The NbS CataTool of the National Biodiversity Future Center

Chiara Catalano

Abstract: Nature-based Solutions (NbS) represent a strategic approach to tackling the climate crisis, biodiversity loss, and other societal challenges in an integrated manner. This chapter retraces the evolution of the NbS concept, from the initial definitions by the European Commission and IUCN to the most recent UNEA formulation. It highlights how the growing relevance of NbS within European policies—including the Green Deal, the Nature Restoration Regulation, and Horizon research programs—has driven the need for decision-support systems (DSS) and monitoring initiatives. The NbS CataTool is a DSS developed within the National Biodiversity Future Center (NBFC) to facilitate the selection, implementation, and mainstreaming of NbS across urban, terrestrial, and marine environments in the Mediterranean context. Built upon a standardised taxonomy of over 100 NbS and an interconnected database of case studies, the tool integrates scientific evidence with practical decision-making needs. The DSS operates through three main functionalities: (1) an NbS Selection Tool, which guides users through a stepwise process based on NbS types, environmental domains, implementation contexts, and societal challenges; (2) a Learning Tool enabling open exploration of NbS through solution attributes; and (3) a Case Study Finder providing georeferenced, metadata-rich examples evaluated through a shared performance framework. Both solutions and case studies are provided with synthetic cards, detailed sheets, and expert-based evaluations linked to 12 global societal challenges. Distinguishing itself from existing DSS, the NbS CataTool offers a comprehensive, evidence-based, cross-domain NbS nomenclature and a harmonised evaluation structure aligned with European policies and standards.

Keywords: NbS Nomenclature, Landscape and Urban Planning, Biodiversity Strategy, Nature Restoration Regulation, Evaluation Framework.

1. Why are NbS important for people and nature?

Nature-based Solutions (NbS) were introduced in the early years of this century (World Bank 2008) and implemented within the European Commission (EC) Research and Innovation (R&I) policies over the past decade (European Commission 2015; 2025; Faivre et al. 2017) as a concrete answer to both the climatic and biodiversity crises, while generating environmental, economic, and social benefits (Dunlop et al. 2024). As introduced in Chapter *Nature and Artifice. An holistic approach to environmental and technological design,* NbS is an 'umbrella-concept' encompassing and derived from various ecosystem-based approaches such as bioengineering, agroforestry, green and blue infrastructure, all desirably working in synergy (Seddon et al. 2021). The path leading to the contemporary understanding of NbS is characterised by several milestones, starting from the first time they were mentioned in the early 2000s and continuing with their definition at the institutional level, as well as the publication of relevant reports, regulations, and resolutions that have supported their adoption in recent policies (Figure 1).

The different NbS definitions mirror the growing importance that biodiversity and ecosystems functioning have gained over time in shaping the concept of NbS, alongside their fundamental role in improving human-wellbeing (Table 1). Initially, according to

Chiara Catalano, CNR - IRET, Research Institute on Terrestrial Ecosystems, Italy, chiara.catalano@cnr.it, 0000-0003-4582-3476

Referee List (DOI 10.36253/fup_referee_list)
FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

Chiara Catalano, *The NbS CataTool of the National Biodiversity Future Center*, © Author(s), CC BY 4.0, DOI 10.36253/979-12-215-0966-3.18, in Roberto Bologna, Anna Lambertini, Luca Solari (edited by), *Nature and City. An Integrated Approach to Urban Biodiversity*, pp. 167-180, 2025, published by Firenze University Press, ISBN 979-12-215-0966-3, DOI 10.36253/979-12-215-0966-3

Fig. 1 – Timeline of the development of the NbS concept and key milestones at EU and global levels. Modified and expanded from Cohen-Shacham et al. (2016) and Somarakis et al. (2019).

the definition introduced by the EC (European Commission 2015) and refined successively by the EC (European Commission, n.d.), NbS are conceived as actions inspired by and supported by nature, excluding solutions that merely imitate natural processes (Bianciardi et al. 2023). Subsequently, with the IUCN definition (Cohen-Shacham et al. 2016), further developed by the United Nations Environment Assembly (UNEA) (Nature-Based Solutions for Supporting Sustainable Development 2022), NbS came to encompass actions aimed at protecting, restoring and sustainably managing natural or modified ecosystems, to simultaneously address economic, environmental, and social challenges, thereby generating benefits for both people and nature. Despite these evolutionary shifts, a clear commonality emerges across definitions: the need to tackle social challenges through the implementation of multifunctional NbS capable of delivering multiple ecosystem services (Nesshöver et al. 2017), either individually or in combination with other nature-inspired or -derived approaches (Cohen-Shacham et al. 2019; IUCN 2020a).

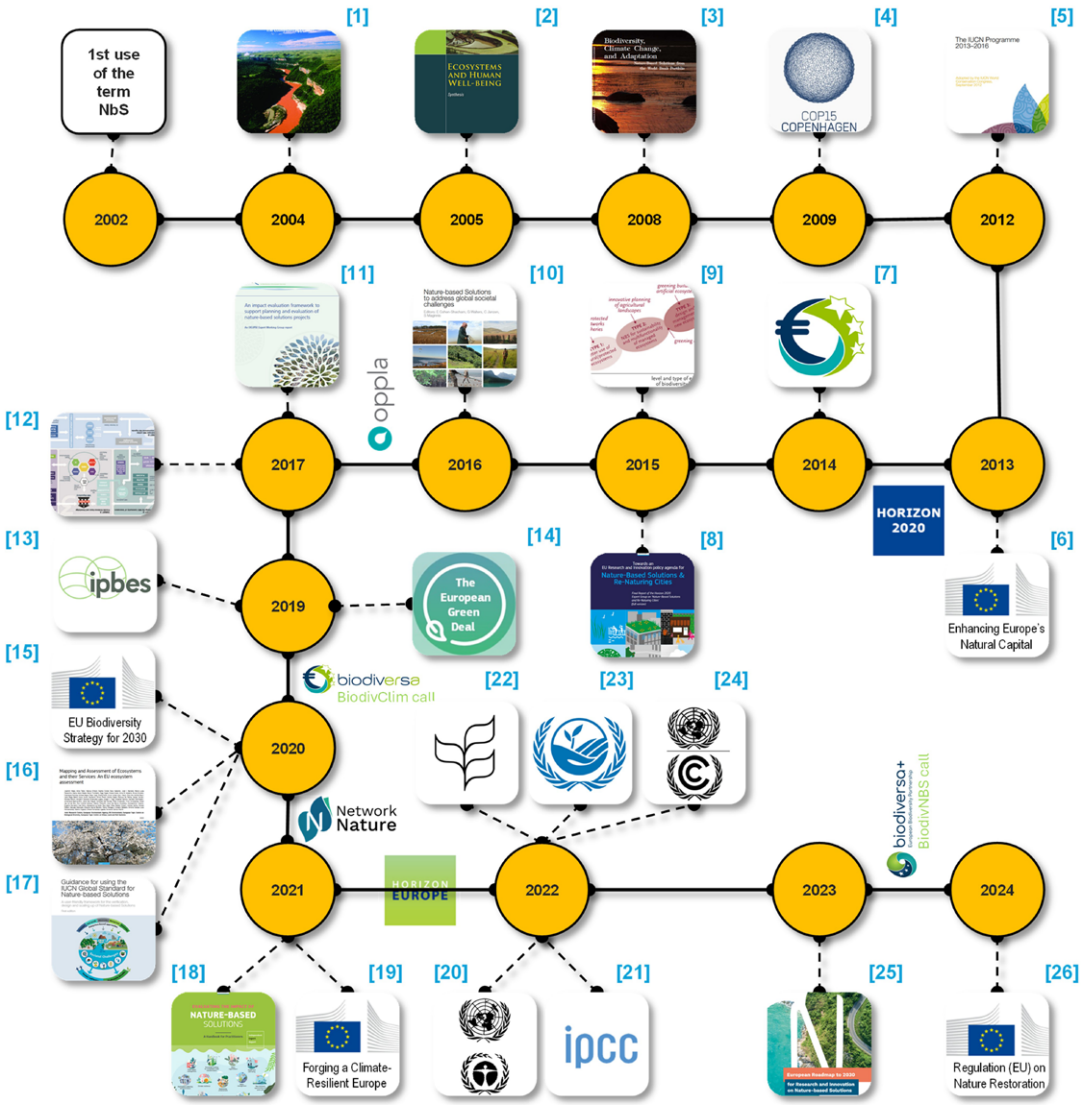
Table 1– Comparison among NbS definitions provided by the European Commission (EC), the International Union for Conservation of Nature (IUCN), and the United Nations Environment Assembly (UNEA). In orange, concepts which changed or gained more weight across definitions; in green, the commonalities across definitions.

EC 2015	EC 2025	IUCN 2016*	UNEA 2022**
"Actions which are inspired by, supported by or copied from nature. Some involve using and enhancing existing natural solutions to challenges, while others are exploring more novel solutions, for example mimicking how non-human organisms and communities cope with environmental extremes. Nature-based solutions use the features and complex system processes of nature [...] to achieve desired outcomes [...]. These nature-based solutions are ideally energy and resource-efficient, and resilient to change, but to be successful they must be adapted to local conditions".	"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".	"Actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits". 	"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, resilience and biodiversity benefits. [...] 

*IUCN definition infographic can be found at IUCN (2020b)
**UNEA definition infographic can be found at https://www.conexusnbs.com/nbs-definition-infographics

The evolution of the definitions is closely related to the adoption of NbS at legislative and operational levels[1] (Figure 1). NbS have been recognised as essential by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

[1] See also Chapter *Policies and regulatory frameworks for urban and riverine nature restoration* for more information on regulatory frameworks.



[1] CBD (2004). The Ecosystem Approach. Secretariat of the Convention on Biological Diversity.
[2] MEA (2005). Ecosystems and human well-being: Synthesis. Millennium Ecosystem Assessment. Island Press.
[3] World Bank (2008). Biodiversity, Climate Change and Adaptation Nature-Based Solutions from the World Bank Portfolio. The World Bank.
[4] IUCN (2009). Position paper. No time to lose – make full use of nature-based solutions in the post-2012 climate change regime. International Union for the Conservation of Nature.
[5] IUCN (2012). The IUCN Programme 2013–2016. International Union for the Conservation of Nature.
[6] Green Infrastructure (GI) - Enhancing Europe's Natural Capital, European Commission, COM(2013) 249 final (2013).
[7] Balian, E., et al. (2014). Output of the Strategic Foresight workshop 'Nature-Based Solutions in a BiodivERsA context'. BiodivERsaA Report.
[8] European Commission (2015). Towards an EU research and innovation policy agenda for nature-based solutions & re-naturing cities. Publications Office of the European Union.
[9] Eggermont, H., et al. (2015). Nature-based Solutions: New Influence for Environmental Management and Research in Europe. GAIA – Ecol. Persp. for Science and Society, 24(4), 243–248.
[10] Cohen-Shacham, E., et al. (Eds.). (2016). Nature-based solutions to address global societal challenges. IUCN International Union for Conservation of Nature.
[11] Raymond, C. M., et al. (2017). An impact evaluation framework to support planning and evaluation of nature-based solutions projects (An EKLIPSE Expert Working Group Report).
[12] Faivre, N., et al. (2017). Nature-Based Solutions in the EU: Innovating with nature to address social, economic and environmental challenges. Environmental Research, 159, 509–518.
[13] IPBES (2019). Global assessment report on biodiversity and ecosystem services. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.
[14] The European Green Deal, European Commission, COM(2019) 640 final (2019).
[15] EU Biodiversity Strategy for 2030. Bringing Nature Back into Our Lives, No. COM(2020) 380 final, European Commission (2020)
[16] Maes, J., et al. (2020). Mapping and assessment of ecosystems and their services. Publications Office of the EU.
[17] IUCN (2020). IUCN Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of NbS. (First edition). IUCN.
[18] Dumitru, A., & Wendling, L. (Eds.) (2021). Evaluating the impact of nature-based solutions: A handbook for practitioners. Publications Office of the European Union.
[19] Forging a Climate-Resilient Europe - the New EU Strategy on Adaptation to Climate Change, No. COM(2021) 82 final, European Commission (2021).
[20] Nature-Based Solutions for Supporting Sustainable Development, United Nations Environment Assembly (UNEA), UNEP/EA.5/Res.5 (2022).
[21] IPCC (2022). Climate Change 2022 – Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press.
[22] Kunming-Montreal Global Biodiversity Framework, 15/4, Convention on Biological Diversity, CBD/COP/DEC/15/4 (2022).
[23] Sharm El-Sheikh Implementation Plan, Decision 1/CP.27, UN Framework Convention on Climate Change, FCCC/CP/2022/10/Add.1 (2023).
[24] Action Taken by the Conference of the Parties at Its Fifteenth Session, UN Convention to Combat Desertification, ICCD/COP(15)/23/Add.1 (2022).
[25] EL Harrak, M. E., & Lemaitre, F. (2023). European Roadmap to 2030 for Research and Innovation on Nature-based Solutions. NetworkNature.
[26] Regulation (EU) on Nature Restoration, 2024/1991, European Parliament (2024).

(IPBES) for achieving the Sustainable Development Goals within and beyond cities (IPBES 2019), and by the Intergovernmental Panel on Climate Change (IPCC) as key to enabling climate-resilient development (IPCC 2022).

Furthermore, NbS as defined by UNEA (Nature-Based Solutions for Supporting Sustainable Development 2022) have been incorporated across the three Rio Conventions[2]: the *Sharm el-Sheikh Implementation Plan* of the UN Climate Change COP27 (Sharm El-Sheikh Implementation Plan 2023) which calls to reverse forest cover and carbon losses; the *Kunming-Montreal Global Biodiversity Framework* of CBF COP15 (Kunming-Montreal Global Biodiversity Framework 2022), which aims to reduce impacts on biodiversity (target 8) while restoring nature's contribution to people (target 11); and the UNCCD COP 15 (Action Taken by the Conference of the Parties at Its Fifteenth Session 2022) where NbS are highlighted as a means of sustainable land management. An important milestone achieved at the COP27 was the launch of the ENACT (Enhancing Nature-based Solutions for an Accelerated Climate Transformation) partnership: a voluntary coalition co-chaired by Egypt and Germany and coordinated by IUCN to contributing shaping a global agenda on NbS and across the Rio Conventions (ENACT 2024). Another significant step forward, is the entry in force of the EU *Nature Restoration Regulation* (NRR) on the 18th August 2024 (Regulation (EU) 2024/1991 2024). The NRR acknowledges the central role of NbS – and other ecosystem-based approaches – within broader policy landscape including the CBD global biodiversity framework, the EU Climate Law on climate neutrality (Regulation (EU) 2021/1119 2021), and the EU Strategy on Adaptation to Climate Change (Forging a Climate-Resilient Europe - the New EU Strategy on Adaptation to Climate Change 2021). It also promotes NbS as a means to increase urban green areas and trees cover in line with the EU biodiversity strategy (EU Biodiversity Strategy for 2030 2020), which calls on European town and cities with at least 20 000 inhabitants to develop Urban Nature Plans (previously named Urban Greening Plans). The policies outlined above were established to advance the targets set by The European Geen Deal[3] (The European Green Deal 2019) which aspires to safeguard and restore ecosystems, halt biodiversity loss, and achieve a climate-resilient Europe by 2050.

Together with the issuing of both binding and facultative policies, the uptake of NbS has been further enabled through substantial EU investments, particularly via Horizon 2020 (2014-2020) and Horizon Europe (2021-2027) Research and Innovation programs. These frameworks have supported more than 100 NbS-related projects within cluster 6: Food, Bioeconomy, Natural Resources, Agriculture and Environment[4], as well as EU-Missions[5] (European Commission 2025). In addition to these funding instruments, the implementation, upscaling and mainstreaming of NbS have been sig-

[2] The three Rio Conventions tackle the interconnected challenges of Climate Change, Desertification and Biodiversity Loss, respectively in the United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD), and Convention on Biological Diversity (CBD).

[3] Further information on the European Green Deal at https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

[4] Further information on Cluster 6 at https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/cluster-6-food-bioeconomy-natural-resources-agriculture-and-environment_en

[5] Further information on EU Missions at https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/learn-more-about-eu-missions_en

nificantly supported by the European co-funded partnership Biodiversa (2015-2022)[6] and Biodiversa+ (2021-2028) in cooperation with NetworkNature[7]. This partnership played from the beginning a pivotal role in shaping the conceptual foundation of NbS and in their mainstreaming into science-driven policies, while fostering stakeholders' engagement across sectors (Balian et al. 2014). Collectively, these initiatives contribute to the long-term vision that by 2050, "people are living in harmony with Nature" (Eggermont et al. 2021; Lemaître and Le Roux 2021).

2. Aims and functions of the NbS CataTool

The complex scenario and the ambitious targets set by the latest EU policies, as outlined in the previous paragraph, pose challenges at the operational level where the implementation of NbS must address context-specific conditions. In this regard, interactive multi-stakeholder tools are essential for enabling evidence-based decision-making and fostering cooperation among different sectors. For example, tools integrating standards and case studies together with reliable monitoring data can enhance citizens' awareness and knowledge while supporting co-design and co-governance initiatives, thereby strengthening NbS credibility and fostering their effective uptake (Catalano et al. 2024; Voskamp et al. 2021).

The National Biodiversity Future Center (NBFC), funded by the NextGeneration EU (European Commission 2021) as part of the Italian National Recovery and Resilience Plan (RRP), has invested substantial efforts in advancing the uptake of NbS through several interconnected activities carried out by the NBFC spokes[8]. Integrating scientific research with innovation and implementation of nature-based solutions, the NBFC aimed to position biodiversity as a central element for sustainable development, addressing global challenges through Monitoring, Conservation, Restoration, and Valorisation (MCRV). This mission is in line with the NbS approach outlined in the previous paragraph and the NbS-Types proposed by Eggermont et al. (2015), which considers the level and type of engineering as a discriminant among NbS (Figure 2).

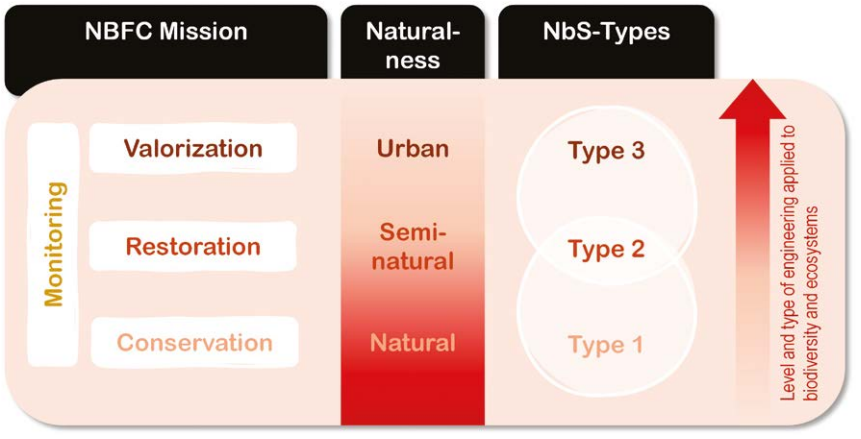


Fig. 2 – Relationship between the MCRV mission of the NBFC, the degree of Naturalness, and the NbS types (as defined by Eggermont et al. 2015).

[6] Details on Biodiversa and Biodiversa+ EU funded project can be found respectively at https://cordis.europa.eu/project/id/642420 and https://cordis.europa.eu/project/id/101052342

[7] Details on NetworkNature and NetworkNature+ can be found respectively at https://cordis.europa.eu/project/id/887396 and https://cordis.europa.eu/project/id/101082213/it

[8] For more information NBFC structure see Introduction of this book

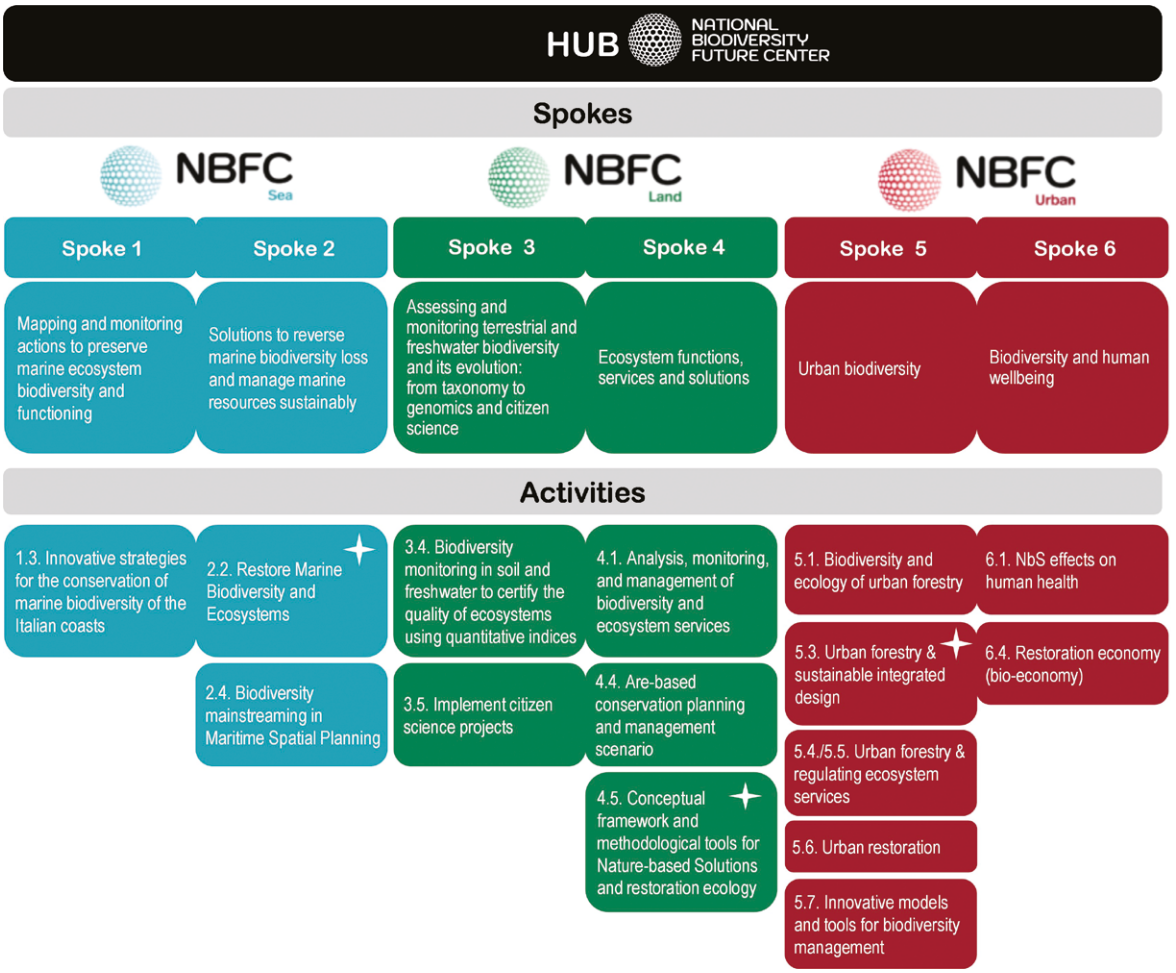


Fig. 3 – Sea, Land and Urban spokes of the National Biodiversity Future Center (NBFC). Stars indicate the activities involved in the development of the NbS CataTool.

This vision also represents the common denominator among the interlinked activities carried out across spokes 5 (Urban), 4 (Land), and 2 (Sea) related to NbS (Figure 3). A key crossing-cut outcome of these activities is the development of the NbS CataTool: a Decision Support System (DSS) aiming at facilitating the implementation and mainstreaming of NbS within the Mediterranean context. The tool encompasses solutions spanning different degrees of naturalness and anthropogenic impact across ecosystems, ranging from urban to natural contexts.

The DSS is an interactive online tool[9] that operates as (1) an *NbS selection tool*, (2) a *Learning tool*, and (3) a *Case study finder*. These functionalities build upon two databases, namely the **NbS database** and the **Case Study database**, which are linked through a shared taxonomy and evaluation framework (Figure 4a).

The *NbS selection tool* allows users to identify a range of NbS following a stepwise procedure (Figure 4b):

[9] The NbS CataTool is freely accessible online (https://tinyurl.com/CataTool) among the digital solution for biodiversity on the Biodiversity Gateway platform of the NBFC (https://www.biodiversitygateway.it/servizi-per-la-biodiversita/servizi-digitali-per-la-gestione-della-biodiversita/).

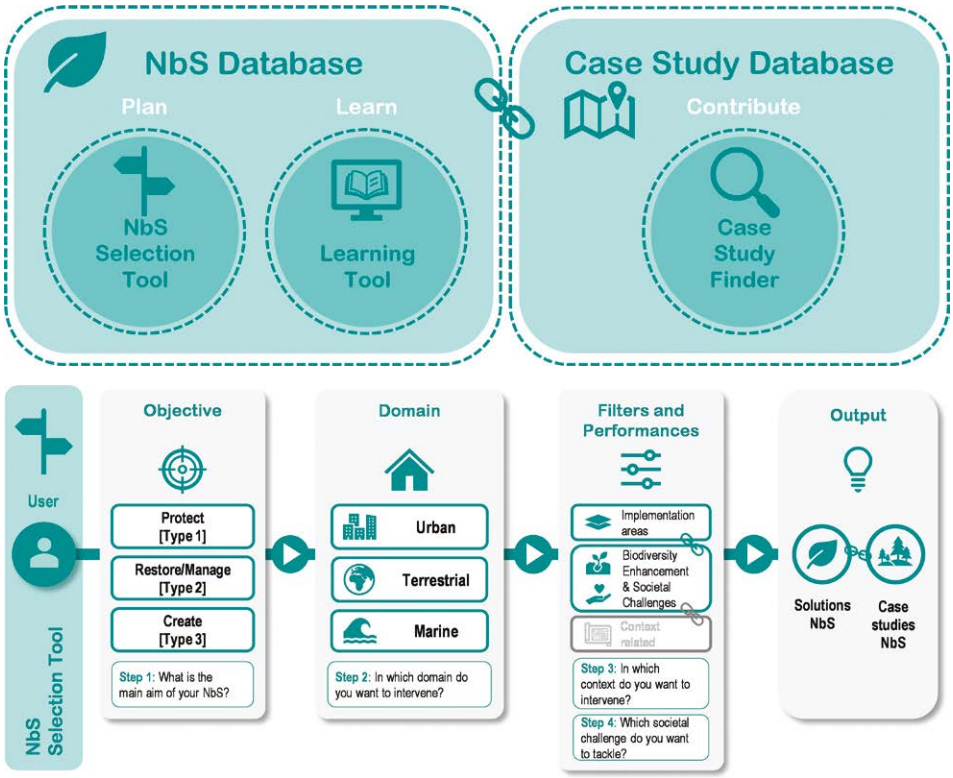
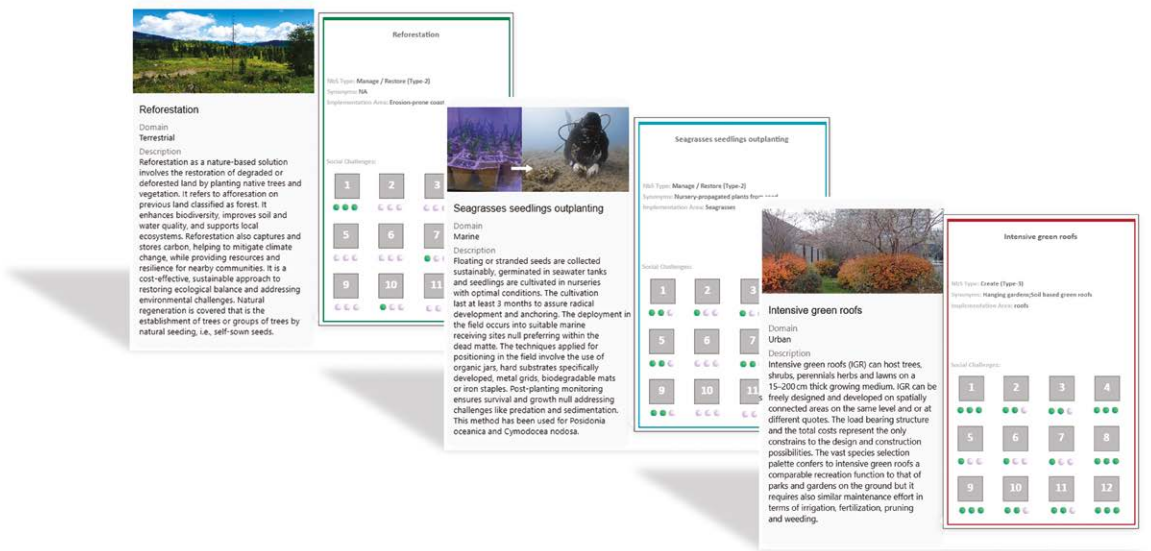


Fig. 4 – Graphical representation of the structure and functionalities of the NbS CataTool (above) and of the NbS Selection tool stepwise procedure (below); in grey the future planned development of the DSS.

Step 1: Define the object of the intervention. Users first select among the possible intervention options which follows the NbS-type classification Eggermont et al. 2015: Type 1, NbS for the protection and conservation of natural ecosystems (requiring minimal or no intervention); Type 2, NbS for the restoration, enhancement and management of natural or modified ecosystems (requiring moderate level of intervention); and Type 3, creation of new ecosystems (requiring high level of engineering effort) (see also Figure 2).

Step 2: Select the domain of intervention. Users must select among the urban, terrestrial, and marine domains. The first domain refers to urbanised environments extending beyond the urban matrix or political boundaries (e.g., transport infrastructure), characterised by novel ecosystems (from the green roofs and walls to road verges and private gardens), diverse habitat patches, and high anthropic pressure (e.g., soil sealing, pollution). Within the terrestrial domain figure protected and managed terrestrial environments including freshwater ecosystems both subjected to human impact (e.g., row material extraction and energy production) as well as climatic and natural hazards (e.g., fires, landslides, floods). The marine domain encompasses subtidal coastal and deep-sea ecosystems impacted also by human activities, exploited for fishery, aquaculture, recreation, mining and subjected to related impacts (e.g., pollution, acidification), biodiversity loss as well as other hazards (e.g., temperature and sea-level rise).

Step 3: Implementation area selection. Implementation areas are related to the context or conditions of the area of intervention, are domain-specific, and are tailored to the practice of different stakeholders involved in NbS planning. These includes landscape and urban planners (primarily operating in the urban domain), as well as envi-



double-sided cards of common urban, terrestrial and marine domains showing: on the front the description, representative photo; on the back the type, synonyms, implementation areas, and the expected performance towards the 12 societal challenges of the European Roadmap on NbS (EL Harrak and Lemaitre 2023).

ronmental engineers and ecologists (acting mostly in terrestrial and marine domains). For this reason, implementation areas in the urban domain are defined by scale and functions (e.g., building-scale solutions such as roofs and walls, or linear infrastructure such as roads and railways); in the terrestrial domain they are defined by hazard- and disturbances (e.g., erosion prone-areas); while in the marine domain they follow ecosystem categories (e.g., macroalgal forests, oyster reefs).

Step 4: Societal challenge selection. Finally, users shall select the societal challenges – beyond enhancing biodiversity, which is, by definition, inherent to all NbS – that the NbS intervention aims to address. The 12 global challenges[10] derive from the NetworkNature roadmap (EL Harrak and Lemaître 2023) resulting from the integration of the IUCN (2020b) and the EC (Dumitru and Wendling 2021) frameworks.

The outcome of the stepwise procedure is a list of ranked theoretical NbS (displaying scores from 1 to 3) relative to the selected societal challenges. The ranking is based on an expert-based, semi-quantitative evaluation based on a shared framework developed for both theoretical solutions and case studies, and consisting of three key performance indicators (KPI) for each of the 12 challenges. These indicators were adapted from the EC handbook (Cardinali et al. 2021) to ensure comparability among all the NbS across the different domains (urban, terrestrial, marine). The identified NbS are also presented as synthetic double-sided cards (Figure 5) whose front side provides a brief description and a representative photograph of a real case study, while the reverse includes information on NbS-type, implementation areas, synonyms, and the performance scores towards all 12 societal challenges (ranging from 0 to 3).

[10] The societal challenges as listed in the NetworkNature EU Roadmap to 2030 (EL Harrak and Lemaître 2023) are: 1) Climate Resilience, 2) Water Management, 3) Food Security, 4) Social Justice and Social Cohesion, 5) New Economic Opportunities and Green Jobs, 6) Participatory Planning and Governance, 7) Natural and Climate Hazards, 8) Health, Well-being and Air Quality, 9) Green Space Management, 10) Place Regeneration, 11) Knowledge and Social Capacity Building for Sustainable Urban Transformation, 12) Biodiversity enhancement.

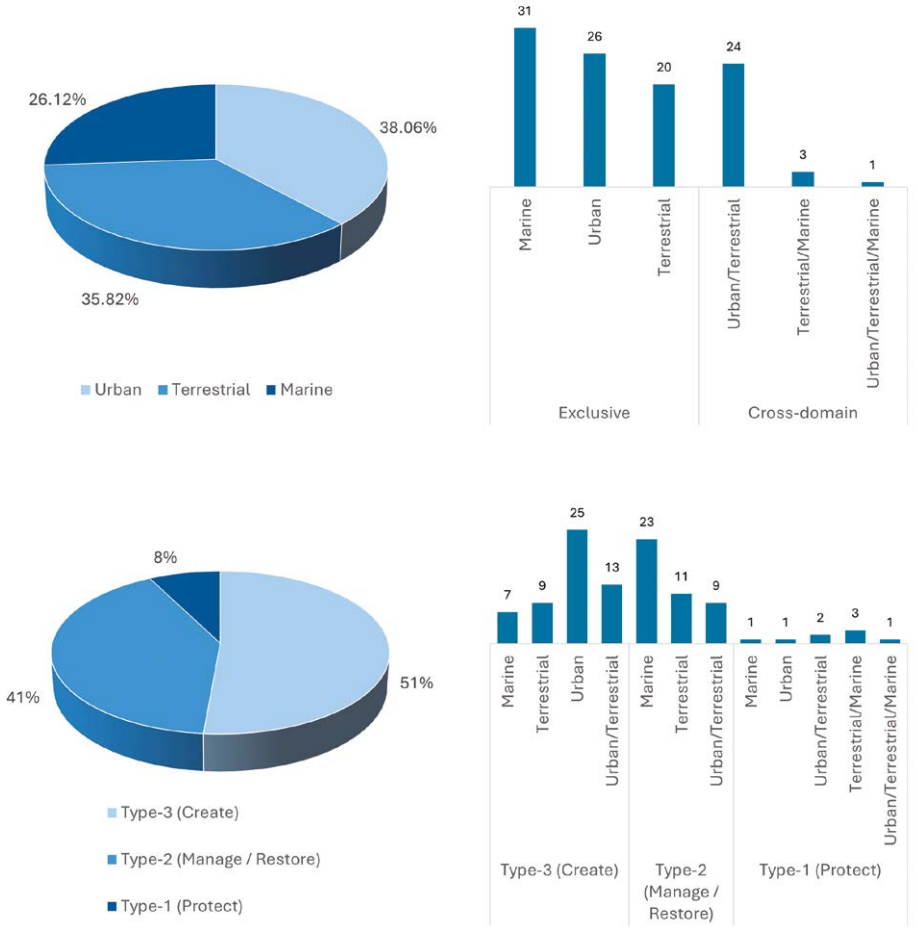


Fig. 6 – Theoretical NbS (a) grouped according to domains, (b) disentangled into exclusive (belonging to one domain only) and cross-domains (belonging to multiple domains), and (c) grouped according to NbS-types, (d) disentangled into NbS-types, domains and cross-domains.

Each NbS is further documented in detail, providing, in-depth description, the associated ecosystems[11], and an explanation behind the expert-based evaluation for all positively scored challenges. Additionally, the detailed sheet provides the link to available case studies, a reference list, and the contact details of the 'curators' responsible for compiling both the synthetic card and the detailed sheet for the corresponding NbS.

All the parameters used to characterise each NbS serve as screening fields within the *learning tool* functionality, which enables users to navigate the contents and search for specific NbS without constraints, for example by using NbS names, synonyms, or associated ecosystems. This functionality is intended to support students, citizens, and planners, particularly in co-design processes, by offering accessible and flexible exploration options.

These two functionalities – the NbS selection tool and Learning tool – are enabled by a structured NbS taxonomy encompassing more than 100 solutions, categorised by NbS-types and domains, which forms the core of the NbS database. The DSS tax-

[11] The classification of the ecosystems follows Maes et al. (2020) and El Harrak and Lemaitre (2023) and consists of 10 ecosystems: urban ecosystem; open ocean; costal ecosystems; rivers, lakes and ponds; forests; grasslands; croplands; wetlands; heathlands and shrubs; sparsely vegetated lands

onomy is the result of a comparative analysis of existing and widely recognised NbS catalogues (Castellar et al. 2021; Debele et al. 2023; Dumitru and Wendling 2021; Eisenberg et al. 2022; Nature4cities 2018; NWRM 2015; Riisager-Simonsen et al. 2022; Somarakis et al. 2019; URBAN GreenUP 2018; World Bank 2021), which has been further expanded drawing on the expert knowledge contributed by the domain-specific working groups (WGs).

Most of the NbS included in the DSS belong to the Marine domain (Figure 6a), whereas cross-domain NbS were largely associated with Urban-Terrestrial systems (Figure 6b), emphasising the strong connection between terrestrial and urban NbS, but a relative disconnection between these and the Marine domain. The majority of classified NbS were of type 3 (create), followed by type 2 (restore/enhance/manage) and type 1 (protect/conserve) (Figure 6c). Most of the type 2 NbS, were predominantly associated with the Marine domain, while type 3 NbS were mostly with the Urban domain, highlighting the hybrid nature of NbS across terrestrial ecosystems, where actions for the restoration or creation occur in nearly equal numbers (Figure 6d).

Finally, the third functionality of the DSS is the *case study finder,* which is based on the Case Studies Database: a comprehensive collection of national NbS real-world examples[12] drawn from well-established repositories such as Oppla and NetworkNature' shared database[13], and GeoIKP, as well as from pilot projects conducted within the NBFC. The case studies can be freely explored using various screening criteria such as the NbS name following the DSS taxonomy, the associated ecosystem, domain and implementation areas, consistent with the metadata structure of the NbS database. They can also be selected directly on a map by clicking on georeferenced points.

Each case is presented, similarly to the theoretical NbS, through a synthetic card and detailed sheet providing further information. Moreover, in the case of monitoring data, implemented NbS are evaluated using the same framework applied for the theoretical NbS by providing information on their impact level, namely 'no impact' (=0), 'positive impact' (1), 'negative impact' (-1), and 'not addressed' (= NA). This evaluation is accompanied by a reasoned justification on the detailed sheet, along with links to data repositories or a contact person for data access, and in some cases, to the IUCN self-assessment evaluation[14] (IUCN 2020b).

3. Conclusive remarks and further developments

The NbS CataTool was conceived as a technological and digital solution that supports the design of efficient and resilient NbS, grounded in evidence and scientific research and aligned with the major European initiatives, such as NetworkNature, IUCN, and Biodiversa partnership. In addition, it can serve as an operational tool to support the implementation of the EU Nature Restoration Regulation and the EU Biodiversity Strategy, for both national restoration and urban nature plans (European Union 2025).

The presented DSS is a product of the NBFC, developed with the involvement of 70 researchers from 19 institutions and harmonised by a central team (activity coordinators) responsible for both the conceptual framework and the coordination of the

[12] Case studies are shown on the NbS Italy hub webpage and are continuously being collected thanks to users and interested partners https://www.nbsitalyhub.it/en/nbs-case-studies/

[13] The case study database is available either on Oppla https://oppla.eu/case-study-finder or NetworkNature https://networknature.eu/networknature/resources/networknature-case-studies websites

[14] IUCN self-assessment tool is available at https://nbs-sat.iucn.org/

Fig. 7 – Institutions involved in the coordination and development of the NbS CataTool Decision Support System.

domain-specific expert WGs (Figure 7). The WG members (i.e., NbS and case study curators) contributed up-to-date content (e.g., NbS descriptions and case studies collection) and evaluated both theoretical NbS and case studies.

Compared to similar online DSS, such as the GeoIKP NbS toolkit[15], ClimateApp[16] and the NbS Performance Assessment Tool[17], the NbS CataTool is a unique example of a comprehensive, evidence-based nomenclature standardisation effort (Bologna and Hasanaj 2023). It integrates solutions across urban, terrestrial and marine domains and related ecosystems, with a focus on the Mediterranean area, and it is built upon a wide corpus of scientific research (e.g., reference lists included in the detailed sheets). Moreover, it is a solid prototype adopting a simplified evaluation framework centred on global environmental, social, and economic challenges, thereby aligning with both the UNEA definition of NbS (Nature-Based Solutions for Supporting Sustainable Development 2022) and the IUCN global standard for NbS (IUCN 2020b). By contrast, other DSS, despite offering other relevant information (e.g., costs and policies) and useful functionalities (e.g., spatially explicit background data), cover a narrower scope. For example, the GeoIKP platform and toolkit focus exclusively on risk reduction (e.g., erosion, flood, drought and landslide), while both ClimateApp and NbS Performance Assessment Tool focus solely on solutions for the urban context, ranked respectively according to adaptation targets (i.e. flooding, heat, drought) and to ecosystem services (i.e., regulating, cultural, supporting, and provisioning).

To conclude, the presented product is continuously evolving prototype that can be further expanded with more advanced functionalities developed in collaboration with diverse stakeholders. For example, case studies could be regularly updated with monitoring data to provide information on the performance related to context-specific challenges, and associated costs. The NbS Selection Tool could be strengthened by

[15] GeoIKP toolkit can be accessed at https://geoikp.operandum-project.eu/nbs/toolkit

[16] Climateapp tool can be accessed at https://climateapp.nl/

[17] The nature-based solutions performance assessment can be accessed at https://icra.shinyapps.io/nbs-list/

adding practical and technical guidance and by ensuring interoperability with external platforms to integrate spatial data, public datasets, and spatial analysis models for identifying suitable intervention areas. Finally, the inclusion of a plant species selection functionality would offer more practical, context-specific recommendations, supported by contributions from nurseries and firms.

References

Balian, E., H. Eggermont, e X. Le Roux. 2014. *Output of the Strategic Foresight Workshop 'Nature-Based Solutions in a BiodivERsA Context'*. BiodivERsA Report. Brussels: BiodivERsA. https://www.biodiversa.org/687/download (2025-08-25).

Bianciardi, Alessandro, Niccolò Becattini, e Gaetano Cascini. 2023. "How Would Nature Design and Implement Nature-Based Solutions?" *Nature-Based Solutions* 3: 100047. https://doi.org/10.1016/j.nbsj.2022.100047.

Bologna, Roberto, e Giulio Hasanaj. 2023. "Advanced Models for the Construction of an NbS Catalogue for Resilience and Biodiversity." *AGATHÓN | International Journal of Architecture, Art and Design* 13: 179-90. https://doi.org/10.19229/2464-9309/13152023.

Cardinali, Marcel, Adina Dumitru, Sofie Vandewoestijne, e Laura Wendling. 2021. *Evaluating the Impact of Nature-Based Solutions. A Summary for Policy Makers*. Luxembourg: Publications Office of the European Union. https://doi.org/10.2777/2219.

Castellar, J.A.C., L.A. Popartan, J. Pueyo-Ros, et al. 2021. "Nature-Based Solutions in the Urban Context: Terminology, Classification and Scoring for Urban Challenges and Ecosystem Services." *Science of the Total Environment* 779: 146237. https://doi.org/10.1016/j.scitotenv.2021.146237.

Catalano, Chiara, Alessandro Campiotti, e Chiara Baldacchini. 2024. *Possible Ways to Foster the Uptake of Nature-Based Solutions*. Biodiversa+. https://doi.org/10.5281/zenodo.14946288.

Cohen-Shacham, E., G. Walters, C. Janzen, e S. Maginnis, a cura di. 2016. *Nature-Based Solutions to Address Global Societal Challenges*. Gland, CH: IUCN. https://doi.org/10.2305/IUCN.CH.2016.13.en.

Cohen-Shacham, Emmanuelle, Angela Andrade, James Dalton, et al. 2019. "Core Principles for Successfully Implementing and Upscaling Nature-Based Solutions." *Environmental Science & Policy* 98: 20-29. https://doi.org/10.1016/j.envsci.2019.04.014.

Convention on Biological Diversity. 2022. *Kunming-Montreal Global Biodiversity Framework*. CBD/COP/DEC/15/4. https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf (2025-08-25).

Debele, Sisay E., Laura S. Leo, Prashant Kumar, et al. 2023. "Nature-Based Solutions Can Help Reduce the Impact of Natural Hazards: A Global Analysis of NBS Case Studies." *Science of the Total Environment* 902: 165824. https://doi.org/10.1016/j.scitotenv.2023.165824.

Dumitru, Adina, e Laura Wendling, a cura di. 2021. *Evaluating the Impact of Nature-Based Solutions: A Handbook for Practitioners*. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2777/244577.

Dunlop, Thomas, Danial Khojasteh, Emmanuelle Cohen-Shacham, et al. 2024. "The Evolution and Future of Research on Nature-Based Solutions to Address Societal Challenges." *Communications Earth & Environment* 5, 1: 1-15. https://doi.org/10.1038/s43247-024-01308-8.

Eggermont, Hilde, Estelle Balian, José Manuel N. Azevedo, et al. 2015. "Nature-Based Solutions: New Influence for Environmental Management and Research in Europe." *GAIA - Ecological Perspectives for Science and Society* 24, 4: 243-48. https://doi.org/10.14512/gaia.24.4.9.

Eggermont, Hilde, Xavier Le Roux, Magnus Tannerfeldt, Josefina Enfedaque, e Karin Zaunberger. 2021. *Strategic Research & Innovation Agenda Horizon Europe Partnership on Biodiversity*. Biodiversa+. https://www.biodiversa.eu/wp-content/uploads/2022/12/strategic-research-innovation-agenda.pdf (2025-08-25).

Eisenberg, Bernd, Cecilia Chiesa, Leonie K. Fischer, Kristen Jakstis, Vera Polcher, e Hans-Georg Schwarz-v.Raumer. 2022. *Nature-Based Solutions. Technical Handbook Factsheets*. UNaLab

Urban Nature Labs e Institut für Landschaftsplanung und Ökologie – ILPÖ. https://unalab.eu/system/files/2022-11/unalab-nbs-technical-handbook-factsheets2022-11-17.pdf (2025-08-25).

El Harrak, Mariem, e Frédéric Lemaître. 2023. *European Roadmap to 2030 for Research and Innovation on Nature-Based Solutions*. NetworkNature. https://networknature.eu/sites/default/files/old_files/uploads/eu-ri-roadmapweb.pdf (2025-08-25).

ENACT. 2024. *State of ENACT NbS Goals Report: Year One Roadmap*. Gland, CH: International Union for Conservation of Nature. https://enactpartnership.org/wp-content/uploads/2024/12/iucn_enact_report_full_25mar_final-compressed.pdf (2025-08-25).

European Commission. 2015. *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"*. Luxembourg: Publications Office of the European Union. https://doi.org/10.2777/765301.

European Commission. 2019. *The European Green Deal*. COM(2019) 640 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640 (2025-08-25).

European Commission. 2020. *EU Biodiversity Strategy for 2030*. COM(2020) 380 final. https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF (2025-08-25).

European Commission. 2021a. *Forging a Climate-Resilient Europe – The New EU Strategy on Adaptation to Climate Change*. COM(2021) 82 final. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0082 (2025-08-25).

European Commission. 2021b. *Facts and Figures: The EU's 2021-2027 Long-Term Budget and Next Generation EU*. Luxembourg: Publications Office of the European Union.

European Commission. 2025. *Nature-Based Solutions: EU-Funded NbS Research Projects Tackle the Climate and Biodiversity Crises*. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2848/2744053.

European Commission. s.d. "Nature-Based Solutions." *Research and Innovation*. https://research-and-innovation.ec.europa.eu/research-area/environment/nature-based-solutions_en (2025-08-25).

European Parliament and Council of the European Union. 2021. *Regulation (EU) 2021/1119 of 30 June 2021 Establishing the Framework for Achieving Climate Neutrality ("European Climate Law")*. L 243/7. http://data.europa.eu/eli/reg/2021/1119/oj (2025-08-25).

European Parliament and Council of the European Union. 2024. *Regulation (EU) 2024/1991 on Nature Restoration*. https://eur-lex.europa.eu/eli/reg/2024/1991/oj/eng (2025-08-25).

European Union. 2025. *The Nature Restoration Regulation*. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2779/5842922.

Faivre, Nicolas, Marco Fritz, Tiago Freitas, Birgit de Boissezon, e Sofie Vandewoestijne. 2017. "Nature-Based Solutions in the EU: Innovating with Nature to Address Social, Economic and Environmental Challenges." *Environmental Research* 159: 509-18. https://doi.org/10.1016/j.envres.2017.08.032.

ICCD/COP(15)/23/Add.1. 2022. *United Nations Convention to Combat Desertification: Report of the Conference of the Parties on Its Fifteenth Session*. https://www.unccd.int/sites/default/files/2022-10/ICCD_COP%2815%29_23_Add.1-2208672E.pdf (2025-08-25).

IPBES. 2019. *Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services*. Zenodo. https://doi.org/10.5281/zenodo.3553579.

IPCC. 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, a cura di H.-O. Pörtner, D.C. Roberts, M. Tignor, et al. Cambridge: Cambridge University Press. https://doi.org/10.1017/9781009325844.

International Union for Conservation of Nature. 2020a. *Guidance for Using the IUCN Global Standard for Nature-Based Solutions: A User-Friendly Framework for the Verification, Design and Scaling up of Nature-Based Solutions*. First Edition. Gland, CH: IUCN. https://doi.org/10.2305/IUCN.CH.2020.09.en.

International Union for Conservation of Nature. 2020b. *IUCN Global Standard for Nature-Based Solutions. A User-Friendly Framework for the Verification, Design and Scaling up of NbS*. First Edition. Gland, CH: IUCN. https://doi.org/10.2305/IUCN.CH.2020.08.en.

Lemaître, Frédéric, e Xavier Le Roux. 2021. *Analysis of the Outputs of BiodivERsA Funded Projects. Projects Completed over 2014 to 2018*. BiodivERsA. https://www.biodiversa.eu/wp-content/uploads/2022/12/ouputs-funded-projects.pdf (2025-08-25).

Maes, Joachim, Anne Teller, Markus Erhard, et al. 2020. *Mapping and Assessment of Ecosystems and Their Services: An EU Wide Ecosystem Assessment in Support of the EU Biodiversity Strategy*. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2760/757183.

Nature4Cities. 2018. *NBS Multi-Scalar and Multi-Thematic Typology and Associated Database*. D1.1. https://www.nature4cities.eu/_files/ugd/55d29d_8813db2df690497e80740537b6a8a844.pdf (2025-08-25).

Nesshöver, Carsten, Timo Assmuth, Katherine N. Irvine, et al. 2017. "The Science, Policy and Practice of Nature-Based Solutions: An Interdisciplinary Perspective." *Science of the Total Environment* 579: 1215-27. https://doi.org/10.1016/j.scitotenv.2016.11.106.

NWRM. 2015. "Catalogue of Water Retention Measures." http://nwrm.eu/measures-catalogue (2025-08-25).

Riisager-Simonsen, Christian, Gianna Fabi, Luc van Hoof, Noél Holmgren, Giovanna Marino, e Dennis Lisbjerg. 2022. "Marine Nature-Based Solutions: Where Societal Challenges and Ecosystem Requirements Meet the Potential of Our Oceans." *Marine Policy* 144: 105198. https://doi.org/10.1016/j.marpol.2022.105198.

Seddon, Nathalie, Alison Smith, Pete Smith, et al. 2021. "Getting the Message Right on Nature-Based Solutions to Climate Change." *Global Change Biology* 27, 8: 1518-46. https://doi.org/10.1111/gcb.15513.

Somarakis, Giorgos, Stavros Stagakis, Nektarios Chrysoulakis, et al. 2019. *ThinkNature Nature-Based Solutions Handbook*. Zenodo. https://zenodo.org/records/7813619 (2025-08-25).

United Nations Environment Assembly. 2022. *Nature-Based Solutions for Supporting Sustainable Development*. UNEP/EA.5/Res.5. https://www.unep.org/resources/resolutions-treaties-and-decisions/UN-Environment-Assembly-5-2 (2025-08-25).

United Nations Framework Convention on Climate Change. 2023. *Sharm El-Sheikh Implementation Plan*. Decision 1/CP.27, FCCC/CP/2022/10/Add.1. https://unfccc.int/sites/default/files/resource/cp2022_10a01_E.pdf (2025-08-25).

URBAN GreenUP. 2018. *Urban GreenUP – D1.1: NBS Catalogue*. Innovation Action – Grant Agreement No. 730426. https://www.urbangreenup.eu/insights/deliverables/d1-1---nbs-catalogue.kl (2025-08-25).

Voskamp, Ilse M., Claudia de Luca, Monserrat Budding Polo-Ballinas, Helena Hulsman, e Reinder Brolsma. 2021. "Nature-Based Solutions Tools for Planning Urban Climate Adaptation: State of the Art." *Sustainability* 13, 11: 6381. https://doi.org/10.3390/su13116381.

World Bank. 2008. *Biodiversity, Climate Change and Adaptation: Nature-Based Solutions from the World Bank Portfolio*. Washington, DC: The World Bank. https://documents1.worldbank.org/curated/en/149141468320661795/pdf/467260WP0REPLA1sity1Sept020081final.pdf (2025-08-25).

World Bank. 2021. *A Catalogue of Nature-Based Solutions for Urban Resilience*. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/36507 (2025-08-25).