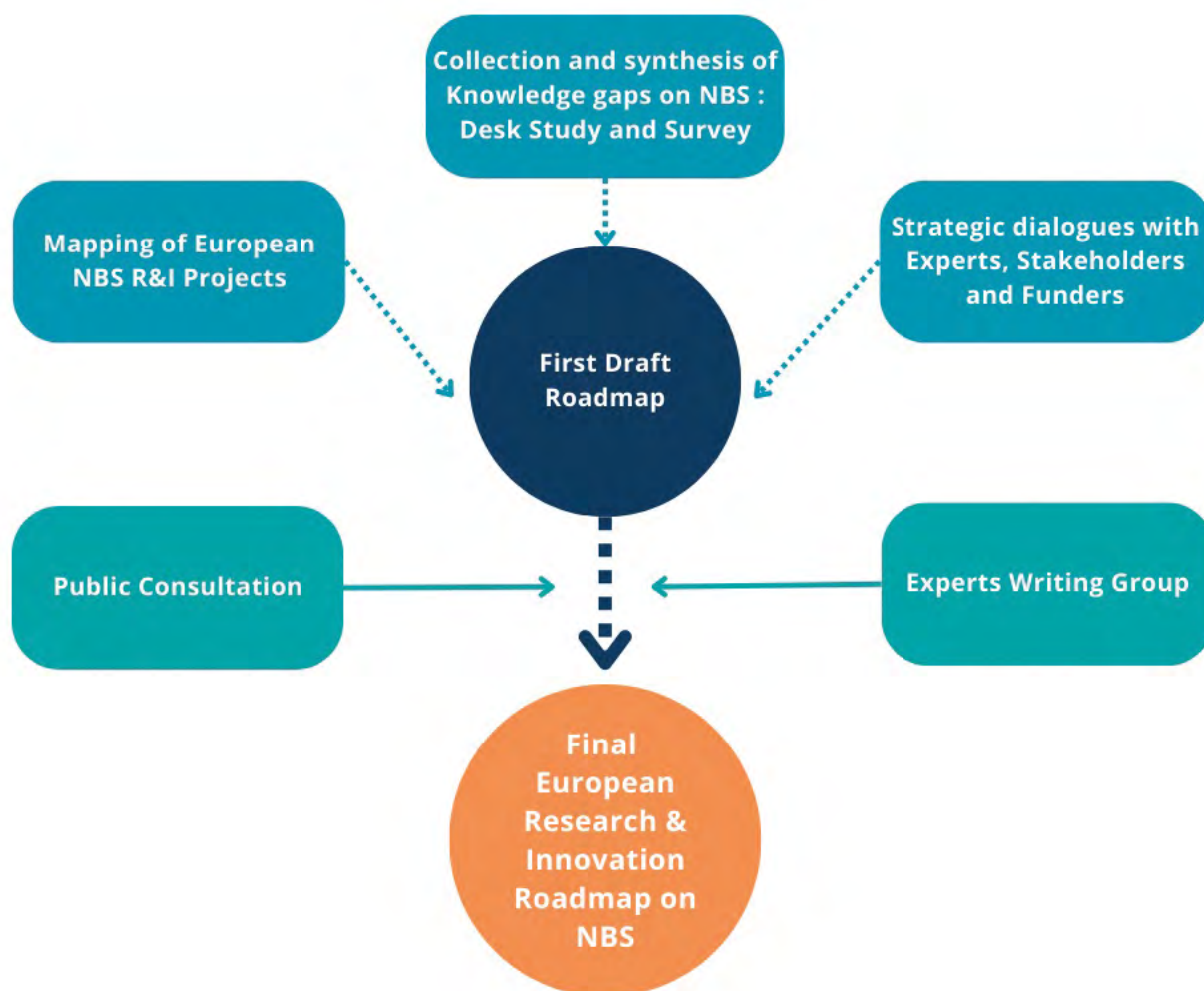
## Supporting R&I on NBS

Nature-based solutions are designed and implemented for and by a variety of actors, in a variety of contexts and through a variety of approaches. NBS are also strongly linked to other sustainability concepts such as nature-based or nature-positive economy<sup>18</sup>. The multiple objectives, impacts and stakeholders of NBS necessarily call for concerted and collaborative design and implementation of interventions in any given context.

Furthermore, as NBS are expected to support the implementation of major EU policies such as the EU Green Deal, it is extremely timely to better coordinate knowledge development and implementation in support of decision-making, and gather European efforts around a common vision and objectives.

# Methodological approach

The European Roadmap on Research and Innovation on NBS was developed as part of NetworkNature and draws on the results of several streams of work (Figure 3). Each stream's methodologies are described in detail in [Annex 1](#).



**Figure 3: Process towards the development of the European Roadmap for R&I on NBS**

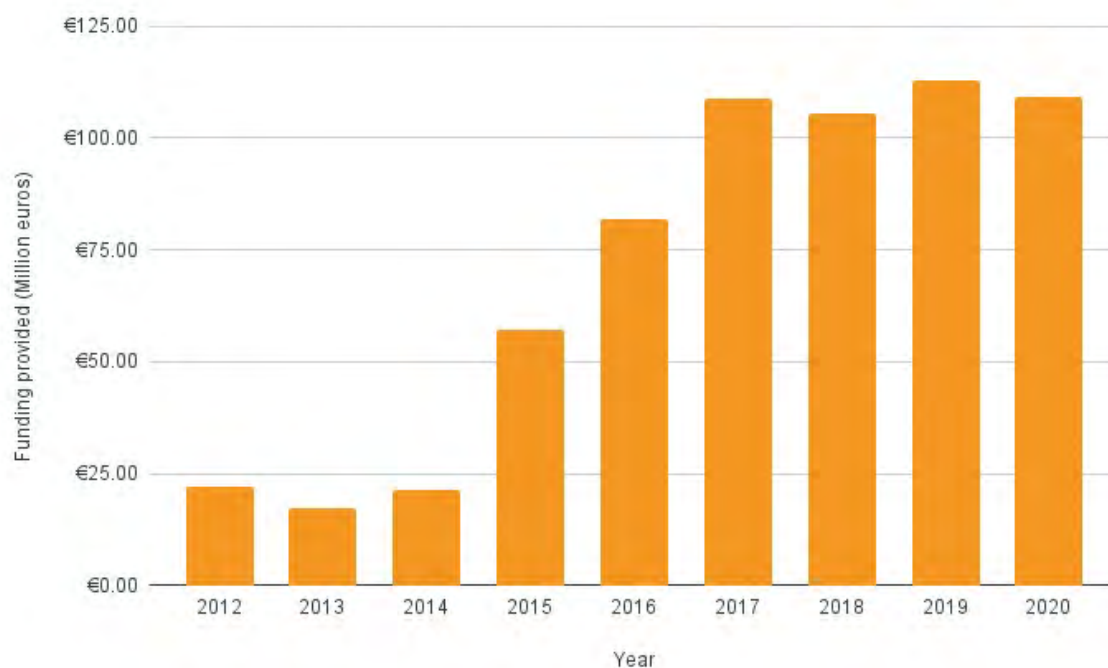
# Taking stock

## 1. Mapping of EU R&I and Implementation projects landscape

Mapping and analysing the current European research, innovation, and implementation landscape of projects on NBS is essential to build the evidence base on NBS by taking stock of what, where and when NBS have been studied and implemented in Europe. As such it is an essential tool to profile EU support of R&I and implementation on NBS and help programme future efforts.

The analysis of the data on funding allocation from the EU NBS Project Database (H2020, FP7, LIFE, BiodivERsA and Interreg) revealed an increase

in funding for NBS projects from 2011 to 2017 in the considered European programmes, increasing from fewer than 25 to more than 100 million euros per year (Figure 4). From 2017 to 2020, NBS project funding through European programmes stabilised at just above 100M euros per year. The same trends can be observed for the number of projects funded per year, with the number of projects tripling in 6 years from 2011 to 2017, then remaining steady at about 30 projects funded per year between 2017 and 2020.



**Figure 4 Funding in million euros of NBS Projects per Year, rolling 3-year average**

The database of projects was categorised using multiple typologies as described in the methodology ([Annex 1](#)). The main findings resulting from this analysis are presented here and detailed figures are available in [Annex 2](#):

- The most studied NBS type in the database of NBS R&I and Implementation projects is Type 2 (solutions based on developing sustainable management protocols and procedures for managed or restored ecosystems), with nearly 50% of all projects focused on these. Type 3 NBS (solutions that involve creating new ecosystems) accounted for 30% of those described in the database of NBS R&I projects, followed by Type 1 (solutions that involve making better use of existing natural or protected ecosystems) NBS, which accounted for less than 10% of the projects.
- The Societal Challenge (SC) most studied is Climate Resilience (27% of project), followed by New Economic Opportunities and Green Jobs (16%), Natural and Climate Hazard (16%) and Food Security (15%).

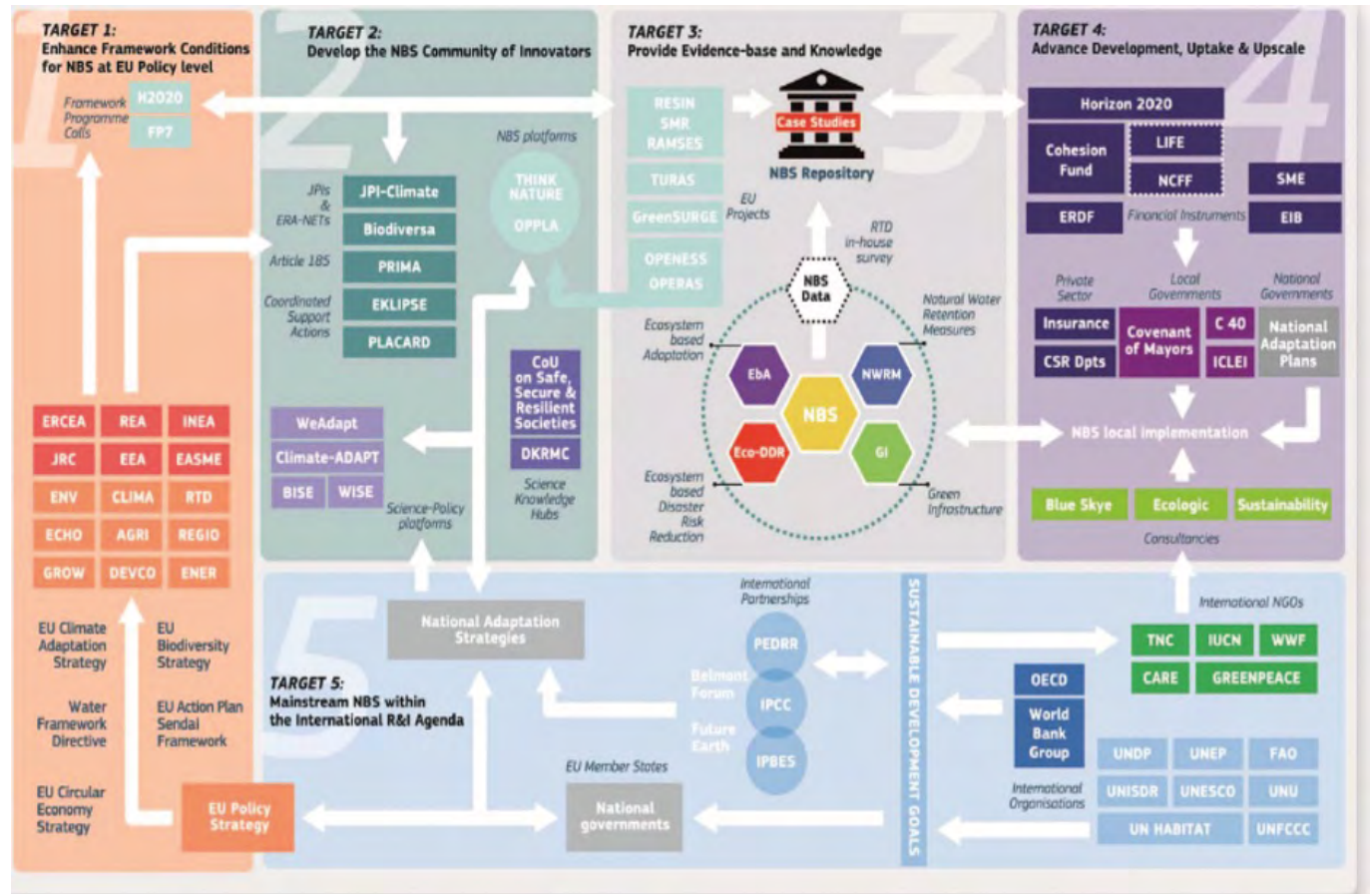
- *Ecosystem-based management approaches* are the most studied, with 31% of all projects relating to these, and the most applied physical interventions being Ecological Restoration, and Green Infrastructure representing 20% and 18% of all projects, respectively.
- Urban Ecosystem and Cropland were the most represented ecosystem types in our database, and focus areas for respectively 23% and 18% of all projects, followed by Coastal, shelf and open ocean, and Forest environments, representing 16.5% and 13% of the projects, respectively.

This mapping focuses on four major EU funding programmes and as such is not exhaustive, since analysing all EU programmes was not possible with available resources. Nonetheless, implementing a similar mapping of NBS projects in other EU programmes (e.g., European Maritime, Fisheries and Aquaculture Fund (EMFAF) or the European agricultural fund for rural development) could certainly help gain clarity on the EU landscape of research, innovation, and implementation projects on NBS.





## 2. Overview of progress on the EU's 2017 research policy goals on NBS



**Figure 5: Mapping of the targets of the Research & Innovation agenda for Nature-Based Solutions from (Favre et al. (2017) - [Read the full article here](#))**

In 2016, the EC developed a policy roadmap for R&I on NBS around five policy goals, intending to further develop knowledge and uptake of NBS by pursuing dialogues and initiatives. This section provides an overview of several major advancements that took place since the launch of these five objectives in 2017.



## 1. Enhancing framework conditions – EU policies

Since 2016, the framework conditions for NBS at the EU policy level have been enhanced in different areas, some key ones being:

### ● The European Green Deal:

The European Green Deal is a comprehensive policy framework and roadmap launched by the EC in 2019, to make the EU's economy sustainable and climate-neutral by 2050. Nature-based solutions are recognized as a key component in achieving its goals and are integrated into the European Biodiversity Strategy for 2030, the EU Forest Strategy, the EU Soil Strategy, the EU's Strategy on Heating and Cooling, the Zero Pollution Action Plan for Air, Water, Soil, and the revised EU Sustainable Blue Economy. Moreover, the Green Infrastructure Strategy and the Urban Greening Plans will foster the implementation of NBS in cities. Also, the EU strategy on adaptation to climate change (2021), clearly identifies NBS for adaptation as one of the main cross-cutting priorities towards the further development and implementation of adaptation strategies and plans at all levels of governance and toward more systemic adaptation.

### ● The EU Missions

The EU Missions, via specific targets, are also investing in R&I towards better implementation and uptake of NBS. Four Missions are of particular interest with respect to NBS:

- ◇ Adaptation to Climate Change: support at least 150 European regions and communities to become climate resilient by 2030,
- ◇ Restore our Ocean and Waters by 2030,
- ◇ 100 Climate-Neutral and Smart Cities by 2030,
- ◇ A Soil Deal for Europe.

### ● The Water Framework Directive, Floods Directive and Marine Strategy Framework Directive

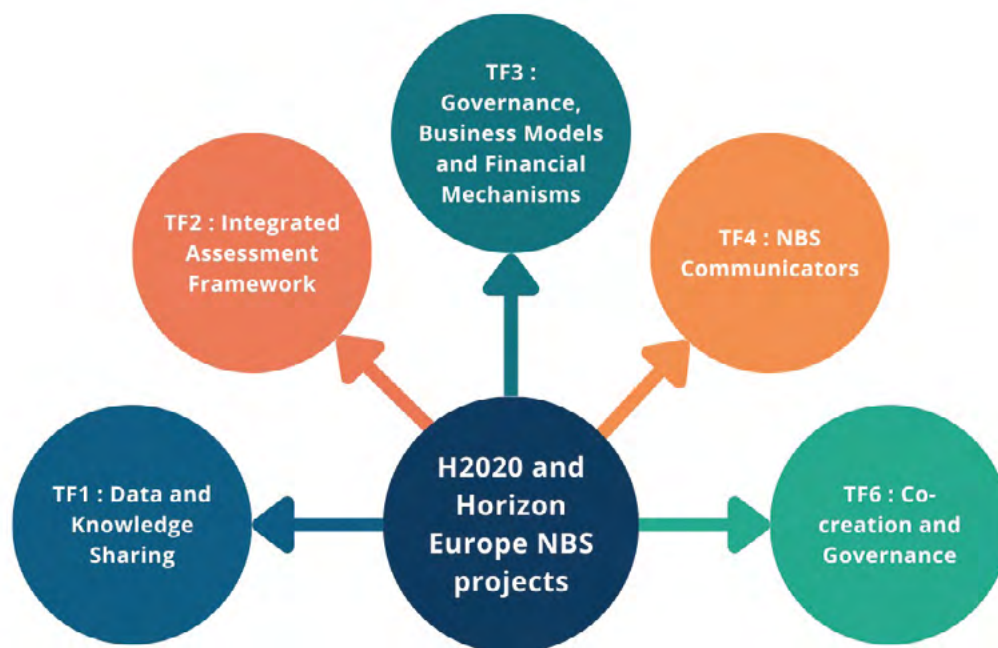
The Fitness Check of the Water Framework Directive and the Floods Directive put forward the need for better implementation of the objectives of these Directives (towards full compliance by 2027) that could be based on “best practices on green infrastructure and cost reduction of pollutants at sources”. This implies that NBS could play a significant role in improving the implementation of the Water Framework Directive and the Floods Directive.



## 2. Develop a community of innovators

The EC supported the development, diversification and expansion of a Community on NBS through specific NBS calls in Horizon 2020 and Horizon Europe, which resulted in funding 46 Horizon 2020 and Horizon Europe projects in 2022<sup>19</sup>. This Community on NBS has been built on the heritage of the FP7 Programme that, while not explicitly addressing NBS, generated a wealth of relevant knowledge and expertise in green infrastructure (GI), ecosystem services, and the multiple benefits of ecosystem-based approaches used to address societal challenges<sup>8</sup>.

Within this cohort of NBS projects funded under Horizon 2020 (including the 1 billion euro European Green Deal call) and Horizon Europe, the NBS Cluster Task Forces were created to gather and synthesise the broad range of approaches and outputs of all these NBS projects within specific (common) topic areas. The objective of the Task Force initiative is to maximise the ecological, social and innovation impacts of these EU-funded projects whilst creating added value and ensuring the policy relevance of project outcomes. Five Task Forces<sup>1</sup> (TFs) are currently in place to tackle a large variety of subjects with each of them having dedicated topical work streams (Figure 6).



**Figure 6: Diagram of the EU NBS Cluster Task Forces**

1. A TFs 5 used to exist on NBS for Hydro-meteorological Risk Reduction but was later integrated to the other TFs

## The EU NBS Task Forces (TF) work to build the evidence base and to address knowledge gaps and needs

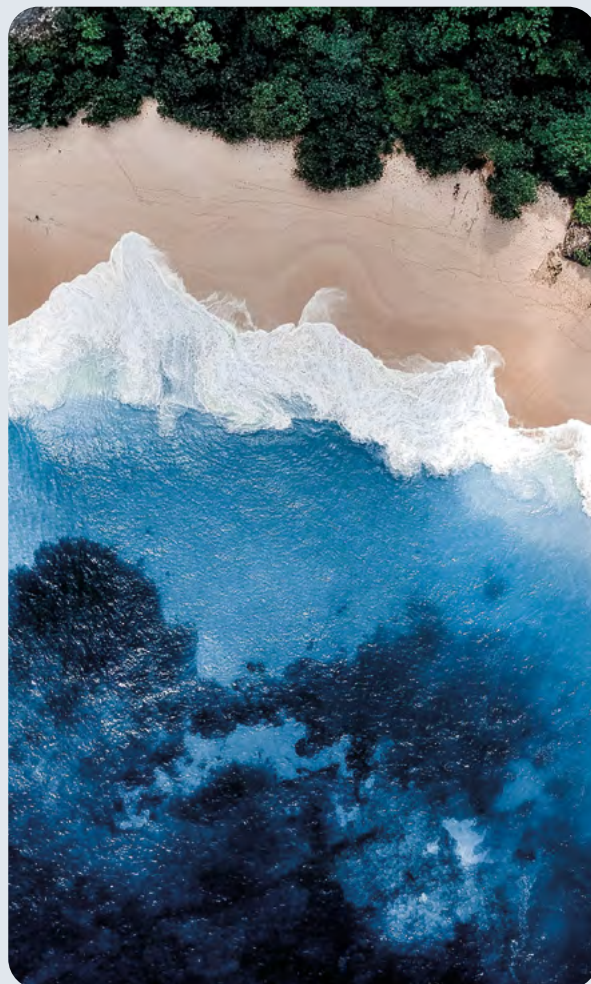
A central objective of the Task Forces is to increase the projects' impact on policy and practice and help develop coordinated approaches to major NBS knowledge and implementation gaps.

In **TF1**, an NBS knowledge repository is being created to allow users and third-party applications to search and retrieve NBS case studies. This work is key to address knowledge and data gaps, by defining and implementing an effective approach to share, search and reuse data and knowledge related to NBS.

**TF2** produced a holistic framework and associated indicators to establish NBS monitoring and assessment schemes, and evaluate the multiple benefits but also trade-offs associated with NBS actions. This collaborative effort among 17 EU funded projects and associated European programmes resulted in the publication of a handbook for practitioners on evaluating NBS impacts<sup>20</sup>, a collaborative effort among 17 EU funded projects and associated European programmes. This handbook details over 400 possible indicators of NBS performance and impact across 12 challenge areas. An associated Appendix of methods<sup>21</sup> provides a detailed description of each method of NBS impact evaluation, as well as guidance on selecting indicators, and related advantages and drawbacks in different contexts.

**TF3** focusses on concrete support and acceleration for private sector uptake and investment in NBS, notably with the development of an NBS public procurement guide<sup>22</sup> and an analysis of the role of nature-based solutions in a nature-positive economy<sup>18</sup>

Addressing knowledge needs and gaps is also tackled in **TF4** and **TF6** also play key roles in helping to address knowledge and knowledge implementation gaps, by increasing the visibility of NBS as well as strengthening co-creation processes for NBS that better involve citizens and stakeholders setting objectives, and then designing, implementing, and monitoring NBS interventions. This includes setting up more sustainable co-governance structures.



### 3. Create and consolidate evidence base

Through Horizon 2020, Horizon Europe and the EU Missions, the EC addressed a wide range of NBS themes within its Work Programmes, in several calls under Cluster 6 and the EU Missions on Adaptation to Climate Change, on Restoration of Ocean and Waters and on Climate neutral and smart Cities under the 2021-2022 Work programme.

The EC also supported the development of platforms, databases and networks (e.g., ThinkNature, NetworkNature and NetworkNature+, the EU Business@Biodiversity Platform, the [Urban Greening Platform](#) and Connecting Nature's Enterprise Platform, and an EU knowledge repository on NBS (Oppla) for understanding NBS benefits and pro-

moting knowledge exchange, e.g. through the BiodivClim knowledge hub on NBS for climate change adaptation and mitigation led by Biodiversa+.

Lastly, an analysis of the outputs of EU R&I on NBS was made by scanning for project results pertaining to key areas (e.g. climate change mitigation, biodiversity, flood mitigation and coastal resilience), to gather the state of the art in EU-funded NBS project areas<sup>8</sup>. The resulting evidence base was used to show the relative cost-effectiveness of NBS, explore how they support policy implementation and highlight policy recommendations and knowledge gaps<sup>8</sup>.

### 4. Advancing the development, uptake, and upscaling of innovative NBS

Significant efforts towards the uptake and upscaling of NBS were driven by the EC through the NBS project portfolio, by analysing case studies and implementing best practices in diverse contexts. This effort has been supported by the work of the EU NBS Task Force, and also by the [NBS Regional Hubs](#). These hubs bring together researchers, policy-makers, businesses, and the public sector to create long-lasting structures for NBS uptake, fos-

ter capacity building and knowledge exchange, and address local specificities of barriers and opportunities for NBS. Lastly, an upcoming study led by the European Investment Bank analyses access-to-finance conditions for innovative NBS, uncovering current market failures, barriers, and bottlenecks, and sets out to derive financial investment profiles for different types of NBS.

### 5. Mainstreaming NBS internationally

The EC has taken several actions that helped mainstream NBS internationally<sup>23</sup>, such as:

- A specific H2020 on “*Strengthening international cooperation on sustainable urbanisation: nature-based solutions for restoration and rehabilitation of urban ecosystems*”, under which four selected projects focus on collaboration with China (CLEARING HOUSE and REGREEN projects) and the Community of Latin American and Caribbean States (CONEXUS and INTERLACE projects).
- *Sector Dialogues on NBS* were organised between Europe and Brazil to link up major Brazilian NBS with European experts and EU-funded R&I projects<sup>23</sup>. As a result, a catalogue of NBS within the Brazilian context is under development, with contributions from EU-funded NBS Projects (e.g., CONEXUS, Connecting Nature), and the EU-CELAC strategic roadmap made explicit references to addressing NBS focus in the region. Work is further on-going

under an EU-LAC Policy Dialogue Support Facility, which will produce a baseline study on NBS and relevant policies and developments in LAC and the EU, and a bi-regional conference on NBS (both planned for 2023).

- European projects also contributed to mainstreaming NBS internationally. For example, UrbanByNature, a collaboration between EU-funded projects, but also Connecting Nature and CLEVER Cities, promote exchange among cities, researchers, SMEs, and NGOs to build bridges with the Nature-Based Solutions communities across Europe, Asia, Latin America, and other interested regions.

All those initiatives and more are instrumental in the growing recognition of NBS on the international stage, resulting in significant traction of the term in the UNFCCC and the CBD, but also by the IPCC and IPBES, although it still meets reluctance among some governments.



# Roadmap to 2030

The European Research and Innovation Roadmap for Nature-based solutions is organised around 4 strategic actions areas for transdisciplinary research:

1. Advancing NBS knowledge and data on NBS
2. Closing the NBS research-implementation gap
3. Mainstreaming NBS in policy
4. Building awareness, capacities, and dialogues on NBS

Together they identify and organise key elements for the effective development and implementation of knowledge on NBS, and the role of research and innovation in promoting the wider uptake and sustainable deployment of NBS. The section below details more precisely each lever and highlights key knowledge gaps for European R&I on NBS.

## Action area 1 – Advancing NBS Knowledge and Data

### 1a. Advancing knowledge for sustainable and effective NBS design and implementation

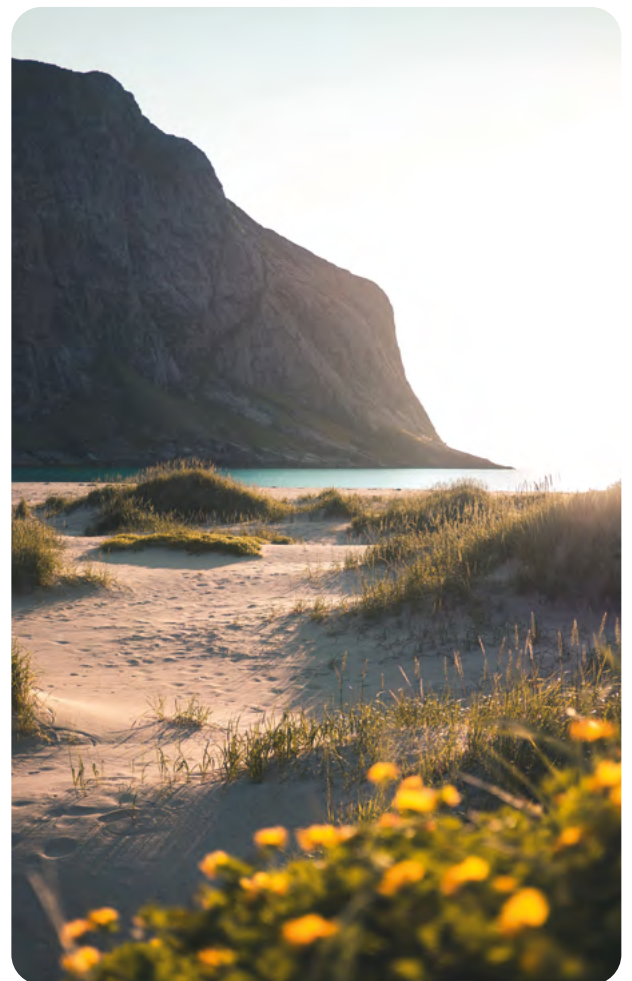
Identifying and understanding the factors underlying NBS performance and sustainability is key to their successful design and implementation. Thematic areas requiring the development of further research and innovation are numerous and questions can be overarching, sometimes environment or context-specific. Yet key structural aspects seem to be the object of a broad consensus, including:

- **Links between biodiversity, ecosystems functioning and the delivery of ecosystem services that enable life on Earth which underpin the effectiveness of NBS actions** are widely recognised as a key area for strategic development<sup>24</sup>. An improved understanding of cascading impacts of extreme events and slow onset changes, and the feedback among ecological integrity (“ecosystem conditions”), biodiversity and ecosystem services delivery at multiple scales and in different biogeographic regions is essential to plan effective NBS actions. There is an urgent need to address the present lack of mechanistic and long-term knowledge regarding the relationships between biological diversity, ecosystem functioning, ecosystem services delivery and societal processes in the face of changing conditions, in order to “future proof” NBS actions<sup>5,25–27</sup>.
- **Identifying and understanding trade-offs between the desired economic, social and environmental objectives of NBS**<sup>8,24,28,29</sup> as well as between benefits for different stakeholder groups<sup>30</sup> would enable a more strategic approach to NBS design and implementation and an improved understanding, management

and evaluation of the multiple impacts of NBS<sup>31,32</sup>.

- **Recognising the diverse values and understandings of nature in NBS design, implementation and assessment** is crucial for more inclusive, equitable and just biodiversity conservation and decision-making<sup>5,33</sup>. There are significant knowledge gaps as to how different worldviews, knowledge systems, and broad and specific values, shape, and influence NBS design, planning and implementation in different decision-making contexts. This includes taking account of the many ways that values can be compared, combined, or used by different groups in parallel. Comparative research on the contribution of different method families (e.g., ‘nature-based’, ‘behaviour-based’, ‘statement-based’ and ‘integrated’ methods) to NBS assessment could significantly guide NBS policy and decision-making<sup>34</sup>.
- **The effective design, performance, and sustainability of NBS over different scales of space and time** is an area with significant margins for improvement:
  - ◇ Planning NBS across geographical scales, from local/small-scale NBS to embedding NBS within landscape, regional or national management plans, either individually or as networks, as well as understanding NBS interdependence and performance at these different scales, remain pressing questions underpinning challenges for replication and upscaling of NBS<sup>8,9,35</sup>.

- ◇ The sustainability of NBS and their performance over time and in the face of global change is also an area of significant unknowns, both in terms of the long-term delivery of benefits by NBS<sup>8,29,36</sup> as well as the costs of NBS over time<sup>18,37,38</sup>. The resilience of biodiversity, ecosystem functions and implemented NBS actions to slow on-set events or pressures such as climate change, land-use change or invasions by non-native species is an area in need of further investigation<sup>5,8,18,30,32,36,39</sup>.
- ◇ Understanding and planning NBS across different socio-ecological contexts, including traditional rural systems, is also an area for improvement of knowledge, whether it be analysing more systematically varying contexts when looking at NBS performance<sup>5</sup>, or exploring different solutions for different contexts, including what NBS are suited for, ranging from e.g., dense urban environments to rural environments used for pastoralism and agriculture<sup>8,38</sup>.
- **Advancing systemic understanding of and approaches to NBS development and implementation** is also referred to in identified gaps and entails:
  - ◇ Developing easy-to-apply and established methods and tools for systematic evaluation of NBS, such as frameworks for identifying, selecting and designing NBS and conducting cost-benefits analyses<sup>5,31</sup>, systematic comparisons of different processes of design and implementation<sup>29</sup> as well as the adoption of standardised indicators for crosscutting measurement of NBS socio-ecological performance<sup>5,18,30,32,38,40</sup>.
  - ◇ Further developing systematic processes and approaches to engage and empower diverse stakeholders and institutions in NBS creation and implementation. Such processes need to address issues of NBS acceptance and environmental justice<sup>41</sup> and pay attention to the tensions associated with biodiversity conservation through NBS<sup>42</sup>. Expert consultations also raised further examples such as the co-development of pathways for NBS implementation across scales with the modelling community, or developing specific governance approaches to, e.g., protected and productive areas, or supporting the identification of investment needs and pathways<sup>43</sup> and better characterisation of NBS markets<sup>18</sup>.
  - ◇ Identifying and synthesising knowledge on the approaches and governance systems that can reinforce innovation with and the deployment of NBS, enable institutional cooperation and allow to include NBS in planning and policy frameworks<sup>24,44</sup>. Expert feedback suggests in particular a need for synthesis and systematisation of existing knowledge to generate adaptive governance and financing strategies, alongside a recognised need for business models and financial mechanisms to support NBS implementation without generating negative socio-economic impacts<sup>8</sup>. This aspect is further highlighted by stakeholders consulted, who experience deep institutional, legal, economic, and governance barriers to implementing NBS at scale and see a strong avenue for science on how to overcome these barriers.





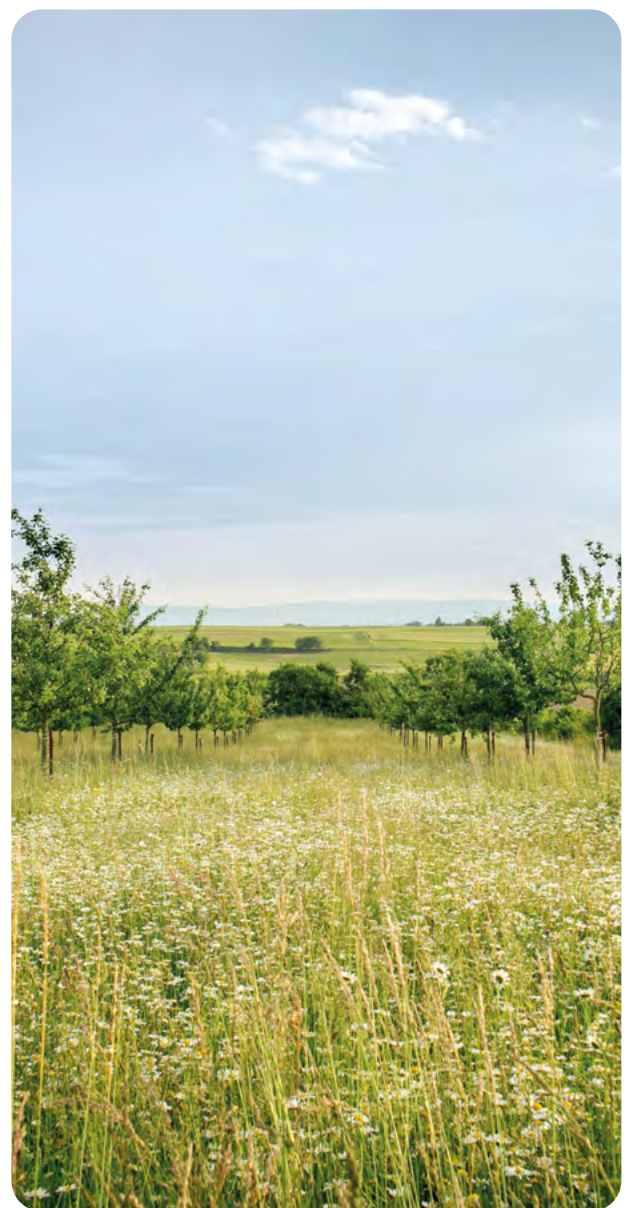
- **Studying the role of NBS in systemic change and transition processes**, including social and environmental justice dimensions of NBS design and implementation. The potential of NBS in contributing to transformative change<sup>17</sup> appears promising. However, whether, how and to what extent NBS engage with diverse values, worldviews and knowledge systems,

community engagement processes, and environmental management practices needs to be more demonstrated<sup>45</sup>. The deployment of NBS at local and regional scales also raises questions in terms of assessing who can access NBS benefits and how to avoid reinforcing existing or creating new inequalities and social injustice, e.g., through gentrification<sup>8,28,38</sup>.

## 1b. Improved evidence-base on NBS effectiveness

The need for data and evidence on NBS is clearly identified as hampering their wider-scale implementation and goes hand in hand with many aspects of advancing knowledge on NBS. The main gaps for better documentation of NBS relate to:

- **Gathering data**, such as integral, structural and comparable data, long-term data on biodiversity feedback and trade-offs between ecosystem services<sup>25-27</sup>, data on ecosystem services at different scales<sup>44</sup> and data on the effectiveness and multiple impacts of NBS, especially in the context of climate change adaptation and disaster risk reduction<sup>32</sup>.
- **Addressing the needs for systemic and comparable analyses and evaluations of NBS**, and underlying monitoring needs, which are often linked to assessing NBS design and performance. This entails an improved documentation of ecosystem functions and services, such as carbon sequestration and storage<sup>8</sup> or services provided by woodlands<sup>45</sup> and also comparing NBS to hybrid and conventional “grey” solutions<sup>4,8,32,36,38</sup>. In this respect, efforts under development towards the set-up of the Knowledge Centre for Biodiversity<sup>2</sup> and related a Science Service<sup>3</sup> appear essential, noting the latter will test demonstration cases on the topic NBS. This lever also relates to monitoring needs, such as enabling long-term monitoring and evaluation of ecosystem performance and functioning<sup>9,44</sup>, as well as monitoring synergies and trade-offs between NBS impacts, different policy objectives and different stakeholder interests<sup>29-31</sup>. There is presently a dearth of knowledge concerning NBS performance and



2. See [https://knowledge4policy.ec.europa.eu/biodiversity\\_en](https://knowledge4policy.ec.europa.eu/biodiversity_en)

3. See demonstration case topics selected in BioAgora project developing the Science Service for Biodiversity (<https://bioagora.eu/science-service-for-biodiversity/>)

impact at multiple scales, in the long term, and across different biogeographic regions. R&I can help simplify NBS planning and design processes and ensure the effectiveness of implemented NBS actions through standardised monitoring and evaluation processes, and by sharing data openly to enable meta-analyses of the effectiveness of individual NBS types or different NBS systems under a range of different conditions. In this respect, key efforts being developed for data integration and monitoring harmonization, such as the co-development of transnational monitoring schemes for Europe<sup>4</sup>.

- **Implementing more relational approaches to NBS assessment and integration** to help design and implement NBS in ways that align with and promote diverse human-nature relationships, and address critiques that NBS are only grounded in market-based logics of performance, cost-effectiveness, and pursuit of unsustainable economic growth, which are associated with the destruction of biodiversity

globally<sup>46</sup>. Similarly, previous studies suggest that NBS are often embedded asymmetrically in urban environments, more often guided by social exclusion, neoliberal governance and growth ideologies<sup>41,47</sup>. To move beyond these logics and foster biodiversity conservation, R&I can document new relational approaches to NBS assessment that take account of different ways that people live from, live with, live in and/or live as nature<sup>27,34,48</sup>, enabling identification of how NBS can be designed and implemented in ways that align with and promote these diverse human-nature relationships. This includes improved consideration of relational values and worldviews, and indigenous and local knowledge perspectives on human-nature relationships which often assume no separation between humans and the benefits one receives from nature<sup>49</sup>.

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4. See <https://www.biodiversa.eu/engagement/key-collaborations/key-collaboration-with-europabon/>



## 1c. Further developing non-monetary and monetary valuation of NBS benefits and cost

Non-monetary and monetary valuations of NBS benefits and cost are largely recognised as a key lever where R&I can support NBS deployment. This relates to:

- **Undertaking research on economic and non-economic costs and benefits of NBS performance**, including social, economic and environmental costs and benefits, and also considering their valuation across time and space<sup>5,24,32,36,50</sup>. The need for better inclusion of multiple costs and benefits, but also trade-offs and disservices in these analyses, is largely highlighted<sup>9,31,51</sup>. These are related, for example, to the creation of jobs or growth<sup>3,18</sup> or to human health and well-being<sup>29,38,52</sup>, and tied with the need for more comprehensive and large-scale evaluation of the cost-effectiveness of NBS<sup>8</sup>. As such this lever closely relates to the operational implementation and evaluation of NBS for practice and policy, described in subsequent pillars.
- **Further developing methods, tools and skills for a clear appraisal of economic costs and benefits of NBS**, e.g., related to natural capital accounting and financing of NBS, is key for the development of attractive business models and cases<sup>18,30</sup>, and advancing the methodologies and tools for systematic evaluation of benefits and co-benefits<sup>8</sup>. More research is also needed to differentiate between financing, governance and business models at different scales of financing<sup>53</sup>. Closely linked to the implementation and capacity building, stakeholder feedback shows that while numerous valuation methods per se exist, a significant challenge remains in capacities and skills required for, e.g., regions or municipalities to consistently evaluate the impacts of NBS, alongside with their communication to the public. Moreover,

more research is needed into the transaction costs for NBS planning and implementation, which sometimes appear to be higher than for traditional engineering projects, because there is a broader set of stakeholders and government agencies that must coordinate on NBS projects. These transaction costs must be factored into any appraisal of the economic costs and benefits of NBS. A clear appraisal is needed to operationalise NBS in business and developing investment capacities for NBS, and is recognised as a priority question by economic actors. As the World Economic Forum states, “*significant barriers are inhibiting their deployment at scale, in particular how investment is linked with inclusive economic benefit, project prioritisation for sustainable financing*”<sup>5</sup>.

- **Non-monetary and monetary valuation methods within the method families of ‘nature-based’, ‘behaviour-based’, ‘statement-based’ and ‘integrated’ methods** can help consider, beyond natural capital or inclusive wealth approaches, the potential for different types of values of nature and NBS in supporting transformative change towards just and sustainable futures<sup>34</sup>. R&I can help identify the ways in which NBS and the multiple values of nature can act as both leverage points and levers for transformative change<sup>54</sup> and opportunities for decision-makers to draw upon NBS and the multiple values of nature to enact change, including motivational, analytical, bridging, negotiation, social and governance<sup>34</sup>. This highlights a role for R&I in uncovering how different methods and institutional structures promote, impede, or exclude different value expressions in NBS design and implementation through norms, conventions, rules, and other systems of power.

5. [https://www.weforum.org/communities/gfc-on-nature-based-solutions?DAG=c1&gclid=CjwKCAjwv-GUBhAzEiwA-SUMm4vsGHHel5yXosKi3V\\_kILBJJSKdFXP1gYJGACXUw5ceOJteLfk\\_jMRoCEngQAvD\\_BwE](https://www.weforum.org/communities/gfc-on-nature-based-solutions?DAG=c1&gclid=CjwKCAjwv-GUBhAzEiwA-SUMm4vsGHHel5yXosKi3V_kILBJJSKdFXP1gYJGACXUw5ceOJteLfk_jMRoCEngQAvD_BwE) consulted on 16/05/23

## Action Area 2 – Closing the NBS research–implementation gap

### 2a. Better integrating research and demonstration

The further integration of excellent research with demonstration is identified as a general strategic lever for bridging the research–implementation gap, closely linked to the co-development and operationalisation of knowledge and the development of transdisciplinary dialogues. While research and demonstration projects yield significant impacts by testing concepts and building pathways to effectively reach out to end-users, some areas call for further attention, such as:

- **Identifying and supporting the enabling framework conditions or environments for stakeholder leadership and empowerment on NBS at an organisational level**, linked to supportive policies and regulatory frameworks, adequate financing mechanisms and building users ownership<sup>5,8,18,35,44</sup>, and as such closely linked to promoting transdisciplinary dialogues and awareness raising highlighted in subsequent pillars. Expert inputs also highlight needs for further R&I efforts in enabling business leadership on NBS, and in supporting the development of corporate social responsibility strategies concerning the design and implementation of NBS in business decision-making and operations at local, national, and transnational scales. Such efforts need to be further targeted to specific business sectors and decision-making contexts.
- **Developing innovative approaches to integrating research and demonstration** is called for in expert feedback. This can entail more coordinated/systematic approaches to demonstration activities, e.g., what would an ideal sampling pattern look like for demonstration projects, building toward a more strategic approach to the location and involvement of non-academic partners involved, or addressing issues in persistence of project outcomes over time, and exploring complementary approaches to the support and implementation of demonstration projects.

### 2b. Operationalising NBS in business contexts

As key actors of potential NBS design and implementation, the active and ongoing engagement of businesses across multiple sectors applicable to the topic of NBS is essential, and opportunities for R&I include:

- **Significantly improve the connection of the development of NBS evidence with business concerns (e.g. incoming requirements of businesses to disclose risks and dependencies on nature (TFND)), applications and also skills and expertise**, e.g., by understanding the value of nature as both an input and output in economic processes<sup>18</sup>, characterising business impacts and dependencies on nature, articulating business questions and actors in R&I early on, as well as ensuring feedback on needs toward R&I and mobilising knowledge and expertise from businesses to help operationalise NBS in these contexts.
- **Accompany and support the development of standard methods and guidance on NBS actions for their operationalisation in business**, which is widely recognised as an important lever for R&I to promote the uptake of NBS. This relates generally to developing the practical design and implementation of NBS at an operational level, e.g., on the need for adaptive management and governance, to refer more clearly to ecosystem complexity, temporal scales, effectiveness, and uncertainty<sup>3,43</sup>. This also includes developing further research on NBS business cases, including economic viability and long-term costs as well as value chains in different sectors, and is tied to the development of elements around the valuation of NBS<sup>8</sup> and of standard and practical methods for NBS integration in business models, such as natural capital accounting methods to enable the mainstreaming of NBS private financing<sup>8,18,38</sup>.

- **Build the capacity of the private sector to deliver NBS for the nature positive economy<sup>6</sup>.** As demand increases for NBS, publications have identified potential bottlenecks in their supply, exacerbated by shortages of skilled and experienced NBS suppliers in the private sector<sup>8</sup>. Research has clearly identified the potential of nature-positive economy to support the delivery of NBS, simultaneously delivering multiple economic benefits in terms of innovations, skills, jobs and enterprises<sup>10,18</sup>. While the potential of NBE to contribute to a just transition toward a more equitable nature positive society has been recognised in the EU and internationally, this area of research remains emergent<sup>56</sup>. Further theoretical and empirical studies are needed to better understand differentiating characteristics with other organisation types and between different sectors, geographical regions, and scales, including internal and external determinants of success and failure and limitations/potential of the concept in these contexts. Specifically, there are significant research needs on the fit between current innovation ecosystems, including early-stage financing and scaling mechanisms, with the needs of nature-based enterprises<sup>37</sup>.
- **Accelerating uptake of nature-based solutions in business.** The World Economic Forum estimates that more than half of the world's GDP – \$44 trillion – is at risk of disruption due to nature loss<sup>57</sup>. Despite such high evidence of dependency, recent benchmarking studies of global leading businesses show that while 50% have set targets to reduce greenhouse gas emissions, only 5% have carried out a science-based assessment looking at how their operations and business model impact and depend on nature and biodiversity (this is expected to change due to Target 15 of the GBF, which requires all large and transnational companies and financial institutions to assess and disclose their risks, impacts and dependencies on nature)<sup>7</sup>. Expert opinions collected in the development of this roadmap point to a key and underexplored role of research to understand the internal organisational and external environmental factors inhibiting business responsiveness to NBS and to support the piloting of new approaches to advance the uptake of the concept in business contexts.

6. Here we are defining nature positive economy under the 10th Core principle defined by the EU Business and Biodiversity Platform<sup>55</sup>.

7. World Benchmarking Alliance, 2021 Nature Benchmark: <https://www.worldbenchmarkingalliance.org/publication/nature/> - consulted 16/05/2023



## 2c. Developing and testing tools to help close the research-implementation gap.

Various sources identify knowledge-intensive tools needed to help bridge the gap between NBS research and implementation. These relate to:

- **Further developing guidance for NBS design and implementation, and tools to facilitate the inclusion of NBS in planning and policy frameworks**, for example using web-based decision support approaches<sup>9</sup>, combining real-time monitoring and control systems<sup>8</sup>, scenarios with NBS and grey infrastructure or different levels of implementation to help understand investment needs<sup>43</sup>, or at the metropolitan level with, e.g., user-friendly valuation tools for the evaluation of risk reduction<sup>8,44</sup> and guidance on measures to spur demand for NBS<sup>18</sup>. Such tools should reflect on the working realities of planners and decision-makers. Another focus should also be on expanding existing planning and design tools, which are already accepted and applied by, e.g., adding a component or module of NBS.
- **Identifying and promoting standards, including technical references, design standards and guidelines**, is called for in various contexts beyond business operationalisation highlighted previously, including for flood risk reduction and climate change adaptation<sup>8,32</sup>. References to standards not only relate to technical aspects, but also to developing indicators for cross-site comparisons<sup>32</sup>, as well as participatory approaches to translating and sharing lessons learned in principles and standards specifically<sup>24</sup>. Consultations in the development of this roadmap tend to support that standardisation of language and methods employed in NBS actions support the translation of research into practice. This specifically relates to the establishment of both a common language and technical methods among experts and practitioners from multiple disciplines and sectors, including NBS terminology, technical references, and design guidelines. Needs for technical guidance were particularly called for to enable the scaling up of NBS and the development of integrated systems of NBS at landscape or even larger scales.

- **Promotion and further development of dynamic resource platforms and knowledge sharing opportunities** on best practices, with a clear need for better accessibility of NBS resources and outcomes over time, but also better communication of existing evidence into policy and practice<sup>36</sup> and help to assess knowledge and better share information on NBS and related initiatives<sup>44</sup>.

While these appear to be important avenues to help closing the research-implementation gap, it should be noted that stakeholder consultations also highlighted the difficulty in handling the multiple standards and best practices already available, suggesting there is a challenge in tying these efforts with the need for systemic analyses mentioned previously. In addition, this aspect is also directly related to subsequent levers of the roadmap on developing capacities, so that guidance and best practices should capture the inherent variability in which NBS works best in each context in a way that is accessible and manageable for end-users.



## Action Area 3 – Mainstreaming the role of R&I in NBS policy

### 3a. Advancing policy implementation across EU sectors and scales

Advancing the policy implementation of NBS across scales and sectors is an area where R&I can provide significant support, to

- **Support better policy implementation of NBS from EU to local scales and integration in the EU regional policy.** Stakeholder inputs highlighted the impression that there is knowledge available on NBS applications at the EU level, particularly through EU demonstration projects and access to a significant number of experts. However, this knowledge is not necessarily found to be reaching the Member States, at different national and local levels of governance, and policies rarely contain quantitative and measurable targets relating to NBS deployment or quality<sup>58</sup>, which can present a barrier to their widespread implementation. Under this lever, R&I can be determinant in, e.g., the development of common grounds of prioritisation of biodiversity, ecosystem services and NBS at various administrative levels<sup>44</sup>, as well as provide science-based advice for the implementation and monitoring of binding and non-binding EU policy targets, e.g. in the EU Biodiversity Strategy to 2030<sup>8</sup>. An example would be providing evidence-based recommendations for assessing the potential and uptake of NBS in the upcoming national nature restoration plans or in the development and implementation of no net loss approaches addressing urban and rural biodiversity via the urban green plans<sup>8</sup>.
- **Assess and support the integration of NBS across sectors** by proposing further research on opportunities, limitations, and mechanisms for cross-policy collaboration leading to increased uptake of NBS across environmental, social, and economic policies, e.g. bioeconomy, circular and nature positive economy, forestry, climate, health, education or agricultural policies, but also toward nexus between policies<sup>18,30</sup>. Research can offer valuable guidance through e.g., cross-sector analyses of NBS incentives, or the development of science-based targets and governance frameworks for improved coherence across sector-specific policy objectives in supporting NBS. Consequently, results can also contribute to the adaptation of existing funding instruments and policies to promote and support NBS.
- **Support to the further integration and reporting of NBS contributions to the EU policy** is also an area of R&I identified as important, especially in stakeholder feedback. Collected examples include developing a framework for evaluating NBS against the EU Biodiversity Strategy to 2030, the EU adaptation strategy to 2050, or streamlining NBS contributions to achieving its objectives, which could help strengthen systemic views on NBS integration throughout the EU but also international policy (see 3c).

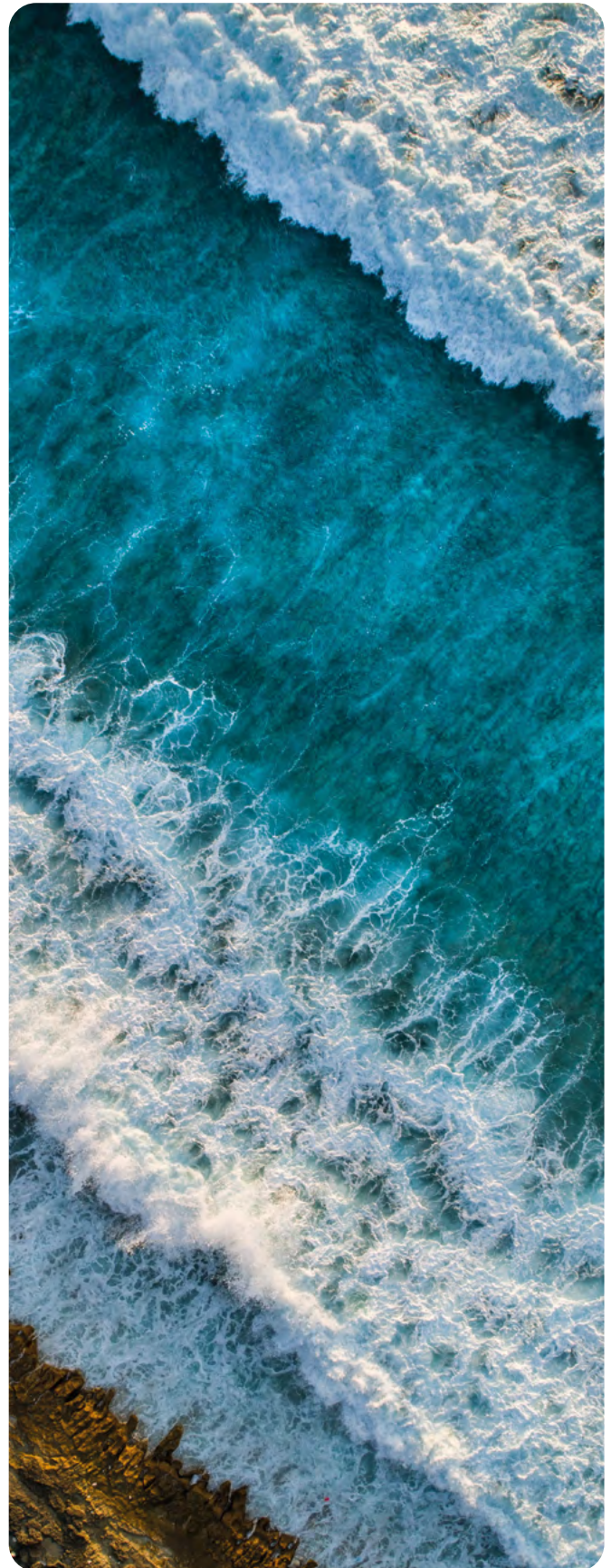
8. [https://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-law\\_en](https://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-law_en), [https://environment.ec.europa.eu/publications/nature-restoration-law\\_en](https://environment.ec.europa.eu/publications/nature-restoration-law_en)



## 3b. Enabling supportive conditions and legal frameworks for NBS through R&I

R&I has a key role in identifying and promoting governance and policy frameworks for enabling favourable and supportive conditions for NBS implementation, by:

- **Identifying supportive legal frameworks for innovation with and deployment of NBS at relevant scales.** A meaningful deployment of NBS needs to be supported by appropriate policy instruments at the national as well as the regional and local levels, in correspondence with a long-term EU strategy and support for NBS, knowledge development and integration, as well as tailored guidance and tools for decision-making<sup>59</sup>. Stakeholder consultations more specifically highlighted the need for clearer integration of and references to NBS in existing national legislative frameworks, e.g., in national building codes, national energy and climate plans, or national nature and landscape protection legislation, and in agricultural policy and funding. In this context, knowledge gaps related to availability of information on the policy and financial incentives and instruments for NBS implementation (including legal, economic, collaboration and awareness raising instruments) and their effectiveness, e.g., for urban governments<sup>8</sup>, or identifying policy instruments to stimulate the demand for NBS, and what criteria to apply in this regard<sup>18</sup>, addressing the challenge of grey, engineered interventions still being the default approach<sup>30</sup>.
- **Identifying and developing collaborative governance systems that enable the successful delivery of multiple NBS benefits,** e.g., toward climate goals such as Nationally Determined Contributions under the Paris Agreement, and actively engaging R&I alongside practitioners, policy makers, NGOs and local residents in the design, planning, implementation and assessment of NBS<sup>5,32</sup>. Expert consultations also brought forward recommendations for innovative approaches, in developing governance systems to overcome administrative and sectorial silos. Specifically, such comments point to a need for governance models that enable multiple government agencies, with different agendas, spatial scales, and capacities, to efficiently develop and implement collaborative NBS plans and actions.





## 3c. EU R&I supporting an ambitious NBS international agenda

EU R&I can support efforts to carry out an ambitious agenda on NBS globally, through:

- **Contributing to the development of a vibrant NBS knowledge-based economy.** This relates to the role of EU R&I in the development of standardised methodologies and metrics for assessing and monitoring NBS, e.g., work of CEN/CENELEC<sup>9</sup> with the IUCN Global Standard on NBS – IUCN 2020 and future integration in ISO standards. By establishing common frameworks for evaluating NBS performance, this would facilitate comparison and knowledge sharing across different projects and regions, help prevent misuse of the term, and allow the identification and assessment of international financing, value-chains and markets underpinning NBS deployment and effectiveness<sup>18</sup>. Expert consultations further highlighted the role of R&I in identifying policy and financial mechanisms detrimental to NBS and raising awareness of their existence (to hopefully suppress them), which is needed for achieving transformative change.
- **Advancing the knowledge base on NBS to further support discussions on the concept in international policy agendas,** providing evidence of the multiple benefits of NBS, where relevant. This lever builds on the role for research in streamlining and communicating the analysis of policy frameworks, barriers and opportunities for integrating NBS into international agendas. More efforts are required to further develop and integrate this knowledge base at the global level and help identify effective approaches to the transfer, replication, and upscaling of NBS as well as knowledge<sup>8</sup>. Key avenues in this context relate to the advancement of knowledge on the role of biodiversity in supporting the delivery of ecosystem services, and on the linkages between NBS, biodiversity and climate, health, and circular and nature-positive economies. Integration of knowledge and evidence on NBS at EU and global scales is also clearly identified as need at the wider science-policy interface on biodiversity, with major initiatives on biodiversity data harmonization identifying NBS as one of the key topics to work on (e.g. in developing the Science Service<sup>10</sup> for the European Knowledge Centre for Biodiversity ).
- **Establishing links between NBS and the implementation of international policy concepts and objectives,** such as the Sustainable Development Goals<sup>8,32</sup> and the Kunming-Montreal Global Biodiversity Framework (GBF) is already the subject of some work<sup>60</sup> and can be further developed to support references to NBS approaches in international agendas. NBS are acknowledged as important actions for the achievement of multiple GBF targets, most importantly targets 8 and 11 (related to climate change and regulating services, respectively), but also for achieving target 3 on the protection of 30% of terrestrial, inland water, coastal and marine areas by 2030 and target 4 on the restoration of 30% of degraded ecosystems. Expert contributions especially point to further exploring the potential of NBS knowledge exchange as elements of national, European, and international policies in support of nature positive practices throughout global value chains leading to increased global resilience to food and other crises. Also, mobilisation of R&I contributions to the design and implementation of relevant and emerging policy initiatives, such as the UN Decade in Ecosystem Restoration, as well as future processes driven by multilateral agreements (e.g., CBD, BBNJ, UNFCCC, UNCCD), is also a significant lever to generate adherence to the concept and achieve an ambitious global NBS agenda.

9. E.g., <https://www.cencenelec.eu/news-and-events/news/2022/press-release/2022-05-24-standards-for-climate/> consulted on 02/06/22

10. See demonstration case topics selected in BioAgora project developing the Science Service for Biodiversity (<https://bioagora.eu/science-service-for-biodiversity/>). For the Knowledge Centre on Biodiversity, see [https://knowledge4policy.ec.europa.eu/biodiversity\\_en](https://knowledge4policy.ec.europa.eu/biodiversity_en)

## Action Area 4 – Exchange, capacity building and awareness

### 4a. Raising awareness of and empowering society on NBS

Co-developing knowledge and solutions and more generally promoting citizen and stakeholder engagement in NBS implementation<sup>5</sup> is essential for their acceptability<sup>32</sup>, as well as to help clarify NBS beneficiaries and accessibility for different groups<sup>8,38</sup>. As such R&I can be instrumental in developing societal awareness on NBS, in particular but not limited to citizens' awareness through information sharing, co-development of knowledge and identifying approaches to NBS design and implementation that empowers stakeholders<sup>35</sup>. This aspect often appears key in expert consultations for successful NBS implementation, also because public opinion is a powerful driver of narrative change and influence on policy and business. R&I can:

- **Contribute to raising the awareness of citizens and other societal actors regarding NBS**, for example, by identifying awareness-raising factors<sup>24</sup> and developing participatory approaches and governance systems that bring together multiple perspectives, e.g., from public administrations to residents<sup>5</sup>, or academics, practitioners, policy makers, NGOs and residents in the design and assessment

of NBS<sup>8</sup>, and can support the resolution of conflicts such as perceived disservices of NBS or conflicting land uses<sup>32</sup>. Promoting Nature-based solution in education was also identified as a key avenue to advancing societal awareness on NBS. From primary to higher education, R&I can help the integration of NBS into educational curricula and materials by e.g., developing educational resources, fostering collaboration with educational institutions, and disseminating research findings<sup>61</sup>.

- **Involve citizens in knowledge co-creation and NBS implementation** by, e.g., developing effective and easy to apply methods and approaches to engage communities in knowledge development, and advancing citizen science in NBS monitoring and management<sup>45</sup>. Furthermore, ways and means need to be found to integrate such methods and approaches into government processes and decision-making (where appropriate) as well as into research and implementation projects, also reflecting equity and addressing inclusiveness (e.g., genre, geographic, socio-economic...).

### 4b. Enabling transdisciplinary dialogue and local knowledge integration

Transdisciplinary approaches to NBS design, implementation and related R&I are of strategic importance from multiple perspectives, ranging from the wide spectrum of stakeholders affected by the implementation of NBS and their co-benefits (as well as trade-offs). This requires participatory design and governance of NBS, and related indicators, to NBS that incorporate local and traditional knowledge and are coherent with the local socio-ecological context. This lever relates to:

- **Providing space and developing methods for the co-production of NBS** for the integration of scientific disciplines and the engagement of stakeholders in knowledge development and implementation. This includes the development of processes for the engagement of stakeholders in NBS design<sup>5,32</sup>, including at the landscape level and across different socio-ecosystems (e.g., urban-rural) and in the

longer-term<sup>8</sup>. It also entails the development of novel approaches in R&I such as open innovation processes to advance the co-production of NBS and secure the active and ongoing participation of stakeholders across sectors in NBS projects<sup>18</sup>, although the regional and cultural component of securing this participation should be recognised, both as a potential opportunity for cross-learning across regions and as a potential barrier for transposing successful processes. In addition, treating NBS dimensions in isolation, whether it be in a perspective of multi- or transdisciplinary, can render negative trade-offs, for example, between biodiversity, carbon sequestration and wood production in forest management<sup>62</sup>, calling for increased investment in inter- and transdisciplinary R&I for achieving the co-benefits of NBS.

- **Better integrating diverse perspectives, values and needs of stakeholders in assessing NBS**, closely linked to the development of valuation methods that take account of NBS co-benefits and the multiple values of nature, including relational, intrinsic and instrumental values, is crucial for advancing the understanding of the delivery of benefits and trade-offs in the complex socio-ecological context of

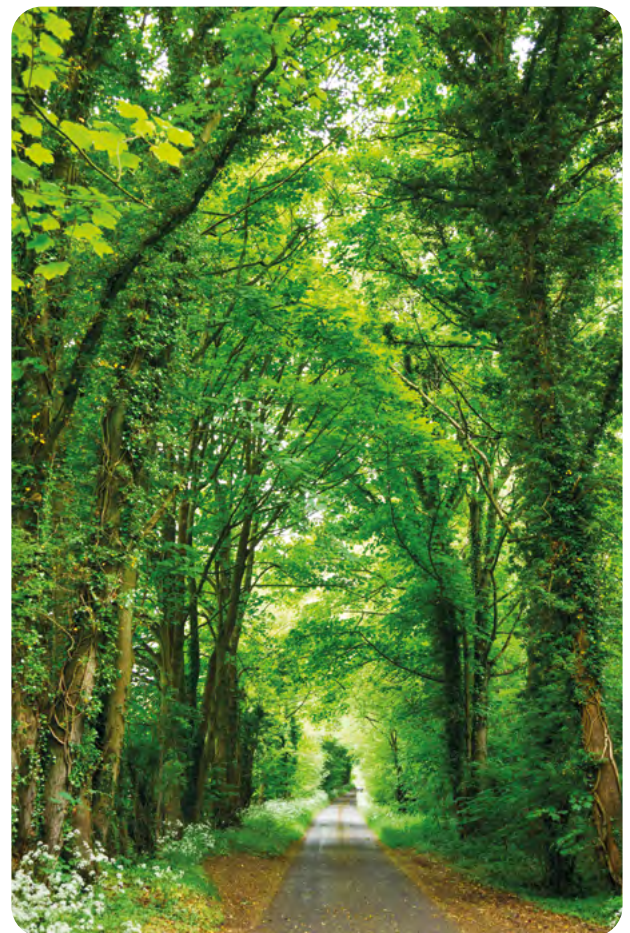
NBS<sup>5,20,32</sup>. This includes mixed-method R&I designs that balance the need for qualitative and quantitative assessment of NBS impacts, but also the relative variation of costs and benefits of NBS in different settings which highlight the challenge for R&I to work with varying perspectives at scale and the need for contextualised and place-specific assessments and indicators of NBS performance<sup>8</sup>.

## 4c. Developing skills and investment capacities for NBS implementation

Relating to the development of the evidence base and knowledge transfer, this lever draws on the role of R&I in:

- **Supporting the development of skills for the planning, implementation, long term stewardship, monitoring and assessment of impacts and adaptive management of NBS**, with a recognised need for further transfer of technical knowledge on NBS, for example, in assessing trade-offs and synergies and optimising the use of technical solutions<sup>8,31</sup>, and also related to issues in access to information and evidence, e.g. issues in communicating thermal tolerance data to local stakeholders in a meaningful way<sup>8</sup> or difficulties in accessing information on legal instruments and requirements for NBS implementation<sup>8</sup>. The overload with existing information and potential indicators also appears to be significantly hindering stakeholder capacities for NBS implementation<sup>51,52,63</sup>, suggesting a potential for R&I in further accompanying stakeholders in doing so.
- **R&I into finance and business models is needed to support the development of comparisons of NBS between NBS and “grey” or “hybrid” solutions** on timescales compatible with global change<sup>3,8,36</sup>, e.g. by helping clarify investment needs through the use of scenarios combining blue-green infrastructure and grey infrastructure or different levels of the implementation of blue-green infrastructure<sup>43</sup>. In addition, advancing the operational understanding of NBS economics appears to be a key component of this lever, from developing financial models for NBS and clarifying NBS benefits in cost-benefit analysis approaches for investment feasibility<sup>30,38</sup>, to better understanding cost structures and maintenance costs of NBS,

or advancing national and EU-wide data and market analyses on emerging and more mature NBS market sectors<sup>18</sup>. More research is needed on how NBS can support the achievement of different sustainability pathways, including those for maximising utility (green economy), those that set minimum and maximum consumption thresholds (degrowth), those that support rights and empowerment of diverse communities (earth stewardship) and those that promote biodiversity conservation<sup>34,64,65</sup>.



# Implementation

The EU R&I Roadmap on Nature-based Solutions (NBS) was collaboratively developed and designed to ensure its relevance, quality, and effective implementation. A diverse range of stakeholders have actively participated in this process through strategic dialogues, collaborative sessions, and consultations. This initial engagement has yielded positive indications of support for the roadmap and the utilisation of its initial outcomes.

To accomplish the roadmap's objectives by 2030 and its vision to empower policy, practice, businesses, and citizens to harness the full potential of Nature-based Solutions, it is crucial to sustain and enhance these efforts by promoting co-implementation among the various stakeholder groups involved. This includes research and innovation (R&I) programmers and funders, R&I performers, policymakers, and society at large.

The implementation of the Roadmap will be facilitated through the NetworkNature+ initiative, which serves as the successor consortium to NetworkNature. NetworkNature+ will run from 2023 to 2027. During this project, a wide range of implementation activities are planned, including evidence and knowledge generation and integration, dialogues with programmers, funders, policymakers, policy integration as well as collaboration with the EC NBS Task Forces. These endeavours will pave the way for the effective deployment of the roadmap and foster greater synergies among its stakeholders.

More specifically, the roadmap will support the following functions:

- **Facilitating Evidence Integration and innovation with NBS:** a strategic framework will be developed to support the implementation of the EU R&I NBS Roadmap, and will inform and guide the priorities and activities of NetworkNature+. Strategic workshops with key EU R&I programs, funders, policymakers, and EU missions will be organised to encourage their use of the roadmap for strategic planning on NBS activities and foster synergies. The roadmap will also be visualised on the website to promote its awareness and adoption.
- **Monitoring the implementation of the Roadmap:** the roadmap, its action areas and related levers are key elements to set out and track progress in implementing the vision for EU R&I support to NBS deployment. It will be monitored through quantitative and qualitative indicators, success stories, and reports.
- **Continuous development and update of the EU Roadmap on NBS:** key elements for the development of this roadmap, including knowledge gaps and the mapping of R&I projects on NBS will be continuously updated during NetworkNature+ and an update of the roadmap itself is planned at the end of NetworkNature+, to further inform on NBS R&I needs and support towards achieving major EU and global policy goals by 2030. The updated roadmap will be co-developed through workshops with national, EU, and international R&I programmers and funders, aiming for a renewed ambition and coherence in EU R&I efforts on NBS. The update process will include participatory approaches and secure the involvement of and relevance to policy and practice.
- **Answering Knowledge Gaps:** The roadmap aims to help address knowledge gaps on NBS by facilitating exchanges and helping develop synergies in support to NBS research, innovation, and implementation. Facilitating dialogues with the NBS Task Forces, NBS regional Hubs, R&I programmers, funders, communities of practices, and other relevant initiatives and partners, engaged in the roadmap co-development and beyond, will be central to implementing this function of the roadmap.

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# Annex

## 1. Mapping the EU Research, Innovation, and Implementation landscape on NBS

The mapping of EU projects provides an overview of the Research, Innovation and Implementation supported to date by the European level on NBS. It was conducted using information from databases on existing European programmes: BiodivERsA, Horizon 2020, Seventh framework programme (FP7), Interreg and LIFE (EU's funding instrument for the environment and climate action) over the years 2011–2021<sup>11</sup>.

The databases were screened using two successive keyword searches on the title and abstract of each project using the software R Studio.

1. First, sorting with “biodiversity” keywords selected from Goudeseune *et al.* 2018<sup>66</sup> ([Annex 3](#))
2. Then sorting with “services and approaches” keywords ([Annex 4](#)), this list was constructed by:
  - i) using the NBS keyword lists developed under NetworkNature<sup>67</sup>
  - ii) further exploratory work on scientific publications and grey literature<sup>6,8,31,32</sup>
  - iii) And testing and adjustment of the draft keyword lists on selected samples of NBS projects.

The projects were compiled within a single database and carefully reviewed to remove projects on topics not related to biodiversity or NBS (e.g., medical research)

The remaining projects' titles and abstracts were manually checked to retain NBS-relevant projects using criteria derived from the EC's definition, in accordance with the criteria defined in the Milestone paper 3.1 of NetworkNature<sup>67</sup>. The list of essential criteria for a project to be considered as R&I on NBS was derived as follows:

- *Biodiversity benefits* Projects designed to maintain (at the minimum) and enhance the functionality and connectivity of ecosystems.

- *Social and economic benefits and/or increased resilience* Projects that maintain and/or increase the quality of life and the delivery of ecosystem services and stimulate economic growth and/or projects increase the capacity of a system to recover from stress and disturbance while retaining the essential functions, structures, and identity.
- *Societal Challenge* Projects designed as a response to one or more societal challenge(s) .

All projects were rated for each criterion using the following rating scale, based on information present in their title and abstracts, using the following scale:

- 0 — the criterion is not mentioned
- 1 — the criterion is mentioned only in the description of the project's context
- 2 — the criterion is mentioned in relation to the core objectives of the project but either not detailed and/or studied
- 3 — the criterion is detailed and studied in the project

### Construction of the EU NBS Project Database

The EU NBS Project Database was constructed using identified projects, which used NBS or were included in the H2020 NBS topics, and if each of the three assessed criteria had a score greater than or equal to 2.

From an initial screening of more than 60.000 projects, the EU NBS Project Database is presently comprised of 300 projects, including 100 projects from H2020 and FP7, 35 NBS projects from BiodivERsA, 86 NBS projects from Interreg and 79 NBS projects from LIFE.

11. This mapping focuses on four major EU research programmes and as such is not exhaustive since analysing all EU programmes was not possible with available resources. Nonetheless, implementing a similar mapping of NBS projects in other EU programmes (e.g., European regional development fund or the European agricultural fund) could certainly help gain clarity on the EU landscape of research, innovation and implementation projects on NBS.

The projects included within the Database were tagged according to:

- **Type of NBS**, following the typology developed by Eggermont et al. 2015<sup>6</sup>

Type	Definition
Type 1	Solutions that involve making better use of existing natural or protected ecosystems
Type 2	Solutions based on developing sustainable management protocols and procedures for managed or restored ecosystems
Type 3	Solutions that involve creating new ecosystems

- **Types of approaches studied**, following an adaptation of the IUCN typology in Cohen-Shacham et al. 2016<sup>4</sup>

Broad categories	Types of Approaches
Ecosystem restoration approaches	<ul style="list-style-type: none"> <li>• Ecological restoration</li> <li>• Ecological engineering</li> </ul>
Issue-specific ecosystem-related approaches	<ul style="list-style-type: none"> <li>• Ecosystem-based adaptation</li> <li>• Ecosystem-based mitigation</li> <li>• Ecosystem-based disaster risk reduction</li> </ul>
Infrastructure-related approaches	<ul style="list-style-type: none"> <li>• Green infrastructure</li> </ul>
Ecosystem-based management approaches	<ul style="list-style-type: none"> <li>• Ecosystem-based water management*</li> <li>• Ecosystem-based fisheries management*</li> <li>• Ecosystem-based Forest management*</li> <li>• Ecosystem-based agricultural management*</li> </ul>
Ecosystem protection approaches	<ul style="list-style-type: none"> <li>• Area-based conservation approaches</li> </ul>

\*Elements added or modified from the original typology

- **Type of environment:**

The ecosystem typologies addressed by the projects were listed based on the policy report “Mapping and assessment of ecosystems and their services (MAES): An EU Ecosystem Assessment Report”<sup>68</sup>. The classification has been slightly adapted for the purpose of this mapping.

- ◇ Coastal, shelf and open ocean
- ◇ Cropland
- ◇ Forest
- ◇ Grassland
- ◇ Inland Wetland
- ◇ Marine inlets and transitional water
- ◇ Mountain
- ◇ Rivers, lakes and ponds
- ◇ Sparsely vegetated land
- ◇ Urban Ecosystem

- **Types of Societal Challenge(s) tackled**, following a typology derived from the EC20 and the IUCN<sup>69</sup> typologies

IUCN Societal Challenge Typology	EC Societal Challenge Typology	Typology Derived for NetworkNature mapping
Climate Change	Climate Resilience	<b>Climate Resilience</b>
Water security	Water Management	<b>Water Management</b>
Food security	-	<b>Food security</b>
Economic and Social Development	Social Justice and Social Cohesion	<b>Social Justice and Social Cohesion</b>
	New Economic Opportunities and Green Jobs	<b>New Economic Opportunities and Green Jobs</b>
	Participatory Planning and Governance	<b>Participatory Planning and Governance</b>
Disaster Risk reduction	Natural and Climate Hazards	<b>Natural and Climate Hazards</b>
Human Health and well-being	Health and well-being	<b>Health, Well-being &amp; Air Quality</b>
	Air Quality	
-	Green Space Management	<b>Green Space Management</b>
	Place Regeneration:	<b>Place Regeneration:</b>
	Knowledge, and Social Capacity Building for Sustainable Transformation	<b>Knowledge, and Social Capacity Building for Sustainable Transformation</b>
Environment degradation and biodiversity loss	Biodiversity Enhancement	<b>Biodiversity Enhancement*</b>

\*Not included in analysis since considered prerequisite for NBS



## 2. Collecting and synthesising knowledge gaps on NBS

The examination of knowledge gaps and needs utilised a desktop study of key European publications on NBS in combination with a review of selected literature. An online survey was used to gather insights from the NBS community.

### Desk Study:

The desk study started with the analysis of key European publications on NBS. The analysis of those publications allowed us to identify knowledge gaps but also to search for additional bibliography for other relevant publications. To further the study, the search engine of Google Scholar, Science Direct, as well as Google for grey literature was used to research relevant publications, prioritising already comprehensive syntheses of knowledge gaps.

The search was made using the terms “knowledge gaps” and “nature-based solutions” (as well as their variations). Since the term nature-based solution is an umbrella term we also used different terminology of approaches linked to NBS (Table 1). The NetworkNature and EC Task Forces on NBS were also mobilised to retrieve further relevant publications.

**Table 1. List of terms searched with “Knowledge gaps.”**

Agro-ecological approaches
Agroforestry
Ecological engineering
Ecological restoration
Ecosystem-based adaptation
Ecosystem-based disaster risk reduction
Ecosystem-based management
Ecosystem-based mitigation
Green and Blue Infrastructure
Nature-based solutions
NBS
Protected area

In total 19 publications synthesising (mostly EU) knowledge gaps on NBS were selected as relevant for the desk study (Annex 5). Knowledge gaps were identified only when clearly stated as such in the publication and citations were gathered into a final database ([NetworkNature Knowledge gaps database](#)), analysed and referred to in this roadmap. 155 unique citations were identified and then re-grouped and categorised into 28 broad gaps.

### Online Consultation:

An online survey of individuals active within the European NBS R&I sphere was conducted to gather direct feedback from a wider community. The consultation was opened from the 4th of September to the 15<sup>th</sup> of October on the NetworkNature website and was relayed via the EC Task Forces, NetworkNature members, on the NetworkNature and Biodiversa+ social media and sent through different mailing lists. Half of the responses originated from academia/higher education, and half from stakeholder organisations including international organisations (17%), private companies and SMEs (13%) and national and local policy makers or advisors (5%). The responses collected identified 48 knowledge gaps, of which 29 were indeed gaps relevant to NBS. Similarly, to the desktop study, these gaps were also organised within the previously identified 28 broad knowledge gaps.

**For more information on the collection and synthesis of knowledge gaps on NBS, [find here the full report on practical, research and innovation needs](#).**

## 3. Developing strategic objectives for NBS R&I

A strategic workshop was organised in November 2021 to directly mobilise high-level EU experts and global R&I programmes' representatives to:

- Present and discuss results of previous work by NetworkNature identifying trends in R&I support for NBS and synthesising key areas where knowledge gaps are prevalent.
- Propose and collectively work on draft topics for the roadmap based on previous work and participants' inputs – either in terms of refining or clustering previously identified topics or

proposing new ones, as well as distinguishing potential knowledge gaps between actual research and innovation needs and gaps in knowledge uptake and implementation.

In total twenty-six experts participated in this workshop and collaboratively identified the important levers for R&I to support the further development and deployment of NBS. The results from this workshop were used to further inform R&I needs, but most importantly to develop the pillars and levers of the present EU R&I Roadmap on NBS.

## 4. Public Consultation and Finalisation of the Roadmap

The first written draft of the roadmap was sent to review to the experts' group mobilised in the November strategic workshop, as well as to the EC and to the Network Nature's partners. After this first review, the Draft Roadmap was finalised, and an online Public Consultation was put into place to gather feedback from the NBS community. The Online Consultation ran from the 1st of August to the 21<sup>st</sup> of October 2022 on the NetworkNature website.

This consultation process allowed to gather 31 responses using the survey function, written feedback by email, as well as direct feedback during

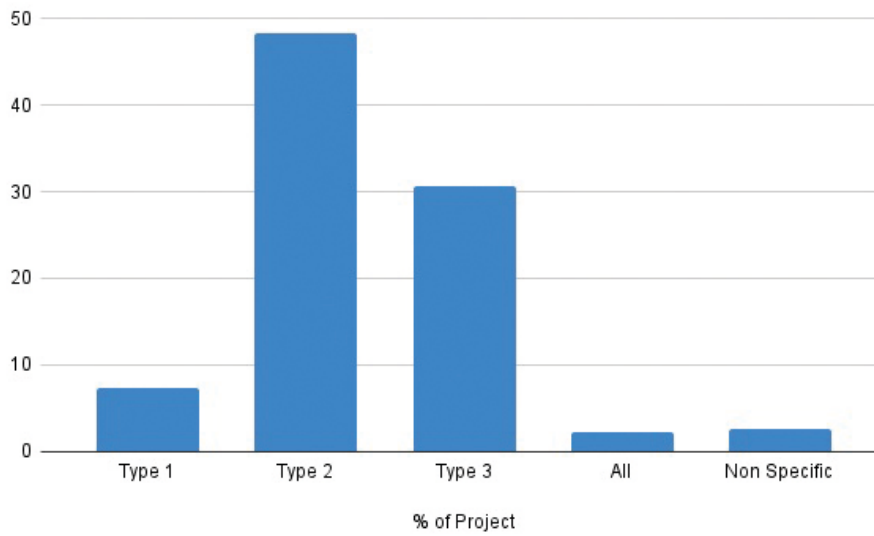
a dedicated session at the NetworkNature Annual Event on the 27<sup>th</sup> of September 2022. Apart from the response, the draft roadmap was viewed more than 2000 times during the consultation period on the NetworkNature website.

Following the results of the public consultation and to integrate the feedbacks and comments received, a writing group was set up composed of 6 experts. The objectives of the writing group were to respond and integrate the feedbacks received from the reviewing process and the open consultation and to help in determining the final structure and key messages of the roadmap.

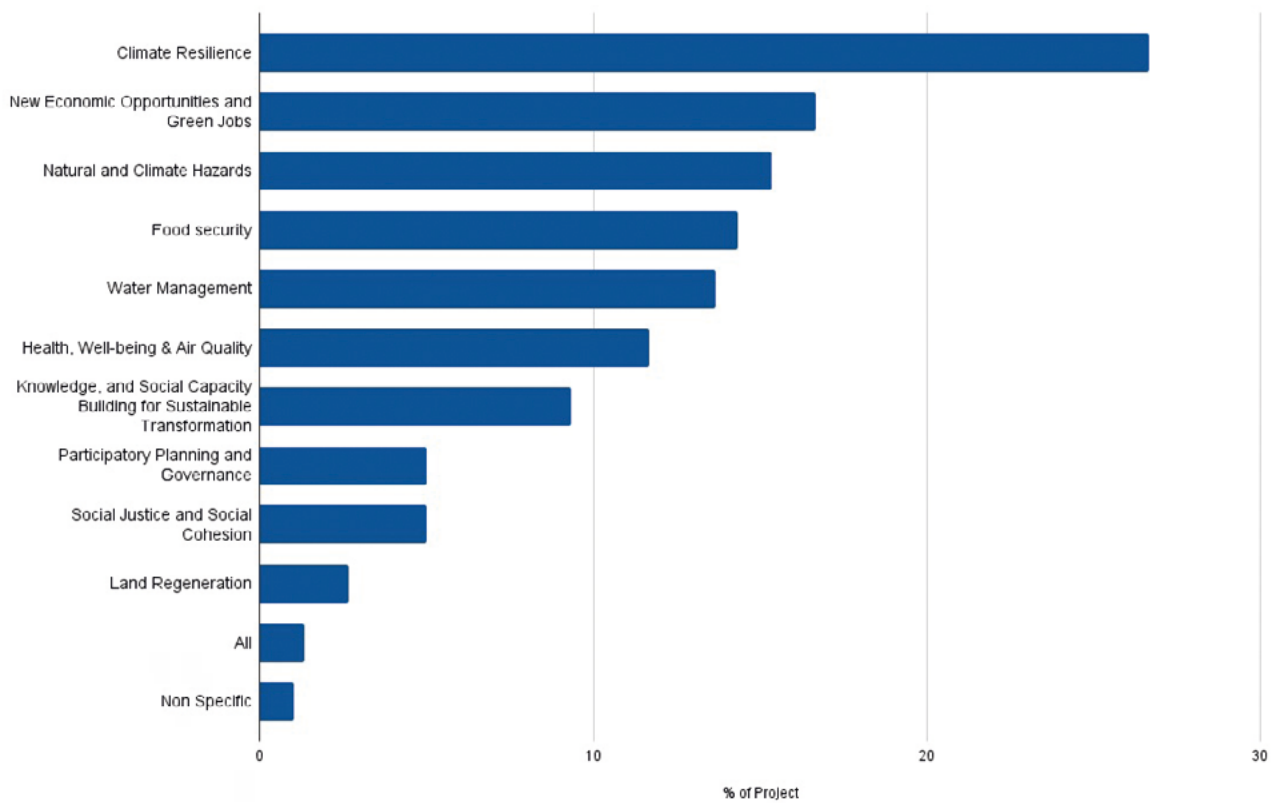




# Annex 2: Detailed Graphs of the mapping NBS projects



**Figure 1: Types of NBS (Sum > 100% 1 project could be categorised in multiple categories)**



**Figure 2: Types of Societal Challenges (Sum > 100% 1 project could be categorised in multiple categories)**

# Annex 2: Detailed Graphs of the mapping NBS projects

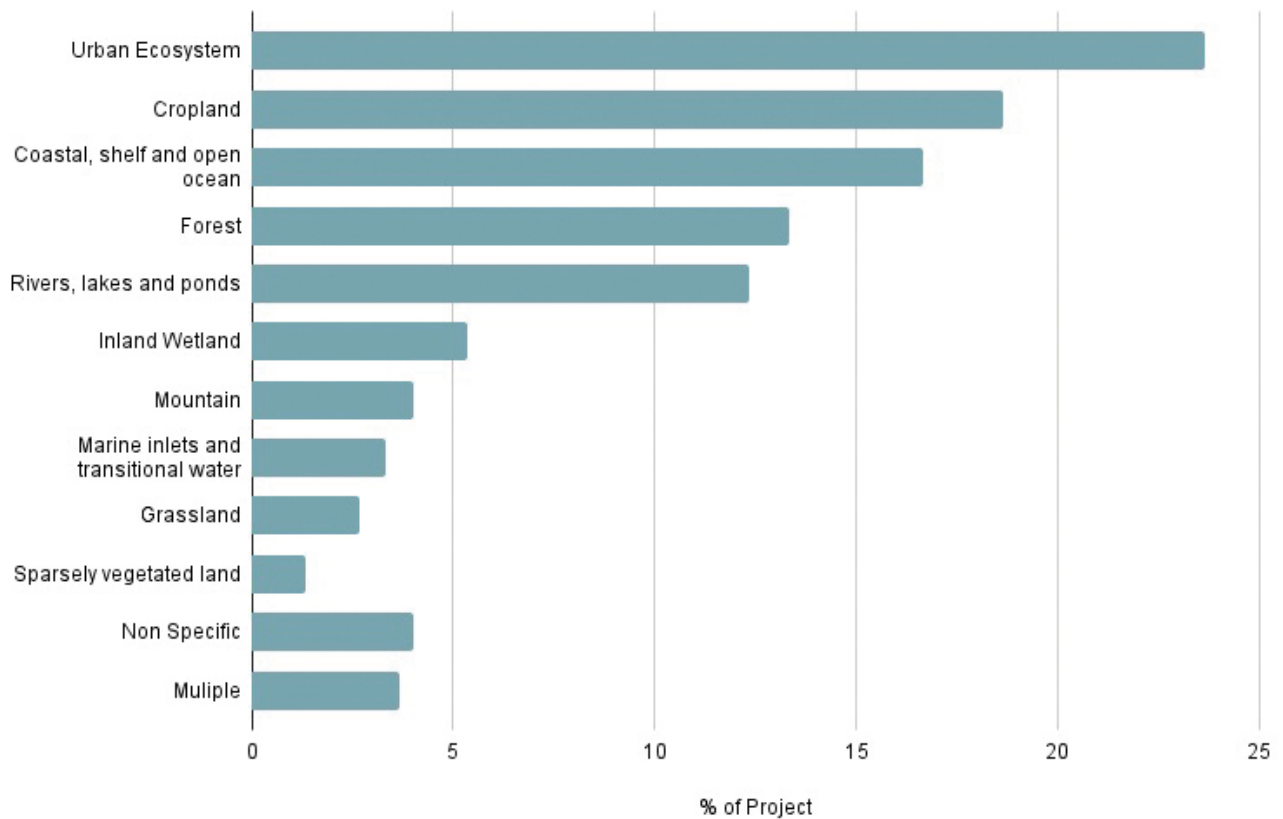


Figure 5: Types of Environment (Sum > 100% 1 project could be categorised in multiple categories)

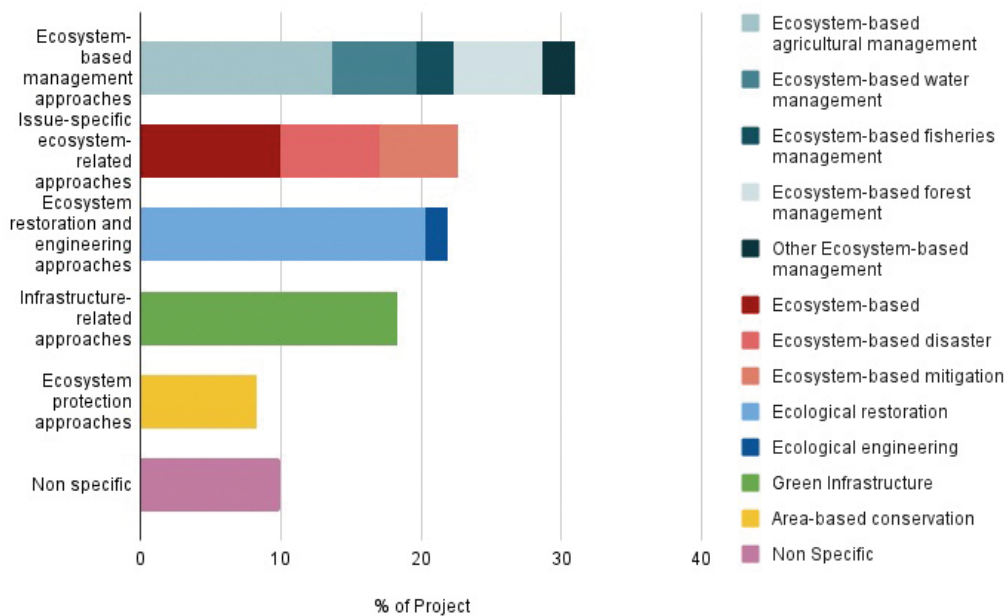


Figure 6: Types of approaches (Sum > 100% 1 project could be categorised in multiple categories)

# Annex 3: List keywords for “Biodiversity”

- agroecolog\*
- agrosystem
- aquatic environment
- arable plant
- biocenosis
- biodiversity
- bioecological
- biogeograph
- biological adaptation
- biological conservation
- biological diversity
- biological indicator
- biological invasion
- biological monitoring
- biological productivity
- biosphere
- blue infrastructure
- breed
- bycatch
- canopy
- coast
- cultivar
- diversity
- ecological
- ecological gen\*
- ecological invader
- ecological network
- ecological speciation
- ecology
- ecosystem
- fauna
- flora
- food web
- forest
- fragmentation
- fragmented habitat
- functional diversity
- functional ecology
- functional group
- functional redundancy
- functional trait
- functional type
- genetic diversity
- grassland
- grazing
- green infrastructure
- green roof
- green space
- habitat adaptation
- habitat conservation
- habitat diversity
- husbandry
- interspecific
- intraspecific
- invasive plant
- invasive species
- invertebrate
- ipbes
- mangrove
- marine
- meadow
- native species
- natura 2000
- natural capital
- natural environment
- natural habitat
- natural heritage
- nature-based
- nbs
- nature improvement
- nature reserve
- ocean biology
- pasture
- peatland
- permanent plots
- pollinator
- population dynamics
- protected area
- reef
- river
- seed
- speciation
- specie
- taxa
- taxon
- terrestrial environment
- tree
- tropical system
- urban environment
- vegetation
- weed
- wetland
- wildlife
- woodland

# Annex 4: List keywords for “Services and approaches”

- adaptation to climate change
- agri-environmental measures
- agroecolog\*
- agroforestry
- area-based conservation
- assisted natural regeneration
- biocontrol
- biodiversity resilience
- bioremediation
- blue infrastructure
- building with nature
- climate adaptation service
- climate adaptation strategy
- climate change adaptation
- climate change mitigation
- climate resilient
- climate-resilient
- disaster resilient
- disaster risk management
- disaster risk reduction
- disaster resilience
- ecological engineering
- ecological restoration
- ecosystem management
- ecosystem-based \*
- erosion risk management
- erosion risk reduction
- flood risk management
- flood risk reduction
- forest based
- green infrastructure
- green space management
- high-nature value
- land restoration
- landscape management
- management of ecosystem
- management of erosion risk
- management of flood risk
- management of green space
- management of landscape
- management of natural resource
- management of urban biodiversity
- management of water resources
- mitigation of climate change
- natural areas
- natural engineered
- natural infrastructure
- natural resource management
- natural treatment processes
- natural water retention
- natural-engineered
- nature based
- nature forestry
- nbs
- protected area
- re-naturing
- reforestation
- resilience management
- resilience to climate change
- resilience to disaster
- resilient to climate change
- resilient to disaster
- restoration
- rewilding
- river basin plans
- soil fertility
- soil rehabilitation
- soil remediation
- sustainable risk reduction
- urban biodiversity management
- urban greening
- urban heat island
- water resource management

# Annex 5: List of publications used in the Knowledge gaps desk Study

- Cohen-Shacham, E. *et al.* Core principles for successfully implementing and upscaling Nature-based Solutions. *Environmental Science & Policy* **98**, 20–29 (2019).
- De Vreese, R. Reviewing the knowledge on the importance of UF-NBS for resilient cities (CLEARINGHOUSE Deliverable 1.2). (2021).
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- Eggermont, H. *et al.* Strategic Research & Innovation Agenda: Horizon Europe Partnership on Biodiversity. (2021).
- EC Directorate-General for Research and Innovation Directorate General for Research and Innovation. *Towards an EU research and innovation policy agenda for nature-based solutions & re-naturing cities: final report of the Horizon 2020 expert group on 'Nature based solutions and re naturing cities': (full version)*. (Publications Office of the European Union, 2015).
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- Nelson, D. R., Bledsoe, B. P., Ferreira, S. & Nibbelink, N. P. Challenges to realizing the potential of nature-based solutions. *Current Opinion in Environmental Sustainability* **45**, 49–55 (2020).
- Raymond, C. M. *et al.* *An impact evaluation framework to support planning and evaluation of nature-based solutions projects: prepared by the EKLIPSE Expert Working Group on nature-based solutions to promote climate resilience in urban areas*. (Centre for Ecology & Hydrology, Wallingford, 2017).
- Ruangpan, L. *et al.* Nature-based solutions for hydro-meteorological risk reduction: a state-of-the-art review of the research area. *Natural Hazards and Earth System Sciences* **20**, 243–270 (2020).
- Seddon, N. *et al.* Understanding the value and limits of nature-based solutions to climate change and other global challenges. *Phil. Trans. R. Soc. B* **375**, 20190120 (2020).
- Somarakis, G., Stagakis, S. & Chrysoulakis, N. ThinkNature / Nature-Based Solutions Handbook. (2019) doi:[10.26225/JERV-W202](https://doi.org/10.26225/JERV-W202).
- UNEP-IEMP. Research on Ecosystem-based Adaptation (EbA): A reference guide. (2019).



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