



The economics of nature-based solutions.

Deliverable 3.1: Economic & financial performance of NbS, including the insurance value of NbS

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TABLE OF CONTENTS

Abbreviations and Acronyms.....	8
Executive Summary	9
1. Introduction.....	11
1.1. Purpose and Target Group	14
1.2. Contributions of Partners	15
2. Methodology	16
2.1. Case analyses of insurance value of NbS.....	16
2.2. Systematic literature review	17
3. Insurance value of NbS – case analyses	21
3.1. Lech River restoration, Tyrol, Austria	21
3.1.1. Scoping	21
3.1.2. Assessment methods and data.....	22
3.1.3. Results	24
3.1.4. Discussion on Investment Strategy design & insurance value assessment....	27
3.1.5. Conclusions	28
3.2. Rewilding of Ribeira Das Vinhas in Cascais, Portugal	29
3.2.1. Scoping	29
3.2.2. Assessment methods and data.....	30
3.2.3. Results	33
3.2.4. Discussion on Investment Strategy design & insurance value assessment....	36
3.2.5. Conclusions	39
4. Economic & financial performance of NbS.....	40
4.1. General overview of NbS economic assessment studies	40
4.2. Water management	48
4.3. Urban areas.....	58
4.4. Coastal & marine areas	66
4.5. Forests	70
4.6. Agriculture	78
4.7. Mountains.....	87
5. Summary of key findings.....	93
5.1. Insurance value of NbS – two implementation cases	93
5.2. Literature review of NbS economic assessments.....	94
6. Discussion & conclusion	97
7. References	99

Annex A – Literature search protocol.....	109
Annex B – Data extraction variables.....	112
Annex C – Water management thematic area studies	124
Annex D – Urban landscape studies.....	132
Annex E – Coastal & marine landscape studies	141
Annex F – Forest landscape studies.....	146
Annex G – Agriculture landscape studies	155
Annex H – Mountain landscape studies.....	161
Annex I - Studies included in data extraction	163

LIST OF TABLES

Table 1. NbS typologies	12
Table 2. Generic and specific benefit categories.	13
Table 3. Contributions of Partners	15
Table 4. Number of buildings affected by flood events by building category.	25
Table 5. Value-at-Risk (VaR) for municipalities in Tyrol and at the Lech River, for Scenarios with and without NbS.	25
Table 6. Number of studies by EU region - all studies	41
Table 7. Number of studies by NbS typology and landscape – all studies	42
Table 8. Rank of challenges addressed across all studies.....	43
Table 9. Benefit assessment approaches.....	45
Table 10. Benefit assessment approaches by landscape/thematic area by number of studies	46
Table 11. Benefit assessment approaches by landscape/thematic area by number of observations.....	46
Table 12. BCR summary statistics.....	47
Table 13. Benefit Cost Ratios across landscapes/thematic areas.....	48
Table 14. Number and percentage of water management related NbS assessment studies across regions.	50
Table 15. Number of studies per water management NbS action.	51
Table 16. Rank of challenges addressed in water management NbS assessment studies	52
Table 17. Assessment approaches applied in water management per number of studies and observations.	53
Table 18. Statistics of BCR analyses, water management landscape.....	54
Table 19. BCR values per type of NbS action in water management NbS assessment studies.	55
Table 20. Number and percentage of urban NbS assessment studies across European regions.....	59
Table 21. Number of studies per urban NbS action.	60
Table 22. Rank of challenges addressed in urban NbS assessment studies.	60
Table 23. Assessment approaches applied in urban landscape per number of studies and observations.	62
Table 24. Statistics of BCR analyses, urban landscape	63
Table 25. BCR values per type of NbS action in the urban landscape.	63
Table 26. Number and percentage of coastal NbS assessment studies across European regions.	66
Table 27. Number of studies per coastal NbS action.	67
Table 28. Rank of challenges addressed in coastal NbS assessment studies.	68
Table 29. Assessment approaches applied in coastal landscapes per number of studies and observations.	69
Table 30. BCR values per type of NbS action in the coastal landscape.	70
Table 31. Number and percentage of forest studies across European regions.	71
Table 32. The count and percentage of studies representing different forest NbS actions.	72
Table 33. Rank of challenges addressed in forest NbS assessment studies.....	73
Table 34. Assessment approaches applied in forest landscapes per the number of studies and observations.	74
Table 35. Descriptive statistics of BCR analyses, forest landscape.	75
Table 36. Descriptive statistics of benefit-cost ratios (BCR) of forest NbS actions.	75
Table 37. Number and percentage of agricultural NbS assessment studies across European regions.	79
Table 38. Number of studies per agricultural NbS action.	80
Table 39. Rank of challenges addressed in agricultural NbS assessment studies.	81
Table 40. Assessment approaches applied in agriculture landscape per number of studies and observations.....	83
Table 41. Statistics of BCR analyses, agricultural landscape.....	84
Table 42. BCR values per type of NbS action in the agricultural landscape.	84
Table 43. Number and percentage of mountain NbS assessment studies across European regions.	87

Table 44. Number of studies per mountain NbS action.....	88
Table 45. Rank of challenges addressed in mountain NbS assessment studies.....	88
Table 46. Overview of assessment approaches in mountain-focused NbS studies.....	90
Table 47. BCR values per type of NbS action in the mountain landscape.....	91
Table 48. Summary of economic and financial NbS assessment studies across landscapes/thematic areas.....	96

LIST OF FIGURES

Figure 1. Extended Total Economic Valuation Framework (TEV4Nature) through integration of Risk Management and insurance value of NbS.....	14
Figure 2. Procedure to determine the eligibility of studies/papers for data extraction.....	18
Figure 3. PRISMA diagram of the systematic review process.....	19
Figure 4. Overview of the Natura 2000 protected area “Naturpark Tyroler Lech” and measures taken within LIFE Lech Projects and accompanying measures.....	22
Figure 5. Estimated model-based distributions of overnight stays.....	27
Figure 6. Cascais municipality and Ribeira das Vinhas map in Portugal.....	29
Figure 7. Ribeira das Vinhas restoration interventions.....	30
Figure 8. Flood risk modelling results for the Ribeira das Vinhas area.....	33
Figure 9. Estimated flood-related damage to buildings based on the combination of flood maps and a flood depth-damage function.....	34
Figure 10. Spatial distribution of the population affected by flooding, categorized by classes of exposure.....	35
Figure 11. Spatial distribution of responses on perceived ecosystem services in the Ribeira das Vinhas area.....	36
Figure 12. Map of number of NbS economic assessment studies per country.....	40
Figure 13. Studies and observations by landscape/thematic areas.....	41
Figure 14. Number of studies by NbS typology – all studies.....	42
Figure 15. Specific challenges ranked as first and second priority in the studies.....	44
Figure 16. Map of number of water management related NbS assessment studies per country.....	50
Figure 17. Specific water management challenges ranked as first and second priority in the studies.....	52
Figure 18. Map of number of urban NbS economic assessment studies per country.....	58
Figure 19. Specific urban challenges ranked as first and second priority in the studies.....	61
Figure 20. Map of number of coastal NbS economic assessment studies per country.....	66
Figure 21. Specific coastal challenges ranked as first and second priority in the studies.....	68
Figure 22. Map of number of forest studies by country.....	71
Figure 23. Specific forest challenges ranked as first and second priority in the studies.....	73
Figure 24. Map of number of agricultural NbS assessment studies per country.....	78
Figure 25. Specific agricultural challenges ranked as first and second priority in the studies.....	82
Figure 26. Map of number of mountains NbS assessment studies per country.....	87
Figure 27. Specific mountain challenges ranked as first and second priority in the studies.....	89

ABBREVIATIONS AND ACRONYMS

ACRONYM	DESCRIPTION
AEB	Annual Equivalent Benefit
AEC	Annual Equivalent Cost
ATT	Average Treatment Effect of the Treated
BCR	Benefit Cost Ratio
BWV	Bundeswasserbauverwaltung
CBA	Cost-benefit analysis
DRR	Disaster Risk Reduction
EAD	Expected Annual Damage
EAPE	Expected Annual Population Exposed
ES	Ecosystem Services
ESG	Environmental, Social and Governance
EU	European Union
HAND	Height Above Nearest Drainage
HORA	Hazard Overview & Risk Assessment Austria
I4N	Invest4Nature
IRR	Internal Rate of Return
LCA	Life-cycle analysis
MCA	Multi-criteria analysis
MPA	Marine Protected Area
NbS	Nature-based Solutions
NPV	Net Present Value
OSM	Open Street Map
QTT	Quantile Treatment Effect
RUM	Random Utility Model
SuDS	Sustainable Urban Drainage System
VaR	Value-at-Risk
WTP	Willingness To Pay

EXECUTIVE SUMMARY

This report explores the economic and financial performance of Nature-based Solutions (NbS), with a particular emphasis on their insurance value, an emerging yet underutilised concept in NbS investment and decision-making. Developed within the Invest4Nature project, the report aims to improve the understanding of NbS as both financial risk management tools and key approaches to improving socio-ecological resilience in relation to health and wellbeing, pollution of air, soil and water, extreme events and socio-economic stability.

NbS are actions that protect, restore, and sustainably manage natural and modified ecosystems to address societal challenges. Despite their broad benefits, including climate adaptation and mitigation, biodiversity enhancement, and disaster risk reduction, NbS are significantly underfunded. A clearer articulation of their economic and financial returns and the inclusion of the multi-faceted insurance values of NbS is needed to mobilise investments at scale.

The report is based on two core components – a systematic literature review on the economic and financial performance of NbS, including the insurance value and in-depth analyses of large-scale NbS implementations from two Living Labs in the Invest4Nature project focusing on the insurance value. While the in-depth cases provide both new evidence and illustrates in detail application of different economic NbS assessments, the literature review provides an overview of how economic assessment studies of NbS, including the insurance value, have been applied across Europe. The literature review synthesises findings from 381 European studies assessing the economic performance of NbS across six landscape/land cover types:

1. urban,
2. water management,
3. agriculture,
4. coastal/marine,
5. forests,
6. mountains.

The studies employ a range of valuation methods, with non-market benefit approaches the being most common. Overall, NbS show promising economic returns, with median Benefit Cost Ratios generally above one across all landscapes—especially high in urban and water-related interventions. However, results vary substantially depending on NbS typology, geographic context, and the scope of costs and benefits included. Most studies focus on direct, monetisable impacts, with fewer capturing broader ecological or long-term benefits. Methodological gaps include inconsistent reporting of assumptions, limited treatment of uncertainty, and minimal integration of insurance-related or risk reduction values. Mountain appear understudied with relatively few studies.

The case analyses apply advanced valuation methods to two implemented NbS to quantify their insurance value. In Tyrol, Austria, the restoration of the Lech River using floodplain rewilding and sediment control infrastructure was assessed through a Value-at-Risk (VaR) framework. The intervention reduced average annual flood damage to buildings by approximately €85,000 and lowered capital-at-risk in a 1-in-200-year event by €4.2 million at the local level, and €1.8 million at the regional (Tyrol-wide) scale. Additional analysis found a positive influence on local tourism, with indications of increased overnight stays attributed to improved landscape quality.

In Cascais, Portugal, the rewilding of the Ribeira das Vinhas river was evaluated using the avoided damage cost method. The restoration reduced expected flood-related damage to

buildings by 43% and decreased the number of residents expected to be displaced in a major flood event by 60%. The number of slightly affected residents increased, showing a shift toward lower severity of exposure. A qualitative survey further confirmed perceived improvements in recreation, biodiversity, and climate regulation among local stakeholders. Together, the in-depth case results show that NbS can deliver quantifiable reductions in physical and financial risks while generating co-benefits that enhance ecological and social resilience.

1. INTRODUCTION

Nature underpins of our society and our economy by providing a multitude of essential provisioning, regulating, cultural and supporting ecosystem services (IPBES, 2019; MEA, 2005). When habitats are degraded or destroyed, those ecosystem services diminish and place our society at fundamental risk including food insecurity, weather-related natural disasters, natural resource shortages, critical change to earth systems, biodiversity loss and ecosystem collapse.

Already today, damage to natural habitats slows down the economy significantly (GFI and eci, 2024) and exposes specific sectors that depend directly on nature for their production such as agriculture with challenges in relation to soil quality and resilience against droughts and flooding; forestry with challenges in relation to wild fires, pests and storm damages; manufacturing, requiring stable, long-term supply chains of raw materials; and utilities, needing surface water for cooling power stations. More than half of the world's GDP is moderately or highly dependent on nature (WEF and PwC, 2020) and cascades of interconnected effects caused by biodiversity decline and climate change across various systems and geographies can escalate and exacerbate existing vulnerabilities and conflicts.

In urban areas, populations are particularly at risk from heat waves and hot days due to the urban heat island effect with heat representing the deadliest type of extreme weather in Europe and causing significant other health and wellbeing problems (EEA, 2022). Also, riverine, coastal and pluvial flooding causes the highest level of economic damages in Europe among extreme events and disrupts the economy and society (EEA, 2024), in particular in dense urban areas due to accelerated run-off from impermeable surfaces and the absence of natural vegetation to retain and percolate excess water.

The European Nature Restoration Regulation (EC, 2024), which entered into force in August 2024, is the first continent-wide comprehensive law of its kind, setting binding targets to restore ecosystems, habitats and species, notably at least 20% of Europe's degraded ecosystems on land and at sea by 2030 and 100% by 2050. With more than 80% of Europe's nature in poor condition, the regulation aims to ensure the long-term and continued recovery of biodiversity and resilient nature, to capture and store carbon, and to prevent and reduce the impacts of natural disasters. Targets have been specified for specific landscapes, including wetlands, forests, grasslands, rivers (including restoring river connectivity), lakes, heath & scrub, rocky habitats and dunes, marine ecosystems. Also, productive landscapes have targets to restore and increase habitats and species: in urban areas to halt the net loss and increase the amount of green urban space; in agricultural areas to increase grassland butterflies, pollinators and farmland birds, the stock of carbon and high-diversity landscape features. The regulation is a key element in the EU Biodiversity Strategy (EC, 2020) and in meeting the international commitment of the Kunming-Montreal Global Biodiversity Framework (CBD, 2023) in addition to supporting the EU Climate Law (EU, 2021) and the new EU Adaptation Strategy (European Commission, 2021).

Nature-based Solutions (NbS) are “actions aimed at protecting, conserving, restoring, and sustainably managing natural or modified terrestrial, freshwater, coastal, and marine ecosystems” (UNEA, 2022) with the purpose to “address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits” (idem). NbS are therefore central in the EU Nature Restoration Regulation, the Climate Law and Adaptation Strategy and are recognised by GBF and IPCC as important in addressing both the biodiversity and climate crises (GBF 2023; IPCC, 2022).

The full range of economic and societal benefits of NbS are not yet systematically integrated into decision-making and used to back the business and investment case for NbS. Nature restoration to increase resilience and rebalance biodiversity are significantly underfunded compared to the scale of restoration needs and the level of financing and public subsidies flowing towards nature negative economic activities. At global level, current financial flows to NbS are estimated at USD200 billion, but this amounts to only one third of the required funds to meet climate, biodiversity, and land degradation targets by 2030 (UNEP, 2023). Meanwhile, nature negative economic and financial systems continue to rapidly degrade nature with an estimated USD7 trillion per year of public and private financial flows negatively impacting nature (idem), representing 8.5 times more than the current finance of NbS.

This report seeks to address the scattered evidence of the economic and financial performance of NbS in Europe, including the insurance value of NbS by providing insights from a systematic literature review and presenting the results of in-depth analyses of two I4N Living Lab cases of large-scale implemented NbS that address multiple challenges including flood risk reduction, biodiversity improvement and strengthening of local tourism and recreation.

Previous work in Invest4Nature provides the basis and framing for the analysis in this report:

- Value categories and approaches to assess NbS economic and financial performance. Invest4Nature Deliverable D2.1 (Lozano et al., 2024).
- Theory and methods of incorporating risk reduction within the total economic valuation (TEV) framework (TEV4Nature). Invest4Nature Deliverable D2.2 (Chen et al., 2025a).

Lozano et al. (2024) provide the framing for understanding the different typologies of NbS (See Table 1) across different landscapes and land uses, describing the specific NbS actions and the underlying ecological processes that lead to the provision of multiple ecosystem services from each type of NbS action for each selected landscape and land use. Landscapes include coastal and mountain areas while land uses comprise urban, agriculture, forests and water management.

NBS TYPOLOGY		DESCRIPTION
NbS Type 1	Protection	No or minimal intervention in ecosystems, with the objective of maintaining or improving the delivery of ecosystem services
NbS Type 2	Modification	Management approaches that develop sustainable and multi-functional ecosystems in extensively/intensively managed landscapes, which improves the delivery of ecosystem services in relation to a more conventional intervention.
NbS Type 3	Creation	Management of ecosystems in very intrusive ways or creating new ecosystems, e.g. green roofs and walls or daylighting and renaturing underground piped streams.

Table 1. NbS typologies

Source : Lozano et al. (2024), based on Eggermont et al. (2015)

In addition to the different typologies of NbS, Lozano et al. offers an overview of generic and specific challenges that NbS can help alleviate, and the associated benefits, when NbS is successful. Five main challenges and associated benefits were identified (See Table 2):

1. adaptation to climate change,
2. mitigation of climate change,
3. disaster risk reduction,
4. environmental management, and
5. socio-economic challenges.

Generic and specific costs of implementing NbS were also categorised with the main elements of capital costs, operational costs, monitoring costs, financing costs, opportunity costs and indirect costs (See Tale 11 in Lozano et al., 2024). An overview of different NbS economic assessment approaches for incorporating the multitude of NbS benefits into decision-making also provides a map and insight into the complexity of assessing NbS benefits.

GENERIC BENEFITS	SPECIFIC BENEFITS
Adaptation to climate change	Reduced flood risks (rivers, wetlands, sea-level)
	Heat mitigation (Urban Heat Island)
	Alleviation of storm impacts
	Reduced incidents of droughts and water scarcity
Mitigation of climate change	Reducing impacts of climate change
Disaster risk reduction	Reduced damage from avalanches, landslides, earthquakes
Improved environmental quality	Reduced erosion
	Improved air quality
	Improved water quality
	Enhanced biodiversity
	Improved noise pollution
Socio-economic benefits	Improved economic possibilities and jobs
	Reduced economic challenges
	Improved health and well-being
	Improved equality, integration, environmental justice, social inclusion, including improved security and reduced crime rates
	Increased awareness and education
	Reduced energy-related challenges, sustainable transport patterns

Table 2. Generic and specific benefit categories.
Source: Lozano et al. (2024).

Chen et al. (2025a) provide the TEV4Nature framework, which is an extension of the traditional Total Economic Valuation (TEV) approach. The TEV4Nature framework seeks to capture the insurance value of Nature-based Solutions (NbS). By integrating the role of NbS in mitigating environmental and climate risks, supporting biodiversity, and enhancing social resilience, the framework identifies four key categories of insurance value:

- Value of protection **OF** nature – maintaining ecosystem functions and reducing risks,
- Value of protection **BY** nature – mitigating environmental and climate impacts,
- Social resilience value – contributing to community wellbeing,
- Value of ensuring the future – securing benefits for future generations.

These insurance value categories are systematically linked to the classical components of the TEV framework: direct use value, indirect use value, option value, existence value, altruistic value, and bequest value.

This report focuses on the insurance value of NbS in terms of the value of protection **OF** nature and the value of protection **BY** nature, while Chen et al. (2025b) focuses in particular on the social resilience value.

Chen et al., 2025a elaborates on how incorporating insurance values into valuation can inform business strategies related to nature investments, support ESG (Environmental, Social, and Governance) reporting, and mobilize finance to scale up NbS implementation. It further examines assessment methods suitable for quantifying insurance value, drawing from both traditional economic valuation and risk assessment approaches. Four key methodologies are detailed, of which two are applied in in-depth analyses in this study: Value-at-Risk and Avoided Damage Costs and two are applied in Chen et al., 2025b: Bayesian Belief Networks and Value Transfer Methods. Figure 1 illustrates the TEV4Nature framework applied in this report.

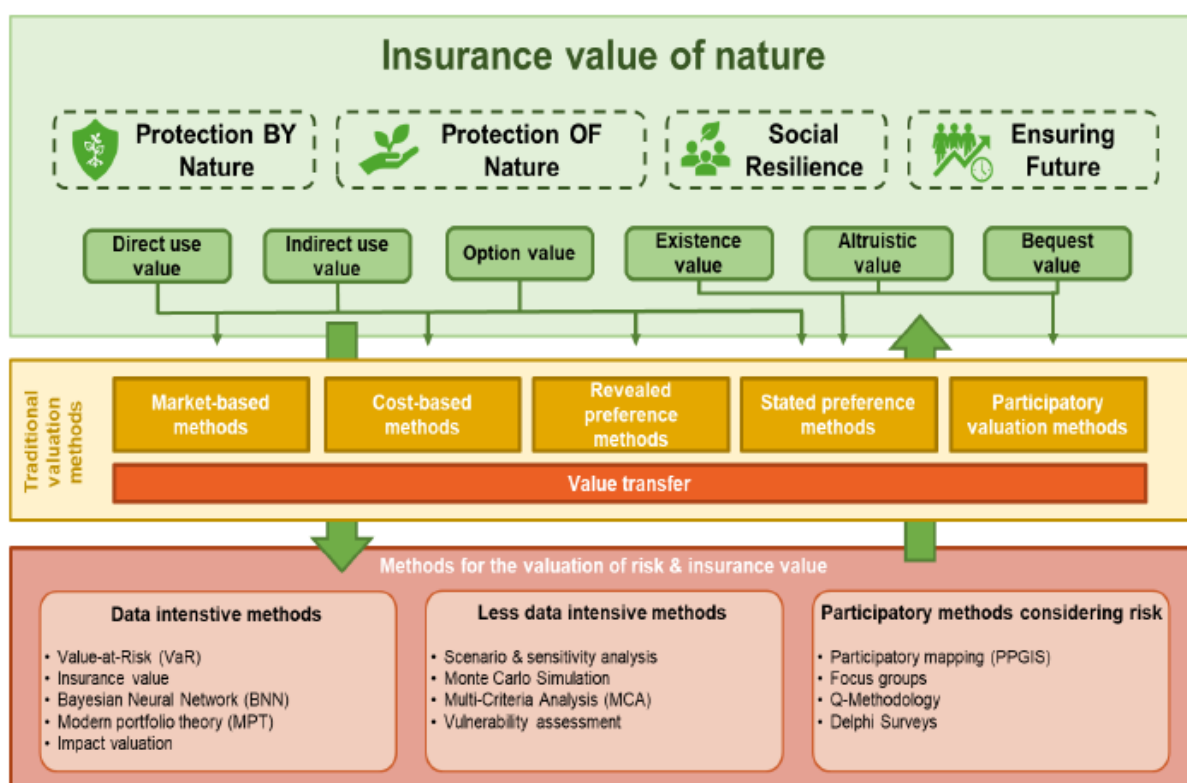


Figure 1. Extended Total Economic Valuation Framework (TEV4Nature) through integration of Risk Management and insurance value of NbS.

Source: Chen et al. (2025a)

1.1. PURPOSE AND TARGET GROUP

The purpose of D3.1 Economic financial performance of NbS including the insurance value of NbS is to collect and synthesise knowledge and evidence on the financial and economic performance of NbS based on an extensive literature review and in-depth analyses of the insurance value of NbS from Living Labs in the Invest4Nature project. The in-depth analyses of the insurance value of NbS are based on flood risk reduction in the region of Tyrol, Austria and the city of Cascais, Portugal.

This report targets practitioners, planners and policymakers along with researchers looking to obtain an overview of the economic and financial performance of NbS in Europe across the landscapes of urban, coastal/marine, agriculture, forests, mountains and the thematic area of water management.

1.2. CONTRIBUTIONS OF PARTNERS

Table 3 lists the main contributors from project partners in the development of this deliverable.

PARTNER SHORT NAME	CONTRIBUTIONS
AU	Study design and set-up, title & abstract screening; full text screening; data extraction. Writing of sections 1, 2,4,5,6. Read and edit entire report.
CMCC	Title & abstract screening; full text screening; data extraction. Analysis and writing of Sections 3 and 4, Read and edit entire report.
JR	Title & abstract screening; full text screening; data extraction and value at risk modeling. Analysis and writing of Sections 3 and 4. Read and edit entire report.
NIVA	Deep dive study design and contribution to flood risk analysis for Section 3.2. Title & abstract screening, data extraction. Analysis and writing of Section 4. Read and edit entire report.

Table 3. Contributions of Partners

2. METHODOLOGY

The overall methodology comprises:

- i) case individual approaches to assess the insurance value and economic impacts of implemented NbS in two different settings: a river restoration of the Alpine river Lech in Austria and a rewilding of the riverbed of Ribeira das Vinhas. Both NbS projects provide flood risk reduction to buildings and infrastructure along with biodiversity, tourism and recreational benefits; and
- ii) a systematic literature review of studies assessing the economic performance of NbS across landscapes and land uses in Europe.

The case analyses provide insights into the richness of context and the type of analysis that can be applied to assess the insurance value of nature, focusing on water management as one landscape/land use type while the literature review covers all six landscapes/land uses selected in the Invest4Nature project, providing wider insights into the economic performance of NbS across landscapes/land uses and challenge areas.

2.1. CASE ANALYSES OF INSURANCE VALUE OF NBS

The methods applied to analyse the insurance value of NbS in the in-depth cases comprise two data intensive methods that are especially designed to incorporate the risk reduction in the economic valuation:

Value-at-Risk (VaR) is a widely used risk management method that quantifies the potential loss of an investment or portfolio over a specified time period with a given confidence level. It estimates the maximum expected loss under normal market conditions, typically expressed as a probability. VaR has been regarded as a promising method to assess the NbS benefits under risks and to guide the investment decisions (Dige et al., 2023).

Avoided damage cost method can be used to assess insurance value of ecosystems by estimating the financial savings from risk reduction measures, such as NbS or infrastructure investments, that lower potential direct economic damages from environmental hazards (Le Coent et al., 2023; Olsen et al., 2015; Staccione et al., 2024). By comparing baseline damages to those under NbS implementation, the method captures the insurance value of nature, often reflected in changes in expected annual damage.

The methods are described in detail in Invest4Nature Deliverable D2.2 (Chen et al. 2025a) and summarised in Sections 3.1.2 and 3.2.2.

2.2. SYSTEMATIC LITERATURE REVIEW

We followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology (Moher et al., 2015), which involves four key stages to ensure transparency and rigor in the review process.

Stage 1: Developing the Research Plan

This initial phase involved defining the scope, objectives, and research questions guiding the systematic review. We began by identifying existing review articles to avoid duplication and to refine the focus of our work. The scope was shaped by insights from Deliverable 2.1, which provided an in-depth examination of Nature-based Solutions (NbS) across various landscape types. This deliverable also informed our understanding of the typology of NbS, the societal challenges they address, and the methodologies for assessing their economic value. In addition, we aligned our efforts with a parallel systematic review under Task 3.3, which examined financing and investment mechanisms, to ensure complementarity and avoid duplication.

Overall, the research plan was guided by the following questions:

1. What is the economic and/or financial performance of NbS for different landscapes/thematic areas?
2. How do Nature-based Solutions perform for different societal challenges and by landscape, sector or thematic area?

To ensure consistency and relevance, we established clear eligibility and exclusion criteria. As illustrated in Figure 2, studies were included in the final data extraction if they met the following four criteria. The studies:

- addressed Nature-based Solutions (NbS);
- contained quantitative, monetary assessments of costs and/or benefits;
- were linked to at least one of the landscape types covered in the I4N project: urban, agriculture, coastal and marine, mountain, or water management; and
- focused on analyses conducted within Europe.

This structured approach in Stage 1 was critical to ensuring that the review would be comprehensive, relevant, and aligned with the project's objectives.

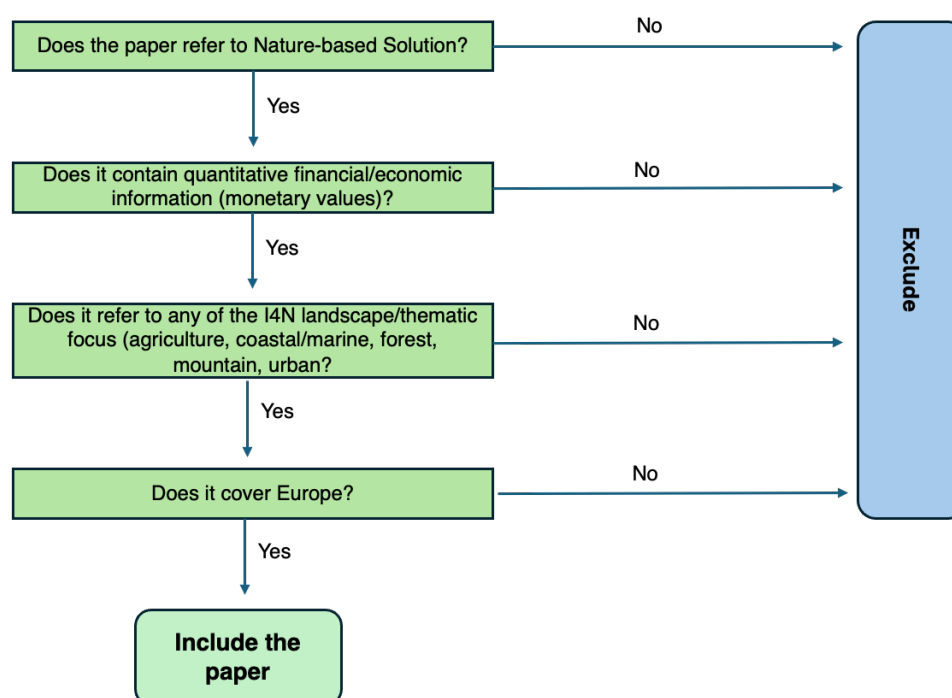


Figure 2. Procedure to determine the eligibility of studies/papers for data extraction.

Stage 2: Systematic literature search

To address the research questions, a comprehensive literature search protocol was developed. This protocol encompassed various types of Nature-based Solutions (NbS) and their associations with different landscape types, sectors, and thematic areas. The literature search specifically focused on publications reporting quantitative, financial, economic, or monetary values. A detailed outline of the search protocol is provided in Annex A – Literature search protocol.

The protocol was developed and refined through iterative discussions with research and project partners involved within the Invest4Nature project, ensuring its relevance and robustness. Once finalized, it was implemented across two prominent academic databases, namely Scopus and Web of Science, chosen for their extensive coverage of high-quality scholarly literature. Search queries were carefully designed to align with the study's objectives and targeted the titles, abstracts, and keywords of publications. The search spanned a five-year period (2018–2023). As a result of this systematic search, combined from both Scopus and Web of Science, 13445 entries were retrieved (see Figure 3).

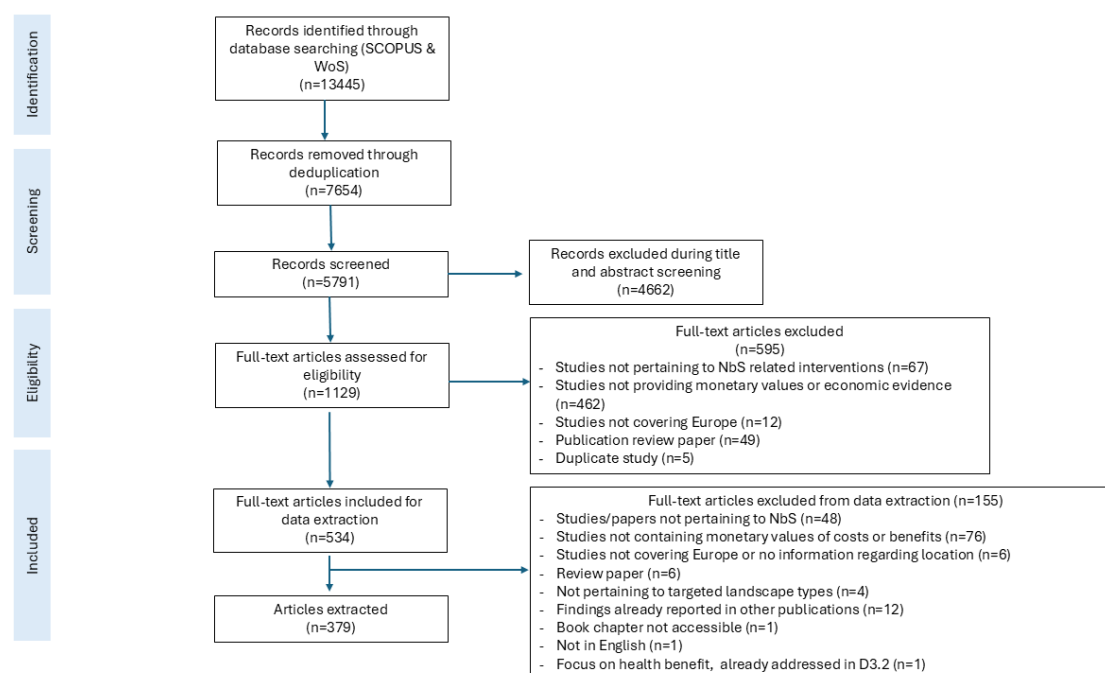


Figure 3. PRISMA diagram of the systematic review process

Stage 3: Review process

The results obtained from these databases were subsequently imported into Hubmeta (Steel et al., 2023), an online platform designed to facilitate the systematic review process. The review began with a deduplication step, where duplicate records identified across the two databases were automatically detected and removed. This ensured that only unique studies were included for subsequent analysis. At this stage, 7654 duplicates were removed, retaining 5791 entries. Following deduplication, the remaining 5791 records underwent a title and abstract review to identify studies that were potentially relevant to the research objectives. Studies that clearly fell outside the scope of the review were excluded at this stage. During the title and abstract screening, 4672 entries were excluded. The studies that passed this screening i.e. 1129 entries then proceeded to a full-text review, which involved a detailed evaluation of the content, methodology, and findings of each study to confirm their eligibility for inclusion in the review. The full text review identified 534 number of studies deemed relevant for inclusion in data extraction.

To ensure efficiency and consistency throughout the review process, especially given the involvement of multiple researchers, a set of clearly defined criteria was established to guide each step. These criteria provided a standardized framework for decision-making and minimized potential bias. At the outset of the review, a test exercise was conducted to align the researchers' understanding and interpretation of the inclusion and exclusion criteria. In this exercise, a fixed number of titles or articles were independently reviewed by all researchers, after which the team convened to discuss their reasoning, especially in cases of divergence. This process was repeated for both the title and abstract review stage and the full-text review stage, fostering consensus and a shared understanding among the team members.

As the review progressed, weekly meetings were held to facilitate communication within the research team. These meetings served as an opportunity to compare notes, resolve emerging issues, and ensure alignment with the established criteria. This collaborative approach helped maintain consistency and address challenges promptly, safeguarding the integrity of the review process.

Stage 4: Data Extraction

Once the full-text review was completed, the next phase involved data extraction for the studies that met the inclusion criteria. A data extraction template was developed and refined iteratively through discussions among the researchers. The data extraction template ensures consistency in capturing a broad range of information relevant to the study. It begins with bibliographic details, such as the title, authors, year of publication, and the type of research conducted. It then records information on the location and extent of the Nature-based Solutions (NbS) described in each study. The template also includes fields for identifying the type of NbS implemented, the landscape context, and the societal challenges the interventions aim to address. In addition, it gathers data on the physical effects of the NbS, along with any available cost and benefit information expressed in monetary terms. Finally, it documents the specific economic assessment methods employed. A complete list of the variables included in the data extraction process can be found in Annex B – Data extraction variables.

At this data extraction stage, the exclusion of irrelevant materials remained possible, as certain studies were found unsuitable during closer examination in the data extraction phase. Eventually, additional 155 number of studies were excluded from data extraction, primarily because they did not contain quantitative cost or benefit information in monetary terms. In the end, data from a total of 374 articles were extracted. Weekly meetings continued during this phase, providing a platform for researchers to share good practices and collectively address any challenges or emerging issues encountered during data extraction.

This systematic and collaborative process ensured that the literature review was conducted with transparency, rigor, and adherence to established standards.

3. INSURANCE VALUE OF NBS – CASE ANALYSES

This section outlines the scoping, assessment methods and data applied to assess the insurance value of NbS in terms of protection **BY** nature and protection **OF** nature in quantitative terms of the following two case studies:

- 1) **Austria, Tyrol** – Revitalization and restoration of the River Lech floodplain as a nature-based solution (NbS), assessed using Value at Risk (VaR) to evaluate NbS insurance values.
- 2) **Portugal, Cascais** – Rewilding of the Ribeira das Vinhas River as an urban-peri-urban NbS, assessed using avoided damage costs to estimate NbS insurance values.

Each case study contains a discussion of investment strategies and the type of insurance value assessment applied and concludes. Detailed methodological descriptions are available from Chen et al. (2025a). Additional two case studies are available on the values of protection **OF** nature, societal resilience values and values of ensuring the future in Chen et al. (2025b).

3.1. LECH RIVER RESTORATION, TYROL, AUSTRIA

3.1.1. SCOPING

The Lech is one of the last natural Alpine rivers in Austria and provides a habitat for a variety of endangered species. The Lech valley became a Natura 2000 protected area in 2000 and a nature park (Naturpark) in 2004. Since 2001, several revitalisation measures have been carried out along the 65km-long valley. First steps have been taken within a LIFE conservation project (2001-2007) where 50 measures have been implemented, which aimed to preserve and restore natural river habitats, stop the deepening of the riverbed and the lowering of groundwater, improve flood protection, protection of endangered animal and plant species and to raise awareness among the population (see Figure 4). The work was continued within a second LIFE restoration project (2016-2022), with 13 hydraulic measures to further reestablish natural river habitats and to provide additional retention areas as well as one measure for species protection (Office of the Tyrolean Regional Government, 2022).

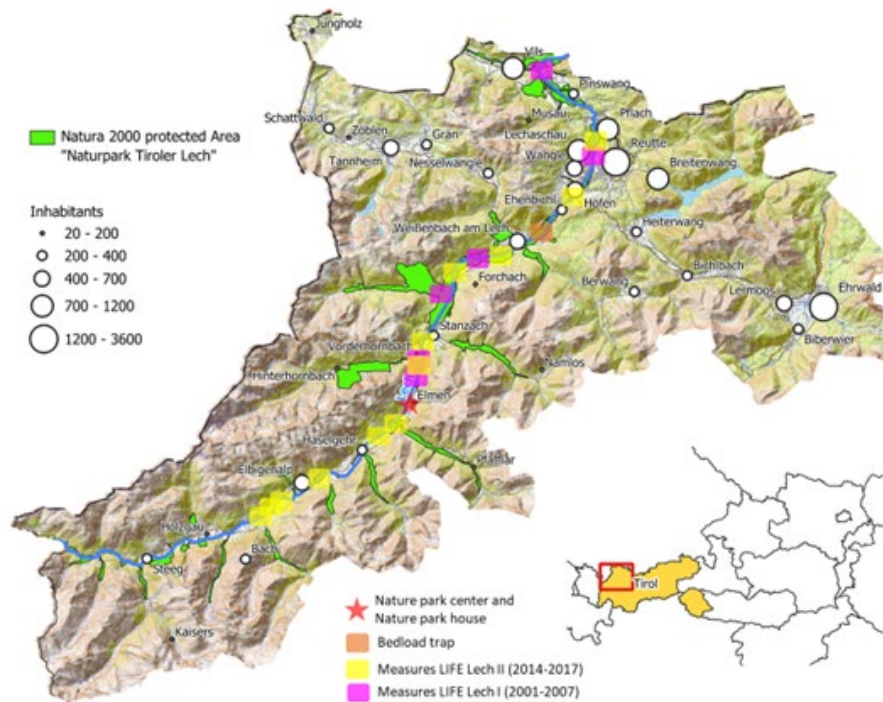


Figure 4. Overview of the Natura 2000 protected area "Naturpark Tyroler Lech" and measures taken within LIFE Lech Projects and accompanying measures

Source: Adapted from Office of the Tyrolean Regional Government (2022)

In addition to the LIFE projects, accompanying measures were taken, such as the construction of a bedload trap to control deposition and to ensure nature-friendly extraction of gravel. Additionally touristic infrastructure has been implemented like the Lech cycle path (Lechradweg) or the Nature Park House (Naturparkhaus). Many of the measures can be seen as nature-based solutions by replacing previously grey solutions with nature-based elements leading to a rewilding of the Lech River. Evaluating the impacts of the NbS implementations presents two main challenges. First, the project involves a wide range of different NbS actions spread across a large geographical area. Second, the implementation phase extends over a long period. Also, the available data is of different quality, frequency and time-series length. To address these issues, a Value-at-Risk (VaR) approach using various time series methods was developed. For flood risk, the analysis focused on expected damages near the Lech River as well as potential spill-over effects on the wider insurance system for Tirol. In the case of tourism, the impact on expected tourism demand was examined.

3.1.2. ASSESSMENT METHODS AND DATA

Method for flood risk

In general, economic risk is a function of three factors: (1) hazard, (2) exposure and (3) vulnerability (Cardona et al., 2012). Hazard represents the physical risk of flooding, including frequency and intensity, while exposure relates to the infrastructure at risk and vulnerability corresponds to the expected damages for a given hazard intensity.

Regarding flood hazard, different data sources are available. Two data sets from Austria's flood risk zoning 2011 and 2021 are available (Blöschl et al., 2021). Additionally, data exist from the federal state of Tyrol on flood areas from runoff studies produced by the Federal Hydraulic Engineering Administration (Bundeswasserbauverwaltung, BWV). According to

experts, the BWV data set, which is based on the local hazard protection plans, has the highest data quality for the Lech. Based on BWV data, buildings can be identified which are in an area with floods predictions of 30-, 100- or 300-year events. The data sets cannot be directly compared due to different approaches in data generation. This implies that these datasets with varying creation date cannot be used to derive changes over time. It is therefore necessary to collect additional information from project documents and from expert interviews to determine the impact of the renaturation measures. To collect data on the exposed infrastructure, there are several data sets on the building stock. The National Statistics Institute provides data on buildings on a 100 x 100 m grid. To generate data on the level of single buildings, data from OpenStreetMaps (OSM), a digital elevation model as well as address data were used.

This data has been integrated into an existing flood risk model for Austria which models regional interdependencies of flood risk events by a Brown-Resnick process¹ (Albrecher et al., 2020). The vulnerability is derived from the expected damage, which is adapted for the buildings in the BWV data set. Minor damage is assumed if the building is in the corresponding BWV zone (i.e. HQ30, HQ100, etc.) and major damage if it is also in the corresponding Natural Hazard Overview & Risk Assessment Austria (HORA) zones with a minimum water depth of 60 cm. Based on that, the following parameters have been calculated: The number of buildings in flood risk zones, the average area per building for the building categories (e.g. residential) the average annual damage per building category and buildings per building category.

The analysis focusses on the implementation of a bedload trap installed in the Lech. The bedload trap is constructed as a bypass channel of about 1km length within the riverbed, which reduces the flow velocity such that a controlled gravel deposition is achieved. This allows for easier removal of gravel and prevents deposition in other areas, thereby achieving a lower flood risk along the river. A possible biodiversity effect occurs, because the removal of gravel happens under controlled conditions within the trap and not in the mainstream. According to the project information, 300 buildings were protected from floods with this measure. From this, it is possible to calculate the difference between before and after treatment. To determine the spill-over effect in insurance to other regions by assuming a Tyrolean wide insurance for flood, in the sense that a reduced risk in one part of a region leads to an reduced expected yearly damage in total, the dependence of floods between the municipalities at the Lech river and other municipalities can be derived by the Brown-Resnick process (Albrecher et al., 2020). Based on this, the impact of protected infrastructure on the insurance premium for a whole region can be calculated.

Method for tourism

For tourism typically, several data sources of different frequency, length and quality are available. Regional statistical offices often collect and publish monthly information on overnight stays for most municipalities in a political region. In addition, daily counts of visitors of specific tourist attractions are available. For the LecP, the number of daily visits of the 'Nature Park' House and daily counts from cyclists counting stations give additional information on tourism demand. Therefore, to calculate the impact of a NbS solution a four-step procedure to estimate the NbS effect on VaR and ecosystem services was developed to make use of information from different data sources with different frequency, data quality and length of the time series. Especially if the implementation of a NbS solution extends over a longer period, additional

¹ The Brown-Resnick is a special max-stable Process that is often applied as a statistical model for the distribution of spatial extremes. Therefore it helps in understanding and predicting extreme events like heat waves, droughts, and floods.

factors such as global trends must be considered. The trend can be decomposed into two parts: (i) an overall (regional) trend in tourism demand and (ii) a local one. The impact of the NbS interventions on tourism can be derived by changes in the local trend in tourism demand.

The proposed four-step procedure consists of the following steps: Step 1: the estimation of an adequate (dynamic) panel data model by regressing the variable of interest, i.e. for which the VaR should be estimated, on the associated risk-drivers. This step already permits the analysis of relevance and significance of the latter. However, a careful variable selection is crucial for the following steps. Step 2: once the relevant risk drivers are selected, their joint probability distribution is estimated (conditional on the variable of interest) using nonparametric techniques (Li and Racine, 2006). Step 3: subsequently, with a rejection sampling procedure (see, for example, (Martino and Míguez, 2011)), random samples of this target probability distribution can be generated. Step 4: finally, predictions for the latter, based on the estimated panel data model from Step 1, help recover the probability distribution of the target variable and thus the calculation of the VaR in each point of time and for everyone in the panel data set.

The proposed procedure makes it also possible to aggregate over a set of individuals and conduct a model-based impact evaluation (see, for example, (Frölich and Sperlich, 2019)) based on the full distribution of the variable of interest. This is an advantage over standard research which relies on program evaluation techniques and focuses on estimating the Average Treatment Effect on the Treated (ATT). Clearly, the interest of a VaR analysis lies in the tails of a probability distribution and not in its mean. Commonly, Difference in Difference Assumptions are employed to credibly identify the ATT (see, for example, (Card, 1990), or Card and Krueger, 1994). We follow Callaway and Li (2019) instead who provide identification and estimation for the Quantile Treatment Effect of the Treated (QTT) under a Distributional Difference in Difference Assumption. However, our target is not the pure QTT itself but a statistically significant increase in the distance of the observed variable of interest to the VaR for the treated to measure the positive impact, for example, of nature-based solutions. Our statistical test is based on a wild bootstrap procedure (Davidson and Flachaire, 2008).

3.1.3. RESULTS

Results for flood risk

Table 4 provides the number of buildings (per building category) which are affected by a flood of return period 30 (HQ30), 100 (HQ100), and 300 (HQ300) years, the average size of the buildings in square meters and the average yearly damage before and after the NbS, which represents an annual damage cost reduction in Euro are provided. This means that we consider the buildings that are statistically affected by a flood at least every 30, 100 and 300 years, but it does not mean that all the buildings are affected by a flood in the same year. As previously mentioned, the analysis focuses on the construction of a gravel trap, in which 300 buildings were secured in relation to flood risk. We observe that in total 716 buildings are affected, of which 240 are residential buildings.

To calculate the needed amount of money we are using the VaR for a flood event with return period of 200 years. When considering only one river segment this would correspond to the damage associated with all the buildings in HQ200 (i.e. all buildings that are affected by a flood with return period (of the river segment that is responsible for the flooding of the building) 200 years. When considering VaR for areas with multiple river segments than the situation is different since a flood event with a given return period does not mean that there is also a flood event with the same return period at every river segment. We use a return period of 200 years

since this is also used in the solvency criteria of for insurances in the Solvency II directive of the EU. It was found that using NbS would prevent roughly 4.2 million € in the case of an 1-in-200-year flood event for the Lech area, and to the reduction of only 1.86 million € in the case of an 1-in-200-year flood event for the whole state of Tyrol because of bigger diversification effects. The used VaR (Lech or Tyrol) depends on the considered risk collective for flood. In this case risk collective refers to the buildings that are grouped together for the compensation of flood risk. I.e. are we only considering flood risk at the Lech or flood risk in the whole state of Tyrol. Diversification effects arise when calculation the common risk within a pool it is smaller than summing up the risks of the single elements. This happens for example when events with the same frequency within a pool does not happen necessarily at the same time but in different years.

BUILDING CATEGORY	HQ30	HQ100	HQ300	AVERAGE M ² / BUILDING	DAMAGE BEFORE (EUR)	DAMAGE AFTER (EUR)	DIFFERENCE (EUR)
Residential	26	135	240	175	93,446	54,293	39,153
Public	2	5	10	626	20,596	11,966	8,630
Service	1	11	21	782	24,974	14,510	10,464
Industry	7	21	38	582	28,379	16,488	11,891
Other	114	278	407	69	34,681	20,150	14,531
Total	150	450	716	160	202,075	117,407	84,668

Table 4. Number of buildings affected by flood events by building category.

Note: Buildings affected by flood events with return period 30, 100, 300 years for the municipalities connected to the Lech river, average value of the size of buildings and expected yearly damage for all buildings before and after the NbS.

The results of the VaR are provided in Table 5. Value-at-Risk (VaR) for municipalities in Tyrol and at the Lech River, for Scenarios with and without NbS. see Table 5 below.

TYPE	VAR TYROL (MIO. EUR)	VAR LECH (MIO. EUR)
Before NbS	1,428	10.1
After NbS	1,426	5.8
Difference	1.86	4.2

Table 5. Value-at-Risk (VaR) for municipalities in Tyrol and at the Lech River, for Scenarios with and without NbS.

Results for tourism

The empirical application for tourism focuses on the number of overnight stays during the summer season in Tyrolean municipalities. The application provides at least three innovations:

- The estimation of a monthly (dynamic) panel data model for overnight stays, which uses meteorological data such as average temperatures or precipitation as explanatory variables and considers spatial and temporal heterogeneity via fixed effects. In this way, the most important risk drivers for the summer tourism industry can be identified.
- Provision of individual (at municipality level) or aggregated (for example, municipalities belonging to the nature park region Lech) dynamic VaRs using a rejection sampling procedure. It is an extension of the traditional VaR concept, which incorporates potential changes of relevant risk drivers or market conditions over time.
- The development of a bootstrap-based test procedure to verify the existence of significant (positive) effects on overnight stays due to nature-based solutions, if there are any. The challenge here lies in long-term and continuous modelling as opposed to one-off or sudden changes.

The variable of interest is the number of overnight stays (overnight) in Tyrolean municipalities during the summer season, from June to October. The month of May was not included as the weather conditions in some ski areas still allow for an extended winter season. The data was provided by the province of Tyrol and cover the period from 2000 to 2023 and include 276 municipalities.

Several meteorological variables had to be developed for the available observation stations and matched with the municipalities. This was based on daily and fixed-time measurements of a large number of meteorological and climatological parameters provided by GeoSphere Austria (2024). The following variables proved to be useful: monthly precipitation (precipitation, in mm), mean temperature (meantemp, in degree Celsius), number of ice days (ice), number of frost days (frost), number of summer days (summer), and number of tropical days (tropic). Using this panel data set, we estimated fixed effects with the model of the following form:

$$\begin{aligned} \log(\text{overnight})_{it} &= \alpha_i + \beta_1 \log(\text{overnight})_{i,t-1} + \beta_2 \log(\text{precipitation})_{it} + \beta_3 \text{meantemp}_{it} \\ &+ \beta_4 \text{meantemp}_{it}^2 + \beta_5 \text{ice}_{it} + \beta_6 \text{frost}_{it} + \beta_7 \text{summer}_{it} + \beta_8 \text{tropic}_{it} + \beta_9 m6 + \dots \\ &+ \beta_{12} m9 + \beta_{13} y02 + \dots + \beta_{34} y23 + u_{it} \end{aligned}$$

where $m6, \dots, m9$ denote dummy variables for the months of June to September, $y02, \dots, y23$ dummy variables for the years 2002 to 2023, and u_{it} error terms fulfilling usual assumptions. Note that the time-lagged variable of overnight stays accounts for unobserved demand factors and alleviates biases due to omitted time-varying variables.

The model fit was good reflected in a high adjusted R-sqr. of 78.3%. All meteorological variables and the monthly dummies are significant at the 5%-level as are most of the yearly dummies. The mean temperature in the summer months considered is modelled as a second-order polynomial. The estimated turning point is 17.6°C, i.e. the number of overnight stays would increase to this value and decrease if exceeded. Similarly, an additional summer day would increase overnight stays by 0.3% on average, while an additional tropical day would reduce them by 2.2%. The results also reflect the fact that October is the month with the lowest number of overnight stays and August the month with the highest. Further, the impact of the Covid-19 pandemic in year 2020 can be observed in the number of overnight stays, which dropped by 32.2% compared to the base year 2001.

The second step in the empirical application is the rejection sampling procedure. As the number of covariates in the econometric panel data model is large, some restrictions had to be imposed to obtain a meaningful estimation of the (conditional) joint density of the regressors. For each municipality, year, and month, the latter is estimated fully nonparametrically (Li and Racine, 2007) with the timely lagged value of overnight stays, the monthly level of precipitation, and the mean temperature. A sample of 5,000 observations was drawn each time from these estimated densities. The number of ice days, the number of frost days, the number of summer days, and the number of tropical days are set constantly to the historically observed median values, as they vary little in the data and have minor economic impact in the panel data model. Based on this sample, the distribution of overnight stays is recovered using the estimated coefficients of the covariates in the panel data model. A corresponding VaR follows immediately from the recovered probability distribution of the number of overnight stays. This procedure is applicable for all subsets of municipalities of interest. For example, Figure 5 (left) shows the distributions of the number of overnight stays for the municipalities located in the nature park Tyrolean Leech (District of Reutte) over the years 2001 to 2023. Figure 5 (right) shows the aggregated distribution of overnight stays for

the municipalities in the nature park Tyrolean Leech (District of Reutte), when the Covid-19 years 2020 and 2021 are excluded.

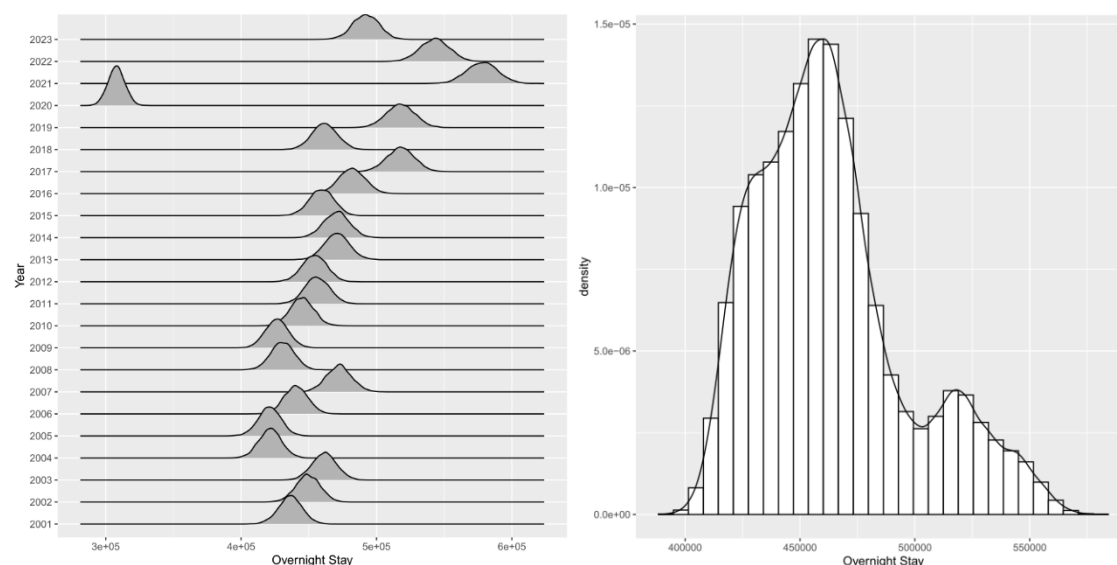


Figure 5. Estimated model-based distributions of overnight stays.

Note: Left panel: Overnight stays for municipalities in the nature park Tyrolean Leech (District of Reutte, 2001 to 2023). Right panel: Overnight stays and estimated model-based distribution of overnight stays for municipalities in the nature park Tyrolean Leech District of Reutte, period: 2001 to 2023, years 2019 and 2020 excluded).

The impact evaluation for NbS is the last step in our empirical application. We constructed a bootstrap based difference-in-difference testing procedure that compares the development of the number of overnight stays in relation to the explored VaR from the panel data model in the district of Reutte – the treatment region in which the nature park Tyrolean Lech is located – with those in the districts of Imst and Landeck – the control regions in closest distance and of similar structure for two given years. Based on the derived distributions, a statistical test will be applied to test for significance of the treatment effect. A special focus will be given to the different development phases of the nature park. The results will be published within an upcoming policy brief of Invest4Nature.

3.1.4. DISCUSSION ON INVESTMENT STRATEGY DESIGN & INSURANCE VALUE ASSESSMENT

In this study we have focused on the reduction in losses of particular risks like flood risk or the impact on the risk for touristic overnight stays according to bad weather at the Lech. Both of these risks are described in the previous section. For the investment strategy derived of such risks there are two important indicators, the expected average yearly damage (which has to be set aside to cover the losses in the long run) but also the solvency capital that is needed to cover the losses in a particular unfavourable year. The solvency capital, for example, can be calculated with VaR. If a NbS reduces the probable losses of a given risk, then the needed solvency capital can be reduced. This means that financial resources can be freed for the risk bearer. Beside the reduction of losses, lower financing and opportunity costs for reserves can represent an additional source of financing for NbS. Additionally multiple benefits can lead to a portfolio effect, which can enhance the financing of a NbS.

If risks are of a similar nature with similar frequency, the solvency capital should be calculated jointly for these risks, meaning that the common distribution of the risks has to be considered from which the solvency capital (i.e. the VaR) can be computed. If only the marginal

distributions of the risks are known, then a possible way is to generate a joint distribution by the use of Copulas to join the distributions together. The Copulas can be estimated from proxy data or derived from expert knowledge. This was done in the case of flood risk, where the spillover effects of the Lech valley to a hypothetical Tyrolian-wide insurance system (like the catastrophe fund) have been estimated. In that case, the contribution of the Lech area to the region wide VaR and hence the reduction in VaR from NbS is smaller than the VaR for the Lech area alone. On the other hand, if the individual risks are not sufficiently similar, or there are different risk bearers, then the best solution is to calculate the VaR for the individual risks and subsequently aggregate them. The total VaR in this case is thus estimated as the sum of the VaR of the individual risks.

3.1.5. CONCLUSIONS

We have demonstrated how NbS in Lech can affect the VaR for flood risk with a reduction of approximately 4.2 million € or approximately 42.6% in expected damages. We have also shown how, by including a bigger portfolio of flood risk for the whole state of Tyrol, the reduction in VaR still represents 1.8 million € or approximately 0.14% in capital that can then be freed by the respective risk bearer.

Further, we analysed the VaR for touristic overnight stays, where a statistic test was developed to test the effect of NbS on the distribution of overnight stays. The expected outcome of the proposed methodology is an econometric model that allows for the identification of potential risk drivers, for the quantification of their impact, and for a statistical test of individual or joint significance.

The quantification of the model-based VaR or ecosystem services is possible for each individual and at each point in time when panel data is available. A formal test of whether the impact of the NbS is statistically significant in comparison to a control region needs to be developed for this approach. Based on this, changes in the VaR can be analysed for interventions such as the implementation of a NbS. To analyse portfolio effects, the VaR of benefits within a NbS or across NbS can be aggregated. The aggregated VaR is in general not equal to the sum of the single VaR as this depends on the dependency structure between the VaRs.

3.2. REWILDING OF RIBEIRA DAS VINHAS IN CASCAIS, PORTUGAL

3.2.1. SCOPING

Cascais is a coastal municipality in western Portugal, about 25 km from Lisbon, bordered by the Atlantic Ocean and the Sintra-Cascais Natural Park (Figure 6). Cascais covers an area of 30 km² with around 210,000 inhabitants. The area of Cascais includes diverse natural landscapes, such as Cabo da Roca (Europe's westmost point) and the Sintra Mountains, influencing its climate, environment and biodiversity. About 33% of Cascais lies within the UNESCO-designated natural park, which is home to about 900 native species.

Cascais developed primarily through tourism, which remains the leading economic sector, contributing approximately one-third of its revenues. As a result, the city is highly dependent on favourable climatic conditions and particularly vulnerable to the impacts of climate change. Major climate-related risks include floods - driven by reduced runoff, shifting rainfall patterns, and more frequent extreme weather events (Rocha et al., 2020) - as well as wildfires and the growing occurrence of heat waves.



Figure 6. Cascais municipality and Ribeira das Vinhas map in Portugal.

The Ribeira das Vinhas is a known flood hotspot, classified as high risk area, with frequent flooding in Cascais's historic centre posing a risk to many buildings and population (Câmara Municipal de Cascais, 2015, 2024). The river's catchment area covers 26 km², extending from the Sintra Mountains Natural Park in the north to its outlet at the Atlantic Ocean in the south (Figure 7). Its final 1 km runs through an underground tunnel beneath the city centre. Like many Mediterranean rivers (Kondolf et al., 2013), its flow is highly variable, with significant floods in autumn and winter, and minimal discharge during the rest of the year. Land use in the catchment shifts from agricultural zones in the north to densely urbanized areas in the south (Moreira Alves et al., 2015).

The city of Cascais developed a first Strategic Plan for Climate Change in 2010, including a dedicated chapter on adaptation and was updated in 2017 (Cascais Ambiente, 2017). The plan

identified key sectors and climate impacts requiring attention and proposed adaptation measures, including green corridors and river requalification.

Specifically, to reduce flood risks, Cascais launched a large-scale restoration project in 2017, covering 1,000 hectares. The initiative features a 10 km green corridor along the Ribeira das Vinhas and a 380-hectare area within the Sintra-Cascais Natural Park. A key component of the project is “Quinta do Pisão”, a restored natural farm developed to help manage flooding while promoting sustainable agriculture. The project incorporates a range of nature-based solutions, including river buffer restoration, the creation of ponds and retention basins, and hybrid engineered elements to create green corridors. Additional interventions include removing pavements and walls, restoring bridges and weirs, planting native vegetation, and creating walking and cycling trails. To slow water flow, obstacles and meanders were introduced, while ponds filled with soil and loose stones now serve as biodiversity hotspots (Empresa Municipal de Ambiente de Cascais, 2020). Overall, the project is expected to benefit over 33,000 residents by improving flood risk reduction and management in the downstream city of Cascais (Value of Protection BY Nature, Chen et al., 2025a). Additionally, the restoration enhances cultural heritage, biodiversity, and recreational opportunities while promoting environmental awareness (Value of Social Resilience, Chen et al., 2025a).



Figure 7. Ribeira das Vinhas restoration interventions

Photos: Empresa Municipal de Ambiente de Cascais, 2020

3.2.2. ASSESSMENT METHODS AND DATA

The Ribeira das Vinhas restoration project primarily aims to mitigate flood risk in the city, particularly downstream. To assess the Value of Protection by Nature in Cascais, the avoided damage approach was followed (Chen et al., 2025a) by evaluating the costs associated with avoiding damage from lost services, replacing damaged assets, or providing equivalent substitute services. In particular, the damage cost avoided approach quantifies ecosystem benefits based on the value of protected assets, or the cost of preventive measures undertaken to mitigate potential damages (Le Coent et al., 2023).

In summary, for the case of Cascais, this approach includes a flood hazard (modelled or observed) before and after the restoration project, serving as input for a water depth-damage function to analyse the changes induced by the restoration to the direct economic damage to buildings and the residential population exposed to flood. In parallel, a qualitative assessment of perceived ecosystem services was conducted to capture local stakeholders' views on the broader social and environmental benefits of the restoration.

This integrated approach provides a comprehensive understanding of how river restoration contributes to flood risk reduction while enhancing protection for both infrastructure and communities in Cascais.

Flood risk modelling

Flood hazard mapping identifies areas at risk of flooding and represents the extent, depth and intensity of flood events. This can be achieved through direct observations, satellite data, or hydrological and hydraulic modelling, which are used to estimate and predict flood risk. Several flood modelling techniques are available for assessing river discharge and generate flood inundation maps that illustrates affected areas and flood depths.

In the case of Cascais, two models were utilised based on the availability of information and the scope of the analysis, in line with the Cascais plans: HEC-HMS and HEC-RAS. These models are widely used for various catchment types and sizes, including urban catchments (Costabile et al., 2020; El-Naqa and Jaber, 2018; Ferreira et al., 2020). In the analysis, HEC-HMS simulates river discharge by generating hydrographs based on precipitation events and high-resolution Digital Terrain Model (DTM - 2m resolution, obtained from the Portuguese General Directorate for Territory²). These hydrographs, which represent the total river flow at the catchment's outlet to the sea and serve as input for HEC-RAS. HEC-RAS then produces flood maps illustrating extent and depth of inundation, using combined hydraulic and hydrological calculations.

The analysis assesses flood risk in the Ribeira das Vinhas catchment by simulating conditions before and after the river restoration. The pre-restoration analysis is based on a 100-year flood simulated by Hidroprojecto (Engenharia e Gestao, 2010) in Cascais, which followed a consistent methodology and serves as the baseline for comparison. The post-restoration analysis was carried out as part of the I4N project (Jähn, 2024). This analysis was supported by fieldwork, during which the 2010 cross-sections were updated to reflect the conditions of the post-restoration phase. The year 2010 is used as the reference point before the restoration, while 2024 serves as the reference year for the post-restoration period.

For the analysis, five precipitation scenarios were considered, based on return periods of 5, 10, 20, 50, and 100 years, using data from the *Economic Assessment of Climate Adaptation Strategies for Ribeira das Vinhas* (Moreira Alves et al., 2015). These scenarios reflect extreme daily maximum rainfall events. The 5- and 20-year return periods were used to validate the effectiveness of river restoration through a before-and-after comparison, while the 100-year event was simulated to assess the impacts of extreme discharges relative to pre-restoration conditions. Precipitation data spanning 2000-2024 was retrieved from the Portuguese Institute for Sea and Atmosphere (IPMA)³.

HEC-RAS hydrological simulations were complemented by the HAND (Height Above Nearest Drainage) method, a terrain-based approach for inundation mapping that utilizes elevation data, discharge–height relationships, and streamflow inputs (Johnson et al., 2019). This approach is widely used to produce reliable inundation maps with limited data requirements. In this study, it is applied as a physical and geomorphological tools to support and integrate the assessment of water extent and depth in both pre- and post-restoration scenarios modelled by HEC-RAS.

Direct damage to the buildings and population exposed reduction

The flood information, particularly water depth (m), is incorporated into damage functions to estimate how hazard intensity impacts the value of exposed assets (Staccione et al., 2024).

² Portuguese General Directorate for Territory – DTM: <https://dados.gov.pt/pt/datasets/modelo-digital-do-terreno-resolucao-2-m-zonas-costeiras-de-portugal-continental-2014-2015/#!/resources>

³ Portuguese Institute for Sea and Atmosphere - rainfall: <https://www.ipma.pt/en/agrometeorologia/precipitacao/>

The analysis is specifically designed for built-up areas assessing the potential reductions in building damage and population exposed. Following the approach of Essenfelder et al. (2022), the analysis relies on a depth-damage vulnerability function that correlates hazard magnitude (water depth) with asset value, such as building costs (Huizinga et al., 2017). For each flood event, expected damages are compared before and after restoration. Population exposure is similarly assessed by categorizing individuals based on water depth: slightly affected (0.5m), moderately affected (0.5-1m), and displaced (>1m).

To assess the direct damage to buildings, essential data include the spatial distribution and classification of buildings (e.g., commercial, residential, industrial), as well as an economic indicator, such as construction costs, maximum value per square meter, insured asset value, or real estate value. Building type and location can be retrieved from EU open-source platforms like OpenStreetMap (OSM, 2024), while economic information is typically available through cadastral sources (e.g. EC-Harris, 2010). Similarly, the estimation of exposed population needs spatial data on residents' numbers, which can be obtained through open-source databases such as GHS-POP (Schiavina et al., 2023) and refined using local census data⁴ for improved accuracy.

In the case of Cascais, the analysis is performed for modelled events with a return period of 100 years before and after the restoration project. The results will be expressed as the percentage of damage to buildings and population exposed. Additionally, the changes are reported as Expected Annual Damage (EAD) and Expected Annual Population Exposed (EAPE), computed using the trapezoidal method (Olsen et al., 2015). The difference between baseline damages and those under NbS implementation represents the value of NbS and the regulatory services they provide (i.e. Value of Protection **BY** Nature).

Ecosystem services

A qualitative analysis was conducted to assess additional co-benefits of river restoration, and to support the quantitative modelling of risk reduction. This evaluation was based on an online stakeholder survey exploring perceived changes in ecosystem services, with a particular focus on climate regulation, water regulation, recreation, biodiversity, and habitat.

The survey aimed to map stakeholder experiences associated with the changes in ecosystem services within the restoration site and its surroundings. Participants, including both citizens and experts, were asked to indicate whether they (i) observed no change, (ii) lacked knowledge about the change, or (iii) could not specify a location. The survey combined multiple-choice, ordinal scale, and location mapping questions. Each response was georeferenced and annotated with the perceived direction of change (positive/negative), the intensity of the change (on a scale of 1–5), and the respondent's certainty in their assessment (on a scale of 1–5). Although this information is subjective and qualitatively assessed, it can support the validation of model results and inform decision-making on NbS investments and planning. Highlighting stakeholder perceptions and the co-benefits of NbS helps to demonstrate their added value in enhancing social resilience through restoration efforts. This information can also support the assessment of Social Resilience Value, meant to reflect improvement in well-being, recreational opportunities, landscape aesthetic, environmental quality and people safety.

⁴ Data Cascais - demography: <https://data.cascais.pt/en/geral/cascais-info>

3.2.3. RESULTS

Flood risk

The flood risk modelling applied to the Ribeira das Vinhas area produced flood depth map before and after the restoration, assuming a flood event with return period of 100 years (Figure 8). Despite limited data availability, the model was able to reproduce an extent of the flood prone areas in line with those identified by Cascais plans (see Figure 8.c)

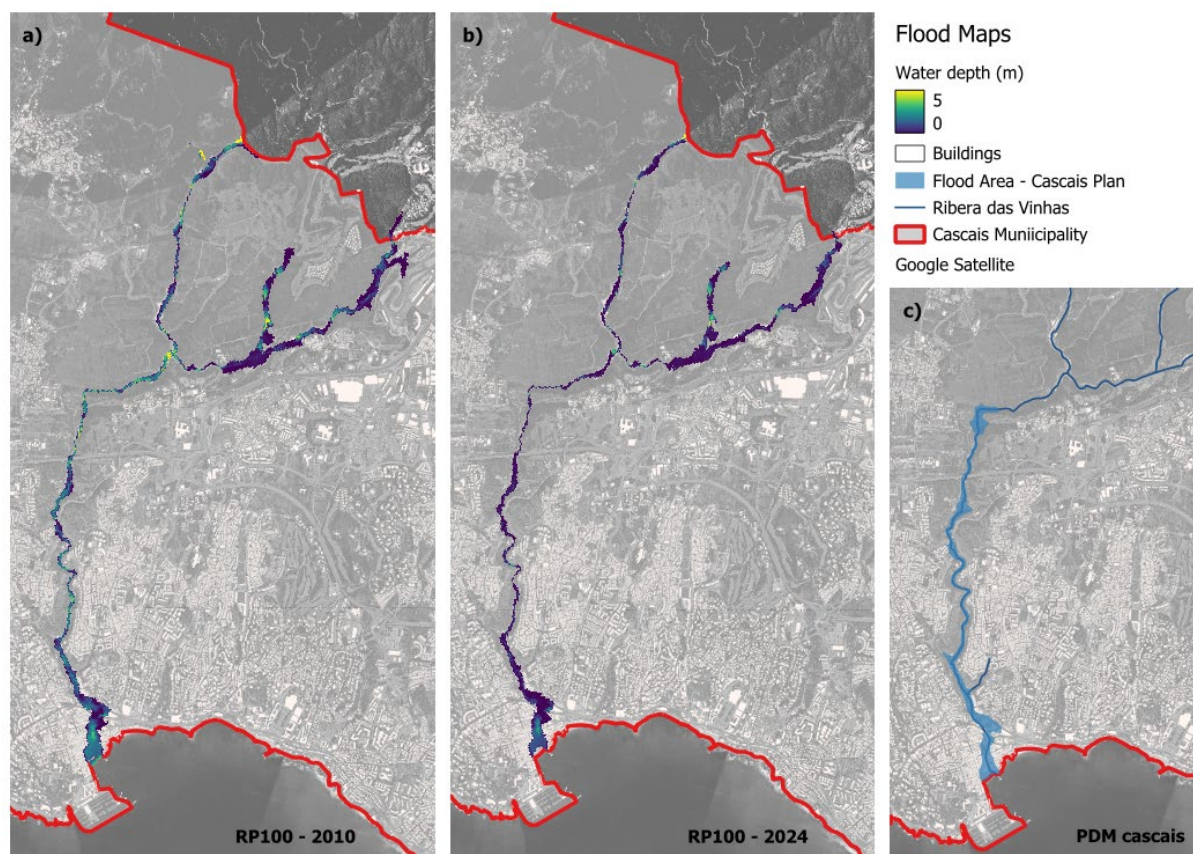


Figure 8. Flood risk modelling results for the Ribeira das Vinhas area.

Note: The charts show flood depth maps before (a) and after (b) restoration, based on a 100-year return period event. Model produced flood extents consistent with the official Cascais plans (c) from Câmara Municipal de Cascais, 2015, 2024.

The maps show several risk hotspot areas along the river course in 2010, with severely impacts to the downtown area of Cascais (Figure 8a). But it can be noticed that the flood extent and water depth is well reduced in the post-restoration map (Figure 8b). These flood characteristics are largely shaped by the area's geomorphology, particularly the riverbed, which flows through a steep and narrow valley descending into the city centre. Before reaching the old town, the river is channelled beneath a street, which adds uncertainty to flood data within the city. Nevertheless, this section becomes a critical point during periods of intense rainfall and flooding. Overall, both the extent and depth of flooding in the city follow the course of the river and are closely linked to the local geomorphological features.

Damage to buildings

By combining the flood maps with the flood depth-damage function, it results that the buildings affected by flooding are primarily concentrated in the downtown area and in the built-up zones along the river upstream (Figure 9). Focusing on the city centre (Figure 9a), the map displays

the estimated flood-related damage to buildings per square meter. This serves as an indicator of the most severely impacted areas and highlights the potential effectiveness of NbS in mitigating flood damage. The total damage to buildings reduces from around 11€ million in 2010 to 6€ million in 2024. Turning this information into Expected Annual Damage (EAD) results in a value of around 110,000€ in 2010, reduced to 62,000€ EAD in 2024. However, rather than emphasizing absolute damage values, which may be influenced by various external factors, the analysis aims to highlight the relative changes before and after the restoration. The estimated reduction in damage across the entire study area, including buildings near the river, is approximately 43%.

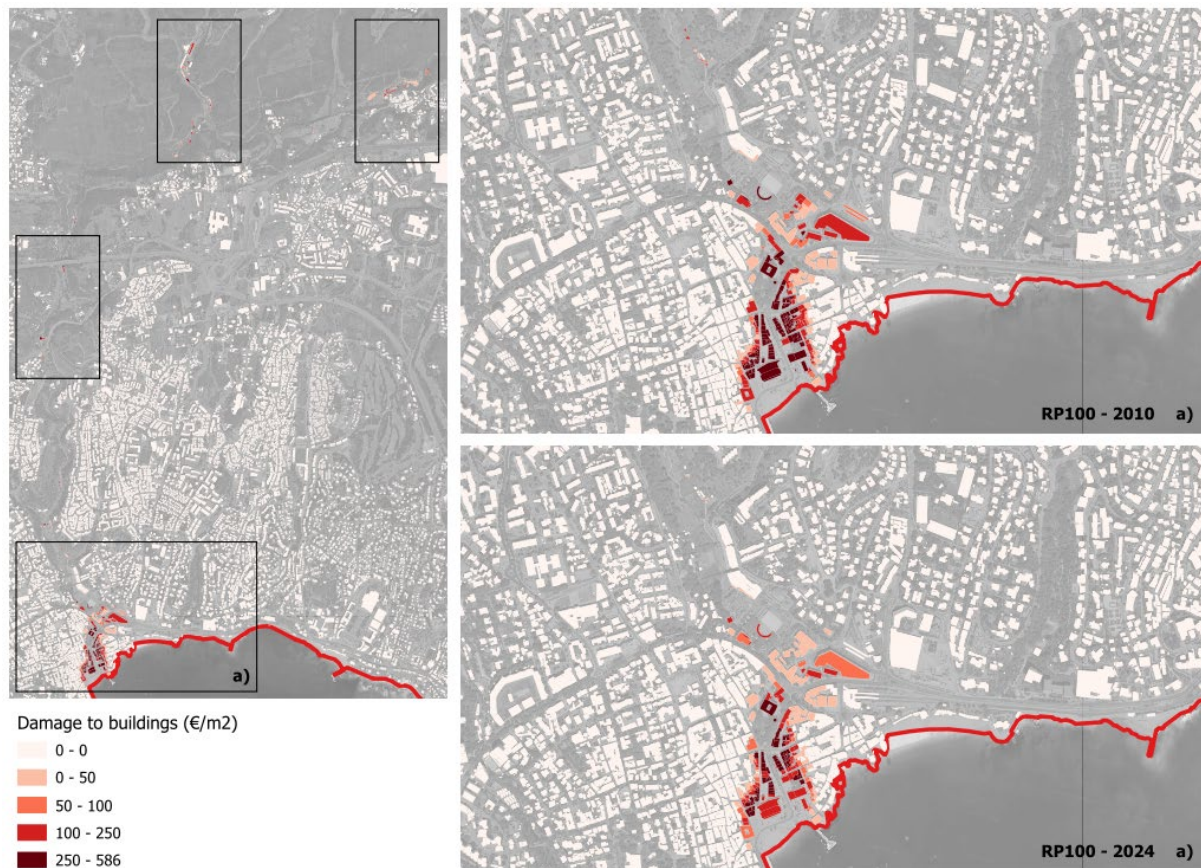


Figure 9. Estimated flood-related damage to buildings based on the combination of flood maps and a flood depth-damage function.

Note: panels (a) focus on the city centre, showing the change of damage estimates per square meter.

Population exposed

Similar to the pattern observed with buildings, the spatial distribution of the residential population affected by flooding is primarily concentrated in areas closer to the river. The map (Figure 10) illustrates the distribution of affected individuals across different classes of exposure. While the overall spatial distribution remains relatively consistent, a shift in exposure severity is evident: in 2010, a larger portion of the population was classified as potentially displaced, whereas by 2024, most of these individuals were reclassified as only slightly affected.

Comparing the pre- and post-restoration scenarios, the total affected population is estimated to have decreased by approximately 9%. More notably, the number of people expected to be displaced annually dropped by around 60%, accompanied by a corresponding 60% increase in the number of people classified as slightly affected. The number of moderately affected

individuals decreased by 18%. Overall, the Expected Annual Population Exposed (EAPE) declined from 130 people in 2010 to 118 in 2024, with the number of expected annual displacements decreasing from 60 to 22.

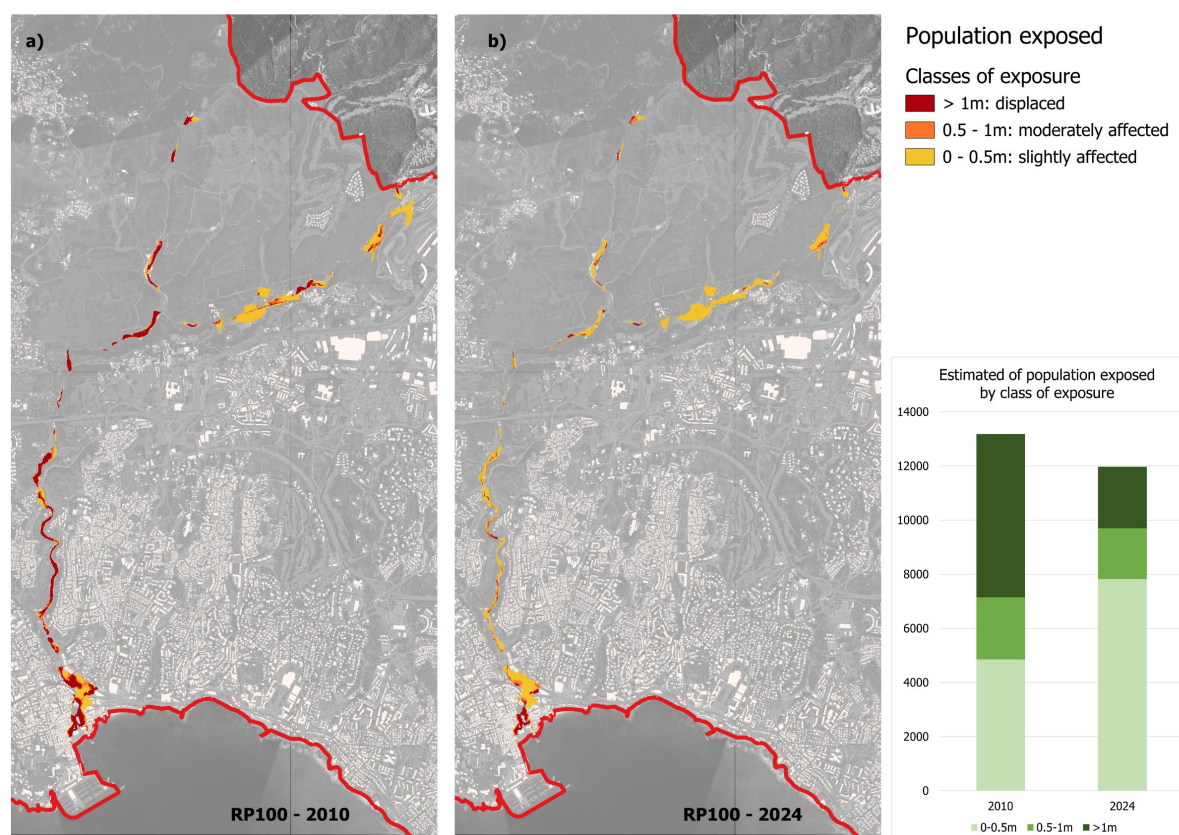


Figure 10. Spatial distribution of the population affected by flooding, categorized by classes of exposure.

Note: the bar chart presents the estimated number of people affected in each exposure class before and after the restoration, highlighting a shift from more severe to less severe exposure levels.

Ecosystem services

The survey captured the perceptions of nine experts from the Municipality of Cascais, focusing on the themes of climate action, ecological structure, and green spaces. Their expertise and in-depth knowledge of local conditions enabled them to provide well-informed responses, often considering large temporal and spatial scales.

The answers on perceived ecosystem services in Ribeira das Vinhas were spatially referenced. Most points were located in green areas along the Ribeira das Vinhas, although some were also placed in adjacent urban zones (see Figure 11). The surveyed local stakeholders consistently reported positive changes across five ecosystem services: climate regulation, resilience, recreation, biodiversity, and habitat. Among these, recreation received the highest number of responses, reflecting the stakeholders' active use of the restored area for leisure activities. Habitat received the fewest responses. Resilience, meant as Cascais's continued functionality during disturbances such as floods, was also perceived positively. Data points indicating perceived changes in resilience were distributed across forested, residential, commercial, and downtown areas. The average values of both the perceived intensity of change and the certainty of change suggest a high level of confidence in the improvements to ecosystem services across the catchment.

Perceptions of resilience benefits both reflect and reinforce the evidence of the value of protection BY nature in reducing damage to buildings and lowering population exposure. The positive shifts reported across all ecosystem services support the social resilience value generated by the river restoration.

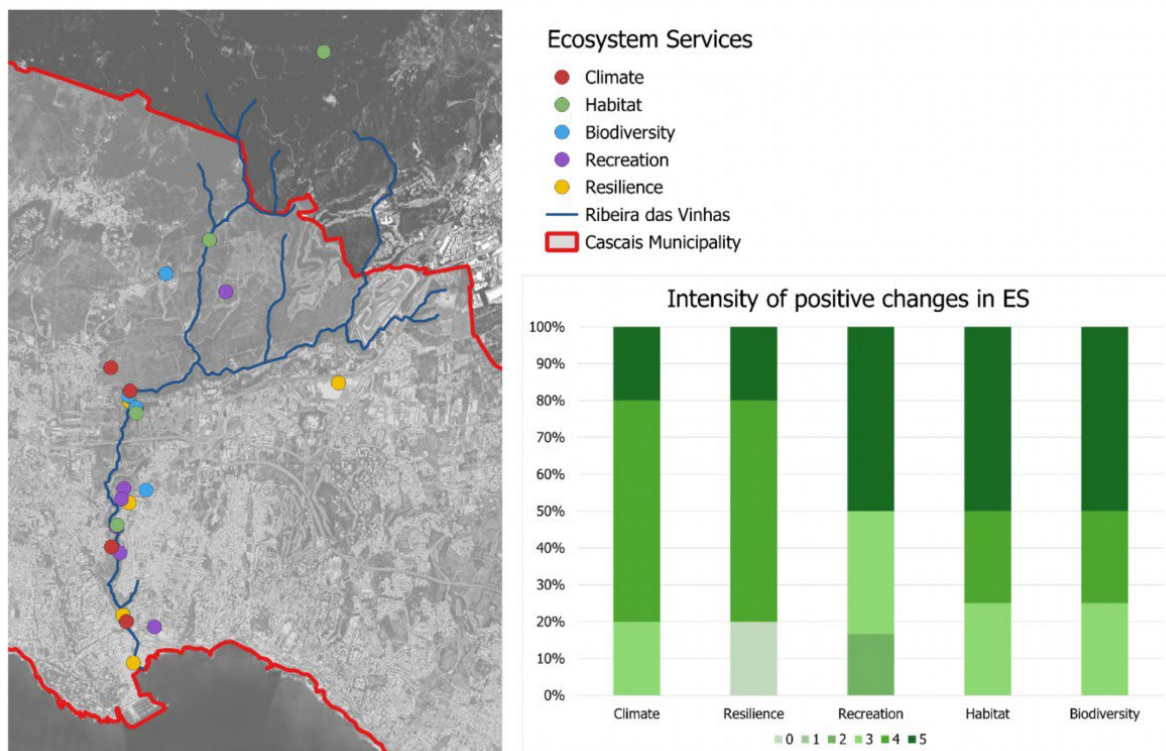


Figure 11. Spatial distribution of responses on perceived ecosystem services in the Ribeira das Vinhas area.

Note: the bar chart displays the perceived intensity of positive changes across the assessed ecosystem services, as reported in the expert survey.

3.2.4. DISCUSSION ON INVESTMENT STRATEGY DESIGN & INSURANCE VALUE ASSESSMENT

The Ribeira das Vinhas river restoration project highlights the potential of NbS in mitigating flood impacts, reducing direct flood damages to building and population exposed to flood, enhancing recreational opportunities, biodiversity, and strengthening urban resilience.

To scale and sustain these benefits, an integrated investment strategy is essential. As seen in Cascais, funding for NbS is often tied to public investments, at local, national or European level. In Europe, for example, the European Investment Bank (EIB) supports environmental and conservation initiatives through its Environment Framework. This financing mechanism channels capital into sustainable, nature-positive projects while ensuring compliance with high environmental and social standards (EIB, 2023). Other EU opportunities include research and innovation programs such as Horizon Europe and the EU Missions. In particular, the Mission on Adaptation to Climate Change (EC, 2021) provides a framework to support local and regional transformative adaptation, aiming to foster systemic change and strengthen climate resilience across Europe. It targets at least 150 regions and communities to become climate-resilient by 2030 through a portfolio of projects that support climate-vulnerable areas with enabling conditions and transformative processes.

However, over half of the global GDP depends directly on nature and its services (WEF, 2024). The loss of nature and biodiversity presents a significant threat to the global economy, with the cost of inaction increasing across key sectors such as agriculture, fisheries, and disaster resilience. To meet climate, biodiversity, and land degradation targets, an estimated \$8.1 trillion investment is needed by 2050, but only \$133 billion is currently invested annually, leaving a \$4.1 trillion financing gap (UNEP, 2021).

While public and blended finance play crucial roles, there is significant untapped potential in private finance, which currently accounts for only 14% of the total. This highlights both a major shortfall and a key opportunity. Private sector engagement can be expanded through market-based mechanisms, innovative financial instruments, corporate strategies, and enabling regulatory frameworks. Within this context, nature-based insurance and investment mechanisms offer promising avenues to scale up NbS implementation by addressing the financing gap (UNEP, 2023). As part of a wider strategy to respond to global challenges, the protective value of NbS can be understood as having an insurance value, thanks to their capability to buffer environmental shocks, which can be translated into avoided damage and co-benefits (Costa et al., 2020). This perspective is gaining traction within the insurance sector.

In Cascais, there is potential to further explore partnerships with the insurance sector. Given the flood risk mitigation potential of NbS, insurers may benefit from fewer claims and lower premiums in covered areas. In regions without existing flood insurance, NbS could enhance insurability and support the development of new insurance products that incorporate nature-based flood protection. This can also enable insurers to expand their client portfolios by offering lower premiums. (EIOPA, 2023).

This strategy could complement the Portuguese context and enhance the development of its insurance landscape. In Portugal, insurance coverage for floods remains moderate, with an estimated less than 50% of households and businesses insured (OECD, 2024). Coastal flood insurance, by contrast, has significantly lower uptake: less than 25% of households and businesses in Portugal are covered. These tendencies are in line with European coverage for climate-related flood risks that remains fragmented, despite flooding being one of the most frequent and damaging hazards in Europe. Coastal flood is generally the least covered hazard in EU insurance schemes, although it tends to have higher penetration rates in Northern and Atlantic countries (Ceolotto et al., 2024).

Generally, traditional and climate insurance policies have not been targeted to account for natural capital and NbS. But this is changing in recent years. For example, in Portugal, this shift has been reflected in the development of new insurance products aimed at safeguarding forest ecosystems, an important ecological asset in the country, from climate-induced risks like wildfires, storms, pests, and diseases. These policies often offer multi-risk coverage and incentives for sustainable forest management. However, uptake remains low due to high premiums in fire-prone areas, lack of mandatory insurance, valuation challenges, and limited data (Lameh et al., 2024). To address such barriers, Portugal has started to experiment with innovative insurance mechanisms such as parametric insurance, which triggers payouts based on environmental indicators, and policies covering post-fire recovery efforts. Government-backed subsidies also support NbS adoption by lowering initial costs and reducing premiums for sustainable (Lameh et al., 2024).

Similar approaches have been developed in different contexts. For example, in the state of Quintana Roo, Mexico, a parametric insurance policy for coral reefs triggered an \$805,000

payout after Hurricane Delta in 2020, financing rapid restoration efforts like coral replanting⁵. In the U.S., a pilot along the Missouri River combined levee setback NbS with a community-based insurance scheme, leading to reduced flood risk and lower premiums⁶. Modelling showed that the NbS costs were entirely offset by insurance savings.

Portuguese experiences, challenges and opportunities are also relevant when considering insurance schemes for riverine flood risk adaptation, particularly when supported by NbS. In the case of Cascais, the proposed approach and resulting insights contribute to a more comprehensive understanding of how NbS can reduce flood risk and deliver broader co-benefits that enhance urban resilience. Data on the effectiveness of NbS interventions in Cascais, such as reduction in flood damages and population exposed, can serve as proxies or indicators for de-risking investments. This information can support reduced insurance premiums and unlock innovative investment opportunities in nature-positive assets. Insurance products that promote NbS can be mutually beneficial: they could offer profitability and risk mitigation for insurance companies while channelling investments into natural infrastructure. Building on emerging models that integrate NbS and insurance, two main opportunities for Cascais could be explored:

- (i) a community-based insurance model, where premium contributions are used to finance the implementation of NbS, similar to the approach used along the Missouri River; and
- (ii) a public-private partnership involving the Municipality of Cascais and local businesses (e.g., from the tourism sector), which would jointly purchase an insurance policy to protect the NbS implemented, following the example of the reef insurance scheme in Quintana Roo.

In the latter case, however, the source of funding remains to be determined. Potential options could include a dedicated surcharge on the local tourist tax or a direct allocation of public funds.

The co-benefits of NbS add significant value in the context of disaster risk reduction. However, fully assessing these co-benefits remains challenging. In the case of Cascais, there are opportunities to improve the analysis of the effectiveness of river restoration, and NbS more broadly, not only in terms of flood risk reduction but also in relation to their associated co-benefits. On the one hand, investigating individuals' perception of ecosystem services helps to build the case for NbS by providing insights into their potential benefits and the full value that NbS can bring to the city. Nevertheless, a direct quantification of these co-benefits is still lacking. This gap could be addressed through integrated approaches that combines, for example, field sampling, modelling, stakeholder engagement, and meta-analysis (Staccione et al., under revision). These methods can generate harmonised, comprehensive datasets and improve assessments in different contexts, enhancing the comparability of results and potentially enabling the translation of co-benefits into economic or monetary terms. On the other hand, flood risk modelling, including approaches applied in Cascais, has some limitations, primarily due to data scarcity and the simplification of complex hydrological and urban processes, which contribute to uncertainty in the results. However, integrating additional data from real flood events, through for example field observations, sensor networks, or satellite imagery, can help to reduce this uncertainty. Additionally, detailed spatial information on the economic value of the assets investigated contribute to improving the accuracy of the results. Building on an improved data foundation, it would also be possible to model flood

⁵ The Nature Conservancy: <https://www.nature.org/en-us/newsroom/first-ever-us-coral-reef-insurance-policy/>

⁶ The Nature Conservancy: <https://www.nature.org/en-us/about-us/where-we-work/priority-landscapes/mississippi-river-basin/>

events under future climate change scenarios, thereby supporting the development of more effective adaptation and risk reduction strategies. This integrated approach, combining modelling with socio-economic analysis, offers opportunities for the rapid identification of risk hotspots. It can also support the evaluation of various greening and NbS scenarios, helping to identify and prioritize areas for intervention (Staccione et al., 2024).

A robust understanding of both the risk reduction benefits and the broader co-benefits of NbS, along with clear identification of their beneficiaries, is vital for cost-effectiveness evaluation and comparison with traditional engineered solutions. This knowledge enables public authorities and (re)insurance companies to make strategic, informed investments that reduce disaster losses while enhancing community resilience and long-term sustainability (Costa et al., 2020). In this context, assessing avoided damages to buildings in Cascais could provide a valuable foundation for developing insurance and financing schemes that support these goals.

3.2.5. CONCLUSIONS

In the case of Cascais, the value of Ribeira das Vinhas restoration is assessed by focusing on flood risk reduction before and after the restoration intervention. The assessment looked at changes in direct damage to buildings and population exposed during flood events of return period of 100 years, providing a comprehensive evaluation of the project's impact on flood resilience.

Flood modelling outputs are used to estimate flood damage to buildings. A depth-damage function establishes the relationship between hazard magnitude (flood depth) and the value of exposed assets (building costs). Beyond economic impacts, the assessment also considers social resilience by evaluating the expected annual population exposed to flooding. This is determined by analysing the number of residents affected at different flood depths, categorized as: slightly affected at 0.5m, moderately affected between 0.5-1m, and displaced at >1m.

The results showed a potential reduction of up to 43% in direct damage to buildings and a 9% decrease of total population exposed, with a significant shift of 60% of people being potentially displaced to being only slightly affected. In parallel, an expert survey highlighted the perceived positive changes of ecosystem services provided by the river restoration (climate regulation, resilience, recreation, biodiversity, and habitat) across the entire river basin.

Scaling up NbS initiatives requires integrated investment strategies, implying closer collaboration between the public and private sectors. Although public funding has played a key role, there is significant untapped potential in private finance, particularly in the form of innovative insurance products that recognise the potential NbS value of protection BY nature and social resilience. The case of Cascais shows opportunities for insurance mechanisms as promising tools to de-risk investments and incentivise NbS implementation. However, better data and integrated assessment methods are needed to quantify co-benefits and improve the accuracy of flood modelling. Ultimately, combining technical, ecological, and financial insights can support more resilient urban planning and unlock sustainable finance for NbS initiatives on a large scale.

4. ECONOMIC & FINANCIAL PERFORMANCE OF NBS

4.1. GENERAL OVERVIEW OF NBS ECONOMIC ASSESSMENT STUDIES

Across the 5 landscapes/thematic areas of urban, agriculture, forestry, coastal, mountains and water management, the literature review yielded a total of 379 studies included after the final check and data extraction. For those studies that assessed either multiple NbS and/or multiple benefits, we extracted multiple observations per study. The dataset contains 3768 observations in total, with an average of about 10 observations per study.

A considerable number of studies (49% of the total) focused on Mediterranean and Southern Europe, especially Spain and Italy, followed by Central Europe (20%), notably Germany and Poland, while close to 12 % originate in Great Britain and Ireland. Studies covering multiple European regions represented 14.3%, reflecting a degree of cross-regional analysis. In contrast, Eastern Europe and Northern Europe were significantly underrepresented, with only 4.8% and 1.1% of studies respectively. This distribution highlights a notable geographical imbalance in the evidence base, with Southern and Western Europe showing the most cases published within the period of interest.

The same geographic pattern is found in terms of number of observations. Figure 12 shows the number of NbS assessment studies by country and Table 6 the distribution of studies across European regions.

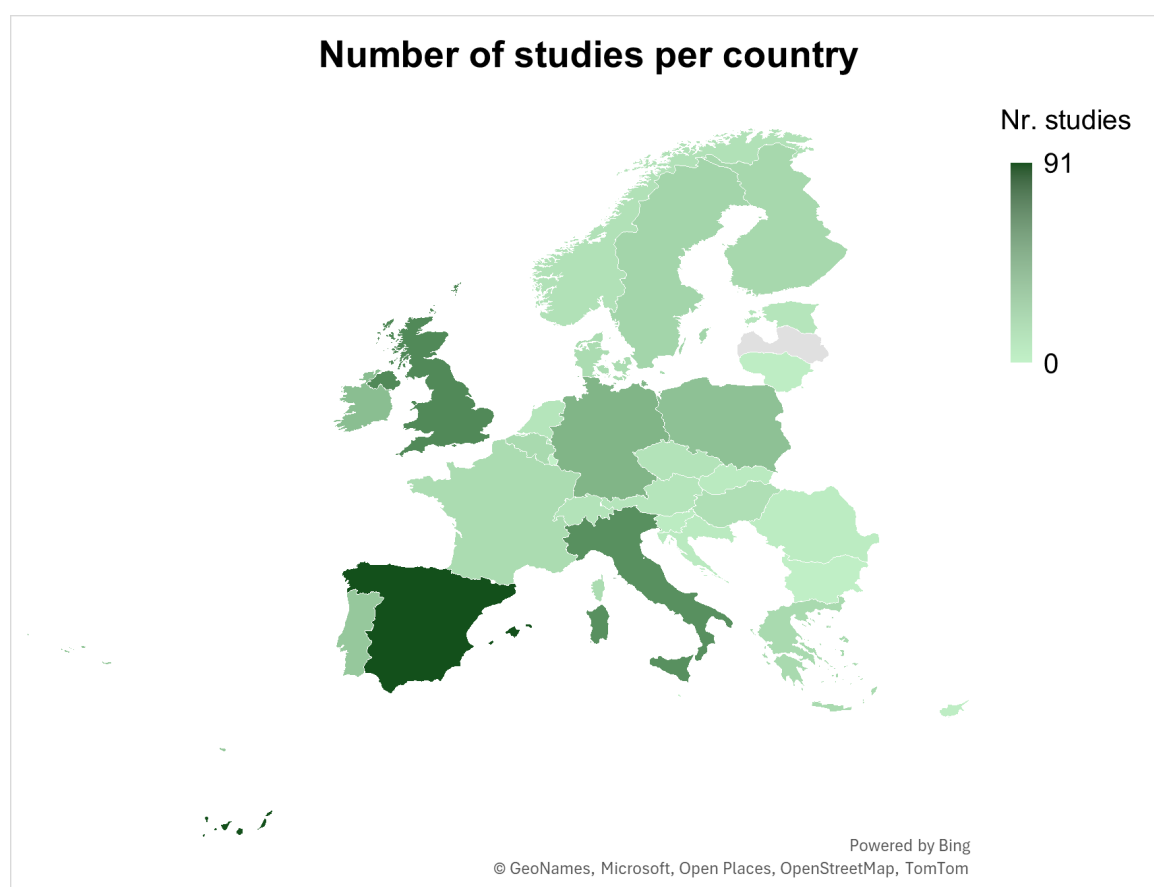


Figure 12. Map of number of NbS economic assessment studies per country

EUROPEAN REGION	NUMBER OF STUDIES	PERCENTAGE (%)
Mediterranean/Southern Europe	185	48.81
Central Europe	74	19.53
More than one European region	54	14.25
Great Britain and Ireland	44	11.61
Eastern Europe	18	4.75
Northern Europe	4	1.06
Total	379	100

Table 6. Number of studies by EU region - all studies

NbS landscapes/thematic areas & typologies

The analysis of 379 NbS economic assessment studies revealed varying levels of attention to different landscape or thematic areas. Forest landscapes were the most frequently represented, appearing in 120 studies (25% of the total). Urban landscapes were the second most common, included in 105 studies (22.0%), followed by water management (95 studies, 20%) and agricultural landscapes (74 studies, 15%). Coastal areas featured in 65 studies (14%), while mountain landscapes were the least represented, appearing in 19 studies (4.0%). These findings indicate a strong research emphasis on forest and urban environments, while mountainous areas remain comparatively underexplored.

In terms of the 3,768 unique observations, urban studies dominate the data with 26% followed by forest and water management, (each 21%). Agriculture and coastal economic NbS assessment studies account for 13-15% of observations and mountains with as few as 4% of the observations.

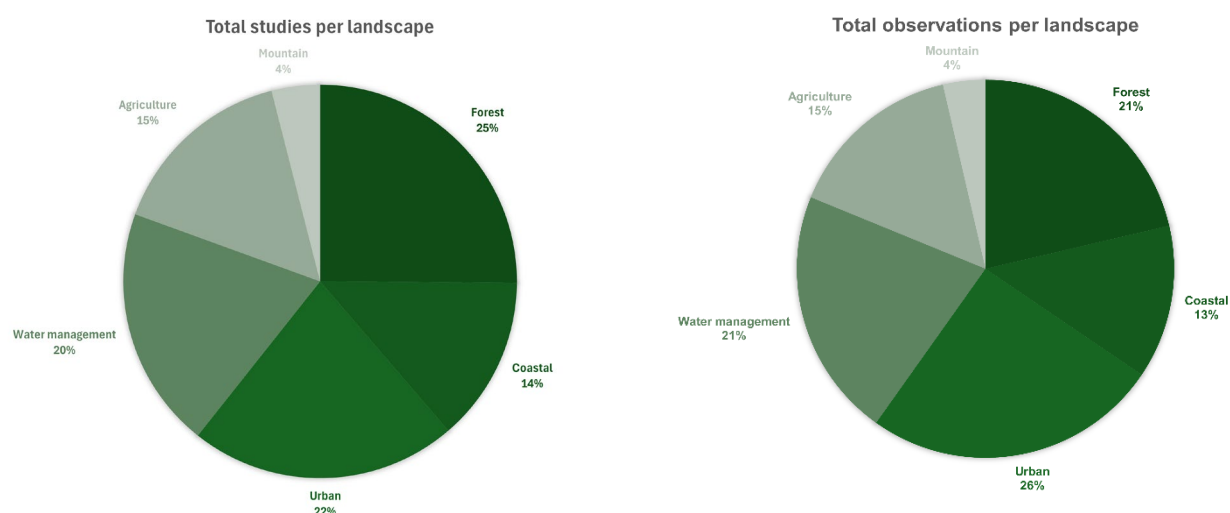


Figure 13. Studies and observations by landscape/thematic areas

Note: As a study can be categorised in more than one landscape, the totals are higher than the unique studies and observations. It provides however an insight into the distribution of studies across landscapes.

NbS can be categorised according to three typologies with respect to the level and type of engineering of biodiversity and ecosystems (Eggermont et al., 2015). Type 1 'protection' consists of no or minimal interventions in ecosystems with the aim to maintain or improve the delivery of ecosystem services and biodiversity. Type 2 'modification' represent actions of modifying existing ecosystems by restoring and rehabilitating degraded ecosystems, which can take place in both protected and productive landscapes. Type 3 'creation' consists of

establishing new ecosystems such as green roofs or stone reefs. Lozano et al., (2024) provides an in-depth description of the different types of NbS across landscapes and thematic areas of agriculture, forestry, urban, coastal, mountains and water management.

The vast majority of the 379 studies relate to the economic performance of NbS in protecting habitats (174 studies, 46%), while a large group of studies cover NbS modifying existing ecosystems (146 studies, 39%) and a smaller group of studies address NbS creating new habitats (59 studies, 16%) (see Figure 14).

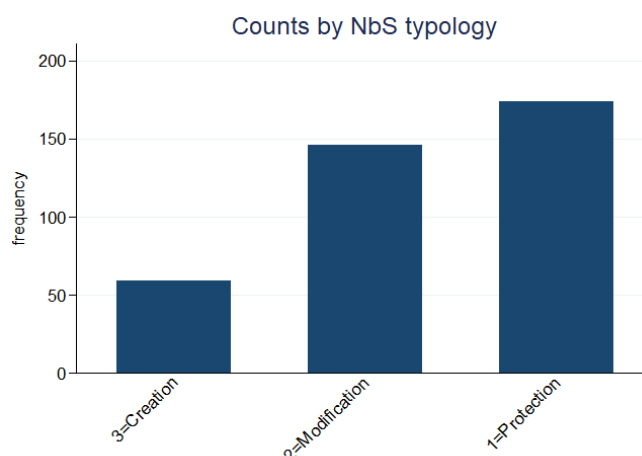


Figure 14. Number of studies by NbS typology – all studies

A study can be categorised into more than one landscape/thematic area and provides an overview of the habitats and thematic themes addressed. NbS actions to protect existing ecosystems are particularly captured in forest (64) and coastal studies (51), while strong modification to existing habitats are found almost equally in forests (64), agriculture (45) and water management (44) and creating new habitats are predominantly found in urban studies (41) followed by water management (20) (See Table 7). The same pattern emerges in terms of observations with 46% protection, 33% modification and 21% creation.

LANDSCAPE/THEMATIC AREA	PROTECT	MODIFY	CREATE
Forest	64	48	8
Coastal	51	11	3
Urban	35	30	41
Water management	31	44	20
Agriculture	25	45	5
Mountain	11	7	1

Table 7. Number of studies by NbS typology and landscape – all studies

Note: One study can belong to more than one landscape/thematic area.

Challenges

As part of the data extraction process, the challenges addressed by the studies were categorized into five thematic groups: climate change adaptation, climate change mitigation, natural hazards, environmental challenges, and socio-economic challenges.

Most studies (173) focus on environmental challenges, including pollution (air, water, soil, noise), biodiversity loss, and water scarcity. Around 70 studies address climate change adaptation (e.g., flooding, heat stress, storms, and droughts) and socio-economic challenges (e.g., health and wellbeing, social segregation, and economic efficiency), while 50 studies

focus on climate change mitigation. A relatively small number of studies (29) specifically address natural hazards such as avalanches, landslides, and earthquakes.

Table 8 presents the ranking of the five general challenge areas across all 379 studies. Since a single study can address multiple challenges, each study was ranked by the relevance of the challenge themes it tackled. The table summarizes the number of times each challenge category was ranked 1st, 2nd, and so on.

RANK	CC ADAPTATION	CC MITIGATION	NATURAL HAZARDS	ENVIRONMENTAL	SOCIO-ECONOMIC
1	71	52	12	173	70
2	15	27	7	59	61
3	10	5	9	11	23
4	1	3	1	8	0
5	1	1	0	0	0
Total	98	88	29	251	154

Table 8. Rank of challenges addressed across all studies

Looking into the specific challenges under the five general challenge areas,

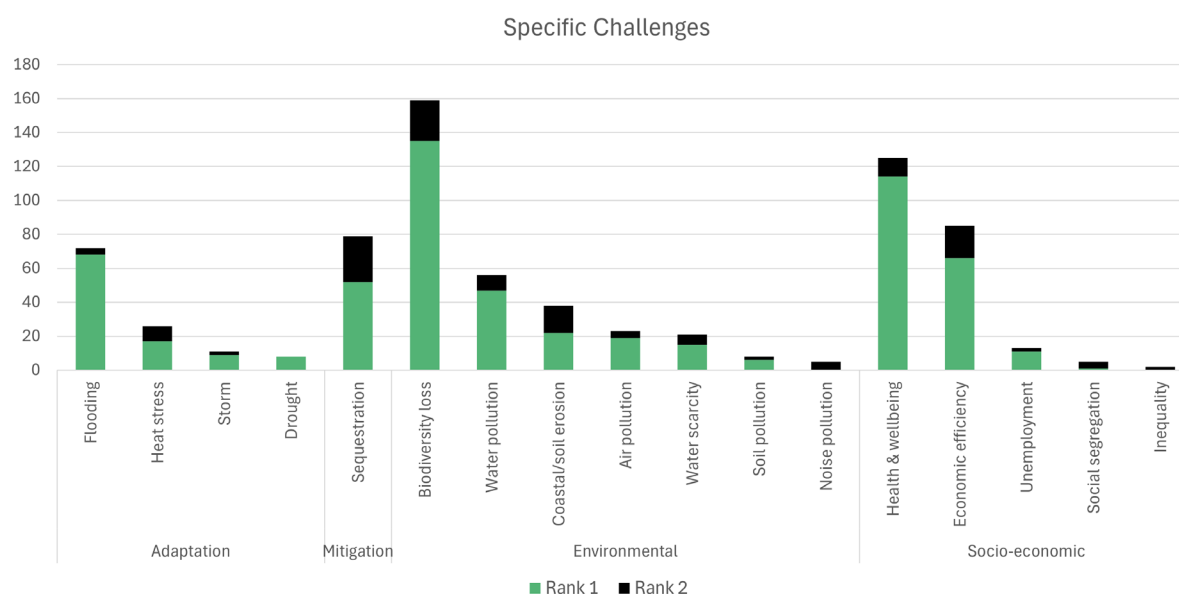


Figure 15 presents a breakdown of the specific challenges identified as either primary (Rank 1) or secondary (Rank 2) across the five overarching thematic areas. This disaggregation allows for a more nuanced understanding of the dominant concerns within each category.

Within the adaptation category, flooding emerges as the most frequently addressed challenge, with 68 studies ranking it first and 4 ranking it second. Other adaptation-related challenges such as heat stress, storm events, and drought are less prevalent, though still notable, particularly heat stress (17 ranked first; 9 ranked second).

In the mitigation category, carbon sequestration is the only specific challenge that can be addressed by nature-based solutions. It is addressed as the primary challenge in 52 studies

and as secondary in 27 studies. This indicates a strong emphasis on nature-based mitigation strategies in the reviewed literature.

Environmental challenges are heavily represented, with biodiversity loss standing out as the single most frequently addressed primary challenge across all categories (135 studies), followed by water pollution (47 primary; 9 secondary) and coastal or soil erosion (22 primary; 16 secondary). Other issues such as air pollution, water scarcity, and soil pollution are also addressed, though less prominently. Interestingly, noise pollution appears only as a secondary concern (5 studies) and was not identified as a primary focus in any study.

Under socio-economic challenges, health and wellbeing is the most frequently addressed, with 114 studies ranking it first and 11 ranking it second. Economic efficiency follows (66 primary; 19 secondary), reflecting a strong interest in the economic viability and efficiency of nature-based actions. Issues such as unemployment, social segregation, and inequality are relatively underrepresented, suggesting potential gaps in the literature on the economic assessment of NbS regarding equity and social justice dimensions.

Overall, the data show that while environmental and health-related challenges are widely acknowledged as primary concerns, there is relatively limited emphasis on certain socio-economic and adaptation challenges, particularly those related to social inequality and disaster-specific risks like drought and environmental risks of noise pollution.

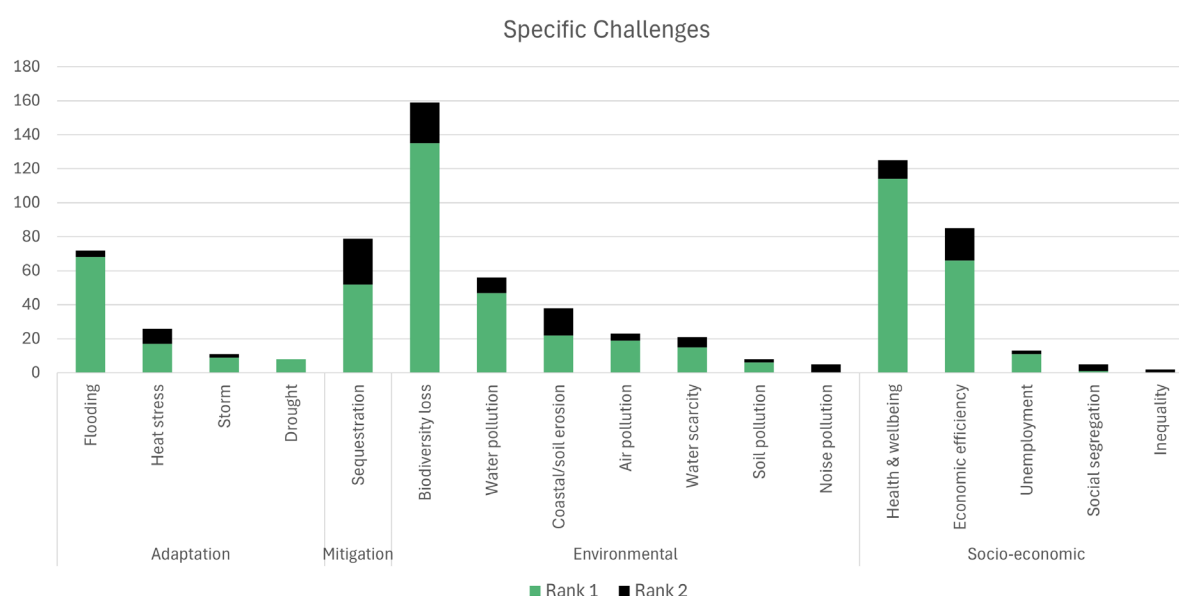


Figure 15. Specific challenges ranked as first and second priority in the studies

Assessment approaches

Of the 379 studies, 166 focus on assessing costs of NbS while 213 studies also assess the economic value of NbS benefits.

An analysis of benefit assessment approaches across studies applying benefit assessment and decision support approaches reveals a strong reliance on stated preference methods, which account for 25% of all studies. This indicates a clear emphasis on capturing public perceptions and willingness to pay for environmental benefits. Decision support tools are also widely used, applied in 19% of studies, reflecting their importance in integrating ecosystem values into planning and policy-making processes. Market-based approaches (15%) are

employed to establish links between ecosystem services and economic systems, while cost-based valuation (e.g. avoided costs or replacement cost methods) (11%) and value transfer methods (10%) are moderately used, often as practical solutions where primary data collection is not feasible. Risk management and revealed preference methods are less commonly applied (10% and 9% respectively), suggesting that approaches relying on observed behaviour or risk analysis are currently underutilized. Overall, the findings demonstrate a diverse methodological landscape, with a notable preference for approaches that elicit stakeholder and societal values directly. Table 9 provides an overview of studies with benefit assessment and the type of assessment.

BENEFIT ASSESSMENT APPROACHES	# STUDIES	PERCENT
Stated preferences	76	25%
Decision support	58	19%
Market based	45	15%
Cost based valuation	34	11%
Value transfer	31	10%
Risk management	29	10%
Revealed preferences	27	9%
Total	300	100

Table 9. Benefit assessment approaches

Note: More than one study can be attributed to more than one landscape/thematic area. The total number of studies listed therefore exceeds the unique number of studies.

Looking at the distribution of benefit assessment approaches applied across landscapes and thematic areas, we find that among the revealed preference assessment methods, the travel cost method is by far the most applied (26 studies and 127 observations), especially in forest landscapes (13 studies), assessing the value of accessing forest areas. A single study applies the random utility method in a coastal setting, assessing the characteristics of preferred landscape components. The hedonic pricing method, quantifying the amenity value of nearby green and blue areas is applied in six studies, 5 of which in an urban setting and one in relation to forest landscape.

Stated preference approaches, comprising contingent valuation and choice experiment, are applied in a total of 75 studies and 804 observations with a fairly equal spread between contingent valuation and choice experiments. Also across landscapes/thematic areas, the application of stated preference methods is spread fairly equally with between 16 and 23 studies in urban, coastal, forest, agriculture and water management landscapes/thematic areas. For the mountain landscape 10 studies apply stated preferences.

Value transfer approaches are often used where time and resources are not available to undertake a primary study, and where previous valuation studies allow for reasonable assumptions to transfer values from one context to another. 32 studies apply value transfer, predominantly single point transfer, but also using ranges of values allowing for sensitivity analysis.

Some 30 studies (269 observations) apply risk-based assessment approaches including quantitative risk assessment, risk benefits, scenario-based and value-at-risk approaches, in particular in coastal studies.

About 48 studies apply market-based approaches such as entry fee revenues, house price differentials, or gross margins on crops while 32 studies applied cost-based approaches such as replacement and damage cost assessments, and production cost assessments.

Decision-support approaches including cost benefit analysis, cost-effectiveness analysis, multiple criteria analysis and ecosystem accounting approaches were applied by 60 studies (592 observations). A total of seven studies applies cost benefit analysis followed by 5 studies on ecosystem accounting while one or two studies applied multi-criteria or cost-effectiveness analysis. Especially coastal studies apply cost-benefit analyses.

A total of 30 studies quantifies NbS performance using risk methods, including quantitative risks (2 studies), risk benefit (1), scenario based (22) and value at risk (1 study). The vast majority of studies using risk-based approaches focus on coastal landscapes and scenarios.

LANDSCAPE/ LAND USE	MARKET -BASED	COST- BASED	REVEALED PREFERENCE ¹	STATED PREFE- RENCE ²	VALUE TRANS- FER ³	RISK MANA- GEMENT	DECI- SION SUPPORT
Urban	4	6	9	16	3	3	5
Agriculture	15	8	0	18	3	0	12
Water management	5	3	7	23	6	1	16
Coastal	3	5	9	18	16	18	20
Mountain	4	0	1	9	0	0	0
Forest	25	11	14	20	4	7	19

Table 10. Benefit assessment approaches by landscape/thematic area by number of studies

Notes: 1 - revealed preference methods comprise travel cost, including random utility method and hedonic pricing. 2 – stated preference methods comprise contingent valuation and choice experiments. 3 – value transfer comprises any of the assessment approaches by transferring a value from an original study to another setting, either using single point transfers or function transfers. As one study can belong to more than one landscape/thematic area, the totals may contain the same study in more than one landscape.

LANDSCAPE/ LANDUSE	MARKET -BASED	COST- BASED	REVEALED PREFERENCE ¹	STATED PREFEREN CE ²	VALUE TRANS FER ³	RISK MANAGE- MENT	DECI- SION SUPPORT
Urban	70	106	25	166	29	25	108
Agriculture	119	89	8	151	31	6	65
Water management	66	44	36	187	124	30	160
Coastal	15	129	19	251	146	203	240
Mountain	39	10	3	78	14	0	6
Forest	222	142	87	159	34	37	114

Table 11. Benefit assessment approaches by landscape/thematic area by number of observations

Evidence of NbS efficiency

Benefit-cost ratios (BCRs) assess the (socio-)economic viability of NbS by comparing the present value of expected benefits to that of associated costs. A BCR greater than 1 indicates that the benefits outweigh the costs, suggesting a positive return on investment. This metric enables comparison across projects, geographies, and scales.

Of the 379 studies included in the final literature set, **28 studies (yielding 350 observations)** reported BCR estimates—primarily in urban and coastal contexts. Among these, **56% of observations** report BCR greater than 1, indicating that a majority of NbS interventions were economically beneficial. A significant share of cases (**19.14%**) showed BCR values exceeding 2, suggesting a high return on investment. The **median BCR** is 1.11, implying a modest typical net benefit, while the **mean BCR** is notably higher at 2.45, indicating the presence of several high-value outliers.

INDICATOR	VALUE
N	350
% BCR>1	56.0
% BCR>2	19.14
Median BCR	1.11
Mean BCR	2.45
Min	0.01
Max	32

Table 12 shows the summary statistics for all 358 observations.

INDICATOR	VALUE
N	350
% BCR>1	56.0
% BCR>2	19.14
Median BCR	1.11
Mean BCR	2.45
Min	0.01
Max	32

Table 12. BCR summary statistics.

Benefit-cost ratios by landscape/thematic area

Across the six landscape/thematic area categories we find the following evidence on the economic viability of NbS projects:

- **Forests** show the **highest economic potential**, with both the highest percentage of BCR >2 (60%) and the highest average BCR (30.1), albeit from a small sample. This suggests some forest-based NbS projects deliver exceptionally high returns.
- **Water-related projects** are **consistently strong performers**, with over 70% of cases exceeding BCR >1 and a substantial 40.8% exceeding BCR >2. Both median (1.6) and mean (7.2) values indicate strong and relatively widespread economic viability.
- **Agricultural landscapes** also perform well, with over 70% of observations above BCR >1. While average returns (mean BCR = 1.8) are modest, the consistency in positive outcomes (median = 1.3) supports their viability.
- **Urban NbS projects** show **moderate performance**, with 65.4% above BCR >1 and 22.3% above 2. While not among the highest performers, they still demonstrate a favourable benefit-cost balance in most cases.

- **Mountain landscapes**, though based on a small sample (n=4), show encouraging signs: 75% of cases are above BCR >1, with respectable median and mean values (1.5 and 1.8). However, the limited data reduces confidence in generalizability.
- **Coastal landscapes** show the relatively low **BCR outcomes** and only few studies investigating BCR. About 20% of observations are above BCR >1 and minimal values above BCR >2. Median and mean BCRs are both below 1. This result either suggests that many projects in coastal areas may not be economically viable without including broader ecosystem or social co-benefits. This also means that future studies evidencing BCR levels is needed for coastal NbS in order to better understand the financing performance of NbS and its wider co-benefits.

Table 13 presents key findings and comparative performance of NbS projects across landscapes.

LANDSCAPE/ THEMATIC AREA	N	% BCR > 1	% BCR > 2	MEDIAN BCR	MEAN BCR
Urban	188	65.4%	22.3%	1.1	3.3
Water	125	72.0%	40.8%	1.6	7.2
Agriculture	44	72.7%	29.5%	1.3	1.8
Forest	12	75.0%	50.0%	2.78	3.86
Coastal	74	19.0%	5.0%	0.63	0.68
Mountain	4	75.0%	25.0%	1.5	1.8

Table 13. Benefit Cost Ratios across landscapes/thematic areas

4.2. WATER MANAGEMENT

Water management is considered a thematic area of NbS rather than a landscape. NbS economic assessment studies covering actions on regulating water quantity and quality is the third most studied theme among the 379 studies included in the literature review accounting for 95 studies (20 %), but with the most observations (2,745) representing 44% of the overall analysis.

Geographical distribution

The distribution of water management-related studies across European countries and regions reveals a strong geographic concentration: overall, the majority of the 95 water management related studies and observations were conducted in Mediterranean/Southern Europe (43 studies and 1174 observations), followed by Central Europe (20 studies and 623 observations) and Great Britain and Ireland (15 studies and 389 observations). Northern Europe accounted for about 10%, while Eastern Europe represented slightly more than 6%. Only one study covered more than one European region.

At the country level, Spain had the highest number of such studies, contributing 19 out of the total 95 studies (20.0%). The United Kingdom followed with 14 studies (14.7%), while Italy accounted for 10 studies (10.5%). Together, these three countries represented nearly 45% of all water management-focused studies. Other countries with notable contributions included Belgium, Germany, and Greece, each with 5 studies (5.3%). Several countries—such as Austria, Bulgaria, Cyprus, Finland, and France—had only one study each (1.05%), highlighting a relatively sparse representation. These results suggest that research on water management in Europe is unevenly distributed during the investigated period, with Southern and Western European

countries being more prominently featured.

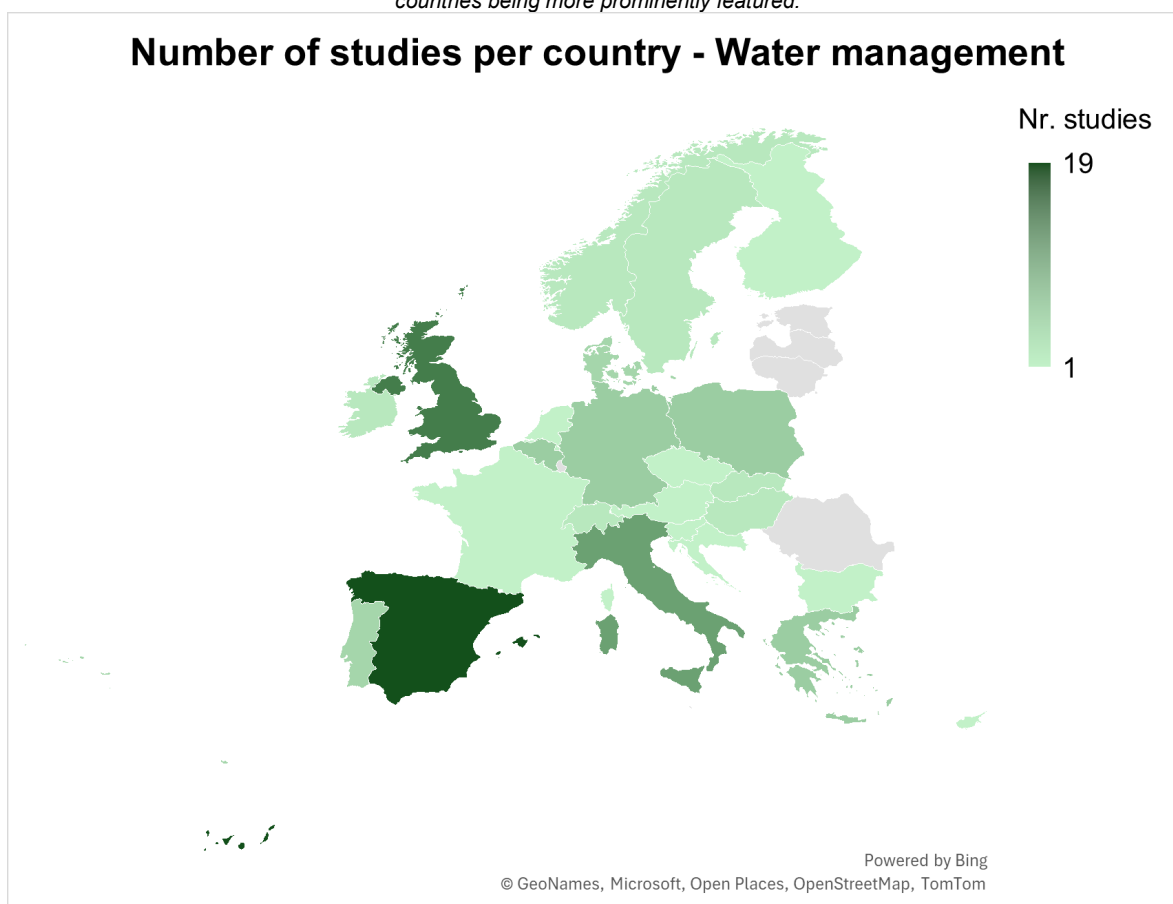


Figure 16 shows the distribution of studies across countries and Table 14 the distribution across European regions.

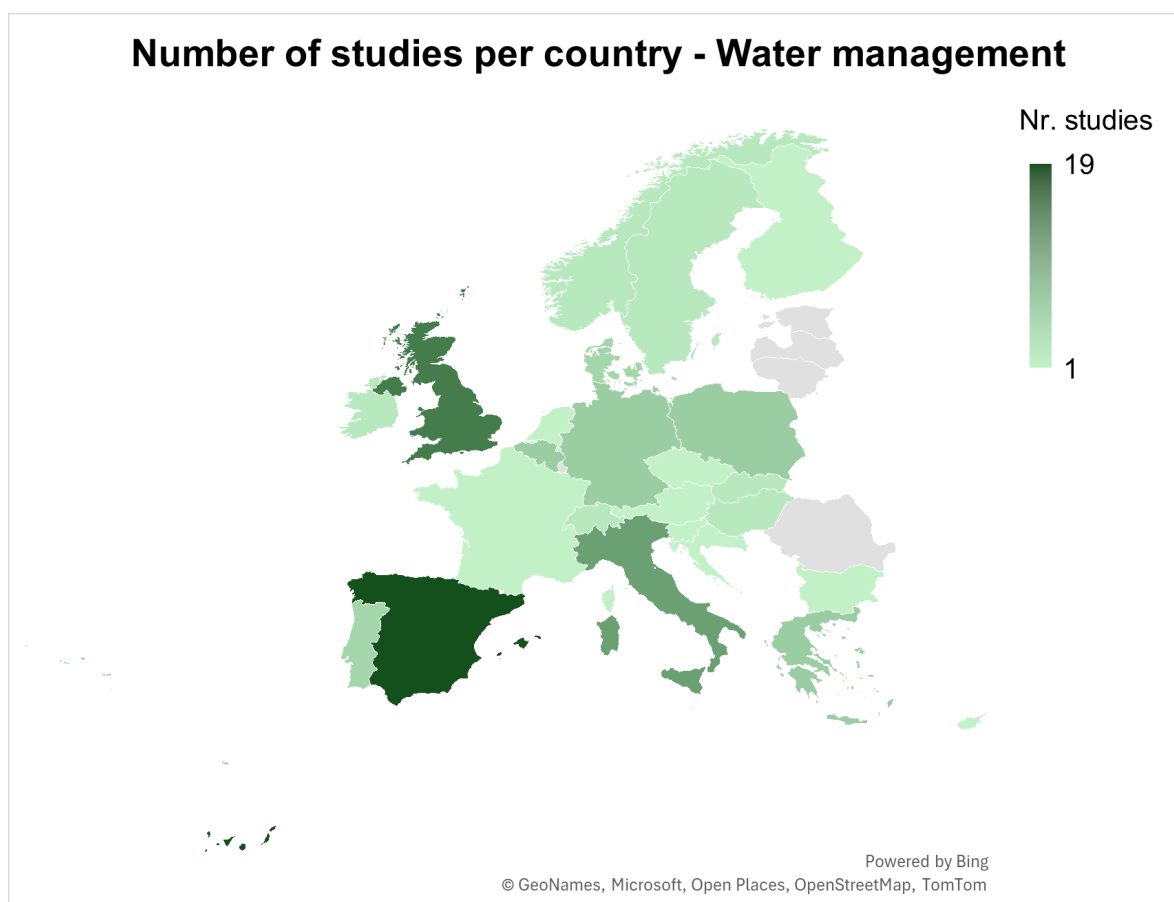


Figure 16. Map of number of water management related NbS assessment studies per country

EUROPEAN REGION	# STUDIES	PERCENTAGE (%)
Central Europe	20	21.05
Eastern Europe	6	6.32
Great Britain and Ireland	15	15.79
Mediterranean/Southern Europe	43	45.26
Northern Europe	10	10.53
More than one European region	1	1,05

Table 14. Number and percentage of water management related NbS assessment studies across regions.

Water management related NbS typologies and actions

Water management-related NbS identified in the studies span the three typologies of creation (19 cases), protection (30), and modification (45). Compared to the overall set of studies, water management exhibits a higher proportion of creation-oriented actions—25% versus 16% overall—though this remains substantially lower than in urban-focused NbS, where creation accounts for 53% of interventions. Modification is the most common approach in water management (45 cases), placing it among the top three landscapes—alongside forest and agriculture—where ecosystem modification is most prevalent (24–26%).

The most frequently studied NbS action within water management was the maintenance of a safe physical environment, comprising 21.3% of all cases. This was followed by swales,

retention ponds, and constructed wetlands (18.6%) and the rehabilitation and restoration of rivers and floodplains (14.6%).

Green roofs, green facades, and rain gardens accounted for 9.6%, while groundwater management and restoration of river buffers represented 7.9% and 5.1%, respectively. Less commonly studied were water-sensitive forest management (4.8%), wetland restoration (3.1%), and the restoration of urban green spaces and corridors, which comprised only 0.6% of the total.

A notable proportion of studies (142) were categorised under ‘Other’ NbS actions, indicating diversity in implementation beyond the predefined classifications. These included land-use transformation approaches, such as periodic flooding of agricultural fields to mitigate urban flooding (Zandersen et al., 2021), runoff and retention interventions, including infiltration gullies, grading, and constructed wetlands, were applied to manage surface water flows on urban brownfield areas (De Valck et al., 2019), while natural flood management was also highlighted as a key strategy (Short et al., 2019). Several actions also involved the use of engineered-natural systems such as algae-based (Santos et al., 2022) and conventional wastewater treatment plants (Pouso et al., 2020), along with reclaimed water reuse (Zabala et al., 2019). Water-retention measures (WRM), riparian woodland management (Vermaat et al., 2021), and restoration of waterside spaces (McDougall et al., 2020) were also reported for their combined hydrological and ecological benefits. This range of actions illustrates the adaptive and multifunctional application of NbS across diverse hydrological and socio-ecological contexts, often integrating multiple benefits such as water quality improvement, nutrient reduction through reforestation, and habitat diversification.

Table 15 presents an overview of the different NbS actions across water management related studies.

NBS ACTION	NR. STUDIES	PERCENTAGE (%)
Maintenance of safe physical environment	210	21.3
Swales, retention ponds, constructed wetlands	183	18.56
Rehabilitation and restoration of rivers and floodplains	144	14.6
Other	142	14.4
Green roofs, green facades, rain garden	95	9.63
Groundwater management	78	7.91
Rehabilitation and restoration of river buffers	50	5.07
Water-sensitive forest management	47	4.77
Wetland restoration	31	3.14
Restoration of urban green space and corridors	6	0.61
Total	986	100

Table 15. Number of studies per water management NbS action.

Challenges

Water management studies primarily focus on environmental issues (38 studies), closely followed by adaptation challenges (33 studies), socio-economic challenges (11 studies) and mitigation (9 studies). Natural hazards are prioritised in 4 studies as a primary challenge. Especially environmental (21 studies) and socio-economic challenges (15 studies) are relevant as secondary priority.

RANK	CC ADAPTATION	CC MITIGATION	NATURAL HAZARDS	ENVIRONMENTAL	SOCIO-ECONOMIC
1	33	9	4	38	11
2	5	7	2	21	15
3	6	0	4	4	6
4	0	2	1	6	0
5	1	1	0	0	0
5	33	9	4	38	11

Table 16. Rank of challenges addressed in water management NbS assessment studies

Note: This table shows the 5 general challenges that each study could be assigned to. As each study can be assigned to more than one challenge, the rank shows which challenge in sum over the urban studies was listed 1st, 2nd etc.

Looking more specifically into the type of challenges addressed in water management related studies reveals that flooding (35 studies), as part of adaptation, health and wellbeing (34 studies), as part of socio-economic challenges, and water pollution (33 studies), as part of environmental issues, are the most frequently 1st ranked considered issues.

Other adaptation issues (heat stress, drought and storms) appear less relevant for water management related studies. Biodiversity loss is addressed as top 1 and 2 priorities in 28 studies among the other environmental challenges, followed by water scarcity (17 studies) and coastal and soil erosion (11 studies). Economic efficiency is the second highest challenge among socio-economic issues with 19.

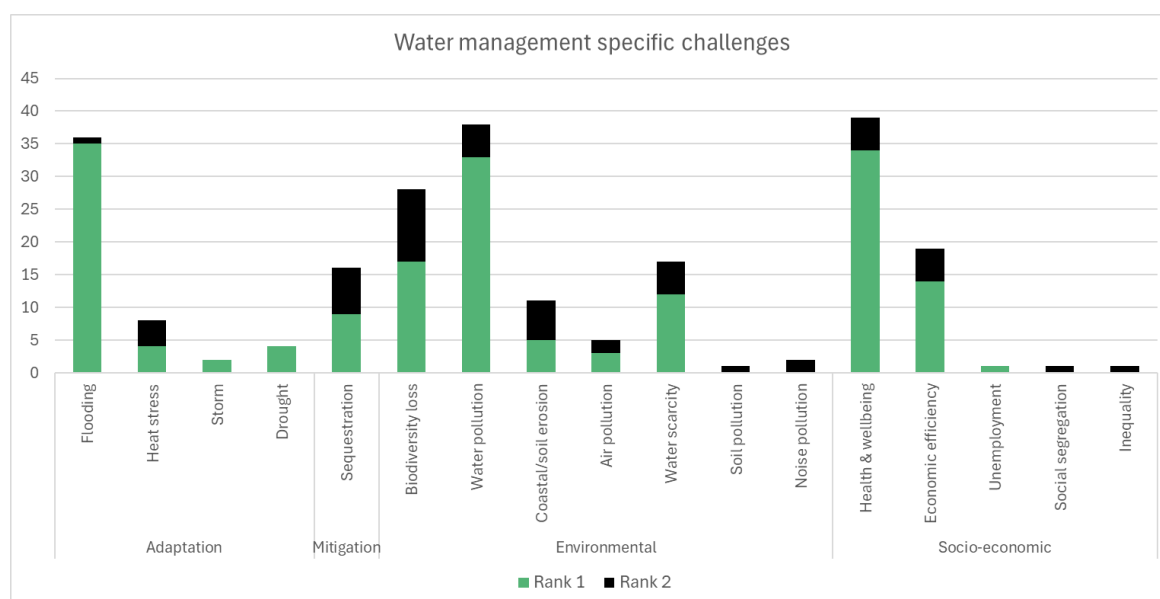


Figure 17. Specific water management challenges ranked as first and second priority in the studies

Assessment methods

The reviewed studies applied a range of economic assessment approaches to evaluate NbS, with varying levels of uptake across methodologies.

The most frequently applied approaches are stated preference techniques through the use of choice experiments (10 studies, 112 observations) and contingent valuation (13 studies, 82 observations). These methods dominate the dataset, reflecting a strong reliance on user preferences to estimate NbS value.

Decision support assessment approaches account for a total of 16 studies (160 observations). Among these, cost-benefit analysis is featured in 8 studies (70 observations), followed by ecosystem accounting (5 studies, 66 observations). Less frequently used approaches included multi-criteria analysis (MCA), cost-effectiveness analysis (CEA), and other decision frameworks, each appearing in only one study.

Value transfer approaches, which can apply to any of the benefit assessment approaches, were applied in a total of 10 studies, accounting for 124 observations (e.g., (Benisiewicz et al., 2021; Carolus et al., 2018; de Groot et al., 2022; Rizzo et al., 2021).

Market-based approaches and cost-based assessments were also commonly applied, appearing in 6 and 7 studies, respectively, with a combined total of 110 observations.

Revealed preference methods were less frequently applied overall, with travel cost and random utility models present in 6 studies (39 observations) (e.g. Afentou et al., 2022; De Nocker et al., 2022; Pouso et al., 2021), and hedonic pricing applied only in 2 studies (3 observations) (Mandić and Petrić, 2021).

Risk management approaches were the least represented. While scenario-based risk assessments were used in 5 studies (30 observations), quantitative risk assessments were entirely absent from the sample.

Overall, the dataset indicates a clear preference for stated preference, value transfer, and market/cost-based methods, with decision-support and risk-based approaches used more selectively.

ASSESSMENT APPROACH		NR. STUDIES	NR. OBSERVATIONS
Stated preference	Contingent valuation	13	82
	Choice experiment	10	112
Revealed preference	Hedonic pricing	2	3
	Travel cost & RUM	6	39
Cost-based		7	44
Market-based		6	66
Value transfer		10	124
Risk management	Quantitative risk assessment	0	0
	Scenario-based	5	30
Decision support	Cost-benefit analysis	8	70
	Ecosystem accounting	5	66
	CEA	1	7
	MCA	1	16
	Other	1	1

Table 17. Assessment approaches applied in water management per number of studies and observations.

Note: Studies may apply different assessment methods across various observations

Benefit-cost ratio of NbS in water management studies

From the systematic review of NbS within the water management landscape, 120 observations of the BCR were recorded. Of the 120 studies categorised under the water management, 70% were economically profitable with a BCR above 1. Close to 40% of the 120 observations were more than double the level of costs with a $BCR > 2$.

The findings reveal a wide distribution of BCR values, with a median of 1.63, indicating that, on average, NbS interventions tend to provide benefits that outweigh their costs. The mean BCR is notably higher at 4.59, reflecting the influence of several high-value projects, as evidenced by a right-skewed distribution (skewness = 1.68) and a maximum value of 21.64. The interquartile range spans from 0.91 (25th percentile) to 7.75 (75th percentile), suggesting considerable variability in outcomes. The kurtosis value of 5.02 further indicates a distribution with a pronounced peak and heavier tails, reflecting the presence of some extreme values. While a small proportion of cases (e.g., 1st and 5th percentiles at 0.11) reported relatively low BCRs, the overall pattern supports the economic viability of NbS in water management, especially under favourable conditions.

DETAILED DESCRIPTIVE STATISTICS					
	Percentiles	Smallest			
1%	0.11	0.01			
5%	0.11	0.01		Observations	120
10%	0.12	0.01		Sum of weights	120
25%	0.91	0.01			
50%	1.63	Largest		Mean	4.59
75%	7.75	21.64		Std dev	5.84
90%	13.54	21.64		Variance	31.06
95%	21.64	21.64		Skewness	1.68
99%	21.64	21.64		Kurtosis	5.02

Table 18. Statistics of BCR analyses, water management landscape.

An analysis of BCRs across specific NbS actions highlights notable variation in economic performance (See Table 19). Green roofs, green facades, and rain gardens show the highest average BCR at 9.77, with a median of 8.04, though results vary considerably (standard deviation = 6.75), ranging from 0.70 to 21.64. Swales, retention ponds, and constructed wetlands also show promising results with a mean BCR of 2.43 and a median of 1.14 across 29 observations, suggesting moderate but variable returns (standard deviation = 4.65). Groundwater management exhibits a wider range of outcomes with a mean of 4.00 and a median of 1.60, reflecting high variability (standard deviation = 5.21). Rehabilitation and restoration of river buffers and water-sensitive forest management present more modest average BCRs of 2.85 and 1.56, respectively, though with less variation in the latter.

These findings indicate that while some NbS actions can deliver high economic returns, performance varies significantly across intervention types, underscoring the importance of context-specific planning and evaluation.

NBS ACTIONS	N	MEAN	MEDIAN	SD	MIN	MAX
Swales, retention ponds, constructed wetlands	29	2425	1.14	4.649	0.11	17.3
Rehabilitation and restoration of rivers and floodplains	1	3.3	3.3	.	3.3	3.3
Green roofs, green facades, rain garden	36	9.77	8.04	6.746	0.7	21.64
Groundwater management	11	4	1.6	5.207	0.1	15.1
Rehabilitation and restoration of river buffers	14	2.846	0.91	3.22	0.86	7.75
Water-sensitive forest management	19	1.557	1.66	0.622	0.49	3.59
Restoration of urban green space and corridors	1	1.025	1.025	.	1.025	1.025
Total	111	4.862	1.67	5.983	0.1	21.64

Table 19. BCR values per type of NbS action in water management NbS assessment studies.

To provide deeper insights into the economic performance of NbS within the water management thematic area, three studies are presented here. Almeida et al. (2021) evaluate the socio-economic feasibility of implementing Nature Based Solutions in public buildings, with a focus on two primary schools in Portugal. Using a comprehensive cost benefit analysis methodology, the research assesses the value of greening interventions from three complementary perspectives: infrastructure, users, and the environment. The analysis operates across financial, economic, and socio-environmental levels, incorporating both direct and indirect costs and benefits. Fourteen greening scenarios were developed to address the identified needs of each school, with ten selected for detailed evaluation. These scenarios encompass various green infrastructure typologies, including extensive green roofs, indoor and outdoor green façades, and living walls. One notable feature of the analysis is the inclusion of runoff management as a key socio-environmental benefit, reinforcing the relevance of these interventions within the broader water management landscape. The two case studies differ in layout and use. CS1 includes kindergarten and first cycle education and is composed of two buildings on an 11,000 square meter plot, with the main building covering around 2,500 square meters. CS2 also serves children from preschool to the first cycle and consists of two buildings on a larger site with a gross area of around 9,000 square meters, including a 2,500 square meter primary school building and a 1,000 square meter kindergarten facility.

The results demonstrate that all proposed scenarios are socio-environmentally viable, though the benefit cost ratios vary considerably depending on the type of intervention and its context. Green façades consistently achieved the highest ratios across both schools, with the indoor green façade in CS2 reaching a benefit cost ratio of 34.99, the highest in the analysis, despite having relatively modest net gains of €149,000. Outdoor green façades also performed well, with ratios of 21.64 and 23.90 in CS1 and CS2 respectively, suggesting a strong return on investment relative to their cost. In contrast, green roofs provided the largest total socio-environmental benefits, including a discounted cumulative gain of €2.5 million in CS2, but with a lower ratio of 10.43 due to higher upfront costs. Living walls were the least cost effective, with ratios ranging from 3.01 to 7.75, mainly due to greater installation and maintenance requirements. Notably, the study emphasizes that if feasibility assessment were limited to the financial level alone, the outcomes would appear negative, as only direct costs would be considered while excluding the many non-market benefits that define the true value of these interventions. These findings underscore the importance of evaluating both investment efficiency and the broader, multidimensional benefits when assessing the feasibility of NbS. These findings underscore the importance of evaluating both investment efficiency and the multi-dimensional benefits when evaluating NbS investments.

Carolus et al. (2018) propose and apply a bottom-up approach to Cost-Benefit Analysis (CBA), where strategies to address environmental issues are developed with input from local stakeholders, rather than imposed top-down through predefined policy options. The goal is to produce solutions that are better suited to local conditions, more socially acceptable, and reflective of stakeholder knowledge and values. Two river catchments, Berze in Latvia and Helge in Sweden, serve as case studies. The Berze region is smaller, rural, and agriculturally intensive, with nutrient pollution as a key issue. Helge is larger, forested, and more urbanized, facing eutrophication and heavy metal contamination. Strategies developed for Helge targeted either aquatic ecosystem restoration (“River”) or sustainable forestry practices (“Forest”). In Berze, strategies addressed point source pollution (“WWTP”), agricultural runoff (“Agriculture”), and hydropower impacts (“Hydropower”). In the Helge River catchment, two overlapping strategies were developed: Strategy 1 (“River”) focused on aquatic ecosystem restoration, and Strategy 2 (“Forest”) targeted sustainable forestry practices to reduce nutrient runoff. In the Berze catchment, strategies were divided by pressure and stakeholder group: Strategy 1 (“WWTP”) addressed wastewater treatment pollution, Strategy 2 (“Agriculture”) targeted agricultural runoff with two variants differing in buffer strip width (10 m in 2a, 5 m in 2b), and Strategy 3 (“Hydropower”) focused on mitigating hydropower impacts on water regulation.

The impact assessment of these strategies considered several ecosystem services including flood risk reduction, erosion and sediment control, and improvements in surface and groundwater quality. Economic valuation relied on a value transfer approach, with present values (PV) of costs and benefits estimated over a period corresponding to 2021–2030, as indicated in the strategy assessments. In the Helge River case, both strategies demonstrated positive net present values (NPVs), with Strategy 1 achieving an NPV of 2212.95 million SEK and a high benefit-cost ratio (BCR) of 7.75. Although Strategy 2 (“Forest”) yielded the highest total benefits (3297.56 million SEK), its costs were also much higher (1868.96 million SEK), resulting in a lower BCR of 1.76. The major burden of costs in Strategy 2 fell on the forestry sector, while benefits included significant gains in reduced water colour, biodiversity, and recreation. For the Berze River catchment, outcomes were more mixed. Strategy 1 (“WWTP”) was the only one with a positive NPV (0.33 million Euro) and a BCR of 1.91, suggesting it was economically efficient. Strategies 2a and 2b, both related to agriculture, had moderate benefits but high agricultural costs, resulting in negative NPVs and BCRs below 1. Strategy 3 (“Hydropower”), though relatively low-cost, yielded a positive NPV (6.51 million Euro) and the highest BCR (17.1), highlighting its cost-effectiveness in improving ecosystem services like biodiversity and recreation.

The findings show that while bottom-up CBA can increase the acceptability of proposed measures by highlighting their social benefits, implementation remains uncertain when private costs outweigh private benefits. Stakeholders emphasized that uptake depends on adequate compensation, whether monetary or in kind, and credible evidence of effectiveness. For example, in the Berze catchment, buffer strips were widely seen as beneficial but were not broadly adopted due to insufficient payments. Similarly, in the Helge case, forest stakeholders were open to measures in principle but demanded proof that actions like those in Strategy 2 would produce real environmental improvements.

Wilbers et al. (2022) evaluate six blue green infrastructure (BGI) strategies and one grey infrastructure alternative for stormwater management in Oslo’s peri-urban Grefsen catchment. The BGIs include wadis; green roofs; a combined green and blue approach (raingardens, rain barrels, and wadis); infiltration crates; water squares; and a separate sewage system. These

were assessed for rainfall events of 60 minutes occurring once every 5, 20, and 100 years under current and future climate scenarios (RCP 8.5).

Investment sizes and costs scale with event intensity. For example, wadis ranged from 479 square meters for the five-year event to 2,835 square meters for the 100-year future event, while green roofs expanded from 9,685 to over 57,000 square meters for the same scenarios. Capital costs and operational costs vary accordingly. For wadis, total costs range from 0.18 million Norwegian kroner for the five-year current event to 1.06 million kroner for the 100-year future event. Green roofs range from 7.29 million to 43.15 million kroner over the same events.

Benefit cost ratios are highest for wadis, ranging from 12.0 to 17.3, separate sewer systems from 7.7 to 15.1, and the green and blue strategy from 1.6 to 2.3. For example, under the 100-year future scenario, wadis provide total benefits estimated at 16.86 million kroner against costs of 1.06 million kroner. Green and blue measures yield 32.78 million kroner benefits for 14.11 million kroner costs, and separate sewer systems deliver 8.65 million kroner benefits for 0.65 million kroner costs. Other strategies such as green roofs and water squares typically show benefit cost ratios below one within the 30-year horizon.

Return on investment periods reinforce these trends. Wadis recoup costs in four to five years, separate sewer systems in five to seven years, and green and blue strategies in ten to fourteen years. Infiltration crates and water squares have much longer payback periods, sometimes exceeding 30 years, especially for smaller events. Sensitivity analyses confirm the robustness of wadis and separate sewer systems' cost-effectiveness against uncertainties in costs, discount rates, and benefit estimates. Water squares and green roofs are more sensitive to such changes.

Overall, the study demonstrates that certain BGIs, particularly wadis and combined green and blue measures, are socially and economically beneficial investments for urban stormwater management in Oslo, offering both immediate and long-term advantages under current and changing climate conditions. These insights support informed decision making on infrastructure choice and flood protection levels.

Key Take Aways – Water management

Water management is a thematic domain rather than a traditional landscape, but it is among the most analytically intensive areas, accounting for 95 studies and 2,745 observations, representing 44% of all recorded data. Research is heavily concentrated in Southern Europe, with notable activity in Central Europe and the UK.

NbS actions in water management are predominantly modification-oriented (45 studies), followed by protection (30) and creation (19). Common actions include the construction of retention ponds and wetlands, river and floodplain restoration, groundwater management, and green infrastructure such as rain gardens. These interventions are often multifunctional, addressing both hydrological and ecological goals.

The challenges most frequently addressed include environmental issues (particularly water pollution and biodiversity loss), adaptation to flooding, and socio-economic concerns like health and well-being. Mitigation and natural hazard risks are less frequently prioritized.

Assessment methods reveal a strong preference for stated preference techniques, followed by value transfer and decision-support tools. Market-based and cost-based approaches are also widely used, while revealed preferences and risk-based assessments are less common. Scenario-based risk assessments are used more frequently here than in other landscapes.

BCR results for water-related NbS are among the most promising. Out of 120 observations, over 70% exceed a BCR of 1 and 38% exceed 2. The mean BCR is 4.59, and the median is 1.63, indicating both strong performance and relatively wide applicability. High BCRs are associated with green roofs, wetland restoration, and river buffer rehabilitation.

4.3. URBAN AREAS

Geographical distribution

Urban landscape resulted to be the second most studied category in terms of studies and the most studied in terms of observations with for 105 studies (22%) and 1244 observations (26%), covering approximately more than 20% of the overall analysis.

Almost half of these studies (45 – 48% out of 106 studies) are concentrated in the Mediterranean and Southern European regions, with particular focus on Italy and Spain. The remaining studies are distributed across Central Europe (29%, mostly in Germany and Poland), Great Britain and Ireland (11%, primarily in UK), Northern Europe (9%), Eastern Europe (4%). Only 2 studies cover more than one European region.

The geographical distribution of urban NbS assessment studies largely mirrors that of the overall dataset. The only notable difference is that Great Britain and Ireland feature slightly more urban studies compared to Northern Europe. Figure 18 shows the number of urban NbS studies by country and Table 20 the distribution of studies across European regions.

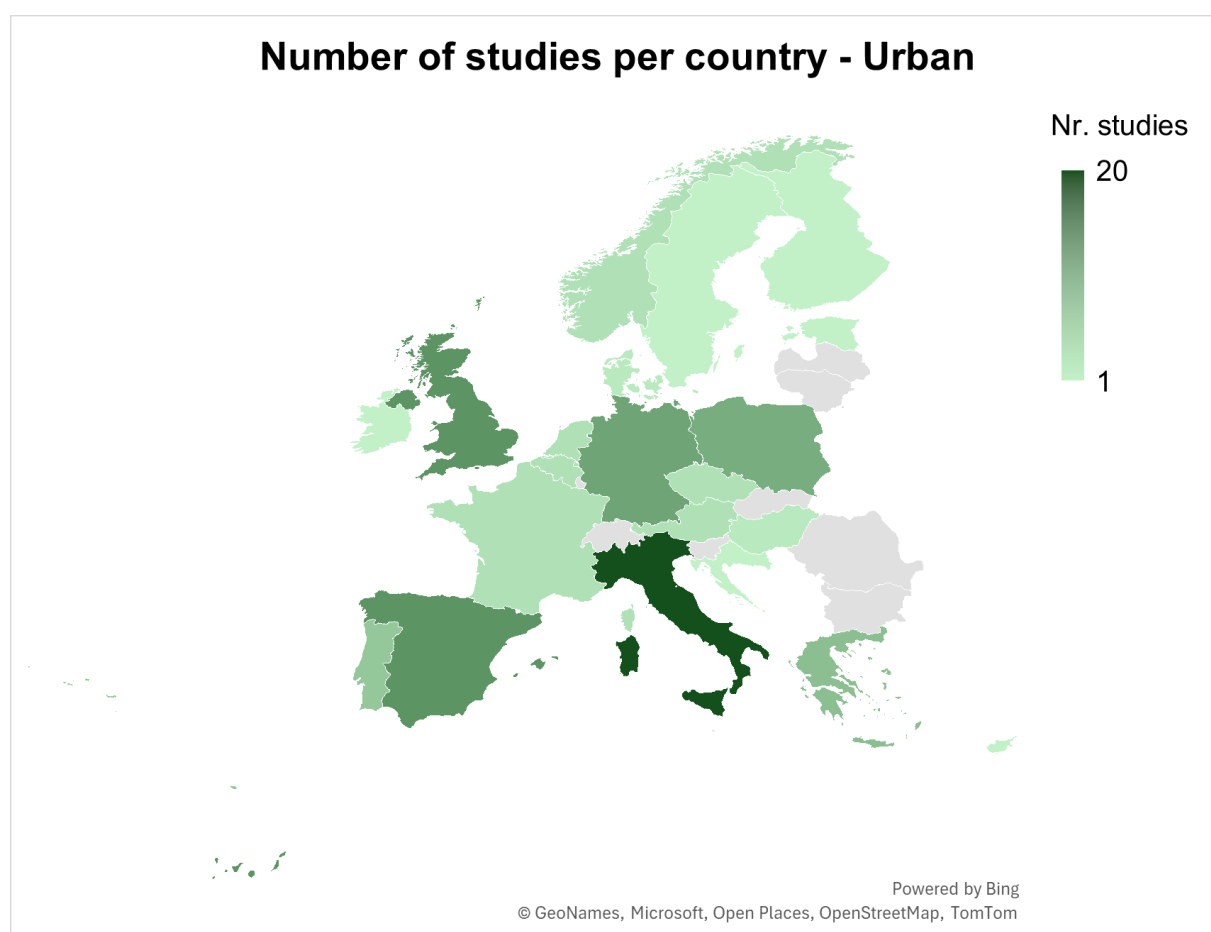


Figure 18. Map of number of urban NbS economic assessment studies per country

EUROPEAN REGION	# STUDIES	PERCENTAGE (%)
Central Europe	31	29.25
Eastern Europe	4	3.77
Great Britain and Ireland	12	11.32
Mediterranean/Southern Europe	48	45.28
Northern Europe	9	8.49
More than one European region	2	1.89

Table 20. Number and percentage of urban NbS assessment studies across European regions.

Urban NbS typologies and actions

Urban NbS addressed in the studies cover creation (41), protection (35) and modification (30) typologies. Compared to the overall set of studies, the urban environment shows a higher prevalence of creation of new ecosystems. The same pattern is replicated in the individual observation records, creation accounts for the highest number of interventions (637), followed by modification (363) and protection (244). This ranking contrasts with that of the overall dataset, where the order is reversed.

The NbS typology is closely linked to the specific types of interventions that define the urban environment, which tends to be more devoted to the creation and maintenance of green spaces - such as parks and gardens, green roofs and green walls, vegetated alleys and street.

For instance, in Turin (northeast Italy), the municipality has planned the conversion of a 150-hectare area at the edge of the city - formerly used for agricultural purposes and now occupied by factories and car dealerships - into a new public green park. This intervention builds on the site's natural features and strategic location to improve ecological connectivity and urban liveability (Bottero et al., 2023). In Getxo (Spain), the Thinking Fadura project proposes to integrate publicly accessible sports facilities with surrounding green spaces. The goal is to promote social cohesion and reconnect citizens with nature through daily activities in a multifunctional urban setting (De Jalón et al., 2020). Similarly, in Berlin, along Potsdamer Straße, the city has planned to enhance the streetscape by planting more street trees and installing green façades. This aims to create a continuous green corridor that contributes to biodiversity, improves microclimate, and supports pedestrian comfort (Fruth et al., 2019). In southern Italy, the city of Lecce has identified the management of green infrastructure in narrow urban streets (so-called street canyons) as a key strategy to improve air quality and mitigate heat, particularly in dense neighbourhoods like Santa Rosa (Buccolieri et al., 2020).

The 'Other' category includes measures that promote enhanced green accessibility and the development of more sustainable water management infrastructure, such as sustainable drainage systems (SuDS) and rain gardens. It also includes combinations of creation, modification, or restoration actions, and highly context-specific solutions. Table 21 overleaf presents an overview of the different NbS actions across urban studies.

NBS ACTIONS	NR. STUDIES	PERCENTAGE (%)
Protection/maintenance of urban green spaces	35	33.33
Creation of new green spaces	24	22.86
Other	13	12.38
Creation of green roofs and green walls	10	9.52
Restoration of urban green spaces	9	8.57
Restoration of urban blue spaces	8	7.62
Creation of new blue spaces	3	2.86
Protection/maintenance of urban blue spaces	3	2.86

Table 21. Number of studies per urban NbS action.

Challenges

Urban studies primarily focus on adaptation challenges as the main priority (37 studies), closely followed by environmental (35 studies), socio-economic challenges (28 studies), and mitigation (9 studies). Natural hazards are prioritized in only one study as a primary challenge but are relevant as a complementary (secondary) priority together with environmental challenges. Table 22 shows rankings of the five general challenges addressed by the urban studies.

RANK	CC ADAPTATION	CC MITIGATION	NATURAL HAZARDS	ENVIRONMENTAL	SOCIO-ECONOMIC
1	37	9	1	35	28
2	7	7	0	16	16
3	7	2	3	4	4
4	0	1	1	4	0
5	1	1	0	0	0

Table 22. Rank of challenges addressed in urban NbS assessment studies.

Note: This table shows the 5 general challenges that each study could be assigned to. As each study can be assigned to more than one challenge, the rank shows which challenge in sum over the urban studies was listed 1st, 2nd etc.

A closer look at the types of challenges addressed in urban studies reveals that air pollution, water pollution, and biodiversity loss are the most frequently considered environmental issues in the urban studies (see Figure 19). In terms of adaptation, flood and heat stress emerge as the primary concerns. Under the socio-economic category, health and well-being receive the most attention, while for mitigation challenges only carbon sequestration was considered.

These priorities are reflected in the types of NbS adopted across European cities. To manage the growing threat of pluvial floods, many cities have implemented NbS such as rain gardens, green roofs, vegetated swales (wadis), and permeable pavements, i.e., measures designed to increase water infiltration and retention, thereby reducing runoff and improving water quality (Godyń, 2022). In Leeds (UK), for instance, Sustainable Urban Drainage Systems (SuDS) have been used to protect the habitat of the endangered, white-clawed crayfish, while simultaneously improving urban water quality (Ashley et al., 2018). In the Netherlands, similar systems not only manage stormwater but also help reduce urban heat through bioretention cells and green gutters that enhance access to greenery (Ashley et al., 2018). These

interventions often produce important co-benefits: boosting biodiversity, improving public health through cooler microclimates and cleaner air, raising property values, and reducing the demand for potable water in urban irrigation (Wilbers et al., 2022). Tree planting is also a common strategy to alleviate heat stress, as shading from trees plays a crucial role in cooling the urban environment and supporting citizen well-being (Horváthová et al., 2021)

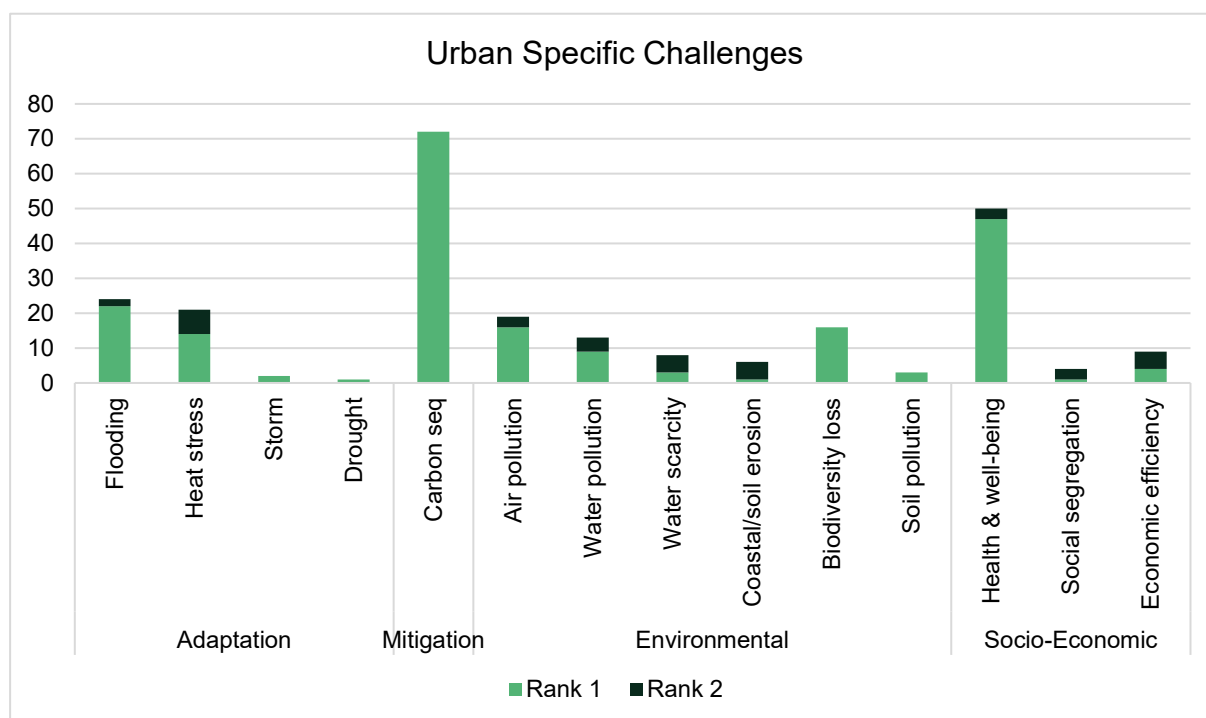


Figure 19. Specific urban challenges ranked as first and second priority in the studies.

Assessment methods

The quantitative valuation methods applied in the urban landscape to assess benefits of NbS are consistent with those used across all landscapes. These include stated preference, cost-based, market-based, value transfer and revealed preference methods.

More in detail, within the stated preference category contingent valuation is used in 10 studies (27 observations) and choice experiment appear in 6 studies but account for 139 observations. The disproportionately high number of observations in choice experiments likely reflects the methodological structure, which involves comparing multiple alternatives. This ranking mirrors that of the overall dataset. In contrast, revealed preference methods show a reversed pattern in urban contexts: hedonic pricing is the most frequently used, followed by the travel cost method, while the random utility model is not applied in any urban case, as the approach does not lend itself to well to very local assessment such as in urban areas.

Quantitative risk methods account for three studies with a total of 25 observations in the urban landscape. Overall, these methods are among the least frequently applied.

Lastly, the most used quantitative decision support methods include cost-benefit analysis and ecosystem accounting, for a total of 5 studies and 108 observations in urban landscape.

These valuation methods can also be applied in combination to generate more accurate and comprehensive estimates of the economic benefits provided by NbS. For example, Bottero et al (2023) employed a mixed-method approach combining stated and revealed preference techniques to estimate the benefits of a planned urban green park in a requalified area. Revealed preference methods were used to assess actual user behaviour, such as visit frequency and travel costs to existing parks in the city. This information was used to estimate econometric parameters like travel cost sensitivity and usage rates, providing an objective basis grounded in observed behaviour. This was then complemented by a discrete choice experiment in which respondents were asked to evaluate and choose between alternative park design scenarios, each varying in recreational opportunities, services, and infrastructure, along with associated travel costs. This allowed the researchers to estimate the marginal rate of substitution (MRS) between specific park features and travel cost, and to derive a final value for the expected benefits of the future park by combining results from both methods. Similarly, Chen et al (2017) used a discrete choice experiment to assess the perceived benefits of restoring the Zenn River, currently affected by urban wastewater discharges. Respondents were presented with combinations of attributes, such as water quality, biodiversity, hydro-morphological conditions, and recreational infrastructure, linked to a hypothetical increase in annual household water tariffs. Preferences expressed through scenario choices enabled the estimation of the total willingness to pay for the proposed restoration. In contrast, revealed preference techniques like hedonic pricing have been employed to capture the value of proximity to urban green spaces through analysis of housing market data. (Giannakidou and Latinopoulos, 2023), for instance, applied this method in Thessaloniki, Greece, to assess how the presence of urban green spaces influenced residential property prices, offering a monetary estimate of their added value within the urban context.

ASSESSMENT APPROACH		NR. STUDIES	NR. OBSERVATIONS
Stated preference	Contingent valuation	10	27
	Choice experiment	6	139
Revealed preference	Hedonic pricing	4	14
	Travel cost	5	6
Cost-based		6	106
Market-based		4	70
Value transfer		3	29
Risk management	Quantitative risk assessment	1	1
	Scenario-based	2	24
Decision support	Cost-benefit analysis	4	101
	Ecosystem accounting	1	7

Table 23. Assessment approaches applied in urban landscape per number of studies and observations.

Note: some studies apply different assessment methods across various observations

Benefit-cost ratio of NbS in urban landscapes

Within the urban landscape, benefit-cost ratios were reported in 10 studies and 188 observations out of a total of 32 studies across landscapes.

Overall, the BCR value for urban NbS are generally positive. The mean BCR across urban observations is 3.3, with a left-skewed distribution. More than half of the observations (around

65%) show that benefits outweigh the costs ($BCR > 1$). Specifically, many values are significantly greater than 1, with around 23% of the observations exceeding a BCR of 2.

DETAILED DESCRIPTIVE STATISTICS					
		Smallest			
1%	0.01	0.01			
5%	0.03	0.01		Observations	188
10%	0.11	0.01		Sum of weights	188
25%	0.755	0.01			
50%	1.135	Largest		Mean	3.302793
75%	1.91	21.64		Std dev	5.418413
90%	9.8	21.64		Variance	29.3592
95%	15.1	21.64		Skewness	2.633249
99%	21.64	21.64		Kurtosis	10.077

Table 24. Statistics of BCR analyses, urban landscape.

Focusing on the benefit-cost ratio (BCR) of various NbS actions, the restoration and creation of urban green spaces emerge as the most effective measures, generating the highest net benefit values. These are followed by the creation of urban blue spaces, which also yield substantial benefits. Positive BCRs are also observed for the implementation of green roofs and walls, and for the restoration of existing urban blue spaces. Protection measures have not been investigated in the studies included in the literature review. Table 25 provides an overview of the number of observations, mean, median, minimum and maximum benefit cost ratios by urban NbS action in addition to the standard deviation.

URBAN NBS ACTIONS	N	MEAN	MEDIAN	SD	MIN	MAX
Creation of green roofs and green walls	58	1.00	1.09	0.69	0.01	1.91
Creation of new blue spaces	14	6.29	1.9	6.52	0.1	17.3
Creation of new green spaces	36	9.77	8.04	6.75	0.7	21.64
Other	76	0.91	0.83	0.45	0.11	1.63
Restoration of urban blue spaces	1	1.03	-	-	1.03	1.03
Restoration of urban green spaces	3	17.55	12.62	12.62	8.66	32
Total	188	3.30	1.14	5.41	0.1	32

Table 25. BCR values per type of NbS action in the urban landscape.

More in detail, two studies focused on the implementation of green roofs and walls in Lisbon, specifically in schools and universities, to address challenges related to heat stress, air pollution, biodiversity loss, and human health and well-being. However, they produced contrasting results. On the one hand, Almeida et al. (2021) evaluate the cost-benefit performance of green roofs and walls in two public primary schools in Lisbon, Portugal. The study examines extensive green roofs, direct and indirect green façades, and modular living walls, in terms of energy savings (both cooling and heating), aesthetics improvement as well as improved property values, increased longevity of structures and materials, sound insulation improvement, air quality improvement and runoff management. These were applied in ten

retrofit scenarios across indoor and outdoor configurations. A 40–50-year cost-benefit analysis was conducted across financial, economic, and socio-environmental dimensions. All scenarios proved economically viable, with benefit-cost ratios ranging from 3.01 to 34.99. The highest absolute gain (€2.5 million) came from a green roof, while the most efficient solution was an indoor green façade. The resulting overall BCR amounted to around 8. On the other hand, Teotónio et al. (2023) conducted a comprehensive evaluation of 16 green roof configurations at the Instituto Superior Técnico in Lisbon, varying by vegetation type, substrate (standard or recycled), and accessibility. A joint approach combining cost-benefit analysis (CBA) and multi-criteria analysis (MCA) was used to account for both monetary and non-monetary impacts. Specifically, runoff retention benefits were estimated in monetary terms in CBA, while co-benefits such as aesthetics, accessibility and use of recycled materials were only considered in non-monetary terms with MCA. In contrast to previous findings, none of the configurations proved economically viable, with BCRs ranging from 0.22 to 0.51, and no scenario exceeding the break-even threshold ($BCR > 1$), mainly due to high installation and maintenance costs and low plant survival rates. While CBA alone resulted in negative NPVs and MCA revealed strong user preferences for accessible roofs and recycled materials, the integrated approach helped reorder priorities and identify more balanced, user-aligned solutions, even in the absence of strict economic feasibility. These two studies show the relevance of including multiple co-benefits in the analysis of NbS effectiveness, especially in economic and monetary terms providing a full value to NbS.

Another example is provided by Johnson and Geisendorf (2019) and Johnson et al (2021). These studies investigate the effectiveness of Urban Green Infrastructure (UGI) at the district level in Berlin, evaluating three scenarios. Although they share a common setting, the scenarios differ slightly in composition and purpose. In the 2019 study, Scenario A emphasizes façade greening and green roofs without rainwater harvesting; Scenario B offers a balanced mix of greening, ponds, tree drains, and rainwater harvesting; Scenario C includes widespread greening and permeable pavements but omits retention filters. In the 2021 study, Scenario A focuses on limited but well-placed greening; Scenario B relies on dense tree drains with moderate roofs and minimal façades; and Scenario C features the most extensive and costly greening. Both studies considered installation and maintenance/operational costs of the different types of NbS included, but they look at different benefits and challenges addressed. Johnson and Geisendorf (2019) focus on stormwater management and ecosystem services, using CBA to evaluate private (e.g., rainwater fee savings, energy efficiency) and social (e.g., water quality, climate regulation) benefits. Over a 50-year period at a 3% discount rate, only Scenario B appear economically viable (NPV: €13.5 million; BCR: 1.33), while A and C face higher costs due to façade greening. The most valuable benefits stem from runoff reduction and increased property values. In the follow-up study, Johnson et al. (2021) assess UGI's role in mitigating the urban heat island (UHI) effect. Combining climate data with CBA, they estimate reductions in heat-related hospitalisations, mortality, and other services (e.g. runoff reduction, building longevity, aesthetic improvements, property value, energy savings, air quality and carbon storage). This time, all three scenarios appear economically feasible ($NPV > 0$; $BCR > 1$), with Scenario B again the most cost-effective (NPV: €32.8 million; BCR: 1.91). Scenario A achieves comparable cooling benefits to Scenario C but at lower cost, thanks to strategic placement. Tree drains deliver the strongest cooling, and urban heat island mitigation accounts for up to 41% of total benefits. These two studies suggest a higher effectiveness of UGI in mitigating UHI with particular focus on the health benefits, while for stormwater management and ecosystem services in general, they appear to have a lower impact.

Key take aways – urban landscapes

Urban areas represent the second most studied landscape type in terms of the number of studies and the most studied in terms of individual observations. Out of 105 studies and 1,244 observations, a significant portion of research is concentrated in Southern and Mediterranean Europe (approximately 45%), particularly Italy and Spain, followed by Central Europe (29%) and the UK. Northern and Eastern Europe remain underrepresented in this thematic area.

Urban NbS assessments are characterised by a strong emphasis on creation-type interventions, such as the installation of green roofs, establishment of new urban parks, and vegetated streetscapes. These actions reflect the potential for structural transformation in densely built environments. Protection and modification typologies are also considered but to a lesser extent. Commonly studied actions include the creation and restoration of both green and blue spaces, often linked with co-benefits such as temperature regulation and pollution reduction.

The dominant challenges addressed in urban NbS studies are climate change adaptation, especially in relation to flood mitigation and heat stress, and environmental issues like air and water pollution. Socio-economic challenges, particularly related to health and well-being, are also well represented, while natural hazards and social inequality are less frequently addressed.

Stated preference methods, including both choice experiments and contingent valuation, are the most commonly applied economic assessment approaches in urban contexts. These are complemented by cost-based and market-based methods, value transfer, and decision-support tools such as cost-benefit analysis (CBA) and ecosystem accounting. Hedonic pricing is the dominant revealed preference method, while risk-based approaches remain sparse.

Benefit-cost ratio (BCR) data for urban NbS is relatively rich, with 188 observations across 10 studies. Approximately 65% of these observations report a BCR greater than 1, and 22% exceed a BCR of 2. The median BCR is 1.1 and the mean is 3.3, suggesting moderate to high economic viability. The most economically promising interventions include the restoration and creation of urban green spaces, followed by blue infrastructure such as green roofs and rain gardens.

4.4. COASTAL & MARINE AREAS

Geographical distribution

Most coastal studies focus on the Mediterranean and Southern Europe, which accounts for 40 out of 61 studies (65%). Great Britain and Ireland also has many studies on coastal and marine NbS with 15 studies (25%). Northern Europe is represented by 5 studies (8%). In contrast, Central Europe has only 1 study and we have not recorded any study from Eastern Europe. Figure 20 shows the number of coastal and marine NbS studies by country and Table 26 the distribution of studies across EU regions.

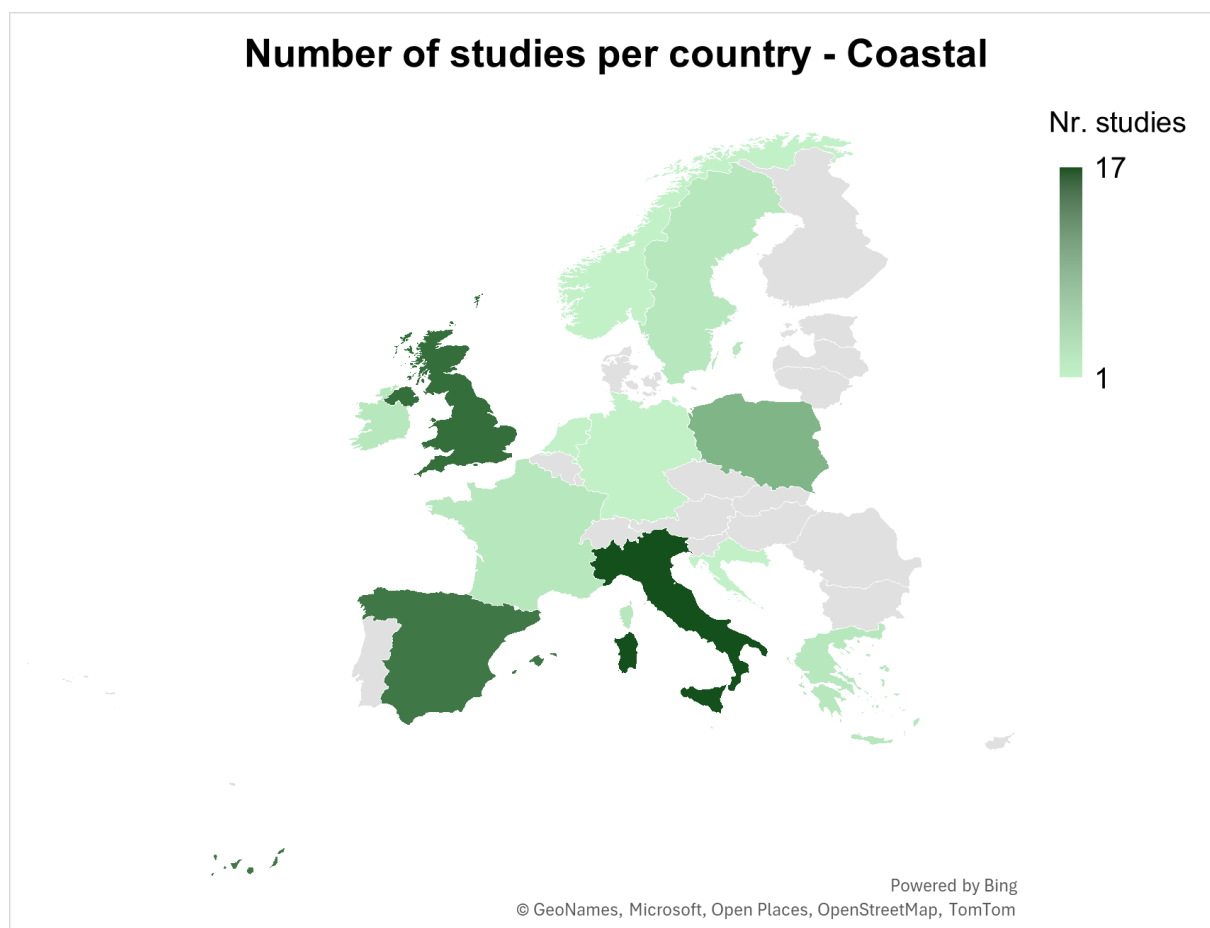


Figure 20. Map of number of coastal NbS economic assessment studies per country

EUROPEAN REGION	# STUDIES	PERCENTAGE (%)
Central Europe	1	2
Great Britain and Ireland	15	25
Mediterranean/Southern Europe	40	66
Northern Europe	5	8
Total	61	100

Table 26. Number and percentage of coastal NbS assessment studies across European regions.

Coastal NbS typologies and actions

Coastal and marine habitat protection and restoration actions count for the majority of the coastal NbS action (more than 75%), with only two studies focusing on managed realignment of coastal areas. The protected and restored habitats include seagrass, reef, sand dune and wetlands. Among those, two thirds of the studies focused on habitat conservation and protection, only one third of the studies focused on habitat restoration. The same pattern is replicated in the individual observation records.

Among the various intervention types examined, protection of coastal habitats emerges as the most studied approach, representing 35 out of 61 studies and accounting for 55,5% of the total. This shows, on one hand, the degradation of these key habitats such as salt marshes, seagrasses, and coastal wetlands. On the other hand, it also demonstrates a strong focus on conserving these ecosystems, as they are crucial for biodiversity, reducing erosion, and sequestering and storing carbon.

Eight studies have interventions categorised as 'Others', including hybrid engineering approaches, policy measures, instruments, combined measures, and cross-sectoral initiatives that don't fall neatly into the defined categories.

Restoration of coastal and marine habitats is addressed in 14 studies (22,5%). The observation is in line with the growing interest and activities in using active ecological restoration to recover degraded ecosystems and the ecosystem services. This approach includes actions such as replanting seagrasses, rebuilding oyster reefs, or restoring hydrology in wetlands.

In contrast, managed realignment of coastal areas is the least studied NbS action, appearing in only 2 studies (3%).

NBS ACTIONS	NR. STUDIES	PERCENTAGE (%)
Beach nourishment (and dune restoration)	2	3
Managed realignment of coastal areas	2	3
Protection of coastal & marine habitats	35	55,5
Restoration of coastal and marine habitats	14	22,5
Other	8	12,5
Total	61	100

Table 27. Number of studies per coastal NbS action.

Challenges

Among the coastal studies, we find environmental challenges represent the main challenge that prompt NbS assessment and implementation, followed by climate change mitigation, climate adaptation and socio-economic challenges. Natural hazards appear as the least frequent reason that NbS is implemented or assessed.

Biodiversity loss, coastal and soil erosion, and water pollution (eutrophication) are the most frequently considered environmental issues. Carbon storage and sequestration are the focus for climate change mitigation. Under the socio-economic category, food security (i.e. fishery) and health and well-being receive the most attention.

Coastal nature-based solutions can help to address both climate issues through carbon regulation and carbon sequestration, or as adaptive measures to coastal erosion.

RANK	CC ADAPTATION	CC MITIGATION	NATURAL HAZARDS	ENVIRONMENTAL	SOCIO ECONOMIC
1	8	13	2	34	4
2	2	7	3	11	13
3	0	2	1	2	7
4	1	0	0	1	0

Table 28. Rank of challenges addressed in coastal NbS assessment studies.

Note: This table shows the 5 general challenges that each study could be assigned to. As each study can be assigned to more than one challenge, the rank shows which challenge in sum over the urban studies was listed 1st, 2nd etc.

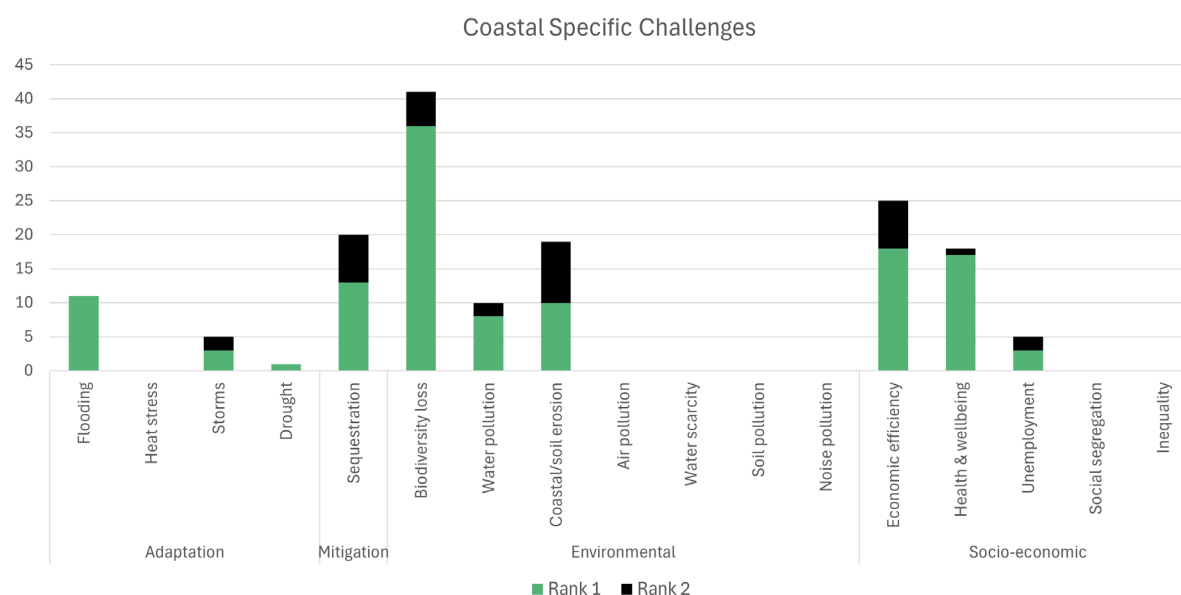


Figure 21. Specific coastal challenges ranked as first and second priority in the studies.

Assessment methods

Various economic methods have been used in evaluating the socioeconomic benefits of coastal NbS. These include are stated preferences (choice experiment, contingent valuation), revealed preferences (hedonic pricing and travel cost methods) and cost-based, market-based methods, value transfer, the risk management methods (incl. quantitative risk assessment, scenario-based methods), and decision support methods such as ecosystem accounting and CBA.

The stated preference methods, particularly choice experiments, account for 11 studies and 199 observations. Contingent valuation is also frequently used, with 7 studies contributing 57 observations. These methods are widely employed to estimate non-market values. This is in line with findings from other landscapes. For example, Hynes et al. (2021) used CE to estimate the benefits from kelp restoration in Northern Norway and found the average willingness to pay for kelp restoration is about 50-70 euro per person annually.

In the category of revealed preference, the travel cost method approach is applied in five studies, and the related Random Utility Model in one study, while hedonic pricing is mentioned in one study. Cost-based approaches have been used in five studies. Although more studies in research have used revealed and stated preference to evaluate NbS benefits, the cost-based methods are still important especially for data availability when carrying out ecosystem

restoration. Market-based approaches, which use observed market prices as an estimate for evaluating the benefits of ecosystem goods and services, are found in three studies.

Value transfer methods, which involve adapting existing valuation estimates to new contexts, are relatively common, appearing in 12 studies with 143 observations. This method is often used for its practicality when primary data collection is not feasible.

In the context of risk management, scenario-based approaches are the most frequently applied in our sample and was found in 12 studies. Other approaches are less frequent, mentioned in about 3 studies.

Under decision support tools, cost-benefit analysis has been applied in six studies. We also found seven studies using ecosystem accounting as a method to track the spatial and temporal change of ecosystem service benefits. Compared to large-scale ecosystem accounting literature, the monetary valuation in ecosystem accounting is relatively sparse. A few studies use either decision-making under uncertainty, multiple criteria analysis or cost-effectiveness analysis.

ASSESSMENT APPROACH		NR. STUDIES	NR. OBSERVATIONS
Stated preference	Contingent valuation	7	57
	Choice experiment	11	199
Revealed preference	Hedonic pricing	1	1
	Travel cost	5	11
	Random Utility Model	1	8
Cost-based		5	128
Market-based		3	14
Value transfer		12	143
Risk management	Other	3	126
	Scenario-based	12	77
Decision support	Cost-benefit analysis	6	129
	Ecosystem accounting	7	102
	Decision making under uncertainty	1	1
	Multiple Criteria Analysis	1	1
	Cost Effectiveness Analysis	1	1

Table 29. Assessment approaches applied in coastal landscapes per number of studies and observations.

Note: some studies apply different assessment methods across various observations

Benefit-cost ratio of NbS in coastal landscapes

Within the time period of the literature review, we only found three studies estimating benefit-cost ratios with 74 observations reported, ranging from 0.12 to 3.4. The remaining studies either focus on cost-effectiveness analysis, benefit evaluations, or use other methods to estimate the costs and benefits, such as net present values (NPV).

A study from Italy by Visintin et al. (2022a) assessed the benefits and costs for establishing the Porto Cesareo Marine Protected Area (MPA). By using market-based prices together with WTP data, the tourism and environmental benefits from various activities are weighted against the and expenditure resulting in a highly viable project with a BCR at 3.4. Visintin et al. (2022b)

conducted the same type of analysis for the Tremiti Islands MPA and also here found a highly profitable project with annual benefit-cost ratios reaching 2.1.

Pais-Barbosa et al. (2023) combined modelling and meta-analytic function transfer to assess the benefits and costs for artificial sand nourishment under future climate scenarios for the Ovar coastal stretch in Portugal. Both physical and economic losses of coastal stretch are projected for two climate scenarios in the short term, midterm and long term. The results indicate a high economic loss for mid- and long-term without the beach nourishment intervention. By carrying out the coastal nourishment project, avoided losses would be high for the mid- and long-term scenarios comparing to the business-as-usual scenario resulting in a BCR >1. BCR was however found to be generally smaller than 1 for the short-term scenarios.

COASTAL NBS ACTIONS	N	MEAN	MEDIAN	SD	MIN	MAX
Protection of coastal & marine habitats	2	2.75	2.75	0.65	2.1	3.4
Beach nourishment (and dune restoration)	72	0.68	0.63	0.38	0.12	2.09
Total	74	0.68	0.630	0.38	0.12	2.09

Table 30. BCR values per type of NbS action in the coastal landscape.

Key take aways – coastal landscapes

The coastal and marine thematic area is addressed in 65 studies. The majority of studies are concentrated in Southern Europe (68%), followed by the UK and Ireland. Central and Eastern Europe are almost entirely absent, given the lack of main/coastal habitats.

Coastal NbS are primarily protection-oriented, focusing on the conservation of natural habitats such as salt marshes, seagrasses, and dunes. Restoration is also addressed but to a lesser extent, while creation actions are rare. Managed realignment is one of the least studied interventions, despite its relevance for coastal resilience.

Challenges in coastal NbS studies are predominantly environmental, including biodiversity loss and eutrophication. Climate change mitigation through carbon sequestration also features strongly. Socio-economic concerns, such as food security and fishery sustainability, are represented but remain secondary.

The economic methods applied are highly varied. Stated preference methods, particularly choice experiments, are common. Revealed preference methods, cost-based and market-based approaches, and value transfer are also used. Risk management, especially scenario-based modelling, is more used in this thematic area than in others. Decision-support tools, such as CBA, play a central role.

Despite the methodological richness, BCR data are sparse in our review for this landscape.

4.5. FORESTS

Geographical distribution

Forest landscape constituted about 120 studies (32%) and 1051 observations (28%) out of the total of 379 and 3768, respectively. With this, the forest landscape holds close to one-third of the overall analysis, making it the most studied NbS landscape.

Nearly 50% of the forest-related studies focused on the Mediterranean/South Europe, followed by Northern (24%) and Central Europe (21%). The rate of studies across Great Britain and Ireland (7%) and Eastern Europe (6%) were almost similar, making them the least concentrated study regions.

Countries such as Italy and Spain altogether comprised 33% of the studies, whereas the remaining 67% were distributed across the other 24 countries. Notably, countries such as Croatia, Ireland and Switzerland provide <1% share, respectively. In addition, a few studies (4 observations) cover more than one EU country, representing a <1% share. Figure 22 shows the number of forest NbS studies by country and Table 31 the distribution of studies across EU regions.

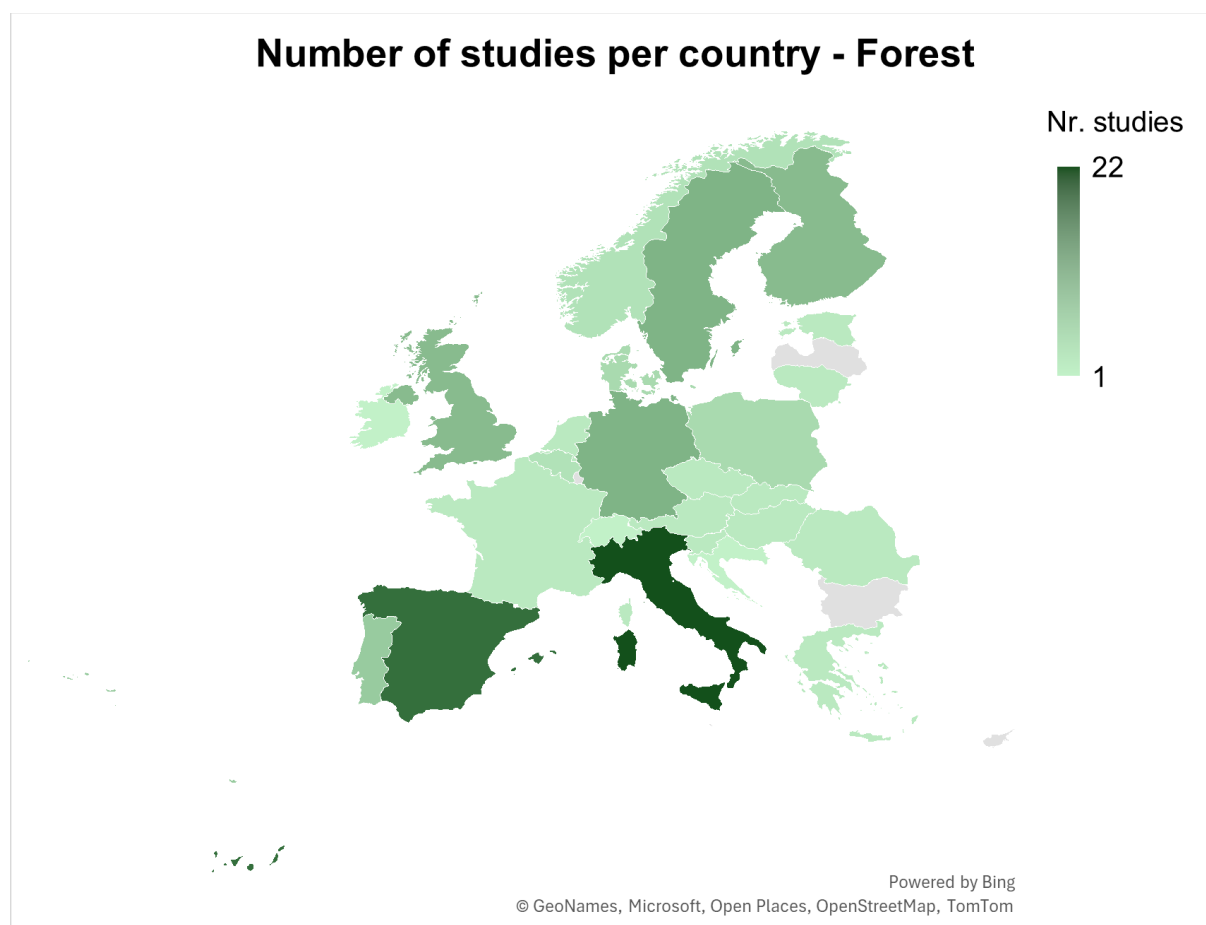


Figure 22. Map of number of forest studies by country.

EUROPEAN REGION	# STUDIES	PERCENTAGE (%)
Mediterranean/South Europe	51	42.5
Northern Europe	29	24.17
Central Europe	25	20.83
Great Britain and Ireland	8	6.67
Eastern Europe	7	5.83

Table 31. Number and percentage of forest studies across European regions.

Forest NbS Typologies and Actions

Forest NbS typologies adopted in these studies are of three types, viz., 1. Protection (64), 2. Modification (45) and 3. Creation (8). Protection measures, such as maintenance of untouched forest cover, constitute more than 50% of the identified protection studies, closely followed by

modification measures, including conversion of forest stands, rewetting of peatlands, and wildfire management. Whereas the creation of forest reserves through planting activities is the least common typology, with less than 10% of studies. A similar trend has been depicted in the distributions of observations across typologies.

Forest NbS actions are typically categorised into specific interventions. These include the maintenance of untouched forest cover, restoration of degraded forest ecosystems, establishment of riparian buffer forests, reforestation, afforestation, wildfire management, integration of trees and forests across various sectors, agroforestry, and converting agricultural land to forest. Additionally, 31% of the studies focus on other critical actions, such as safeguarding forests for ecosystem services, including air pollution removal, carbon sequestration, and flood protection (Atkinson and Ovando, 2022; Vallecillo et al., 2019), sustainable forest management practices, like silviculture, pest control, wildfire prevention, and reforestation (Enríquez-de-Salamanca, 2023), afforestation of river catchments (Johnen et al., 2022) and pasture lands, rewetting of peatland forests (Makrickas et al., 2023), transitioning from coniferous to deciduous forests (De Nocker et al., 2022), enhancing biodiversity through tree retention and increasing species diversity (Bakhtiari et al., 2018) and creating forest reserves with deadwood islands (Augustynczyk, 2021), resin tapping (Langkilde-Lauesen et al., 2022), continuous cover forestry (Soliño et al., 2018), intermediate stand cutting (Likus-Cieślik et al., 2023), and enhancing recreational and cultural values for tourism (Mäntymaa et al., 2018).

FOREST NBS ACTIONS	NO. OF STUDIES	PERCENTAGE (%)
Afforestation	5	4.42
Reforestation	7	6.19
Agroforestry	4	3.54
Implementing forests in the riparian buffer	1	0.88
Land use conversion from agriculture to forest	7	6.19
Integrating trees and forests in other sectors	2	1.77
Maintenance of untouched forest cover	39	34.51
Restoring degraded forest ecosystems	16	14.16
Wildfire management	1	0.88
Other	31	27.43

Table 32. The count and percentage of studies representing different forest NbS actions.

Challenges

Forest landscape NbS studies focus on environmental challenges as the main priority (54 studies), closely followed by socio-economic (28 studies), mitigation (22 studies) and adaptation (11 studies). Natural hazards occur as the main challenge in 5 studies. Especially, environmental (16 studies), socio-economic (14 studies) and carbon sequestration challenges (10 studies) are assessed as secondary priorities in the forest landscape studies.

RANK	CC ADAPTATION	CC MITIGATION	NATURAL HAZARDS	ENVIRONMENTAL	SOCIO ECONOMIC
1	11	22	5	54	28
2	1	10	4	16	14
3	2	1	4	3	5
4	0	1	0	4	0

Table 33. Rank of challenges addressed in forest NbS assessment studies

Note: This table shows the 5 general challenges that each study could be assigned to. As each study can be assigned to more than one challenge, the rank shows which challenge in sum over the urban studies was listed 1st, 2nd etc

Examining the specific challenges addressed in forest landscape studies reveals that the most frequently identified primary issues include biodiversity loss (50 studies), health and well-being (32 studies) and economic efficiency (25 studies). Carbon sequestration is addressed as a main challenge in 22 studies. Additionally, flooding is addressed as a significant adaptation challenge in 14 studies. Other environmental, adaptation and socio-economic challenges appear to be less significant in forest NbS. Notably, there were no forest landscape studies addressing drought, noise pollution, or inequality as challenges.

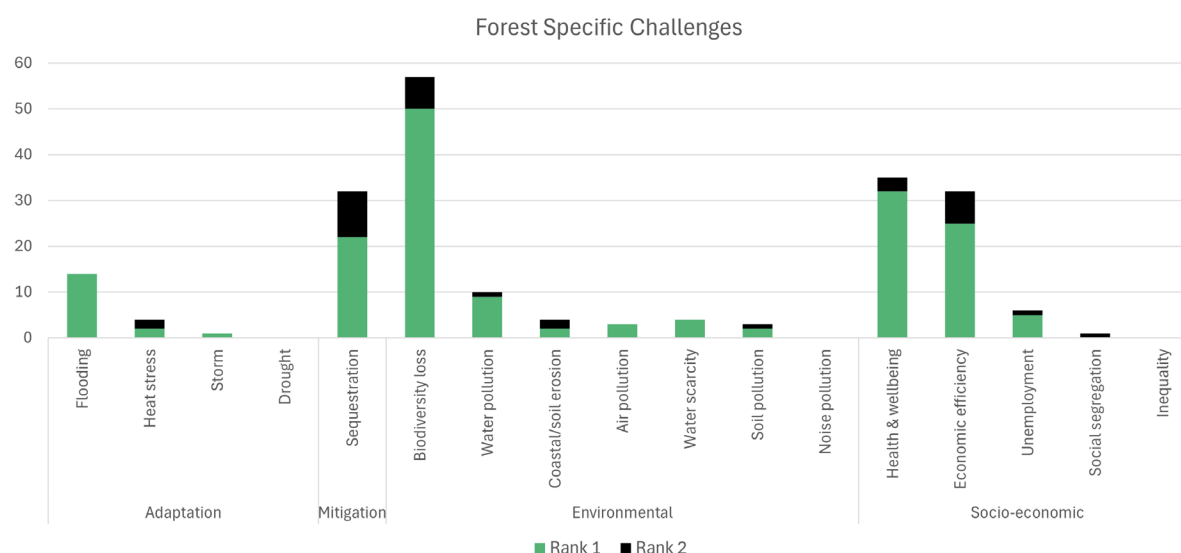


Figure 23. Specific forest challenges ranked as first and second priority in the studies.

Assessment methods

The quantitative valuation methods applied in the forest landscape to assess the benefits of NbS include stated preference, revealed preference, cost-based, market-based, and value transfer.

In contrast, revealed preference methods exhibit a distinct pattern in forest contexts: travel cost methods dominate with 12 studies and 84 observations, leveraging visitor behaviour to estimate recreational values, while hedonic pricing is sparingly applied, with only 1 study and 2 observations, likely due to its limited applicability to forest-specific attributes. Cost-based methods feature in 11 studies with 142 observations, providing a practical approach to estimating restoration and maintenance costs. The disproportionately high number of studies (24) and observations (222) in market-based methods underscores their critical role in quantifying tangible economic benefits derived from forest resources. Value transfer, used in 4 studies with 34 observations, facilitates the application of existing valuation data to new contexts, though its use is relatively limited.

Risk management approaches are underrepresented, with quantitative risk assessment absent (0 studies, 0 observations) and scenario-based methods appearing in 4 studies with 25 observations, indicating a gap in integrating risk considerations into forest NbS valuations. Decision support methods play a significant role in informing policy and management decisions by integrating cost-benefit analysis (6 studies, 70 observations) and ecosystem accounting (7 studies, 24 observations).

ASSESSMENT APPROACH		NR. STUDIES	NR. OBSERVATIONS
Stated preference	Contingent valuation	13	95
	Choice experiment	8	66
Revealed preference	Hedonic pricing	1	2
	Travel cost	12	84
Cost-based		11	142
Market-based		24	222
Value transfer		4	34
Risk management	Quantitative risk assessment	0	0
	Scenario-based	4	25
Decision support	Cost-benefit analysis	6	70
	Ecosystem accounting	7	24

Table 34. Assessment approaches applied in forest landscapes per the number of studies and observations.

Benefit-cost ratio of NbS in forest landscapes

Benefit-cost ratios (BCR) associated with forest landscapes were detailed in 4 studies and 12 observations, which collectively represent approximately 1% of the total studies reviewed. This makes forest landscapes the second least-examined NbS category, following mountains with no studies. Overall, the BCR value for forest NbS is generally positive. The mean BCR across forest observations is 3.86, with a right-skewed distribution. 75% of the observations show that the benefits of the forest NbS project outweigh the costs ($BCR > 1$) with 50% exceeding a BCR of 2 (See Table 35).

DETAILED DESCRIPTIVE STATISTICS				
	Percentiles	Smallest		
1%	0.49	0.49		
5%	0.49	0.69	Observations	12
10%	0.69	0.84	Sum of weights	12
25%	0.97	1.1	Mean	3.859667
50%	2.78		Standard deviation	3.57058
		Largest		
75%	5.454	5.245	Variance	12.74904
90%	8.66	5.663	Skewness	1.096168
95%	12	8.66	Kurtosis	3.255261
99%	12	12		

Table 35. Descriptive statistics of BCR analyses, forest landscape.

The reported BCR values pertain to various forest NbS actions, including the conversion of agricultural land to forest, reforestation, restoration of degraded ecosystems and others. Notably, only one observation each was recorded for the restoration of degraded forest ecosystems and afforestation activities, with a BCR of 12 and 8.66, respectively (Bockarjova et al., 2022). This reflects an impressive potential of such NbS projects to outweigh costs through greater benefits. In addition, the conversion of agricultural land to forest yielded an average BCR of 5, which represents the positive benefits (Zachariou and Burgess, 2023). In contrast, the BCRs for interventions such as reforestation and other activities ranged from 0.5 to 3.6, with a mean value between 1.1 and 1.8 (Johnen et al., 2022; Zabala et al., 2022). While these values are beneficial, they are not as financially advantageous as the other three actions. Table 36 provides an overview of BCR descriptive statistics by forest NbS action.

FOREST NBS ACTIONS	N	MEAN	MEDIAN	SD	MIN	MAX
Reforestation	4	1.79	1.54	1.35	0.49	3.59
Land use conversion from agriculture to forest	3	5.03	5.25	0.77	4.18	5.67
Afforestation	1	8.66	8.66	-	8.66	8.66
Restoring degraded forest ecosystems	1	12	12	-	12	12
Other	3	1.14	0.84	0.65	0.69	1.89
Total	12	28.62	28.285	2.765	26.02	31.81

Table 36. Descriptive statistics of benefit-cost ratios (BCR) of forest NbS actions.

To dive deeper, three relevant studies have been provided as an excerpt to underscore the value of forest measures in NbS projects' economic viability. Bockarjova et al. (2022) estimated the social benefit-to-cost analysis using the benefit transfer method for 60 out of 85 NbS projects that were implemented across 13 European countries. These projects adopted a wide range of interventions, such as the planting of street trees, green walls and roofs, community fruit and vegetable gardens, urban parks and forests, green squares, rain gardens, green corridors, revitalization of urban riverbanks, lakes and streams, vertical gardening, neighbourhood regeneration, sustainable urban drainage systems (SUDS). Although most of the interventions fall under more than one NbS category, the planting of trees and creation of urban forests can be directly related to forest NbS. The findings revealed that the climate change adaptation of humid forests in Münster (Germany) generated an attractive BCR of 12,

and the transformation of the former lignite mining area in Leipzig (Germany) returned a BCR of 8.66. This proves the immense potential of forest actions to yield a net present value of benefits which outweigh the implementation costs. While the authors selected only interventions that are qualified as high-quality, uncertainties in the previous cost data could affect BCRs. Overall, 65% of the projects had a positive NPV for the threshold scenario (40 years lifetime of urban nature, 3% discount rate) and can thus be considered ‘socially profitable.’

Further, the effect of afforestation on peak river flows and selected ecosystem services within the Glinščica River catchment in Slovenia has been evaluated by Johnen et al (2022) using a hydrological modelling and cost-benefit analysis (CBA) approach. The study evaluated NPV, IRR, and BCR for three different scenarios of afforestation: 1. afforestation upstream (244 ha), 2. afforestation downstream (77 ha), and 3. afforestation everywhere (341 ha), over a period of 100 years at a 4% discount rate. Of these, scenarios 1 and 3 produced a negative NPV with BCR less than 1, while scenario 2 had a positive NPV and BCR close to 2. The 2nd scenario “Afforestation downstream” is characterised by a much smaller afforested area just within the section of the hydraulic model, compared to scenario 3 “Afforestation everywhere” and scenario 1 “Afforestation upstream.” Consequently, positive net present values could be found only for scenario “Afforestation downstream”, even though the NPV benefits were dominated by the benefits of flood protection measures. The main reason for the negative NPV values in scenarios 1 and 3 lies in the fact that large areas would need to be afforested in case of “Afforestation everywhere” and “Afforestation upstream” scenarios. Consequently, the costs of land acquisition are high, and obviously, flood damage is smaller than these costs and maintenance costs. By this, the researchers underline the importance of also valuing other ecosystem co-benefits of the natural water retention measures (NWRM) to understand whether a given NbS implementation is economically worthwhile.

The study conducted by Zabala et al (2022) explored the social factors that influence the willingness to pay (WTP) for sustainable nature conservation in the Cabezo de la Jara and Rambla de Nogalte protected areas (PNA) in Southeast Spain, with an emphasis on informing policy through benefit-cost ratio (BCR) considerations. Applying a contingent valuation method, the research evaluates social preferences for conservation initiatives, including flora protection and reforestation as NbS, employing Tobit models and a latent class approach. This study outlined the expected financial implications of implementing these initiatives alongside an economic assessment, specifically through cost-benefit analysis, distinguishing between use and non-use values as sources of socio-economic and environmental benefits. The annual equivalent cost (AEC) and annual equivalent benefit (AEB) were utilised to quantify the economic and financial costs and benefits of the proposed measures. AEC is applied similarly in both economic and financial evaluations, as only financial costs were considered in its estimation. In the economic assessment, AEB incorporates the non-market benefits derived from the contingent valuation study, while in the financial assessment, AEB accounts for the projected income from green taxes and user fees, estimated based on local population data regarding household income and environmental commitment levels. Over six years and using a discount rate of 3.5%, the study focused on 85,720 households in the area. The economic assessment results indicate that the benefits from use values alone (BCR 0.49) are insufficient to cover the conservation costs of the PNA. This underscores the necessity of incorporating both use and non-use values (BCR 3.59) of environmental benefits into the policy design agenda to effectively address conservation costs.

Key take aways – forest landscapes

Forest landscapes are the most frequently represented thematic area in the literature, comprising 120 studies and 1,051 observations. These are mainly concentrated in Southern

Europe, with substantial contributions from Northern and Central Europe. However, Eastern Europe and the British Isles are notably underrepresented.

The typology of forest NbS is dominated by protection (64 studies), followed by modification (45), while creation actions are rare. Protection measures focus on maintaining untouched forest cover, while modification includes reforestation, peatland rewetting, and wildfire management. Creation measures, such as afforestation and forest reserve establishment, are less common but show strong economic potential when assessed.

Challenges addressed in forest studies centre on environmental concerns, particularly biodiversity loss, followed by socio-economic issues such as human health and economic efficiency. Mitigation challenges are prominently addressed through carbon sequestration, and adaptation concerns like flood management appear in a subset of the literature.

Economic assessment methods in forest landscapes reflect the diversity of ecosystem services provided. Market-based approaches, especially related to timber and carbon markets, are common, followed by cost-based and stated preference methods. Revealed preferences, particularly the travel cost method, are frequently used to assess recreational values. Risk-based methods, especially quantitative approaches, are largely absent.

Although only 12 observations across four studies report BCR values, the results indicate high economic potential. Seventy-five percent of BCRs exceed 1, and 50% are above 2. Mean and median values are 3.86 and 2.78 respectively. Notably, afforestation, reforestation, and conversion of agricultural land to forest yield some of the highest returns, suggesting that forest-based NbS can deliver substantial socio-economic benefits when designed effectively.

4.6. AGRICULTURE

The economic performance of NbS in agricultural landscapes across Europe is drawn from 69 peer-reviewed studies, which yield a total of 745 individual observations. Overall, in terms of geographic coverage, the Mediterranean and Southern European region emerges as the most frequently addressed, contributing 37 of the 74 studies (50%), and 295 of the 745 observations, accounting for 40 percent. Central Europe follows with 15 studies and 170 observations, while Northern Europe contributes 7 studies and 119 observations. Great Britain and Ireland are represented by 9 studies and 104 observations, and Eastern Europe by 4 studies and 44 observations. A small number of studies (2) and observations (13) span more than one European region (See Table 37).

At the country level, the United Kingdom accounts for the highest number of observations with 159, followed by Spain with 144 and Portugal with 87. Together, these three countries represent over half of all observations. Germany, Italy, and Czechia also show high representation with 73, 58, and 40 observations, respectively. In terms of study distribution, Spain again leads with 20 studies, followed by the United Kingdom with 10 and Italy with 8. Other countries are represented by one to six studies, underscoring a recent research focus on Western and Southern Europe. Figure 24 shows the number of urban NbS studies by country.

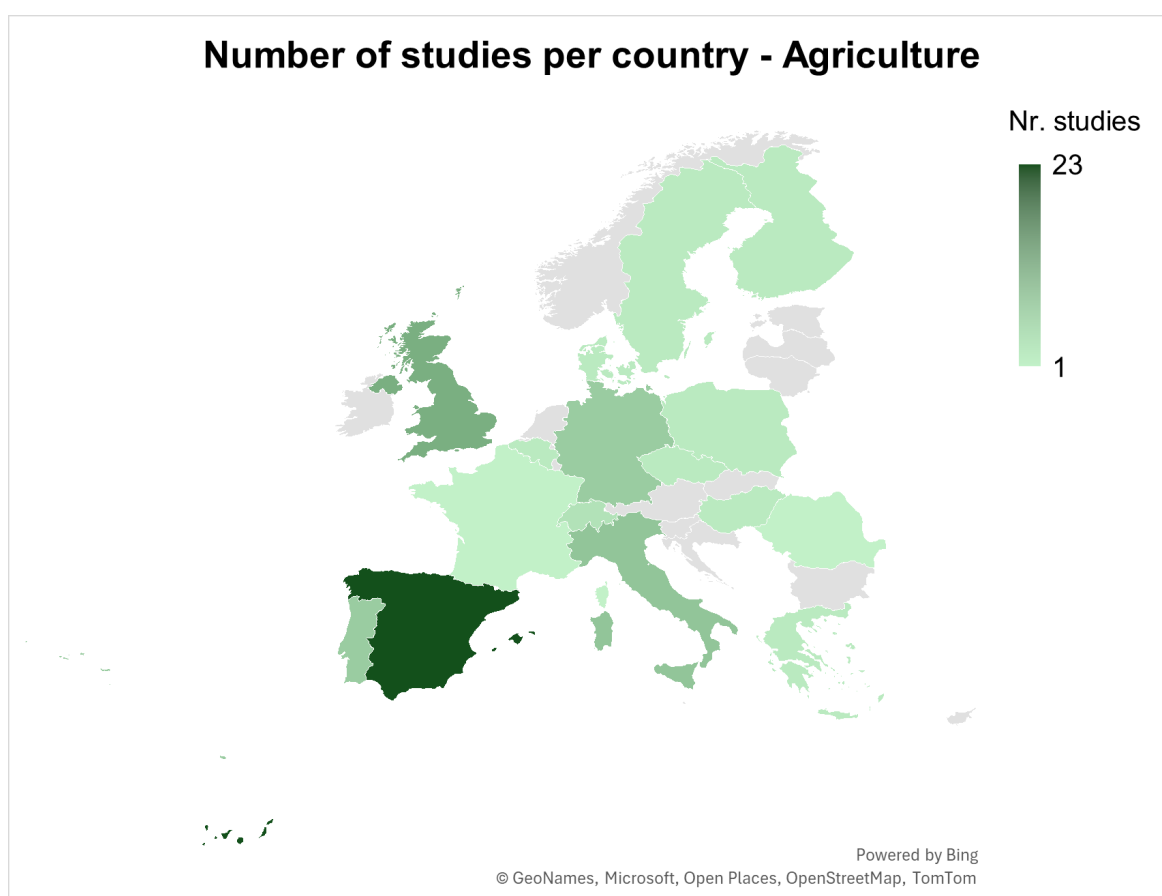


Figure 24. Map of number of agricultural NbS assessment studies per country

EUROPEAN REGION	# STUDIES	PERCENTAGE (%)
Mediterranean/South Europe	37	50,0
Central Europe	15	20,3
Great Britain and Ireland	9	12,2
Northern Europe	7	9,5
Eastern Europe	4	5,4
More than one European region	2	2,7
Total	69	100

Table 37. Number and percentage of agricultural NbS assessment studies across European regions.

Agriculture NbS typologies and actions

Within the agricultural landscape, the review categorises 745 observations according to three overarching Nature-based Solution (NbS) typologies: protection, modification, and creation. Modification-type interventions are the most common, comprising 401 observations (approximately 54 percent) and represented in 44 studies. Protection-focused solutions follow with 274 observations (about 37 percent) across 21 studies, while creation-based approaches account for 70 observations (roughly 9 percent) and appear in 4 studies. In total, 69 studies were categorised under at least one typology, with the trend remaining consistent across both observation and study counts. Solutions classified under modification are addressed in the largest number of studies (44), followed by those focused on protection (21 studies), and, to a lesser extent, creation (4 studies). This typology pattern suggests that NbS aiming to enhance or adapt existing agricultural systems are more commonly assessed than those targeting ecosystem protection or new ecosystem establishment.

The systematic review identified a diverse range of Nature-based Solutions (NbS) actions implemented in agricultural landscapes. Among the reviewed studies, "Other" NbS actions emerged as the most frequently reported category, accounting for 31.88% (22 studies) of the total. This was followed by agroforestry, which featured 21.74% (15 studies), and conservation or regenerative agriculture approaches, represented in 17.39% (12 studies). Maintenance of mixed-crop livestock systems, crop diversification and rotation, and the maintenance of high mountain traditional practices were each reported in 5.80% (4 studies) of the cases. Mulching and the use of cover crops, along with paludiculture or peatland restoration, were each documented in 4.35% (3 studies), while no or minimum tillage appeared in 2.90% (2 studies).

The "Other" category, which constituted the largest share of reported actions, includes a variety of NbS practices that did not fit neatly into the main predefined classifications. Within this "other" category, a significant number of entries involve land management for conservation purposes, including the protection of croplands and grasslands (e.g., Horák and Marada, 2023; Valatin et al., 2022; Vallecillo et al., 2019) due to their ecosystem service functions and grazing management in saltmarshes (e.g., Muenzel and Martino, 2018). Other examples include agro-ecosystems for flood regulation (e.g., Martínez-García et al., 2022) and integrated urban-rural NbS planning at a catchment scale (Liu et al., 2023). Sustainable agricultural practices are also prominent. Examples include aquaponic farming, air pollution removal in farmland (especially semi-natural grasslands), and the introduction of appropriate crop types. Some systems emphasize eco-labelling (e.g., for olive cultivation), and others demonstrate multifunctional land use by integrating almonds, cereals, legumes, and natural vegetation with sheep grazing and pollinator habitats. These often adopt sustainable land management (SLM)

techniques such as green cover, composting, organic methods, and reduced tillage. Actions supporting biodiversity and ecological health include agri-environment schemes targeted at bird conservation and woodland plantations in less productive farmland. Additionally, grassland conservation appears repeatedly, highlighting the importance of these habitats in agricultural landscapes. Several entries illustrate agriculture's role in public health, referencing farming to enhance health benefits. Others focus on runoff attenuation features, contour ploughing, swales, and earth banks, demonstrating physical landscape modifications for water management. There are also interventions reflecting land-use change, including the reduction or abandonment of agriculture, conversion to natural grassland, and flood protection via croplands. This may involve buying agricultural land to be used for nature purposes. A few actions centre on maintenance, such as maintaining timber production, freshwater, pollination functions, and vegetable gardens. Finally, some entries reflect evaluation-based approaches, with recurring mention of ecosystem service assessments. In a few cases, reclaimed water reuse and periodic field flooding are employed to mitigate urban flooding, bridging agricultural function and urban resilience.

NBS ACTION	NR. STUDIES	PERCENTAGE (%)
Other	22	31.88
Agroforestry	15	21.74
Conservation/regenerative agriculture	12	17.39
Maintenance of mixed-crop livestock sys	4	5.80
Crop diversification and rotation	4	5.80
Maintenance of high mountain traditional practices	4	5.80
Mulching and use of cover crops	3	4.35
Paludiculture or peatland restoration	3	4.35
No or minimum tillage	2	2.90
Total	69	100

Table 38. Number of studies per agricultural NbS action.

Overall, the findings of this review reveal an uneven distribution in both geographic and thematic focus of NbS studies within the agricultural landscape in Europe. Most studies are concentrated in Western and Southern Europe, with limited representation from the Northern and Eastern regions. Similarly, the strong emphasis on solutions that modify existing agricultural systems points to a prevailing preference for interventions that are more compatible with current land-use practices. By contrast, solutions focused on protection or creation, which may offer broader long-term ecological benefits, are less frequently evaluated in economic terms. These patterns highlight the need for more regionally diverse research and for greater attention to the full spectrum of NbS in order to inform balanced, evidence-based policy and investment in NbS within the agricultural sector across Europe.

Challenges

The data indicates that environmental management is the most frequently addressed societal challenge through NbS in agriculture, with 427 observations ranked first and a total of 592 across all ranks. Socio-economic challenges follow, with 258 observations, most of which are concentrated in the second (102) and fourth (52) ranks. Climate change mitigation records 190 observations in total, with a notable presence in the first (86) and second (96) ranks, suggesting it is often a secondary priority. Climate change adaptation has 121 observations, primarily in the first rank (100), with fewer mentions in subsequent ranks. Natural hazard management has the lowest number of observations overall (90), with 61 in the first rank and

smaller counts in the lower ranks. Overall, the trend shows that NbS are most frequently associated with environmental and socio-economic issues, while their application to natural hazards and climate-related challenges appears more limited and unevenly distributed across priority ranks.

RANK	CC ADAPTATION	CC MITIGATION	NATURAL HAZARDS	ENVIRONMENTAL MANAGEMENT	SOCIO-ECONOMIC
1	73	53	12	170	71
2	15	26	7	58	61
3	9	5	9	11	23
4	1	3	1	0	0
5	1	1	0	0	0

Table 39. Rank of challenges addressed in agricultural NbS assessment studies.

The data shows that environmental challenges are the most frequently addressed by NbS in agriculture (See Figure 25). Biodiversity loss stands out as the top challenge addressed, with 323 observations ranked first and a total of 406 across the top three ranks. Other major environmental issues include water pollution (137 total, mostly in rank 1) and water scarcity (101 total, spread across ranks 1 to 3). Coastal and soil erosion is addressed equally in ranks 1 and 2 (54 each), while air pollution (9) and soil pollution (10) challenges receive less attention.

Among climate change adaptation challenges, flooding is the most frequently addressed (108 in rank 1), followed by drought (17), while heat stress receives less attention (2 in rank 2).

For climate change mitigation, all 172 observations relate to carbon sequestration, concentrated entirely in rank 1. Under natural hazards, landslides and erosion are addressed with 92 observations in rank 1 and none in lower ranks.

Within socio-economic challenges, health and wellbeing is the most frequently noted (184 total), followed by economic efficiency (163 total), whereas inequality (8 in rank 2) and unemployment (2 in rank 1) challenges receive less attention.

In summary, the most frequently addressed challenges are biodiversity loss, carbon sequestration, flooding, water-related issues, and health and wellbeing, while challenges such as heat stress, air and soil pollution, inequality, and unemployment receive less attention within current NbS applications in the agricultural landscape.

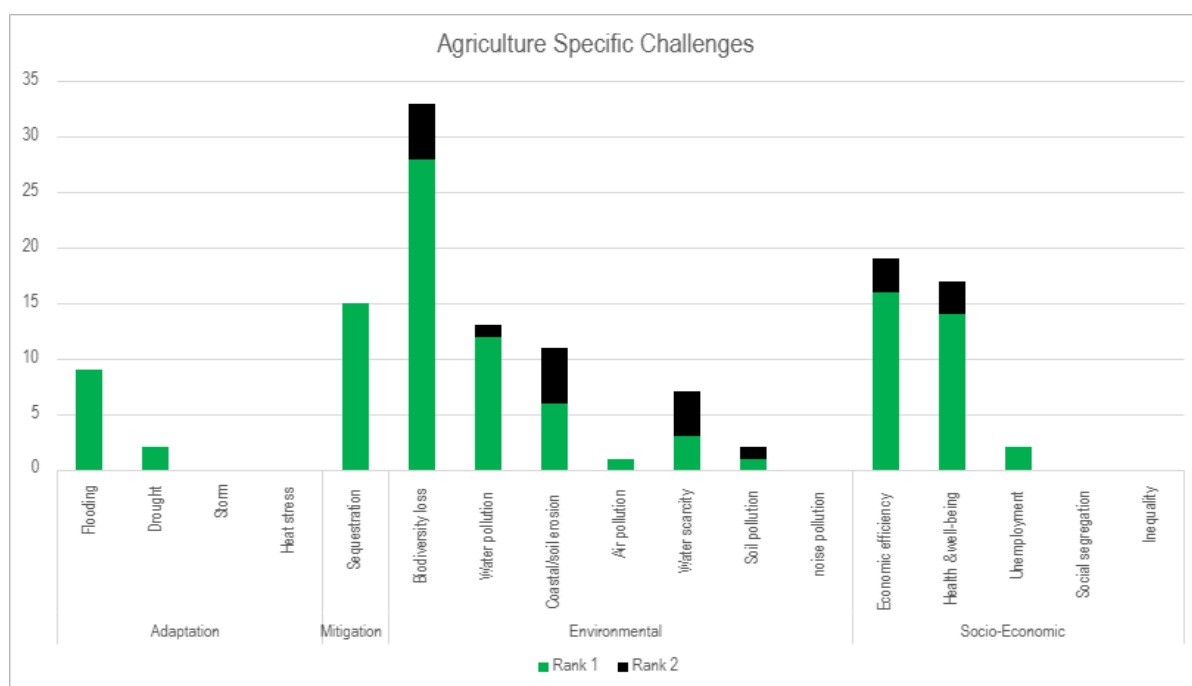


Figure 25. Specific agricultural challenges ranked as first and second priority in the studies.

Assessment methods

A variety of economic valuation methods have been applied to assess the performance of NbS in agricultural landscapes, with notable differences in their frequency of use. Stated preference methods are the most commonly employed, accounting for 45.5 percent of all studies (25 out of 55) and 40.2 percent of observations (189 out of 470). This category includes choice experiments (16 studies, 29.1 percent; 147 observations, 31.3 percent) and contingent valuation methods (9 studies; 42 observations). These approaches are widely used to capture social preferences and willingness to pay for ecosystem services. For instance, Alcon et al(2020) used a choice experiment in South-East Spain to evaluate the non-market benefits of intercropping with woody crops, identifying strong public support due to environmental advantages such as reduced soil erosion and improved soil quality. Bernués et al(2019) similarly assessed willingness to pay for multiple ecosystem services across different European agroecosystems, revealing broad support for biodiversity and multifunctional landscapes. In a contingent valuation study, Otter and Langenberg(2020) found that 65.1 percent of German taxpayers surveyed were willing to pay an average of €36.59 annually to support agroforestry systems such as alley cropping, with pro-environmental attitudes significantly influencing willingness to pay.

Market-based methods were the second most common, appearing in 12 studies (21.8 percent) with 119 observations (25.3 percent). These typically draw on the market prices of crops or carbon credits. For example, Roberts et al. (2023) used crop market prices to compare outputs from conventional and low-input regenerative farming systems, while Flack et al. (2022) applied carbon pricing to evaluate woodland planting under three land-use scenarios: arable, pasture, and a stakeholder-approved model.

Cost-based valuation methods were used in 8 studies (14.5 percent) with 89 observations (18.9 percent) and provide practical estimates by referencing the costs of replacing or maintaining ecosystem services through artificial or financial means. Stachowicz et al. (2022), for instance, assessed the water retention value of peatlands by calculating the cost of constructing artificial reservoirs, dividing total construction costs by reservoir volume and applying a depreciation rate, thereby reflecting the avoided cost of engineered substitutes. de Groot et al. (2022) estimated the value of steppe bird habitat conservation by using subsidy rates for maintaining natural farmland (€75 per hectare per year), leading to an annual value of €1,125 for a 15-hectare sustainable land management farm.

Cost-benefit analysis was used in 4 studies, contributing 33 observations (7.0 percent), while value transfer methods appeared in 3 studies with 31 observations (6.6 percent). Risk-oriented methods, including scenario-based approaches and quantitative risk assessment, were applied in 2 studies with a total of 6 observations. Finally, revealed preference methods such as the travel cost method and hedonic pricing were the least used, appearing in only 2 studies with 3 observations. Overall, these figures highlight the dominance of stated preference and market-based approaches while also underscoring the methodological diversity used to evaluate the economic performance of NbS in agricultural contexts.

ASSESSMENT APPROACH		NR. STUDIES	NR. OBSERVATIONS
Stated preference	Contingent valuation	7	42
	Choice experiment	15	147
Revealed preference	Hedonic pricing	1	1
	Travel cost	1	2
Cost-based		9	89
Market-based		14	119
Value transfer		4	31
Risk management	Quantitative risk assessment	1	2
	Scenario-based	1	4
Decision support	Cost-benefit analysis	4	33
	Ecosystem accounting	6	24
	Life Cycle Analysis	1	4
	Other	2	4

Table 40. Assessment approaches applied in agriculture landscape per number of studies and observations.

Benefit-cost ratio of NbS in agricultural landscapes

For studies reviewed within the agricultural landscape, BCR is captured in 44 observations in total. The analysis indicates that NbS implemented in agricultural settings generally present favourable economic outcomes, with a median BCR of 1.26 and a mean of 1.84. Although some interventions yield relatively low returns, as seen in the 1st percentile (0.05) and 5th percentile (0.32), many others demonstrate higher benefit-cost performance, with the 75th percentile reaching 2.46 and the maximum recorded BCR at 7.03. The distribution shows moderate right skewness (1.51), a standard deviation of 1.50, and a kurtosis value of 5.16, indicating a relatively peaked distribution with some extreme values. These statistics reflect a moderate level of variation in outcomes across cases. The findings suggest that NbS can be

economically viable across agricultural landscapes, and it could be important to tailor interventions to local ecological and socio-economic conditions to improve outcomes.

DETAILED DESCRIPTIVE STATISTICS					
	Percentiles	Smallest			
1%	0.05	0.05			
5%	0.32	0.18		Observations	44
10%	0.49	0.32		Sum of weights	44
25%	0.97	0.49			
50%	1.26	Largest		Mean	1.84
75%	2.46	3.96		Std dev	1.50
90%	3.74	4.66		Variance	2.24
95%	4.66	5.57		Skewness	1.51
99%	7.03	7.03		Kurtosis	5.16

Table 41. Statistics of BCR analyses, agricultural landscape.

The data shows the variation in BCR for different NbS used in agriculture. Among the NbS actions, conservation and regenerative agriculture stands out with the highest average BCR of 3.22, meaning that, on average, the benefits are more than three times the costs. However, the results vary widely, with some cases having BCR as low as 1.07 and others as high as 7.03, showing that outcomes depend heavily on specific conditions. Crop diversification and rotation had a high BCR of 3.51, but this is based on a single example, so more data would be needed to confirm if this is consistently true. Other actions like agroforestry, mulching and cover crops, and no or minimum tillage have average BCRs close to 1, suggesting that their benefits generally balance out the costs, making them economically neutral but potentially valuable for other reasons. Practices grouped as other show a lower average BCR of 0.95, with a wide range from very low (0.05) to moderately high (2.67), indicating that some of these actions might not be cost-effective in all cases. Overall, the variation in BCR highlights how important local context and implementation are in determining the economic performance of these NbS actions.

AGRICULTURAL NBS ACTIONS	N	MEAN	MEDIAN	SD	MIN	MAX
Agroforestry	2	1.06	1.06	0.29	0.85	1.26
Conservation/regenerative agriculture	14	3.22	3.07	1.69	1.07	7.03
Crop diversification and rotation	1	3.51	3.51		3.51	3.51
Maintenance of high mountain traditional practices	4	1.79	1.53	1.35	0.49	3.59
Mulching and use of cover crops	13	1.03	1.18	0.42	0.18	1.56
No or minimum tillage	3	1	1.11	0.46	0.49	1.40
Other	7	0.95	0.78	0.86	0.05	2.67

Table 42. BCR values per type of NbS action in the agricultural landscape.

Two cases have been selected to provide more in-depth insights into the characteristics and economic performance of NbS within the agricultural landscape. The first case comes from Roberts et al. (2023), drawn from their study based at the James Hutton Institute's Centre for

Sustainable Cropping (CSC) at Balruddery Farm in the UK, where a long-term experimental platform has been established to explore low-input, regenerative approaches to arable farming. The integrated system entails alternative crop management, including reduced tillage, incorporation of chopped straw to improve soil organic matter, and the use of green manures and cover crops such as oil radish, rye, and clover. Other measures include selective weed management to support a more diverse ground flora, integrated pest management to reduce pesticide impacts, and the introduction of wildflower margins to benefit pollinators and natural pest enemies.

The integrated system has been shown to deliver environmental benefits, but financial performance was lower than that of the conventional system. Over a six-year full crop rotation, the benefit–cost ratio (BCR) was reduced by 26 percent, from 4.66 in the conventional system to 3.05 in the integrated one. For individual crops, the differences were more substantial: oilseed rape and beans showed BCR reductions of 53 percent and 50 percent respectively, while potatoes saw a 21 percent decline. The transition to the integrated system resulted in an average gross margin loss of £509 per hectare per year, with potatoes experiencing the highest per-hectare losses at £722 annually. The study concluded that these short-term financial losses, which cannot be recovered through market returns, may create a significant economic barrier for farmers. Agro-forestry financial challenges are a major factor limiting the adoption of alternative crop management, the results highlight the need for appropriate financial incentives to encourage uptake of low-input, agroecological practices that can improve environmental outcomes on agricultural land.

It can be argued, however, that the economic evaluation presented by the study does not capture the full picture. The analysis of the conventional farming system does not account for the environmental costs it generates, such as degradation of natural resources or impacts on biodiversity. At the same time, the evaluation of the integrated system does not reflect the non-market values of the environmental goods it provides. As a result, the financial disadvantage associated with the integrated system may be overstated, while the broader societal benefits it offers remain unaccounted for.

The second case comes from Zabala et al. (2022), based on a contingent valuation study conducted in the Cabezo de la Jara and Rambla de Nogalte protected areas (PNA) in the Region of Murcia, southeastern Spain. These areas, covering a total of 1,377 hectares, are part of the Natura 2000 Network as Special Areas of Conservation. The study assessed the local population's willingness to pay for sustainable management measures aimed at conserving the PNA. These measures include, among other things, agricultural practices designed to mitigate soil erosion, reflecting the role of Nature-based Solutions in preserving ecological integrity within managed landscapes.

The economic assessment was carried out over a six-year period using a social discount rate of 3.5 percent and considering 85,270 households. When only the use value of environmental benefits was included, the benefit to cost ratio (BCR) was 0.49, indicating that the costs of conservation measures would outweigh their direct economic benefits under a narrow market-based view. However, when both use and non-use values were included, such as the value people place on conservation regardless of direct use, the BCR rose significantly to 3.59. This shift underscores the considerable contribution of non-market values to the overall worth of sustainable land management in the area.

The study highlights the critical importance of including both use and non-use values of environmental goods in the policy making and design process. By doing so, the full benefits of conservation efforts can be properly accounted for, helping to justify investment in sustainable

practices that may otherwise appear economically unviable. In this case, incorporating a broader valuation framework reveals that the local population perceives the long-term ecological health of the PNA as a valuable public good, supporting the case for implementing sustainable management measures, including agricultural interventions, despite their initial costs.

Key Take Away – agricultural landscapes

NbS in agricultural settings are addressed in 69 studies, accounting for 745 observations. Southern Europe again dominates the geographical spread, contributing half of all studies, followed by Central Europe and the British Isles. Eastern and Northern Europe remain underexplored during the period investigated and in this context.

The majority of agricultural NbS interventions fall under the modification typology, with 54% of observations addressing ecosystem enhancement strategies such as regenerative agriculture, agroforestry, and crop diversification. Protection-focused interventions represent 37% of the dataset, while creation-type actions are limited to just 9%.

Agricultural NbS are primarily designed to tackle economic and environmental challenges, particularly biodiversity loss and land degradation. Flooding and carbon sequestration are also addressed, though drought and soil degradation receive comparatively less attention.

Economic assessments frequently apply stated preference methods, particularly for estimating non-market benefits like biodiversity or water regulation. Market-based approaches are widely used, often related to crop value or cost savings. Cost-based and decision-support tools such as CBA are also employed, whereas revealed and risk-based methods are rarely applied.

Despite a modest number of BCR observations (n=44), the results are encouraging: 73% report BCR >1 and nearly 30% exceed 2. The mean BCR is 1.8, with a median of 1.3, suggesting reliable and consistent economic returns for well-designed NbS in agricultural contexts.

4.7. MOUNTAINS

Geographical distribution

Mountain landscapes appear to be the least studied landscape category, accounting for 19 studies (5%) and 178 observations (4.7%), covering only 5% of the overall analysis.

Most of these studies (68% - 13 out of 19) are concentrated in the Mediterranean and Southern Europe regions, particularly in Italy and Spain. The remaining studies are primarily situated in Central Europe (26%), notably Switzerland and Germany, while a single study focuses on Great Britain and Ireland (5%).

While the predominance of studies from the Mediterranean region reflects the overall trend, the geographic distribution of mountain NbS assessment studies otherwise diverge, with relatively few studies conducted in other parts of Europe.

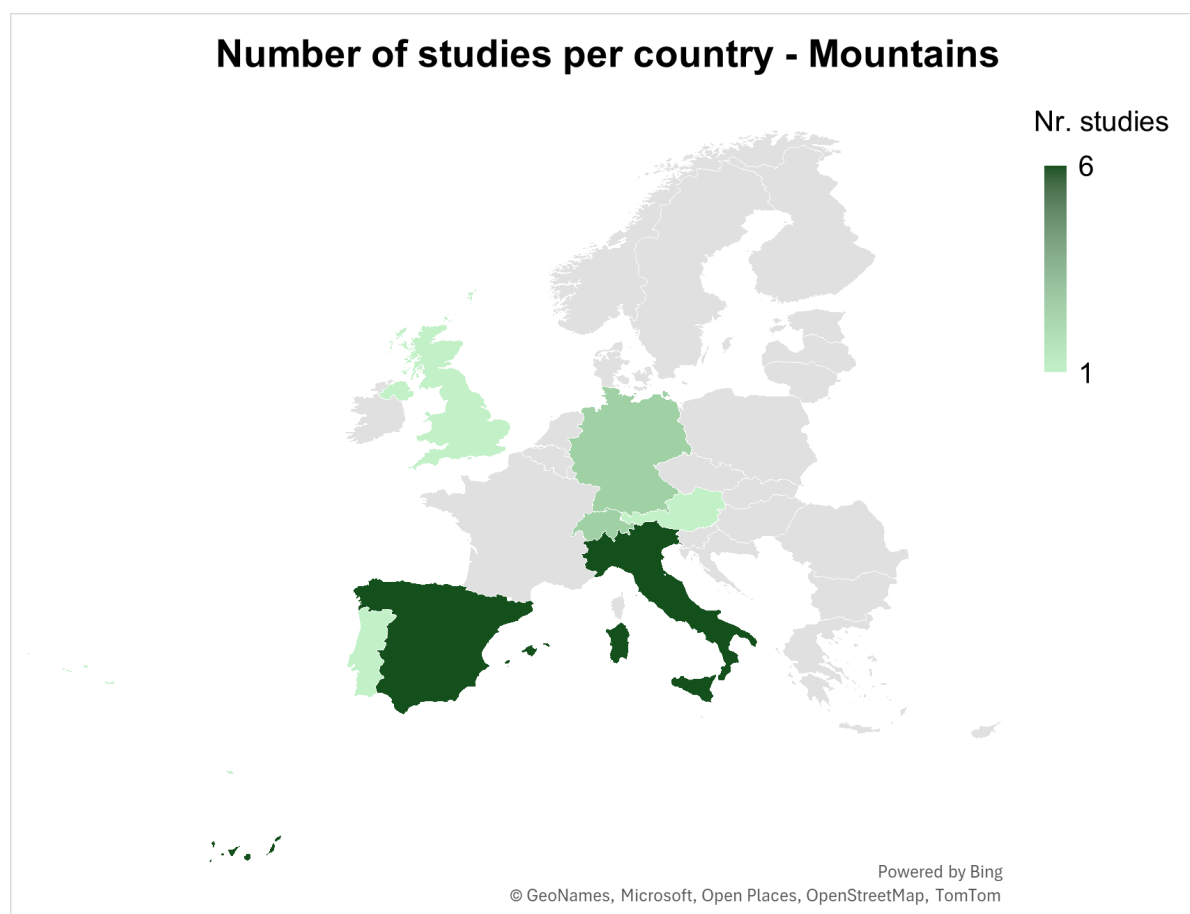


Figure 26. Map of number of mountain NbS assessment studies per country

REGION	NR. STUDIES	PERCENTAGE (%)
Central Europe	5	26.32
Great Britain and Ireland	1	5.26
Mediterranean/Southern Europe	13	68.42

Table 43. Number and percentage of mountain NbS assessment studies across European regions.

Mountain NbS typologies and actions

The NbS addressed in the studies on mountain landscapes encompass protection (11), modification (7), and creation (1) typologies. In comparison to the overall set of studies,

mountain landscapes exhibit a slightly higher emphasis on protection measures and a markedly lower representation of creation interventions. In terms of individual observations, the typology ranking remains consistent, with protection accounting for the highest number of interventions (129), followed by modification (39) and creation (10). However, the proportion of protection interventions (72%) is significantly higher than in the overall set of studies.

The typology of NbS is closely tied to the specific types of interventions characteristic of mountain landscapes. The interventions of the protection typology predominantly focus on the maintenance of protection forests (for example see Tempesta and Vecchiato, 2018), as well as actions categorized as “other”, such as the preservation of traditional landscapes and biodiversity (Faccioni et al., 2019), species conservation efforts (Bednar-Friedl et al., 2022), and the sustainable management of protected areas (Alcon et al., 2019). NbS actions under the modification typology include slope stabilisation with reforestation and/or revegetation of mountain area (Zabala et al., 2022), slope stabilization via terracing (García-Llorente et al., 2012), as well as “other” interventions such as reforestation efforts (Vecchiato et al., 2023), and forest fire prevention measures (Bernués et al., 2019). The only intervention identified under the creation typology falls within the “Other” category and involves the construction of snow avalanche defence structures (Bründl et al., 2006).

NBS ACTIONS	NR. STUDIES	PERCENTAGE (%)
Maintenance of protection forests	5	26.32
Other	12	63.16
Slope stabilisation – reforestation and/or revegetation of mountain area	1	5.26
Slope stabilisation - terracing	1	5.26

Table 44. Number of studies per mountain NbS action.

Challenges

Studies of NbS actions in mountain landscapes primarily focus on environmental management (6), followed by CC mitigation (4), CC adaption (4), and natural hazards (3). Socio-economic challenges are identified as primary concerns in only two studies (Alessandro et al., 2023, García-Llorente et al., 2012). However, they are frequently acknowledged as secondary or complementary issues, alongside challenges such as climate change mitigation and environmental concerns.

RANK	CC ADAPTATION	CC MITIGATION	NATURAL HAZARDS	ENVIRONMENTAL	SOCIO-ECONOMIC
1	4	4	3	6	2
2	1	2	1	3	2
3	0	0	1	3	1
4	0	0	0	0	2

Table 45. Rank of challenges addressed in mountain NbS assessment studies.

A closer analysis of the specific challenges addressed in mountain studies indicates that biodiversity loss and carbon sequestration are the most frequently addressed issues. For instance, (Alcon et al., 2019) highlight the local population's demand for environmental management alternatives - such as the protection of flora and fauna and the promotion of ecotourism - as a response to biodiversity loss in a protected natural area in south-eastern Spain.

In relation to climate change adaptation, flooding is identified as the primary challenge in four studies, while drought appears only once as a secondary issue. For instance, Zabala et al.

(2022) mention flooding as one of the main issues in a protected area in Spain that can be addressed by sustainable management measures. Landslides and erosion are mentioned more frequently (3) as both primary and secondary challenges within the category of natural hazards, whereas avalanches are noted in only one instance. Regarding socio-economic challenges, health and well-being, along with unemployment and social segregation, are highlighted as key concerns. Alessandro et al., (2023) address unemployment and social segregation by establishing nature-based recreation and thereby facilitating social interactions and cohesion as well as creating job opportunities.

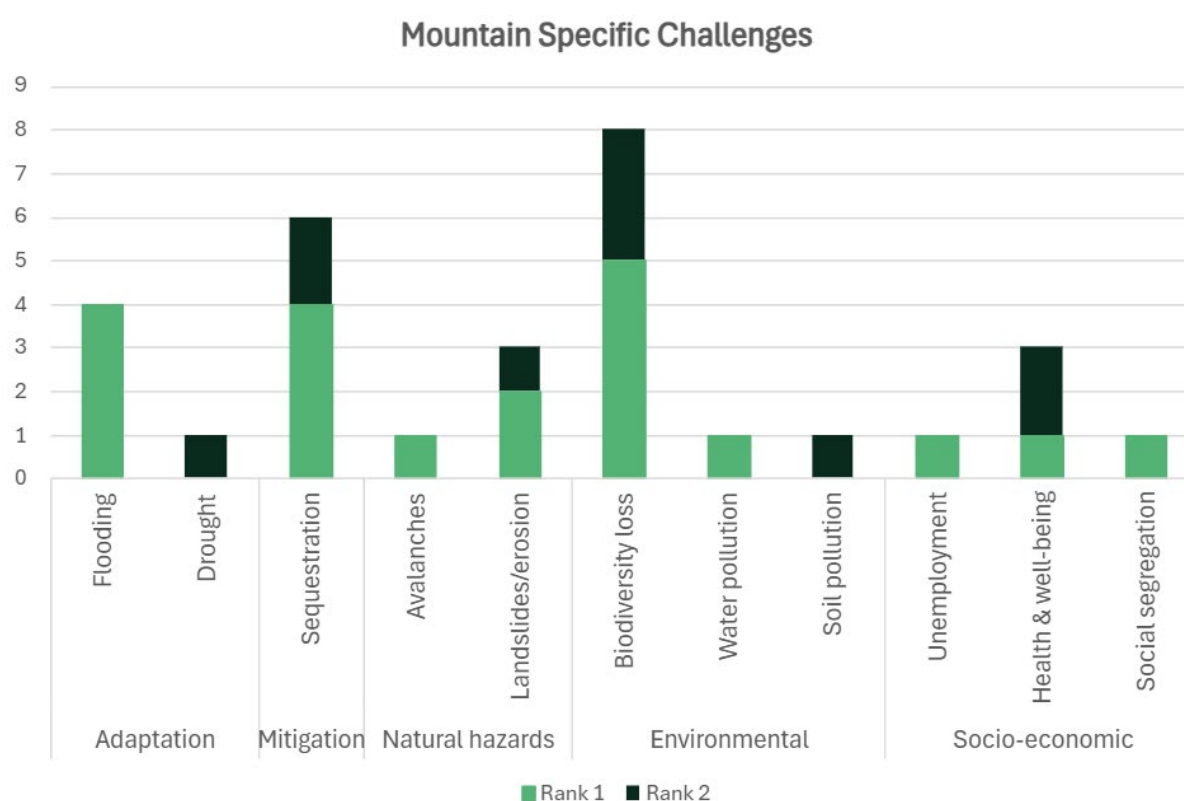


Figure 27. Specific mountain challenges ranked as first and second priority in the studies.

Assessment methods

The quantitative valuation methods applied in mountain landscapes to assess the costs and benefits of NbS are consistent with those used across all landscape types. These include stated preference, cost-based, market-based, value transfer, and revealed preference methods (See Table 46 for studies and observations by the different value assessment approaches).

Within the stated preference category, contingent valuation is employed in two studies, accounting for 19 observations. Choice experiments appear in 8 studies but represent a significantly higher number of observations (57), likely due to their methodological design, which involves evaluating multiple alternatives. In contrast, only the travel cost method is used among revealed preference approaches in mountain contexts, while methods such as hedonic pricing and the random utility model are not applied in any of the mountain case studies. Among market-based methods, four studies contribute a total of 39 observations, making it

one of the most frequently used approaches. Conversely, value transfer and cost-based methods are rarely employed.

Quantitative risk assessment methods - including scenario-based approaches and insurance value estimations - are notably absent in mountain studies. Quantitative decision-support tools are used in only one study (Marta-Pedroso et al., 2018), which includes six observations using ecosystem accounting to evaluate the economic value of ecosystem services such as erosion regulation, carbon sequestration, and biodiversity conservation.

Mountain studies using the choice experiment method assess locals' willingness to pay for protecting or enhancing ecosystem services in mountain agroecosystems or forests. For example, Tempesta and Vecchiato (2018) valued the benefits of recreational improvements in Italy's Veneto region, while Faccioni et al. (2019) ranked and valued alpine agroecosystem functions in northeastern Italy based on local preferences. Similarly, contingent valuation studies, such as Bednar-Friedl (2009), estimate willingness to pay for sustainable management, like species conservation in an Austrian national park.

The travel cost method is used in only one study by Alessandro et al. (2018) to assess the recreational value of mountain forests in Italy, finding a consumer surplus between €7.33 and €17.37 per visit. Market-based approaches are employed to value ecosystem services, as demonstrated by Häyhä et al. (2015) for provisioning services such as timber, mushrooms, and berries in Italian Alpine forests, and by Marta-Pedroso et al. (2018) for crops, fibre, and extensive animal production in a Portuguese protected area. Additionally, Marta-Pedroso et al. (2018) apply the method of value transfer to estimate ecosystem service values for erosion control and carbon sequestration and use ecosystem accounting to assess the economic value of these services. Cost-based methods are applied in Pires-Marques et al. (2021) by using avoided erosion costs to value soil and nutrient loss in Northern Portugal, and in Häyhä et al. (2015) by estimating regulating and cultural ecosystem service values using permit costs.

	ASSESSMENT APPROACH	NR. STUDIES	NR. OBSERVATIONS
Stated preference	Contingent valuation	2	19
	Choice experiment	8	57
Revealed preference	Hedonic pricing		
	Travel cost	1	3
Cost-based		2	10
Market-based		4	39
Value transfer		1	14
Risk management	Quantitative risk assessment	0	0
	Scenario-based	0	0
Decision support	Cost-benefit analysis	0	0
	Ecosystem accounting	1	6

Table 46. Overview of assessment approaches in mountain-focused NbS studies

Note: some studies apply several assessment methods, captured across various observations

Benefit-cost ratio of NbS

For mountain landscapes, only one study among the 19 studies assessed the Benefit-Cost Ratio (BCR) with four observations reported by Zabala et al., (2022), which also encompass agricultural and forest landscapes, along with water management. The study estimates BCR values ranging from 0.49 to 3.59, based on a six-year time horizon and a discount rate of 3.5%, focusing on slope stabilisation through reforestation and/or revegetation categorized under the NbS typology modification. In three out of the four BCR results, benefits outweigh costs (BCR >1), with a median of 1.5 and a mean of 1.8. The results of the economic assessment demonstrate that the benefits derived from use values alone (0.49) are insufficient to offset the conservation costs of the PNA.

This underscores the significance of incorporating the use and non-use values of environmental benefits within the policy design agenda, thereby ensuring comprehensive consideration of conservation costs. The distribution is slightly skewed to the right, indicating that a few higher BCR values increase the average. Kurtosis is 1.8, which is below the normal distribution's value of 3, suggesting a flatter distribution with fewer outliers. Although the small sample size limits broader generalisations, the results indicate that projects with a mountainous landscape component tend to deliver favourable cost-benefit outcomes.

MOUNTAIN NBS ACTIONS	N	MEAN	MEDIAN	SD	MIN	MAX
Slope stabilisation, reforestation and/or revegetation of mountain areas	4	1.79	1.54	1.35	0.49	3.59

Table 47. BCR values per type of NbS action in the mountain landscape

In more detail, the study by Zabala et al. (2022) explores the economic viability of sustainable nature conservation through an intervention in the Cabezo de la Jara and Rambla de Nogalte protected areas, located in the Region of Murcia, Spain. Covering 1,377 hectares within the Natura 2000 Network, the study area was the focus of proposed environmental (e.g., reforestation, watercourse maintenance, biodiversity protection), social (e.g., enhanced recreational opportunities), and economic (e.g., local food production) management measures aimed at long-term conservation.

The study employed a contingent valuation survey to estimate local households' willingness to pay (WTP) for these measures, incorporating preference heterogeneity to capture the diversity of values placed on conservation. Two financial instruments, namely green taxes and user fees, were considered as potential funding mechanisms.

To determine economic viability, the authors conducted a cost-benefit analysis using a six-year time horizon and a 3.5% discount rate. The analysis revealed that use values alone generated a BCR of 0.49, indicating that these benefits would not offset the costs of conservation. However, when non-use values were included, the BCR rose significantly to 3.59. Both green taxes and user fees resulted in BCRs above 1, suggesting financial feasibility, although green taxes as a payment vehicle were favoured for being more equitable and less burdensome on low-income households.

These findings highlight the critical role of non-use values in justifying conservation investments and underscore the need to integrate non-use values into policy and financing frameworks to achieve both ecological sustainability and social acceptability. The only methodological approaches available to include non-use values are stated preference methods such as contingent valuation and choice experiment.

To offer a broader perspective on NbS in mountain landscapes - though without a formal BCR analysis - the case study by (Bednar-Friedl, 2009) explores the potential for visitor contributions to support species conservation efforts in Hohe Tauern National Park, Austria. As the largest national park in Central Europe, covering approximately 1,800 km², it offers a valuable context for assessing the economic and ecological impacts of conservation financing through tourism.

The authors evaluate visitors' willingness to pay (WTP) for the conservation of two species, namely the alpine ibex and the rock partridge, which differ in their levels of endangerment and public recognition. Mean WTP per person was about € 6.90 for the rock partridge, and € 8.70 for the ibex program. These figures are low, given WTP for species conservation programs in other protected areas. However, WTP cannot readily be compared across studies, since environmental valuation crucially depends on the context of valuation. Findings indicate that WTP is driven more by visitors' general attitudes toward nature conservation than by species-specific characteristics.

Although voluntary contributions from visitors may offer a useful supplementary funding source, the study cautions against relying on them as a substitute for public funding. Given the potential instability of such payments and their tendency to reflect broad conservation values rather than targeted species support, the authors underscore the importance of a stable public funding framework as the foundation for effective conservation, with private contributions functioning as a complementary mechanism.

Key take aways – mountain landscapes

Mountain landscapes are the least studied of all thematic areas, with only 19 studies and 151 observations. Representation is limited across all European regions, and the existing evidence base is too small to support generalisations.

Most mountain NbS fall under protection or modification typologies. Creation-type interventions are almost absent. Common actions include slope stabilisation, habitat conservation, and the application of traditional land management practices that support both ecological and cultural values.

The primary challenges addressed include biodiversity loss and land degradation, as well as climate change adaptation, particularly in terms of flood and erosion control. Socio-economic issues, such as rural depopulation or tourism pressures, are underrepresented in the literature.

Assessment methods are limited, with a small number of stated preference studies and very few applications of market-based, revealed preference, or decision-support tools. Risk-based approaches are entirely absent, reflecting both methodological and data limitations.

Although BCR data is extremely limited (n=4), results appear encouraging: 75% of observations report a BCR >1, with a mean and median of 1.8 and 1.5, respectively. However, the small sample size necessitates caution in interpretation and points to a need for further research in this underexplored landscape.

5. SUMMARY OF KEY FINDINGS

5.1. INSURANCE VALUE OF NBS – TWO IMPLEMENTATION CASES

Chapter 3 examined the insurance value of NbS through two distinct case studies: the revitalisation of the Lech River floodplain in Tyrol, Austria, and the rewilding of the Ribeira das Vinhas in Cascais, Portugal. Both projects demonstrate how NbS can substantially reduce flood risk while delivering co-benefits such as improved ecosystem services and community resilience. The cases use different methodologies: Value-at-Risk (VaR) and avoided damage costs, to assess these benefits in quantitative terms.

Lech River, Tyrol, Austria: Restoring Nature to Manage Risk

In Tyrol, Austria, the Lech River revitalisation project was implemented over more than two decades. Originally a conservation initiative under the EU LIFE program, it involved over 50 measures aimed at restoring natural river habitats, controlling sediment, and enhancing flood protection. A key intervention was the installation of a gravel trap, which protected 300 buildings from potential flood events. The project area, designated as a Natura 2000 site and nature park, also supports biodiversity and eco-tourism.

To evaluate the insurance value of these interventions, a Value-at-Risk (VaR) approach was employed. This method assessed the expected damages from floods with and without the NbS, using local zoning and building data, coupled with advanced statistical modelling. The results were significant: average annual flood damage to buildings decreased from approximately €202,000 to €117,000, a reduction of €84,668. Residential buildings alone saw a drop of €39,000 in annual damages.

For extreme events like a 1-in-200-year flood, the reduction in VaR was estimated at €4.2 million for the Lech region, representing an approximately 42% reduction in expected damages. When integrated into a hypothetical regional insurance pool for Tyrol, the benefit still amounted to €1.86 million due to spill-over effects and risk diversification.

Beyond flood risk, the project's impact on tourism was also assessed. A dynamic panel model linked meteorological data to overnight stays in Tyrolean municipalities. Statistical testing showed that NbS contributed positively to tourism demand, especially in areas near the restored river. The enhanced natural landscape and green infrastructure, like the Lech Radweg cycle path, likely played a role in drawing visitors.

This dual benefit, reduced flood risk and increased tourism, illustrates the strategic value of NbS. It lowers both the average annual damage, and the capital required to buffer extreme events, freeing resources and enhancing regional insurance capacity. By combining environmental restoration with financial modelling, the Lech River case highlights how NbS can function as natural insurance infrastructure.

Ribeira das Vinhas, Cascais, Portugal: A Green Corridor Against Urban Flooding

In Cascais, a coastal city near Lisbon, the restoration of the Ribeira das Vinhas River was undertaken to reduce frequent urban flooding and support climate adaptation. The project began in 2017 and spanned a 10-kilometre green corridor, incorporating NbS such as riverbank restoration, constructed ponds, and removal of hard infrastructure. It aimed to protect around 33,000 residents in a flood-prone area, while also revitalizing the landscape and promoting biodiversity.

To quantify the project's impact, an avoided damage cost approach was applied. Using hydrological models and a high-resolution terrain model, the team simulated 100-year flood events before and after the restoration. Although the model outputs are subject to uncertainty, the results indicated that the total damage to buildings decreased from approximately €11 million to €6 million - a 43% reduction. The Expected Annual Damage (EAD) fell from €110,000 to €62,000.

The analysis of population exposure revealed similarly impressive benefits. The number of people potentially displaced during major floods dropped by 60%, while those slightly affected increased. Overall, total population exposure fell by 9%, with a major shift from severe to minor flood impact classes.

In addition to the quantitative modelling, a qualitative survey captured local perceptions of the restored area's ecosystem services. Experts from the municipality reported consistent improvements in climate regulation, recreation, biodiversity, and flood resilience. Recreation emerged as the most recognized benefit, while perceived resilience gains reinforced the modelled reductions in damage and exposure.

This case also explored the potential of integrating insurance mechanisms into NbS strategies. In Portugal, flood insurance uptake is relatively low, especially for coastal floods. By providing measurable risk reduction, projects like Ribeira das Vinhas could support the development of nature-linked insurance products. Options include community-based insurance schemes or public-private partnerships that insure the NbS assets themselves.

International examples, from coral reef insurance in Mexico to floodplain-based insurance in the U.S., highlight the feasibility of such mechanisms. Cascais could adopt similar models, financed through tourist taxes or municipal budgets, to secure long-term benefits and reduce financial vulnerability to climate shocks.

5.2. LITERATURE REVIEW OF NBS ECONOMIC ASSESSMENTS

Chapter 4 presented the results of the systematic literature review on the economic and financial performance of NbS in Europe across landscapes covered the period 2018 to 2023.

NbS economic and financial performance varies by landscape type and geographical coverage:

Urban landscapes are among the most studied, with 105 studies and 1,244 observations—especially concentrated in Southern Europe. Interventions focus on creation-type actions like green roofs and parks, addressing climate adaptation (flooding, heat), pollution, and public health. Stated preference methods dominate, particularly contingent valuation and choice experiments, alongside cost-benefit analysis (CBA). Of 188 BCR observations, 65% exceed 1, and 22% exceed 2, with a mean BCR of 3.3, reflecting strong potential, especially for urban greening and blue infrastructure.

Forest landscapes are the most researched in terms of studies (120) and second in observations (1,051), mostly in Southern and Central Europe. NbS here focus on protection and modification (e.g., reforestation, wildfire control), targeting biodiversity, carbon sequestration, and water regulation. Economic evaluations are diverse, with strong use of market-based and recreational value methods (e.g., travel cost). While BCR data is limited (12 observations), 75% show BCR >1, with a mean of 3.86, indicating high potential, particularly for afforestation and land-use conversion.

Agricultural landscapes (69 studies, 745 observations) emphasize modification, such as agroforestry and regenerative practices, primarily in Southern and Central Europe. Challenges include biodiversity loss, land degradation, and food system sustainability. Economic assessments rely on stated and market-based methods, often estimating benefits like crop value or water quality. With 44 BCR observations, 73% are above 1 and mean BCR is 1.8, suggesting consistent, moderate returns.

Water management is a thematic domain with the highest number of observations (2,745 across 95 studies), particularly in Southern Europe. NbS focus on modification, such as wetland restoration and green infrastructure, addressing pollution, flooding, and biodiversity. Assessments favour stated preference and value transfer methods. With 120 BCR data points, over 70% exceed 1 and 38% exceed 2, yielding a mean BCR of 4.59—the highest among all landscapes—highlighting strong financial performance, especially for multifunctional water-based interventions.

Coastal and marine areas (64 studies) are underrepresented in BCR data (84 observations), despite diverse valuation methods including scenario-based risk modelling. Most interventions are protection-focused (e.g., dunes, seagrasses), tackling biodiversity and carbon challenges. However, only 25% of BCRs exceed 1, with a mean of 0.85, suggesting current costs or under-valuation of co-benefits may hinder positive appraisals.

Mountain landscapes are least studied (19 studies, 151 observations), with NbS focused on protection and modification like slope stabilization and habitat management. Economic assessments are sparse and lack methodological diversity. Though BCR data is minimal (n=4), 75% exceed 1, and mean BCR is 1.8—indicating potential despite the need for more evidence.

Table 48 overleaf summarises the geographic focus, dominant NbS action, main challenges addressed, key assessment methods and BCR performance by landscape.

LANDSCAPE / THEMATIC AREA	GEOGRAPHIC FOCUS	DOMINANT NBS TYPOLOGY / ACTIONS	MAIN CHALLENGES ADDRESSED	KEY ASSESSMENT METHODS	BCR PERFORMANCE
Urban	Southern & Central Europe (Italy, Spain, Germany, UK)	Creation (e.g., green roofs, parks); also restoration & modification	Adaptation (flooding, heat), environmental (air/water pollution), socio-economic (health)	Stated preferences (esp. choice experiments), hedonic pricing, CBA, cost-based	65% >1; 22% >2; Mean: 3.3; Median: 1.1 (n=188)
Forest	Southern Europe, Northern & Central Europe	Protection (intact forests), modification (reforestation, peatland rewetting), creation (afforestation)	Biodiversity, carbon sequestration, health & economic efficiency	Market-based (timber, carbon), travel cost, cost-based, CBA	75% >1; 50% >2; Mean: 3.86; Median: 2.78 (n=12)
Agriculture	Southern Europe (esp. Spain), Central Europe, UK & Ireland	Modification (agroforestry, regenerative practices), protection; limited creation	Biodiversity, land degradation, economic viability	Stated preferences, market-based (crop values), cost-based, CBA	73% >1; 30% >2; Mean: 1.8; Median: 1.3 (n=44)
Water Management	Southern Europe, Central Europe, UK	Modification (wetlands, swales), protection, creation (urban drainage, buffers)	Water pollution, flooding, biodiversity, health	Stated preferences, value transfer, CBA, scenario-based risk methods	71% >1; 38% >2; Mean: 4.59; Median: 1.63 (n=125)
Coastal & Marine	Southern Europe, UK/Ireland	Protection (wetlands, dunes), some restoration; creation rare	Biodiversity, eutrophication, carbon storage; limited socio-economic focus	Stated preferences, value transfer, scenario-based risk, CBA	19% >1; Mean: 0.68; Median: 0.63 (n=74)
Mountain	Sparse coverage across all regions	Protection & modification (slope stabilisation, traditional practices); minimal creation	Biodiversity, erosion, adaptation (floods); socio-economic underexplored	Limited: some stated preferences; very few market/revealed/risk-based	75% >1; Mean: 1.8; Median: 1.5 (n=4)

Table 48. Summary of economic and financial NbS assessment studies across landscapes/thematic areas.

6. DISCUSSION & CONCLUSION

Nature and its services are chronically underpriced because our economy and society fail to incorporate the full costs of ecosystem overuse, degradation and pollution and omit to account for the full benefits of ecosystem services provided, including direct and indirect use values, option values, existence, altruistic and bequest values. We can only manage what we measure and value, hence the importance of understanding and including evidence on the economic and financial performance of NbS, including the insurance value of NbS.

Previous work in the Invest4Nature project has provided clarity and operationalisation in analysing NbS performance by linking a typology of NbS (protect, modify, create) with an overarching typology of environmental, social and socio-economic challenges and benefits and establishing well-defined benefit and cost categories (Lozano et al., 2024). These have been applied in the case studies and in the data extraction and analysis of the literature review, enabling and operationalising a consistent framework.

Another previous work in Invest4Nature extends the TEV framework with four categories to accommodate the insurance value of nature, coined the TEV4Nature framework (Chen et al., 2025a, Deliverable D2.2): The *Protection OF Nature*, which reduces the risk of undesirable regime shifts by enhancing ecosystem stability; the *Protection BY Nature*, where NbS act as natural protective barriers against risks of adverse weather events and/or enhance ecosystem productivity; the *Social Resilience* insurance value, whereby NbS provides multiple benefits to community well-being and strengthens the human-nature relationship; and *Ensuring the Future* insurance value, where NbS preserves the quality and functionality of ecosystems for future generations and their resilience and well-being. This extension of the TEV framework and the identification and elaboration of key methods for valuing the risk and insurance values provide useful and much needed direction for future NbS assessments to include the insurance value of NbS.

The Lech River in Austria and Ribeira Das Vinhas River in Portugal NbS case studies represent examples of valuing the insurance value in terms of *Protect BY Nature* and *Protection OF Nature*. Together, these two cases provide compelling evidence for the insurance value of NbS, using the framework and illustrating the application of two data intensive methods. In Austria, VaR analysis confirmed that ecosystem restoration reduced significantly both expected and extreme-event losses and can free up substantial capital. In Portugal, flood modelling and stakeholder surveys demonstrated how NbS can cut damages by nearly half while improving urban resilience and social well-being.

These cases reinforce the idea that NbS are not just ecological or aesthetic interventions. They also serve as financial risk management tools. By quantifying avoided damage and identifying the multiple benefits, such strategies can inform better investment decisions, attract blended finance, and help integrate nature into insurance frameworks. As climate risks intensify, these insights offer a blueprint for how cities and regions can align adaptation goals with sustainable finance. Chen et al., 2025b from the Invest4Nature project provides illustrative evidence of the insurance value of NbS in relation to Social Resilience and Ensuring Future generations.

The systematic literature review of NbS economic assessments in Europe across land cover and land uses and over a 5-year period demonstrate a diverse methodological landscape, reflecting the different foci, scale and objectives of the studies, the landscapes in which the NbS assessments are situated, the challenges being addressed, the ecological processes harnessed, the type of stakeholders affected, and the types of NbS actions. The literature review revealed a predominance on studies that use benefit assessment approaches including

non-market valuation, market- and cost-based approaches, predominantly primary valuation studies (as opposed to value transfers), while one third applied decision-support and risk management approaches. Lozano et al. (2024) and Lozano et al. (forthcoming) analysed the Ecosystem Valuation Database (ESVD) and the BlueValue database in terms of landscapes, ecosystem services and valuation methods applied. The key distinctive feature of the present review is its explicit focus on NbS rather than ecosystem services. As found in the present literature review, the analysis of the ESVD also reveal i) a lack of evidence and studies covering mountainous landscapes; ii) a wide application of the different methods with a minority of studies using value transfer; iii) a preponderance of non-market valuation approaches in urban and coastal settings compared to a higher share of market- and cost-based approaches in the agriculture and forest landscapes. This review also included risk management and decision support approaches

Benefit cost ratios are useful indicators for arguing in favour of planning and implementing NbS, if the benefits outweigh the costs. The complex ecological processes, resulting multifunctionality of NbS and the associated wide range of use and non-use values involved has understandably led to the general perception that NbS are cost-effective and a preferred option, as evidenced by the EC definition of NbS (EC, 2020) that includes cost-effectiveness as part of the definition. The evidence found in the literature review of NbS economic assessment indicates, however, that only slightly more than half the NbS are found to be economically viable with a $BCR > 1$ and about 20% of assessed NbS suggesting a strong economic case with a $BCR > 2$. Several reasons can explain this result:

- i) **excluding non-use values** from the benefits of a given NbS may result in apparent non-economically viable NbS, compared to when including non-use values as in the study by Zabala et al. (2022) on valuing sustainable nature conservation in a protected area or Teotonio et al. (2018) when valuing a narrow set of benefits from green roofs;
- ii) **a single focus on one or few benefits** to the detriment of including a wide range of substantial co-benefits provided by NbS may lead to a false negative BCR result as found in Teotónio et al. (2023), who did not include co-benefits such as user preferences for aesthetics in green roofs, but focused on runoff retention benefits primarily, while a similar study on green roofs and walls in the same city indicate a very favourable economic return with BCR between 3 and 35 (Almeida et al. 2021);
- iii) **a focus on short term benefits** without factoring in the long term resilience and stability of ecosystem productivity from implementing a NbS may lead to a lower BCR compared to a non-NbS alternative, resulting in a financial strain on NbS owners, if the long term gains are not included, as was found when comparing conventional agriculture with regenerative agriculture (Roberts et al., 2023); and
- iv) **costs may simply outweigh benefits** in specific cases, as was found by Bockarjova et al. (2022) in 35% of 85 NbS forest and urban projects across Europe.

The wide variation of BCR found in the studies, point to the need to understand the individual scope and context of analysis. While benefit-cost ratios provide a useful metric for comparing economic returns, they remain limited in capturing the full complexity of ecological processes and the long-term, often uncertain, co-benefits of NbS. Many ecological interactions, feedback, and thresholds are not yet fully understood, and reliance solely on quantifiable metrics risks overlooking critical system functions. Therefore, in addition to economic assessments, there is a compelling rationale for applying the precautionary principle in assessing the insurance value of NbS.

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ANNEX A – LITERATURE SEARCH PROTOCOL

Theme	Search string
Economic and financial performance	“cost*” or “costing” or “investment” or “operating cost*” or “operational cost*” or “opportunity cost” or “direct cost*” or “administrative cost*” or “labor cost*” or “labour cost*” or “capital cost*” or “establishment cost*” or “implementation cost*” or “maintenance cost”
Type of NbS	“nature-based solutions” or “nature-oriented” or “nature-based intervention” or “nbs intervention” or “nbs action” or “nature-based policy” or “nature-based” or “nbs” or “NbS” or “NbS” or “green infrastructure” or “blue infrastructure” or “green-blue infrastructure” or “blue-green infrastructure” or “BGI” or “GBI” or “GI” or “green space” or “blue space” or “blue-green space” or “natural infrastructure” or “ecosystem restoration” or “eco-engineering” or “ecological engineering” or “ecological restoration” or “climate adaptation service” or “ecosystem-based mitigation” or “ecosystem-based adaptation” or “ecosystem-based disaster risk reduction” or “eco-DRR” or “ecosystem approach” or “ecosystem-based approach” or “ecosystem-based management” or “ecosystem-based solution” or “area-based conservation approach” or “protected area management” or “low impact development” or “best management practice” or “ecosystem protection approach” or “sustainable management” or “sustainable land management” or “natural infrastructure” or “ecological corridor” or “nature protection” or “nature preservation” or “nature conservation” or “nature restoration” or “biodiversity conservation” or “nature enhancement” or “protection of nature” or “preservation of nature” or “conservation of nature” or “restoration of nature” or “enhancement of nature” or “ecosystem protection” or “ecosystem preservation” or “ecosystem conservation” or “ecosystem restoration” or “ecosystem enhancement” or “protection of ecosystem” or “preservation of ecosystem” or “conservation of ecosystem” or “restoration of ecosystem” or “enhancement of ecosystem” or “natural system” or “ecosystem service” or “disaster risk reduction” or “risk reduction”
<u>Landscape, sector or thematic area type</u>	Urban: “urban” or “peri-urban” or “urban forests” or “urban forestation” or “urban landscape” or “peri-urban landscape” or “green belt” or “green roof” or “green wall” or “green facade” or canal or “open space” or “green space” or “urban green*” or “blue amenities” or park or parks or “community garden” or “sponge city” or garden or “green infrastructure” or “blue infrastructure” or “urban green space” or “urban habitats” or “river banks” or streams or “forest parks” or “urban trees” or “urban forests” or “peri-urban forests” or “roof garden” or “rooftop garden” or “green roof” or “green facade” or “urban planning” or “urban biodiversity” or “urban heat island” or pond* or depavement or “rain garden” or “green corridor” or

	bioswale* or swale* or “urban socio-ecological corridor” or “urban socio-cological corridor” or “vertical forest” or “green corridor” OR <u>Water management:</u> “water” or “watershed” or “wetland” or “water asset” or “water bodies” or canals or “water stream” or groundwater or “water catchment” or lake or “water management” or “integrated water resources management” or “IWRM” or “water quality” or “river restoration” or “river bed” or “river buffer” or hydrology or “hydrological ecosystem” or “hydrogeological stability” or “groundwater resources” or “water-related ecosystem” or floodplain or “water-sensitive” or “groundwater management” or “rain garden” or swale or “retention pond” or “constructed wetland” or “natural water retention measure” or “NRWM” or “bioswale” or “sustainable drainage system” or “permeable pavement” or “pervious pavement” or “water-sensitive urban design” or “WSUD*” or “water-sensitive building design” or “stream restoration” or “wetland restoration” or “riparian buffer” or “remeandering” or “re-meandering” or “re-naturalisation” or “re-naturalization” or “river bank*” or “natural bank stabilisation” or “natural bank stabilization” OR <u>Coastal:</u> “coast*” or “coastal ecosystem” or “habitat ecosystem” or “marine protected area” or “MPA” or “coastal habitat” or “sustainable fishery” or “blue garden” or “integrated coastal zone management” or “barrier islands” or “sea grasses” or “seafloor vegetation” or “salt marshes” or “coastal vegetation” or “coastal area” or beach or dune or wetland or “coral reef” or “near-shore” or seashore or coastal or “coastal cliff” or “coastal shoreline” or “green dikes” or “coastal built structures” or “coastal natural features” or “kelp forest” or mussels or “oyster reefs” or “marine spatial planning” or “MSP” or “maritime spatial planning” or estuarine or “estuarine ecosystem” OR <u>Forestry/forestation:</u> “forest*” or “woodland” or “forest restoration” or “forest cover” or “forest management” or “degraded forest” or “riparian buffers” or “old-growth forest” or “primary forest” or “land use conversion” or reforestation or regrowth or trees or “sustainable forest management” or “SFM” or afforestation or “agro-forestry” or “regenerative forestry” or “sustainable forestry” or “restoration of forest” or “protective forest” or “protection forest” or “forest protection” or “forest conservation” or “conservation of forest” OR
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	<u>Mountain:</u> mountain* or “mountain ecosystem” or “mountain areas” or “hill slopes” or “terraced slope” or “timber structures” or “protection forests” or “slope stabilization” or “slope stabilisation” or “slope management” or “revegetation” or “hydro seeding” or “spray cover” or “reforestation” or “afforestation” or “green flood barriers” or “grazing” or “mountain pastures” or “Alpine pastures” or “Alps” or “Alpine” or “landslide*” or “soil erosion” or “avalanche” OR <u>Agriculture:</u> agricultur* or farm* or “agricultural ecosystem” or “mixed-crop livestock system” or “mountain grazing” or “paludiculture” or “peatland restoration” or “reduced tillage” or “conservation agriculture” or “crop diversification” or “crop rotation” or “mulching” or “cover crops” or “agroforestry” or “rainwater harvesting” or “micro-relief” or “regenerative agriculture” or “permaculture” or “biodynamic farming” or “sustainable agriculture” or “sustainable farming” or “climate-resilient farming” or “agro-ecology” or “soil management” or “buffer strip” or “hedgerow*” or “agricultural habitat” AND
Limiting search to EUROPE	“Europe” or “Mediterranean/South Europe” or “Mediterranean” or “South Europe” or “Southern Europe” or “Central Europe” or “Eastern Europe” or “Northern Europe” or “Croatia” or “Greece” or “Italy” or “Portugal” or “Spain” or “Slovenia” or “Cyprus” or “Austria” or “Belgium” or “France” or “Germany” or “Netherlands” or “Poland” or “Switzerland” or “Czech Republic” or “Hungary” or “Romania” or “Slovakia” or “Estonia” or “Denmark” or “Finland” or “Latvia” or “Lithuania” or “Norway” or “Sweden” or “United Kingdom” or “Ireland” or “Great Britain” or “Great Britain and Ireland” or “England”

ANNEX B – DATA EXTRACTION VARIABLES

ID #	Variable name	Description	Coding and Values/units of measurement
Bibliographic information			
V00	Study_ID	Study number	
V01	Study_ID_obs	Observation number within study	
v02	Partner	Abbreviation of partner organisation reviewing	
V021	Reviewer	Reviewer	Organisation/firstname
V02	Peer reviewed	Is the study peer-reviewed?	1=Yes; 0=no
V03	Publication year	Year of publication	full year [e.g. 2018]
V04	Doi	Full doi address (https:...)	
V05	Authors & year	e.g. Kotogani et al., 2019	
V06	Reference	Full reference (author, (year), title, journal/Source	
V07	Type of research	1= review paper, 2=original research, 3=value transfer	
V09	Include/Exclude	Include, exclude	Include, exclude
V10	Include/Exclude argument	Description of why chosen to include/exclude	free text
General background			
V1.1	EUROPEAN REGION	See 'Region_Country' names sheet	Coded
V1.2	CTRY_NAME	Country identifier. See 'Region_Country' names sheet for which country belongs to which region	Coded
V1.3	STATE_REG_NAMES	State, region or local authority name (or other geographic name) (e.g. metropolitan area=regional; municipality=local; city=local; street=local; building=local)	Free Text
V1.4	SPATIAL_SCALE	Variable indicating at which spatial scale the study/project is oriented	1=local 2=regional 3=national, 4=international
V1.5	EXTENT OF NbS	Free text on size of NbS (e.g. m2 or ha if a park, km length if a river; km2 if airshed...)	Free text
V1.6a	NbS Option	Short description of the type of NbS implemented (<i>e.g. river restoration by moving dykes inland, restoring wetlands, renaturing banks, remeandering</i>)	Free text
V1.6b	NbS IMPLEMENT	Is the NbS implemented according to the study or not?	1=NbS is implemented; 0=NbS is not yet implemented
V1.7	NbS TYPOLOGY	Type of NbS	Protection=1; Modification=2; Creation=3
v1.8a1	LANDSCAPE - Urban	Type of landscape in which the NbS is situated. More landscapes can be relevant.	1=Yes; 0=No

ID #	Variable name	Description	Coding and Values/units of measurement
V1.8a2	NbS Urban action	Type of urban NbS action	Protection/maintenance of urban green space; Protection/maintenance of urban blue space; Restoration of urban green space; Restoration of urban blue space; Creation of green roofs or green walls; Creation of new green space; Creation of new blue space; Other
V1.8a3	Other NbS Urban action(s)		Free text
V1.8b1	LANDSCAPE - Water Management	Type of landscape in which the NbS is situated. More landscapes can be relevant.	1=Yes; 0=No
V1.8b2	NbS Water Management Action	Type of water management action	Maintenance of safe physical environments (e.g. hydrogeological stability), Rehabilitation and restoration of river buffers, Rehabilitation and restoration of rivers and floodplains, Water-sensitive forest management, Groundwater management, Restoration of urban green space and corridors, Wetland restoration, Green roofs, green facades, rain gardens, Swales, retention ponds, constructed wetlands, Other
V1.8b3	Other NbS Water management action(s)	If more than one mentioned or another type, do add here in free text, if relevant using the same categories as in V1.8b2	Free text
V1.8c1	LANDSCAPE - Agriculture	Type of landscape in which the NbS is situated. More landscapes can be relevant.	1=Yes; 0=No
V1.8c2	NbS Agriculture action	Type of NbS agriculture action	Maintenance of mixed-crop livestock systems, Maintenance of high mountain traditional practices, Paludiculture or peatland restoration, No or minimum tillage, Conservation/regenerative agriculture, Crop diversification and rotation, Mulching and use of cover crops, Agroforestry, Rainwater harvesting and (re)creation of micro-relief
V1.8c3	Other NbS Agriculture action(s)	If more than one mentioned or another type, do add here in free text, if relevant using the same categories as in V1.8c2	Free text

ID #	Variable name	Description	Coding and Values/units of measurement
V1.8d1	LANDSCAPE - Forests/ Forestry	Type of landscape in which the NbS is situated. More landscapes can be relevant.	1=Yes; 0=No Maintenance of untouched forest cover, Restoring degraded forest, ecosystems, Implementing forests in riparian buffers,
V1.8d2	NbS Forest action(s)	Type of forest/forestry NbS action	Reforestation, Wild fire management, Integrating trees and forests in other sectors, Agro-forestry, Land use conversion from agriculture to forest, Other
V1.8d3	Other NbS Forest action	If more than one mentioned or another type, do add here in free text, if relevant using the same categories as in V1.8d2	Free text
V1.8e1	LANDSCAPE - Coastal	Type of landscape in which the NbS is situated. More landscapes can be relevant.	1=Yes; 0=No Protection of barrier islands, sea grasses, salt marshes and coastal vegetation, Managed realignment of coastal areas, Restoration of coastal habitats in transitional waters - dune restoration, cliff stabilization, seagrasses restoration, restoration wetland, saltmarsh restoration, reef restoration, restoration of barrier islands, beach nourishment, Engineered hybrid solutions, Other
V1.8e2	NbS Coastal action	Type of coastal NbS action	
V1.8e3	Other NbS Coastal action(s)	If more than one mentioned or another type, do add here in free text, if relevant using the same categories as in V1.8e2	Free text
V1.8f1	LANDSCAPE - Mountains	Type of landscape in which the NbS is situated. More landscapes can be relevant.	1=Yes; 0=No Maintenance of protection forests, terracing, reforestation/revegetation, Green flood barriers (e.g., construction of retention basins), Installation of timber structures to retain water, Other
V1.8f2	NbS Mountain action	Type of mountain NbS action	
V1.8f3	Other NbS Mountain action(s)	If more than one mentioned or another type, do add here in free text, if relevant using the same categories as in V1.8f2	Free text

ID #	Variable name	Description	Coding and Values/units of measurement
V1.9	INVESTMENT PERIOD	Period in which the NbS investment is planned for	Free text
V1.10a	MAIN_CHALL_GENERIC_1	Most important generic societal challenge addressed by NbS	1=Climate change adaptation; 2= climate change mitigation, 3= natural hazards, 4= environmental management, 5= socio-economic challenges
V1.10b	MAIN_CHALL_GENERIC_2		
V1.10c	MAIN_CHALL_GENERIC_3	Additional generic societal challenge addressed - second most important challenge - if relevant. If not relevant, leave blank	
V1.10d	MAIN_CHALL_GENERIC_4		
V1.10e	MAIN_CHALL_GENERIC_5		
V1.11a	ADAPTATION_CHALL_1	Main adaptation challenge addressed. If not relevant, leave blank	1=flooding, 2= heat stress, 3= storms, 4=droughts,
V1.11b	ADAPTATION_CHALL_2	Additional specific adaptation challenge if relevant. If not relevant, leave blank	
V1.11c	ADAPTATION_CHALL_3	Additional specific adaptation challenge if relevant. If not relevant, leave blank	
V1.11d	ADAPTATION_CHALL_4	Additional specific adaptation challenge if relevant. If not relevant, leave blank	
V1.12	MITIGATION_CHALL	Mitigation challenge addressed. If not relevant, leave blank	1= Carbon sequestration
V1.13a	HAZARD_CHALL_1	Main Natural hazards challenge addressed. If not relevant, leave blank	1=avalanches, 2= landslides, 3=earthquakes

ID #	Variable name	Description	Coding and Values/units of measurement
V1.13b	HAZARD_CHALL_1	Additional specific natural hazards challenge if relevant. If not relevant, leave blank	
V1.13c	HAZARD_CHALL_1	Additional specific natural hazards challenge if relevant. If not relevant, leave blank	
V1.14a	ENVIRON_CHALL_1	Main environmental challenge addressed. If not relevant, leave blank	1= air pollution, 2= noise pollution, 3= water pollution, 4= water scarcity, 5= coastal/soil erosion, 6=biodiversity loss, 7= soil pollution
V1.14b	ENVIRON_CHALL_2	Additional environmental challenge if relevant. If not relevant, leave blank	
V1.14c	ENVIRON_CHALL_3	Additional environmental challenge if relevant. If not relevant, leave blank	
V1.14d	ENVIRON_CHALL_4	Additional environmental challenge if relevant. If not relevant, leave blank	
V1.14e	ENVIRON_CHALL_5	Additional environmental challenge if relevant. If not relevant, leave blank	
V1.15a	SOCIO-ECON_CHALL_1	Main socio-economic challenge addressed if relevant. If not relevant, leave blank	1=unemployment, 2=inequality, 3=health & wellbeing, 4= social segregation, 5= economic efficiency
V1.15b	SOCIO-ECON_CHALL_2	Additional socio-economic challenge addressed if relevant. If not relevant, leave blank	
V1.15c	SOCIO-ECON_CHALL_3	Additional socio-economic challenge addressed if relevant. If not relevant, leave blank	
V1.15d	SOCIO-ECON_CHALL_4	Additional socio-economic challenge addressed if relevant. If not relevant, leave blank	
V1.15e	SOCIO-ECON_CHALL_5	Additional socio-economic challenge addressed if relevant. If not relevant, leave blank	
V1.16	TRADE OFFS	If paper addresses trade offs of NbS action(s)	Free text - e.g. 'gentrification when greening a neighbourhood'
V1.17	BACKGROUND NOTES	Relevant background information not captured in this background section.	Free text

ID #	Variable name	Description	Coding and Values/units of measurement
V1.18	GREY_COMPARISON	Dummy variable if study compares cost, benefits, effectiveness with grey infrastructure (e.g. piped solutions)	1=Yes; 0=no
Cost values			
V2.1	COST NAME/SCENARIO	Free text to state what cost(s) is/are being valued or if scenarios are applied, what are they about. Are they empirical or modelled etc.?	Free text - e.g. 'avoided damage costs of reducing flood risks'
V2.1.1	COST UNIT	Unit cost used	Free text - e.g. 'costs per ha' or 'costs per m3'
V2.2	CURRENCY	Currency in which the values are reported	EUR, GBP, USD, DKR, SEK, NOK, CF, PLN, CZK, BGN, HUF, RON, Other
V2.3	YEAR of CURRENCY	Year for which the currency of the costs is reported (e.g. 2020)	[value]
V2.4	HORIZON	Time horizon/Period of cost values (number of years) (e.g. 5 for 5 years)	[value]
V2.5	DISCOUNT RATE	Discount rate applied in estimating net present values (if applicable)	% - if sensitivity analysis and several results and discount rates, make a new observation (row) for each
V2.6	OVERALL COSTS	Overall costs reported in the paper. If at least 2 types of costs included, include the sum as overall costs.	[value]
V2.6a	OVERALL COSTS_CPI	Consumer price adjusted overall costs in national currency to 2023 levels	Own calculation
V2.6b	OVERALL COSTS_CPI_PPP	PPP adjusted overall costs to EUR 2022 levels	Own calculation
V2.6.1	MIN COST COSTS_CPI	If applicable - report/calculate the minimum cost of an activity	[value] (could be calculated using =min formula)
V2.6.1a	MIN COST COSTS_CPI_2023	minimum costs adjusted in national currency to 2023 levels	Own calculation
V2.6.1b	MIN_COST_CPI_PPP_EUR2023	minimum costs adjusted in national currency and PPP to EUR2023 levels	Own calculation
V2.6.2	MAX COST	If applicable - report/calculate the maximum cost of an activity	[value] (could be calculated using =max formula)
V2.6.2a	MAX COST_CPI_2023	Maximum costs adjusted in national currency to 2023 levels	Own calculation
V2.6.2b	MAX_COST_CPI_PPP_EUR2023	Maximum costs adjusted in national currency and PPP to EUR2023 levels	Own calculation
V2.6.3	AVG COST	If applicable - report/calculate the average cost of an activity	[value] (could be calculated using =average formula)
V2.6.3a	AVG COST_CPI_2023	Average costs adjusted in national currency to 2023 levels	Own calculation
V2.6.3b	AVG COST_CPI_PPP_EUR2023	Average costs adjusted in national currency and PPP to EUR2023 levels	Own calculation
V2.6.4	MED COST	If applicable - report/calculate the median cost of an activity	[value] (could be calculated using =median formula)
V2.6.4a	MED COST_CPI_2023	Median costs adjusted in national currency to 2023 levels	Own calculation
V2.6.4b	MED COST_CPI_PPP_EUR2023	Median costs adjusted in national currency and PPP to EUR2023 levels	Own calculation

ID #	Variable name	Description	Coding and Values/units of measurement
V2.7	CAPEX	Includes feasibility studies, design, R&D, land acquisition, construction and installation, relocation, stakeholder involvement, capital...if included	[value]
V2.7a	CAPEX_CPI_2023	Implementation costs CPI 2023 adjusted	Own calculation
V2.7b	CAPEX_CPI_PPP_EUR2023	Implementation costs CPI & PPP EUR 2023 adjusted	Own calculation
V2.8	OPEX	Running costs, incurred after starting the operation of the project. Includes labour & training, land rent, capital, transport, stakeholder involvement...if included	[value]
V2.8a	UNIT OPEX	Unit applied in describing the maintenance costs (e.g. eur/ha/yr)	Free text
V2.8b	OPEX_CPI_2023	Operational costs CPI 2023 adjusted	Own calculation
V2.8c	OPEX_CPI_PPP_EUR2023	Operational costs CPI & PPP EUR 2023 adjusted	Own calculation
V2.9	MONITORING COSTS	Costs of tracking and observations ex-ante & ex-post of NbS project. if included	[value]
V2.9a	MONITOR_COST_CPI_2023	Monitoring costs CPI 2023 adjusted	Own calculation
V2.9b	MONITOR_COST_CPI_PPP_EUR2023	Monitoring costs CPI & PPP EUR2023 adjusted	Own calculation
V2.10	FINANCING COSTS	Interests, fees, lease payments. if included	[value]
V2.11	OPPORTUNITY COSTS	Foregone benefits associated with other land uses if included; costs related to trade offs from NbS action(s)	[value]
V2.11a	OPP_COST_CPI_2023	Foregone benefits CPI 2023 adjusted	Own calculation
V2.11b	OPP_COST_CPI_PPP_EUR2023	Foregone benefits CPI & PPP EUR2023 adjusted	Own calculation
V2.12	REPLACEMENT COSTS	Replacement cost at the end of the NbS lifetime	[Value]
V2.12a	REPLAC_COST_CPI_2023	Replacement costs CPI 2023 adjusted	Own calculation
V2.12b	REPLAC_COST_CPI_PPP_EUR2023	Replacement costs CPI & PPP EUR2023 adjusted	Own calculation
V2.12c	UNIT REPLACEMENT COSTS	Unit of replacement cost at the end of the NbS lifetime	Free text
V2.13	INDIRECT COSTS	Remaining costs to society or private land owners after NbS project has been implemented if included	[value]
V2.13a	INDIR_COST_CPI_2023	Indirect costs CPI 2023 adjusted	Own calculation
V2.13b	INDIR_COST_CPI_PPP_EUR2023	Indirect costs CPI & PPP EUR 2023 adjusted	Own calculation
V2.13	COST NOTES	Relevant information on the costs not captured. For instance, what types of costs are included in 'overall costs'? Are trade off costs mentioned qualitatively?	Free text
Effects in physical, qualitative or non-quantitative terms			
V3.1	EFFECTS/BENEFITS ASSESSED	[free text to state what effects/benefit(s) have been assessed]	Free text

ID #	Variable name	Description	Coding and Values/units of measurement
V3.2	CLIMATE ADAPTTION BENEFIT	1=river flood regulation, 2= coastal flood regulation, 3= pluvial flood regulation, 4= thermal control & cooling, 5=storm regulation, 6=water storage & infiltration	[value and indicator of benefit]
V3.3	CLIMATE MITIGATION BENEFIT	1=terrestrial C sequestration , 2=aquatic C sequestration, 3rd= terrestrial and aquatic	[value and indicator of benefit]
V3.4	HAZARD BENEFIT	1=slope stabilisation,	[value and indicator of benefit]
V3.5	ENVIRONMENTAL BENEFITS	1=air purification, 2= water purification, 3=noise mitigation, 4=water storage & groundwater recharge, 5=coastal erosion, 6=soil erosion control, 7=biodiversity & connectivity	[value and indicator of benefit]
V3.6	SOCIO-ECONOMIC BENEFITS	1=jobs & businesses, 2=equity, justice, inclusion, crime reduction; 3=health&well-being, 4=awareness & education	[value and indicator of benefit]
V3.7	OTHER BENEFITS	Free text, if not covered in V3.1 - V3.5; this is also applicable for papers on ecosystem services that may not be easy to "translate" into the categories of benefits.	[Free text]
V3.8a	PHYSICAL EFFECT INDICATOR	Describe what indicator of physical effect of NbS is used (e.g. % flood risk reduced, ambient temperature reduced during nights in summer..). If more than one indicator is used to account for different benefits, then add a new row (observation)	[Free text]
V3.8b	PHYSICAL EFFECT VALUE	Add the value of the NbS effect estimated/calculated. If more than one value due to differences in calculations or due to different type of indicator, then add a new row (observation)	[value]
V3.9a	NON-PHYSICAL INDICATOR	Describe what indicator of non-physical effect of NbS is used (e.g. recreation or wellbeing benefits). If more than one indicator is used to account for different benefits, then add a new row (observation)	[Free text]
V3.9b	NON-PHYSICAL VALUE	Add the value of the NbS effect estimated/calculated. If more than one value due to differences in calculations or due to different type of indicator, then add a new row (observation)	[value]
V3.10	EFFECT NOTES	Relevant information on effects/impacts of NbS not captured	Free text
Economic assessment approach			

ID #	Variable name	Description	Coding and Values/units of measurement
V4.1	ORIGINAL MONETARY VALUE OF BENEFITS	Monetary value reported of benefits incurred by the NbS project reported by paper. If several different value estimates due to model specification or different scenarios or different types of benefits assessed, add additional row(s) (observation). [Value in original unit (national current prices at time of study)]	[monetary value]
V4.1a	BENEFIT_VALUE_CPI_2023	Original monetary value of benefits CPI 2023 adjusted	Own calculation
V4.1b	BENEFIT_VALUE_CPI_PPP_EUR2023	Original monetary value of benefits CPI & PPP EUR 2023 adjusted	Own calculation
V4.1.1	If applicable, (MINIMUM) MONETARY VALUE OF BENEFITS	Minimum of original monetary value, if applicable	[value]
V4.1.1a	BENEFIT_MIN_CPI_2023	Minimum benefit adjusted CPI 2023, if applicable	Own calculation
V4.1.1b	BENEFIT_MIN_CPI_PPP_EUR2023	Minimum benefit adjusted CPI & PPP EUR2023	Own calculation
V4.1.2	If applicable, (MAXIMUM) MONETARY VALUE OF BENEFITS	Maximum of original monetary value	[value]
V4.1.2a	BENEFIT_MAX_CPI_2023	Maximum benefit adjusted CPI 2023, if applicable	Own calculation
V4.1.2b	BENEFIT_MAX_CPI_PPP_EUR2023	Maximum benefit adjusted CPI & PPP EUR2023	Own calculation
V4.1.3	MARGINAL MONETARY VALUE OF BENEFITS [Value]	Monetary value of benefits at a per unit level, based on information from paper [own calculation]	[monetary value, own calculation]
V4.1.4	Marginal Monetary value unit	Unit of monetary value	
V4.2	BENEFIT UNIT	Describe what unit of benefit has been used for the quantitative estimate (e.g. eur/ha; number of visitors per day; %increase in housepx from unit increase of green space)	Free text
V4.3	CURRENCY	Specify currency reported using drop down menu	[drop down]
V4.4	VALUE INDICATOR	Specify if Willingness to pay (WTP), Marginal WTP; Consumer surplus (CS), Total Economic Value (TEV), other (for instance WTA),	1= WTP, 2=mWTP; 3= CS; TEV=4; Other= 5;
V4.4.1	VALUE OTHER	If Other in V4.2, pls specify in free text	[free text]
V4.5	DESCRIPTION OF BENEFIT VALUE/SCENARIO	Description of benefit indicator used in the economic valuation (e.g recreation - number of visitors per year, groundwater recharge, coastal flood protection....). All details not captured otherwise.	Free text [Indicator of benefit value assessed]
V4.6	BCR DUMMY	Dummy variable if Benefit Cost Ratio (BCR) provided	1= yes, 2= no
V4.7	BCR VALUE	Specify the value of the Benefit-Cost Ratio, if included	[value]

ID #	Variable name	Description	Coding and Values/units of measurement
V4.8	HORIZON	Specify the horizon specified for the value (e.g. next 10 years, 20 years...); 999999 signifies infinity. Values are in years	[value]
V4.09	DISCOUNT RATE	Specify the discount rate applied (e.g. If 3% write 3)	[value]
V4.10	QUANTITATIVE VALUE METHOD	General valuation approach applied	1=market based, 2= cost based, 3= revealed, 4= stated, 5=value transfer
V4.11	REVEALED PREFERENCE	Approach that estimates WTP/WTa/CS based on revealed behaviour	1= travel cost, 2= Hedonic pricing, 3= random utility model
V4.12	STATED PREFERENCE	Approach that estimates WTP/WTa based on stated preferences	1=contingent valuation, 2= choice experiment
V4.13	OTHER VALUE METHOD	Specify quantitative valuation approach applied (e.g., for market-based or cost-based). Example: Replacement cost. This variable is for valuation approaches that do not fall under either stated or revealed preference methods captured in the preceding columns.	
V4.14	QUANTITATIVE RISK METHOD	Quantitative risk valuation approach applied - broad types	1=quantitative risk, 2= risk benefit, 3= scenario, 4=insurance value, 5= value at risk, 6=other
V4.15	OTHER QUANTITATIVE RISK METHOD	If 6=other in V4.14, describe which other method applied	Free text
V4.16	QUANTITATIVE DECISION SUPPORT	Quantitative decision support approaches applied - broad types	1=CBA, 2=CEA, 3=Decision making under uncertainty, 4=MCA, 5=LCA, 6=Ecosystem accounting, 7=Cost utility analysis, 8=cost-minimisation, 9=corporate ecosystem valuation, 10=other
V4.17	OTHER QUANTITATIVE DECISION SUPPORT	If 8=other in V4.16, describe which other method applied	Free text
V4.18	ASSESSMENT NOTES	Additional relevant information on the economic assessment not captured	Free text
BENEFIT MEASURES - only if non-market valuation is applied			
V5.1	ESTIMATE_ID	Unique identifier for each WTP observation in the dataset. (Use STUDY_ID as prefix, e.g. number 302 would be observation 2 from study number 3)	ID number
V5.2	MEAN	Dummy for mean WTP/CS reported	1=mean WTP/CS, 0=median WTP/CS (mean should always be reported where possible)
V5.3	CURRENCY	abbreviation for currency used in study	Text (3 letters)
V5.3.1	YEAR of CURRENCY	Year for which the currency of the benefits is reported (e.g. 2020). If not	

ID #	Variable name	Description	Coding and Values/units of measurement
		reported, default is the year of submission.	
V5.4	ORIGVALUNITS	Period that the WTP covers	1=One day, 2=one month; 3=One trip, 4=Season (less than one year), 5=One year, 6=multi-period (more than one year but less than infinite), 7=infinite, 8=not specified
V5.5	LUMP_SUM	Dummy for lump-sum payment (a one time payment covering several years).	1=lump sum payment, 0=otherwise
V5.6	SHORT_TIME	Dummy for annual payments for less than 10 years	1=payment for less than 10 years, 0=otherwise
V5.7	ANNUAL_YEARS	The number of years for which the annual payment will be made. If infinite time horizon, or time horizon not specified, then leave blank.	Number
V5.8	PER_PERSON	Dummy for per person WTP per year	1=WTP per person, 0=otherwise (per household)
V5.9	WTP_ORIG	Value in original unit per year (national current prices at time of study)	Number
V5.9a	WTP_ORIG_CPI_2023	Value in original unit per year CPI 2023 adjusted	Own calculation
V5.9b	WTP_ORIG_CPI_PPP_EUR2023	Value in original unit per year CPI & PPP 2023 adjusted	Own calculation
V5.10	WTP_ORIG_HH	If WTP is per person, convert to per household (national current prices at time of study) by multiplying with the average household size in the given country (see Eurostat Household sheet)	Number
V5.11	WTP_ORIG_HH_Y	Value converted to per household per year (national current prices at time of study). If lump-sum payment, calculate annual equivalent payment amortized over the period used in the study using 4% discount rate. If annual payments are specified for less than 10 years, then calculate present value of annual amount and re-amortize to per year payments over a period of 10 years	Number
V5.13	WTP_CUR_EUR_HH_Y	Converted value in EUR 2018, PPP adjusted	Number
V5.14	STD_ERR	Std error of mean WTP	Number
V5.15	CONF_INT	Dummy indicating whether confidence interval is reported in study (at 10% or better)	1= Confidence Interval included in report at 10% or better, 0=otherwise
V5.16	PARAMETRIC	Dummy indicating if WTP is calculated using parametric approach (as opposed to non-parametric)	1=WTP calculated from parametric model, 0=otherwise

ID #	Variable name	Description	Coding and Values/units of measurement
V5.17	WTP_SPACE	Dummy variable indicating if the model is estimated in WTP space. This is for discrete choice models. WTP space means that the estimated parameters in the regression models have units of WTP. This is different from discrete choice models that are estimated in 'preference space', in the latter case, estimated parameters have units of utility and you need to divide the parameter with the price parameter in order to obtain the marginal WTP. This is something that a paper will report /you can read out from the description of the model specification.	1=WTP space; 0 otherwise
V5.18	ECONOMETRIC_MODEL	Type of econometric model used to estimate the data	1=MNL (multinomial logit); 2=LCM (latent class model); 3=RPL (random parameter logit/mixed logit); 4=EC (error component model) ;5=RPL-EC (random parameter logit-error component model) ;6=GMNL (Generalized Multinomial Logit Model); 7=GMXL (Generalized Multinomial Logit Model); 8=OLS (ordinary least squares); 9=binary probit;10=binary logit; 11= interval regression; 12=tobit/sample self-selection; 13=poisson; 14=negative binomial
V5.19	BENEFIT MEASURE NOTES		

ANNEX C – WATER MANAGEMENT THEMATIC AREA STUDIES

Authors	Year	European region	Country	Typology	NbS action	BCR
Abramowicz, D. S., M.	2020	Central Europe	Poland	1=Protection	Swales, retention ponds, constructed wetlands	No
Acuna-Alonso, C. N., A.;Rodriguez, J. L.;Varandas, S.;Alvarez, X.	2022	Mediterranean/South Europe	Spain	3=Creation	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Afentou, N. M., P.;Hull, K.;Shepherd, J.;Elliott, S.;Frew, E.	2022	Great Britain and Ireland	United Kingdom	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Albaladejo-García, J. A., Zabala, J. Á., Navarro, N., Alcon, F., & Martínez-Paz, J. M.	2021	Mediterranean/South Europe	Spain	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Almeida, C. T., I.;Silva, C. M.;Cruz, C. O.	2021	Mediterranean/South Europe	Portugal	3=Creation	Green roofs, green facades, rain gardens	Yes
Andreopoulos, D. D., D.;Comiti, F.;Fischer, C.	2015	Mediterranean/South Europe	Greece	2=Modification	Rehabilitation and restoration of rivers and floodplains	No
Arfaoui, N., Gnonlonfin, A.	2022	Mediterranean/South Europe	France	2=Modification	Rehabilitation and restoration of rivers and floodplains	No
Ashley, R.M., Gersonius, B., Digman, C., Horton, B., Bacchin, T., Smith, B., Shaffer, P., Baylis, A.,	2018	Great Britain and Ireland	United Kingdom	3=Creation	Restoration of urban green space and corridors	Yes
Atkinson, G. O., P.	2022	Great Britain and Ireland	United Kingdom	1=Protection	Other	No
Börger, T., Campbell, D., White, M. P., Elliott, L. R., Fleming, L. E., Garrett, J. K., Hattam, C., Hynes, S., Lankia, T., & Taylor, T.	2021	Eastern Europe	Bulgaria	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Babí Almenar, J., Petucco, C., Sonnemann, G., Geneletti, D., Elliot, T., & Rugani, B.	2023	Mediterranean/South Europe	Spain	3=Creation	Regulation of hydrological cycle & water cycle	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Barrios-Crespo, E. T.-O., S.;D��az-Simal, P.	2021	Mediterranean/South Europe	Spain	2=Modification	Restoration of urban green space and corridors	No
Benisiewicz, B. M., A.;Leggatt, A.;Holman, I. P.	2021	Great Britain and Ireland	United Kingdom	2=Modification	Rehabilitation and restoration of rivers and floodplains	No
Bisaro, A. d. B., M.;Hinkel, J.;Kok, S.;Bouwer, L. M.	2020	Central Europe	Netherlands	2=Modification	Rehabilitation and restoration of rivers and floodplains	No
Boguniewicz-Zab��ocka, J., & Capodaglio, A. G.	2020	Central Europe	Poland	3=Creation	Groundwater management	No
Bokhove, O. K., M. A.;Kent, T.;Piton, G.;Tacnet, J. M.	2019	Central Europe	Czechia	2=Modification	Rehabilitation and restoration of rivers and floodplains	No
Borrego-Mar��n, M. M., & Berbel, J.	2019	Mediterranean/South Europe	Spain	2=Modification	Rehabilitation and restoration of rivers and floodplains	Yes
Bujnovsk��y, R.	2018	Central Europe	Slovakia	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Bus, A., & Szelagowska, A.	2021	Central Europe	Poland	3=Creation	Green roofs, green facades, rain gardens	No
Calvo Robledo, A., MacDonald, M. A., & Butt, C.	2020	Mediterranean/South Europe	Spain	2=Modification	Wetland restoration	No
Carolus, J. F., Hanley, N., Olsen, S. B., & Pedersen, S. M.	2018	Northern Europe	Sweden	2=Modification	Rehabilitation and restoration of river buffers, Water-sensitive forest management	Yes
Custodio, E., Sahuquillo, A., & Albiac, J.	2019	Mediterranean/South Europe	Spain	1=Protection	Groundwater management	No
de Groot, R. M., S.;de Vente, J.;De Leijster, V.;Ramos, M. E.;Robles, A. B.;Schoonhoven, Y.;Verweij, P.	2022	Mediterranean/South Europe	Spain	2=Modification	Other	No
De Nocker, L., Liekens, I., Beckx, C., & Broekx, S.	2023	Central Europe	Belgium	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No

Authors	Year	European region	Country	Typology	NbS action	BCR
De Nocker, L.;Liekens, I.;Verachtert, E.;De Valck, J.;Staes, J.;Vreboos, D., & Broekx, S.	2022	Central Europe	Belgium	2=Modification	Other	No
De Valck, J. B., A.;Liekens, I.;Bettens, M.;Seuntjens, P.;Broekx, S.	2019	Central Europe	Belgium	2=Modification	Other	No
Deely, J. H., S.	2020	Great Britain and Ireland	Ireland	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Di Grazia, F. G., B.;Galgani, L.;Troiani, E.;Ferri, M.;Loiselle, S. A.	2021	Mediterranean/South Europe	Italy	2=Modification	Other	No
Dimopoulos, V. T., C.;Mirasgedis, S.	2022	Mediterranean/South Europe	Greece	1=Protection	Wetland restoration	No
Diti, I. L., S. E.;Caffi, T.;Rossi, V.;Canali, G.;Bosso, A.;Cancila, E.;Anelli, S.;Trioli, G.;Kleshcheva, E.;Gatti, M.;Poni, S.	2020	Mediterranean/South Europe	Italy	2=Modification	Groundwater management	No
Ekinci B, Grunewald K, Meier S, Schwarz S, Schweppe-Kraft B, Syrbe R-U	2022	Central Europe	Germany	2=Modification	Wetland restoration	No
Enríquez-de-Salamanca, Á.	2023	Mediterranean/South Europe	Spain	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Furuseth, I. S., Seifert-Dähnn, I., Azhar, S. Q. & Braskerud, B. C.	2018	Northern Europe	Norway	3=Creation	Swales, retention ponds, constructed wetlands	No
Gómez-Aguayo, A. & Estruch-Guitart, V.	2019	Mediterranean/South Europe	Spain	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Gallay, I., Olah, B., Gallayová, Z., & Lepeška, T.	2021	Eastern Europe	Slovakia	2=Modification	Water-sensitive forest management	No
García-Herrero, L., Lavrnić, S., Guerrieri, V., Toscano, A., Milani, M., Cirelli, G. L., & Vittuari, M.	2022	Mediterranean/South Europe	Italy	3=Creation	Swales, retention ponds, constructed wetlands	No
Glenk, K. F., M.;Martin-Ortega, J.;Schulze, C.;Potts, J.	2021	Great Britain and Ireland	United Kingdom	2=Modification	Wetland restoration	No
Godyń, I.	2022	Eastern Europe	Poland	3=Creation	Swales, retention ponds, constructed wetlands	Yes
Godyń, I., Grela, A., Stajno, D., & Tokarska, P.	2020	Eastern Europe	Poland	3=Creation	Swales, retention ponds, constructed wetlands	No
Hankin, B. P., T.;McShane, G.;Chappell, N.;Spray, C.;Black, A.;Comins, L.	2021	Great Britain and Ireland	United Kingdom	2=Modification	Rehabilitation and restoration of rivers and floodplains	No
Jensen, A. K. U., K. C.;Jacobsen, B. H.;Jensen, J. D.;Hasler, B.	2019	Northern Europe	Denmark	3=Creation	Other	No
Kotsia, D. D., A.;Fyllas, N. M.;Stasinakis, A. S.;Fountoulakis, M. S.	2020	Mediterranean/South Europe	Greece	3=Creation	Swales, retention ponds, constructed wetlands	No
Kozma, Z. J., Z.;Kardos, M. K.;MuzelÁjk, B.;Koncsos, L.	2022	Central Europe	Hungary	2=Modification	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
La Notte, A. L., C.;Grizzetti, B.;Maes, J.;Egoh, B.;Paracchini, M.	2015	Mediterranean/South Europe	EU-27	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Liu, L., Dobson, B., & Mijic, A.	2023	Northern Europe	United Kingdom	3=Creation	Swales, retention ponds, constructed wetlands	No
Logar, I., Brouwer, R., & Paillex, A.	2019	Central Europe	Switzerland	2=Modification	Rehabilitation and restoration of river buffers	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Lopes, L. F. G., dos Santos Bento, J. M. R., Arede Correia Cristovão, A. F., & Baptista, F. O.	2015	Mediterranean/South Europe	Portugal	1=Protection	Other	No
Mandić, A., & Petrić, L.	2021	Mediterranean/South Europe	Croatia	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Martínez-Paz, J. M., Albaladejo-García, J. A., Barreiro-Hurle, J., Pleite, F. M. C., & Perni, Á.	2021	Mediterranean/South Europe	Spain	2=Modification	Rehabilitation and restoration of river buffers	No
Marta-Pedroso, C. L., L.;Gama, I.;Domingos, T.	2018	Mediterranean/South Europe	Portugal	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Mastrorilli, M. R., G.;Verdiani, G.;Tedeschi, G.;Fumai, A.;Russo, G.	2018	Mediterranean/South Europe	Italy	1=Protection	Water-sensitive forest management	No
McDougall, C. W., Hanley, N., Quilliam, R. S., Needham, K., & Oliver, D. M.	2020	Great Britain and Ireland	United Kingdom	2=Modification	Other	No
Morri, E., & Santolini, R.	2022	Mediterranean/South Europe	Italy	2=Modification	Other	No
Needham, K., & Hanley, N.	2019	Great Britain and Ireland	United Kingdom	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Panagopoulos, Y., & Dimitriou, E.	2020	Mediterranean/South Europe	Greece	3=Creation	Wetland restoration	No
Perosa, F. G., M.;Zwirgmaier, V.;Arias-Rodriguez, L. F.;Zingraff-Hamed, A.;Cyffka, B.;Disse, M.	2021	Mediterranean/South Europe	Slovenia	2=Modification	Rehabilitation and restoration of rivers and floodplains	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Rayanov, M., Denhardt, A., Glockmann, M., Hartje, V., Hirschfeld, J., Lindow, M., Sagebiel, J., Thiele, J., Welling, M.,	2018	Central Europe	Germany	2=Modification	Rehabilitation and restoration of river buffers	No
Ricci, G. F. D. A., E.;De Girolamo, A. M.;Gentile, F.	2022	Mediterranean/South Europe	Italy	2=Modification	Water-sensitive forest management	Yes
Rizzo, A. C., G.;Masi, F.	2021	Mediterranean/South Europe	Italy	3=Creation	Swales, retention ponds, constructed wetlands	No
Ruberto, M. B., G.;Troiano, S.;Zucaro, R.	2022	Mediterranean/South Europe	Italy	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Santos, E. A., A.;Lisboa, I.;Murray, P.;Ermis, H.	2022	Mediterranean/South Europe	Portugal	2=Modification	Other	No
Schaafsma, M. F., S.;Harwood, A. R.;Bateman, I. J.	2015	Great Britain and Ireland	United Kingdom	2=Modification	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Short, C. C., L.;Carnelli, F.;Uttley, C.;Smith, B.	2019	Great Britain and Ireland	United Kingdom	2=Modification	Other	No
Staccione, A. B., D.;Mazzoli, P.;Bagli, S.;Mysiak, J.	2021	Mediterranean/South Europe	Italy	2=Modification	Swales, retention ponds, constructed wetlands	No
Strazzera, E. A., R.;Meleddu, D.;Statzu, V.	2021	Mediterranean/South Europe	Italy	2=Modification	Rehabilitation and restoration of rivers and floodplains	No
Stuip, M., & van Dam, A. A.	2018	Northern Europe	Denmark	2=Modification	Rehabilitation and restoration of rivers and floodplains	No
Sušnik, J., Masia, S., Kravčík, M., Pokorný, J., & Hesslerová, P.	2022	Eastern Europe	EU-27	2=Modification	Other	No
Turkelboom, F. D., R.;Vranken, L.;De Becker, P.;Raymaekers, F.;De Smet, L.	2021	Central Europe	Belgium	2=Modification	Rehabilitation and restoration of river buffers	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Ungvári, G.	2022	Eastern Europe	Hungary	1=Protection	Swales, retention ponds, constructed wetlands	No
Västilä, K., Väisänen, S., Koskiahio, J., Lehtoranta, V., Karttunen, K., Kuussaari, M., Järvelä, J., & Koikkalainen, K.	2021	Northern Europe	Finland	2=Modification	Rehabilitation and restoration of rivers and floodplains	No
Vermaat, J. E. P., M.;Piffady, J.;Putnins, A.;Kail, J.	2021	Central Europe	Germany	1=Protection	Other	No
Villamayor-Tomas, S. S., J.;Olschewski, R.	2019	Central Europe	Switzerland	1=Protection	Groundwater management	No
Warachowska, W., Alvarez, X., Bezak, N., Gómez-Rúa, M., Janeiro-Otero, A., Matczak, P., Vidal-Puga, J., & Zupanc, V.	2022	Central Europe	Germany	3=Creation	Water-sensitive forest management	No
Watson, S. C. L.;Preston, J.;Beaumont, N. J., & Watson, G. J.	2020	Great Britain and Ireland	United Kingdom	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Widen, A. R., B. M.;Degerman, E.;Wisaeus, D.;Jansson, R.	2022	Northern Europe	Sweden	2=Modification	Rehabilitation and restoration of rivers and floodplains	No
Wilbers, G. J., de Bruin, K., Seifert-Dähnn, I., Lekkerkerk, W., Li, H., & Budding-Polo Ballinas, M.	2022	Northern Europe	Norway	3=Creation	Swales, retention ponds, constructed wetlands	Yes
Zabala, J. A. A.-G., J. A.;Navarro, N.;Martinez-Paz, J. M.;Alcon, F.	2022	Mediterranean/South Europe	Spain	1=Protection	Water-sensitive forest management	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Zabala, J. A., Dolores de Miguel, M., Martínez-Paz, J. M., & Alcon, F.	2019	Mediterranean/South Europe	Spain	2=Modification	Other	No
Zabala, J. A., Martínez-Paz, J. M., & Alcon, F.	2021	Mediterranean/South Europe	Spain	1=Protection	Groundwater management	No
Zandersen, M., Oddershede, J. S., Pedersen, A. B., Nielsen, H. Ø., & Termansen, M.	2021	Northern Europe	Denmark	1=Protection	Other	No
Ziogou, I. M., A.;Voulgari, V.;Zachariadis, T.	2018	Mediterranean/South Europe	Cyprus	3=Creation	Green roofs, green facades, rain gardens	No
Pueyo-Ros, J.;Garcia, X.;Ribas, A., & Fraguell, R. M.	2018	Mediterranean/South Europe	Spain	1=Protection	Wetland restoration	No
Graversgaard, M.;Jacobsen, B. H.;Hoffmann, C. C.;Dalgaard, T.;Odgaard, M. V.;Kjaergaard, C.;Powell, N.;Strand, J. A.;Feuerbach, P., & Tonderski, K.	2021	Northern Europe	Denmark	2=Modification	Wetland restoration	No
Gonzalez-Flo, E.;Romero, X., & García, J.	2023	Mediterranean/South Europe	Spain	3=Creation	Swales, retention ponds, constructed wetlands	Yes
Hughes, F. M. R.;Adams, W. M.;Butchart, S. H. M.;Field, R. H.;Peh, K. S. H., & Warrington, S.	2016	Great Britain and Ireland	United Kingdom	3=Creation	Other	No
Pouso, S.;Borja, A., & Uyarra, M. C.	2020	Mediterranean/South Europe	Spain	1=Protection	Other	No
Watson, S. C. L.;Watson, G. J.;Beaumont, N. J., & Preston, J.	2022	Great Britain and Ireland	United Kingdom	1=Protection	Maintenance of safe physical environments (e.g. hydrogeological stability)	No
Pouso, S.;Ferrini, S.;Kerry Turner, R.;Borja, Á., & Uyarra, M. C.	2021	Mediterranean/South Europe	Spain	1=Protection	Other	No

ANNEX D – URBAN LANDSCAPE STUDIES

Authors	Year	European region	Country	Typology	NbS action	BCR
Abramowicz, D. S., M.	2020	Central Europe	Poland	1=Protection	Protection/maintenance of urban green space	No
Afentou, N. M., P.; Hull, K.; Shepherd, J.; Elliott, S.; Frew, E.	2022	Great Britain and Ireland	United Kingdom	1=Protection	Protection/maintenance of urban blue space	No
Albaladejo-García, J. A. A., F.; Martínez-Paz, J. M.	2021	Mediterranean/South Europe	Spain	3=Creation	Creation of new green space	No
Almeida, C. T., I.; Silva, C. M.; Cruz, C. O.	2021	Mediterranean/South Europe	Portugal	3=Creation	Creation of new green space	Yes
Ascioti, F. A. C., V.; Menguzzato, G.; Marciandò, C.	2019	Mediterranean/South Europe	Italy	1=Protection	Protection/maintenance of urban green space	No
Asciuto, A. S., E.; Cottone, C.; Borsellino, V.	2019	Mediterranean/South Europe	Italy	3=Creation	Other	Yes
Ashley, R.M.; Gersonius, B., Digman, C.; Horton, B., Bacchin, T.; Smith, B., Shaffer, P.; Baylis, A.,	2018	Great Britain and Ireland	United Kingdom	3=Creation	Restoration of urban blue space	Yes
Babì Almenar, J. P., C.; Sonnemann, G.; Geneletti, D.; Elliot, T.; Rugani, B.	2023	Mediterranean/South Europe	Spain	3=Creation	Creation of new green space	No
Balkova, M. K., L.; Prokopova, M.; Sedlak, P.; Bajer, A.	2021	Central Europe	Czechia	3=Creation	Creation of new green space	No
Barrios-Crespo, E. T.-O.; S.; Díaz-Simal, P.	2021	Mediterranean/South Europe	Spain	2=Modification	Protection/maintenance of urban green space	No
Barseghyan, A. S., S.; Kostyakova, A.; Naamo, G. S.; Qinbr, M. I.	2023	Mediterranean/South Europe	Spain	3=Creation	Creation of new green space	No
Biasin, A. M., M.; Amato, G.; Pettenella, D.	2023	Mediterranean/South Europe	Italy	3=Creation	Creation of new green space	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Bisaro, A. d. B., M.; Hinkel, J.; Kok, S.; Bouwer, L. M.	2020	Central Europe	Netherlands	2=Modification	Protection/maintenance of urban blue space	No
Bliem, M. G., M.	2012	Central Europe	Austria	2=Modification	Restoration of urban blue space	No
Bockarjova, M. B., Wouter J. W.; Bulkeley, H. A.; Toxopeus, H.	2022	Central Europe	Germany	2=Modification	Restoration of urban green space	Yes
Bockarjova, M. B., W. J. W.; Koetse, M. J.	2020	Mediterranean/South Europe	Spain	2=Modification	Restoration of urban green space	No
Boguniewicz-Zabłocka, J.; Capodaglio A. G.	2020	Central Europe	Poland	3=Creation	Creation of new blue space	No
Bottero, M. B., M.; Caprioli, C.; Dell'Anna, F.	2023	Mediterranean/South Europe	Italy	3=Creation	Creation of new green space	No
Buccolieri, R. G., E.; Manisco, M.; Ippolito, F.; Santiago, J. L.; Gao, Z.	2020	Mediterranean/South Europe	Italy	1=Protection	Protection/maintenance of urban green space	No
Bus, A. S., A.	2021	Central Europe	Poland	3=Creation	Creation of new green space	No
Capotorti, G. A. O., M. M.; Copiz, R.; Fusaro, L.; Mollo, B.; Salvatori, E.; Zavattero, L.	2019	Mediterranean/South Europe	Italy	2=Modification	Restoration of urban green space	No
Cappucci, S. N., S.; Cappelli, A.	2022	Mediterranean/South Europe	Italy	2=Modification	Protection/maintenance of urban green space	No
Cardone, B. D. A., V.; Di Martino, F.; Miraglia, V.; Rigillo, M.	2023	Mediterranean/South Europe	Italy	2=Modification	Restoration of urban green space	No
Chen, W. Y. L., I.; Broekx, S.	2017	Central Europe	Belgium	2=Modification	Protection/maintenance of urban blue space	No
Cimburova, Z. B., D. N.	2020	Northern Europe	Norway	1=Protection	Protection/maintenance of urban green space	No
Claron, C. M., M.; Levrel, H.; Tardieu, L.	2022	Central Europe	France	1=Protection	Protection/maintenance of urban green space	No
Clemente, M. F.; D'Ambrosio, V.; Di Martino, F., & Miraglia, V.	2018	Mediterranean/South Europe	Italy	3=Creation	Creation of new green space	No

Authors	Year	European region	Country	Typology	NbS action	BCR
De Jalón, S. G. C., A. Tague, A. M.; Artaza, N.; De Ayala, A.; Quiroga, S.; Kruize, H.; Suñer, C.; Bell, R.; Taylor, T.	2020	Mediterranean/South Europe	Spain	2=Modification	Other	Yes
De Nocker, L. L., I.; Beckx, C.; Broekx, S.	2023	Central Europe	Belgium	1=Protection	Protection/maintenance of urban green space	No
De Valck, J. B., A.; Liekens, I.; Bettens, M.; Seuntjens, P.; Broekx, S.	2019	Central Europe	Belgium	2=Modification	Protection/maintenance of urban green space	No
Deely, J. H., S.	2020	Great Britain and Ireland	Ireland	1=Protection	Protection/maintenance of urban green space	No
Durlak, W. D., M.; Milecka, M.	2022	Central Europe	Poland	1=Protection	Protection/maintenance of urban green space	No
Daams, M. N. S., F. J.; Veneri, P.	2019	Central Europe	Netherlands	1=Protection	Protection/maintenance of urban green space	No
Ehrlich, Ü.	2021	Northern Europe	Estonia	1=Protection	Protection/maintenance of urban green space	No
Ekinci, B. G., K.; Meier, S.; Schwarz, S.; Schweppe-Kraft, B.; Syrbe, R. U.	2022	Central Europe	Germany	1=Protection	Protection/maintenance of urban green space	No
Expósito, A., Espinosa, M., Villa-Damas, A.,	2021	Mediterranean/South Europe	Spain	1=Protection	Protection/maintenance of urban green space	No
Fletcher, D. H. G., J. K.; Thomas, A.; Fitch, A.; Cryle, P.; Shilton, S.; Jones, L.	2022	Great Britain and Ireland	United Kingdom	2=Modification	Creation of new green space	No
Fruth, E. K., M. Marshall, J.; Pfeifer, L.; Rau, L.; Sagebiel, J.; Soto, D.; Tarpey, J.; Weir, J.; Winiarski, B.	2019	Central Europe	Germany	2=Modification	Other	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Furuseth, I. S., Seifert-Dähnn, I., Azhar, S. Q. & Braskerud, B. C.	2018	Northern Europe	Norway	3=Creation	Other	No
Getzner, M.	2020	Central Europe	Austria	2=Modification	Other	No
Giannakidou, A. L., D.	2023	Mediterranean/South Europe	Greece	1=Protection	Protection/maintenance of urban green space	No
Godyń, I.	2022	Eastern Europe	Poland	3=Creation	Other	Yes
Godyń, I. G., A.; Stajno, D.; Tokarska, P.	2020	Eastern Europe	Poland	3=Creation	Other	No
Guarini, M. R. M., P.; Sica, F.	2019	Mediterranean/South Europe	Italy	3=Creation	Creation of new green space	No
Hérivaux, C. C., P. L.	2021	Mediterranean/South Europe	France	1=Protection	Protection/maintenance of urban green space	No
Halkos, G. L., A.; Petropoulos, C.; Sardianou, E.	2022	Mediterranean/South Europe	Greece	1=Protection	Protection/maintenance of urban green space	No
Halkos, G. L., A.; Sardianou, E.	2022	Mediterranean/South Europe	Greece	1=Protection	Protection/maintenance of urban green space	No
Hegedüs, A. G., M.; Bérces, R.	2011	Central Europe	Hungary	1=Protection		No
Herman, K. S., M.; Panagopoulos, T.	2018	Mediterranean/South Europe	Portugal	3=Creation	Creation of new green space	No
Horváthová, E. B., T.; Duchkov, H.	2021	Eastern Europe	Czechia	1=Protection	Other	No
Hunter, R. F. D., M. A. T.; Tully, M. A.; Heron, L.; O'Neill, C.; Kee, F.	2022	Great Britain and Ireland	United Kingdom	2=Modification	Restoration of urban green space	No
Ivancsics, V. S., Z.; Obertik, J.; Balás, G.	2019	Eastern Europe	Hungary	3=Creation	Creation of new green space	No
Johnson, D. E., J.; Geisendorf, S.	2021	Central Europe	Germany	2=Modification	Creation of green roofs or green walls	Yes
Johnson, D. G., S.	2022	Central Europe	Germany	2=Modification	Other	No
Johnson, D. G., S.	2019	Central Europe	Germany	2=Modification	Other	Yes
Johnson, D. S., L.; Oswald, S. M.; Prokop, G.; Krisztin, T.	2021	Central Europe	Austria	2=Modification	Other	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Kalfas, D. G. Z., D. T.; Dragozi, E. I.; Zagkas, T. D.	2020	Mediterranean/South Europe	Greece	3=Creation	Restoration of urban green space	No
Koroxenidis, E. T., T.	2021	Mediterranean/South Europe	Greece	3=Creation	Creation of green roofs or green walls	No
Koroxenidis, E. T., T.	2021	Mediterranean/South Europe	Greece	3=Creation	Creation of green roofs or green walls	No
Kotsia, D. D., A.; Fyllas, N. M.; Stasinakis, A. S.; Fountoulakis, M. S.	2020	Mediterranean/South Europe	Greece	3=Creation	Other	No
Lausi, L. A., M.; Sebastiani, A.; Fusaro, L.; Manes, F.	2022	Mediterranean/South Europe	Italy	1=Protection	Protection/maintenance of urban green space	No
Liberalesso, T. S., C. M.; Cruz, C. O.	2023	Mediterranean/South Europe	Portugal	3=Creation	Creation of green roofs or green walls	No
Liebelt, V. B., S.; Schwarz, N.	2018	Central Europe	Germany	1=Protection	Protection/maintenance of urban green space	No
Locatelli, L. G., M.; Russo, B.; Mart��nez-Gomariz, E.; Sunyer, D.; Mart��nez, M.	2020	Mediterranean/South Europe	Spain	3=Creation	Creation of new green space	No
Lorite, J. B., M.; Garcia-Robles, H.; Canadas, E. M.	2021	Mediterranean/South Europe	Spain	2=Modification	Other	No
M��ntymaa, E. J., M.; Juutinen, A.; Lankia, T.; Louhi, P.	2021	Northern Europe	Finland	3=Creation	Creation of new green space	No
Mach���c, J. L., J.	2019	Central Europe	Czechia	3=Creation	Creation of new blue space	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Marshall, C. A. M. W., M. T.; Hadfield, P. M.; Rogers, S. M.; Shanklin, J. D.; Eversham, B. C.; Healey, R.; Kranse, O. P.; Preston, C. D.; Coghill, S. J.; McGonigle, K. L.; Moggridge, G. D.; Pilbeam, P. G.; Marza, A. C.; Szigecsan, D.; Mitchell, J.; Hicks, M. A.; Wallis, S. M.; Xu, Z. F.; Toccaceli, F.; McLennan, C. M.; Eves-van den Akker, S.	2023	Northern Europe	United Kingdom	3=Creation	Creation of new green space	No
Martínez-Paz, J. M. A.-G., J. A.; Barreiro-Hurle, J.; Pleite, F. M. C.; Perni, Á.	2021	Mediterranean/South Europe	Spain	2=Modification	Restoration of urban blue space	No
Martin, J. G. C. S., A.; Linnerooth-Bayer, J.; Liu, W.; Balsiger, J.	2021	Central Europe	Germany	2=Modification	Restoration of urban blue space	No
Masiero, M. B., A.; Amato, G.; Malaggi, F.; Pettenella, D.; Nastasio, P.; Anelli, S.	2022	Mediterranean/South Europe	Italy	3=Creation	Restoration of urban green space	No
Matos Silva, C. S., J.; Dinis Ferreira, P.; Teotónio, I.	2019	Mediterranean/South Europe	Portugal	3=Creation	Creation of green roofs or green walls	No
Melo, C. T., I.; Silva, C. M.; Cruz, C. O.	2020	Mediterranean/South Europe	Portugal	3=Creation	Creation of green roofs or green walls	No
Moss, J. L. D., K. J.; Smith, S.; Shahrestani, M.	2019	Great Britain and Ireland	United Kingdom	1=Protection	Protection/maintenance of urban green space	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Mueller, N. R.-R., D.; Khreis, H.; Cirach, M.; Andrés, D.; Ballester, J.; Bartoll, X.; Daher, C.; Deluca, A.; Echave, C.; Milà, C.; Márquez, S.; Palou, J.; Pérez, K.; Tonne, C.; Stevenson, M.; Rueda, S.; Nieuwenhuijsen, M.	2020	Mediterranean/South Europe	Spain	3=Creation	Creation of new green space	No
Muresan, A. N. S., A.; Gaglio, M.; Fano, E. A.; Manes, F.	2022	Mediterranean/South Europe	Italy	1=Protection	Protection/maintenance of urban green space	No
Naber, E. V., R.; Mormann, K.; Boehnke, D.; Lutzendorf, T.; Schulmann, F.	2022	Central Europe	Germany	3=Creation	Creation of green roofs or green walls	No
Napoli, G. C., R.; Scaccianoce, G.; Barbaro, S.; Cirrincione, L.	2022	Mediterranean/South Europe	Italy	2=Modification	Restoration of urban green space	No
Oliveira, M. S., R.; Kaiser, S.; Liu, Y.; Vassillo, C.; Ghisellini, P.; Liu, G.; Ulgiati, S.	2022	Mediterranean/South Europe	Italy	1=Protection	Protection/maintenance of urban green space	No
Opacak, M. W., E. D.	2019	Mediterranean/South Europe	Croatia	3=Creation	Creation of new green space	No
Panduro, T. E. J., C. U.; Lundhede, T. H.; von Graevenitz, K.; Thorsen, B. J.	2018	Northern Europe	Denmark	1=Protection	Protection/maintenance of urban green space	No
Pantaloni, M. M., G.; Santilocchi, R.; Minelli, A.; Neri, D.	2022	Mediterranean/South Europe	Italy	1=Protection	Protection/maintenance of urban green space	No
Peacock, J. T., J.; Bacon, K. L.	2018	Great Britain and Ireland	United Kingdom	1=Protection	Protection/maintenance of urban green space	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Ramirez-Juidias, E. A.-M., J. L.; Leiva-Piedra, J. L.	2022	Mediterranean/South Europe	Spain	3=Creation	Creation of new green space	No
Rayanov, M., Denhardt, A., Glockmann, M., Hartje, V., Hirschfeld, J., Lindow, M., Sagebiel, J., Thiele, J., Welling, M.,	2018	Central Europe	Germany	2=Modification	Restoration of urban blue space	No
Riegels, N. L.-J., A.; Krogsgaard Jensen, J.; Gerner, N. V.; Anzaldúa, G.; Mark, O.; Butts, M.; Birk, S.	2020	Northern Europe	Denmark	2=Modification	Restoration of urban blue space	No
Russo, A. C., W. T.; Cirella, G. T.	2021	Great Britain and Ireland	United Kingdom	1=Protection	Protection/maintenance of urban green space	No
Salizzoni, E. A., M.; Murgese, D.; Quaglio, G.	2020	Mediterranean/South Europe	Italy	3=Creation	Creation of new green space	No
Suchocka, M. H., J.; Błaszczyk, M.; Adamczyk, J.; Gaworski, M.; Gawłowska, A.; Mojski, J.; Kalaji, H. M.; Kais, K.; Kosno-Jończy, J.; Heciak, M. W.	2023	Central Europe	Poland	2=Modification	Restoration of urban green space	No
Sylla, M. L., T.; Szewrański, S.	2019	Central Europe	Poland	1=Protection	Protection/maintenance of urban green space	No
Szkop, Z.	2022	Central Europe	Poland	1=Protection	Protection/maintenance of urban green space	No
Ta, M. T. T., L.; Levrel, H.	2022	Central Europe	France	3=Creation	Creation of new green space	No
Teotónio, I. O. C., C.; Matos Silva, C.; Lopes, R. F. R.	2023	Mediterranean/South Europe	Portugal	3=Creation	Creation of green roofs or green walls	Yes
Tirendi, D.	2020	Mediterranean/South Europe	Italy	1=Protection	Protection/maintenance of urban green space	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Vallecillo, S. K., G.; La Notte, A.; Feyen, L.; Dottori, F.; Maes, J.	2020	More than one European region	EU-27	1=Protection	Other	No
Vallecillo, S. L. N., A.; Zulian, G.; Ferrini, S.; Maes, J.	2019	More than one European region	EU-27	1=Protection	Protection/maintenance of urban green space	No
Van Oijstaeijen, W. S., M. F. E.; Back, P.; Collins, A.; Verheyen, K.; De Beelde, R.; Cools, J.; Van Passel, S.	2023	Central Europe	Netherlands	3=Creation	Creation of new green space	No
Wilbers, G. J. d. B., K.; Seifert-Dähnn, I.; Lekkerkerk, W.; Li, H.; Budding-Polo Ballinas, M.	2022	Northern Europe	Norway	3=Creation	Creation of new blue space	Yes
Zalejska-Jonsson, A. W., S.; Wahlund, R.; Cunningham, R.	2023	Northern Europe	Sweden	3=Creation	Creation of new green space	No
Ziogou, I. M., A.; Voulgari, V.; Zachariadis, T.	2018	Mediterranean/South Europe	Cyprus	3=Creation	Creation of green roofs or green walls	No
Sebastiani, A.; Buonocore, E.; Franzese, P. P.; Riccio, A.; Chianese, E.; Nardella, L.; Manes, F.	2021	Mediterranean/South Europe	Italy	1=Protection	Protection/maintenance of urban green space	No

ANNEX E – COASTAL & MARINE LANDSCAPE STUDIES

Authors	Year	EU Region	Country	Typology	NbS Action	BCR
Ankamah-Yeboah, I. A., C. W.;Hynes, S.;Xuan, B. B.;Simpson, K.	2022	Northern Europe	Norway	2=Modification	Protection of coastal & marine habitats	No
Appolloni, L. S., R.;Vetrano, G.;Russo, G. F.	2018	Mediterranean/South Europe	Italy	1=Protection	Protection of coastal & marine habitats	No
Armstrong, C. W.;Aanesen, M.;van Rensburg, T. M., & Sandorf, E. D.	2019	Northern Europe	Norway	1=Protection	Protection of coastal & marine habitats	No
Atkinson, G. O., P.	2022	Great Britain and Ireland	United Kingdom	1=Protection	Protection of coastal & marine habitats	No
Bañolas, G.;Fernández, S.;Espino, F.;Haroun, R., & Tuya, F.	2020	Mediterranean/South Europe	Spain	1=Protection	Protection of coastal & marine habitats	No
Barrios-Crespo, E. T.-O., S.;Díaz-Simal, P.	2021	Mediterranean/South Europe	Spain	2=Modification	Restoration of coastal and marine habitats	No
Boeri, M.;Stojanovic, T. A.;Wright, L. J.;Burton, N. H. K.;Hockley, N., & Bradbury, R. B.	2020	Great Britain and Ireland	United Kingdom	2=Modification	Protection of coastal & marine habitats	No
Buonocore, E.;Donnarumma, L.;Appolloni, L.;Miccio, A.;Russo, G. F., & Franzese, P. P.	2020	Mediterranean/South Europe	Italy	1=Protection	Protection of coastal & marine habitats	No
Buonocore, E.;Russo, G. F., & Franzese, P. P.	2020	Mediterranean/South Europe	Italy	1=Protection	Protection of coastal & marine habitats	No
Buonocore, Elvira.;Appolloni, Luca .;Russo, Giovanni. F., & Franzese, Pier Paolo	2020	Mediterranean/South Europe	Italy	1=Protection	Protection of coastal & marine habitats	No
Börger, T.;Hattam, C.;Burdon, D.;Atkins, J. P., & Austen, M. C.	2014	Great Britain and Ireland	United Kingdom	1=Protection	Protection of coastal & marine habitats	No
Börger, T.;Hattam, C.;Burdon, D.;Atkins, J. P., & Austen, M. C.	2020	Great Britain and Ireland	United Kingdom	2=Modification	Protection of coastal & marine habitats	No
Campos, F. S.;David, J.;Lourenço-de-Moraes, R.;Rodrigues, P.;Silva, B.;Vieira da Silva, C., & Cabral, P.	2021	Mediterranean/South Europe	Portugal	1=Protection	Protection of coastal & marine habitats	No
Chen, W.;Wallhead, P.;Hynes, S.;Groeneveld, R.;O'Connor, E.;Gambi, C.;Danovaro, R.;Tinch, R.;Papadopoulou, N., & Smith, C.	2022	Mediterranean/South Europe	Italy	1=Protection	Restoration of coastal and marine habitats	No

Authors	Year	EU Region	Country	Typology	NbS Action	BCR
Clara, I.;Dyack, B.;Rolfe, J.;Newton, A.;Borg, D.;Povilanskas, R., & Brito, A. C.	2018	Mediterranean/South Europe	Portugal	1=Protection	Protection of coastal & marine habitats	No
Colletti, A.;Savinelli, B.;Di Muzio, G.;Rizzo, L.;Tamburello, L.;Fraschetti, S.;Musco, L., & Danovaro, R.	2020	Mediterranean/South Europe	Italy	1=Protection	Restoration of coastal and marine habitats	No
Elvira Buonocore, Maria Cristina Buia, Giovanni F.Russo, Pier Paolo Franzese	2021	Mediterranean/South Europe	Italy	1=Protection	Protection of coastal & marine habitats	No
Fernández-Montblanc, T.;Duo, E., & Ciavola, P.	2020	Mediterranean/South Europe	Italy	2=Modification	Restoration of coastal and marine habitats	No
Galati, A.;Tulone, A.;Vrontis, D.;Thrassou, A., & Crescimanno, M.	2023	Mediterranean/South Europe	Italy	1=Protection	Protection of coastal & marine habitats	No
Gómez-Aguayo, A. & Estruch-Guitart, V.	2019	Mediterranean/South Europe	Spain	1=Protection	Protection of coastal & marine habitats	No
González-García, A.;Arias, M.;García-Tiscar, S.;Alcorlo, P., & Santos-Martín, F.	2022	Mediterranean/South Europe	Spain	1=Protection	Protection of coastal & marine habitats	No
Green, A.;Chadwick, M. A., & Jones, P. J. S.	2018	Great Britain and Ireland	United Kingdom	1=Protection	Protection of coastal & marine habitats	No
Hasselström, L.;Thomas, J. B.;Nordström, J.;Cervin, G.;Nylund, G. M.;Pavia, H., & Gröndahl, F.	2020	Northern Europe	Sweden	3=Creation	Restoration of coastal and marine habitats	No
Hérivaux, C.;Rey-Valette, H.;Rulleau, B.;Agenais, A. L.;Grisel, M.;Kuhfuss, L.;Maton, L., & Vinchon, C.	2018	Mediterranean/South Europe	France	1=Protection	Beach nourishment (and dune restoration)	No
Hussain, S. S.;Winrow-Giffin, A.;Moran, D.;Robinson, L. A.;Fofana, A.;Paramor, O. A. L., & Frid, C. L. J.	2010	Great Britain and Ireland	United Kingdom	1=Protection	Protection of coastal & marine habitats	No
Hynes, S.;Chen, W.;Vondolia, K.;Armstrong, C., & O'Connor, E.	2021	Northern Europe	Norway	2=Modification	Restoration of coastal and marine habitats	No
Kok, S.;Bisaro, A.;de Bel, M.;Hinkel, J., & Bouwer, L. M.	2021	Central Europe	Netherlands	2=Modification	Beach nourishment (and dune restoration)	No
Latinopoulos, D.	2019	Mediterranean/South Europe	Greece	1=Protection	Protection of coastal & marine habitats	No
MacDonald, M. A.;de Ruyck, C.;Field, R. H.;Bedford, A., & Bradbury, R. B.	2020	Great Britain and Ireland	United Kingdom	3=Creation	Managed realignment of coastal areas	No

Authors	Year	EU Region	Country	Typology	NbS Action	BCR
Martino, S., & Amos, C. L.	2019	Great Britain and Ireland	United Kingdom	3=Creation	Managed realignment of coastal areas	No
Marusic, Z.;Sever, I.;Basta, J., & Zmuk, B.	2018	Mediterranean/South Europe	Croatia	1=Protection	Restoration of coastal and marine habitats	No
Mayer, M. W., M.	2018	Central Europe	Germany	1=Protection	Protection of coastal & marine habitats	No
Mentzafou, A. C., A.;Dimitriou, E.	2020	Mediterranean/South Europe	Greece	1=Protection	Protection of coastal & marine habitats	No
Montero-Hidalgo, M.;Tuya, F.;Otero-Ferrer, F.;Haroun, R., & Santos-Martín, F.	2023	Mediterranean/South Europe	Spain	1=Protection	Protection of coastal & marine habitats	No
Montseny, M.;Linares, C.;Viladrich, N.;Biel, M.;Gracias, N.;Baena, P.;Quintanilla, E.;Ambroso, S.;Grinyó, J.;Santín, A.;Salazar, J.;Carreras, M.;Palomeras, N.;Magí, L.;Vallicrosa, G.;Gili, J. M., & Gori, A.	2021	Mediterranean/South Europe	Spain	2=Modification	Restoration of coastal and marine habitats	No
Pais-Barbosa, J.;Ferreira, A. M.;Lima, M.;Filho, L. M.;Roebeling, P., & Coelho, C.	2023	Mediterranean/South Europe	Portugal	1=Protection	Beach nourishment (and dune restoration)	Yes
Perni, Á., & Martínez-Paz, J. M.	2023	Mediterranean/South Europe	Spain	2=Modification	Restoration of coastal and marine habitats	No
Pires-Marques, É. C., C.;Pinto, L. M. C.	2021	Mediterranean/South Europe	Portugal	1=Protection	Beach nourishment (and dune restoration)	No
Pouso, S.;Borja, A., & Uyarra, M. C.	2020	Mediterranean/South Europe	Spain	1=Protection	Restoration of coastal and marine habitats	No
Pouso, S.;Borja, A., & Uyarra, M. C.	2021	Mediterranean/South Europe	Spain	1=Protection	Restoration of coastal and marine habitats	No
Remoundou, K.;Diaz-Simal, P.;Koundouri, P., & Rulleau, B.	2015	Mediterranean/South Europe	Spain	1=Protection	Other	No
Rendón, O. R.;Sandorf, E. D., & Beaumont, N. J.	2022	Great Britain and Ireland	United Kingdom	1=Protection	Protection of coastal & marine habitats	No
Scanu, S.;Piazzolla, D.;Bonamano, S.;Penna, M.;Piermattei, V.;Madonia, A.;Frattarelli, F. M.;Mellini, S.;Dolce, T.;Valentini, R.;Coppini, G.;Fersini, G., & Marcelli, M.	2022	Mediterranean/South Europe	Italy	1=Protection	Protection of coastal & marine habitats	No

Authors	Year	EU Region	Country	Typology	NbS Action	BCR
Schenau, S. v. B., J.;Bogaart, P.;Blom, C.;Driessen, C.;de Jongh, L.;de Jong, R.;Horlings, E.;Mosterd, R.;Hein, L.;Lof, M.	2022	Central Europe	Netherlands	1=Protection	Protection of coastal & marine habitats	No
Sfriso, A.;Buosi, A.;Facca, C.;Sfriso, A. A.;Tomio, Y.;Juhmani, A. S.;Wolf, M. A.;Franzoi, P.;Scapin, L.;Ponis, E.;Cornello, M.;Rampazzo, F.;Berto, D.;Gion, C.;Oselladore, F.;Boscolo Brusà, R., & Bonometto, A.	2021	Mediterranean/South Europe	Italy	1=Protection	Restoration of coastal and marine habitats	No
Silva, E. N., W.;Salvaneschi, P.;Climent-Gil, E.;Derak, M.;López, G.;Bonet, A.;Aledo, A.;Cortina-Segarra, J.	2023	Mediterranean/South Europe	Spain	2=Modification	Restoration of coastal and marine habitats	No
Soares, J. O., & Soares, F. C.	2021	Mediterranean/South Europe	Portugal	1=Protection	Protection of coastal & marine habitats	No
Szalaj, D.;Wise, L.;Rodríguez-Climent, S.;Angélico, M. M.;Marques, V.;Chaves, C.;Silva, A., & Cabral, H.	2018	Mediterranean/South Europe	Portugal	1=Protection	Protection of coastal & marine habitats	No
Trégarot, E.;Caillaud, A.;Cornet, C. C.;Taureau, F.;Catry, T.;Cragg, S. M., & Failler, P.	2021	Mediterranean/South Europe	France	1=Protection	Protection of coastal & marine habitats	No
Tyllianakis, E.	2022	Mediterranean/South Europe	Malta	1=Protection	Protection of coastal & marine habitats	No
Tyllianakis, E.	2020	Great Britain and Ireland	United Kingdom	1=Protection	Protection of coastal & marine habitats	No
Vallecillo, S. L. N., A.;Zulian, G.;Ferrini, S.;Maes, J.	2019	More than one European region	EU-27	1=Protection	Protection of coastal & marine habitats	No
Velasco, A. M.;Pérez-Ruzafa, A.;Martínez-Paz, J. M., & Marcos, C.	2018	Mediterranean/South Europe	Spain	1=Protection	Restoration of coastal and marine habitats	No
Visintin, F., Tomasinsig, E., Spoto, M., Marangon, F., Mastrototaro, F., Chimienti, G., Montesanto, F., Troiano, S.,	2022	Mediterranean/South Europe	Italy	1=Protection	Protection of coastal & marine habitats	No
Visintin, F.;Tomasinsig, E.;Spoto, M.;Marangon, F.;D'Ambrosio, P.;Muscogiuri, L.;Fai, S., & Troiano, S.	2022	Mediterranean/South Europe	Italy	1=Protection	Protection of coastal & marine habitats	Yes

Authors	Year	EU Region	Country	Typology	NbS Action	BCR
Watson, S. C. L.;Preston, J.;Beaumont, N. J., & Watson, G. J.	2020	Great Britain and Ireland	United Kingdom	1=Protection	Protection of coastal & marine habitats	No
Watson, S. C. L.;Watson, G. J.;Beaumont, N. J., & Preston, J.	2022	Great Britain and Ireland	United Kingdom	1=Protection	Protection of coastal & marine habitats	No
Williams, C.;Rees, S.;Sheehan, E. V.;Ashley, M., & Davies, W.	2022	Great Britain and Ireland	United Kingdom	1=Protection	Restoration of coastal and marine habitats	No

ANNEX F – FOREST LANDSCAPE STUDIES

Authors	Year	European region	Country	Typology	NbS action	BCR
Acuna-Alonso, C., Novo, A., Rodriguez, J. L., Varandas, S., & Alvarez, X.	2022	Mediterranean/South Europe	Spain	3=Creation	Other	No
Adermann, V., Padari, A., Sirgmets, R., Kosk, A., & Kaimre, P.	2015	Northern Europe	Estonia	1=Protection	Maintenance of untouched forest cover	No
Alcasena, F., Rodrigues, M., Gelabert, P., Ager, A., Salis, M., Ameztegui, A., Cervera, T., & Vega-García, C.	2021	Mediterranean/South Europe	Spain	2=Modification	Wildfire management	No
Alessandro, P., De Meo, I., Grilli, G., & Notaro, S.	2023	Mediterranean/South Europe	Italy	2=Modification	Restoring degraded forest ecosystems	No
Alessandro, P., Claudio, F., Gianluca, G.	2022	Mediterranean/South Europe	Italy	1=Protection	Other	No
Ascioti, F. A., Crea, V., Menguzzato, G., & Marcianò, C.	2019	Mediterranean/South Europe	Italy	1=Protection	Maintenance of untouched forest cover	No
Asmantaite, V., Dapkus, R., Karadzic, V., Korneeva, E., & Ghauri, S. P.	2021	Northern Europe	Lithuania	1=Protection	Maintenance of untouched forest cover	No
Atkinson, G., & Ovando, P.	2022	Great Britain and Ireland	United Kingdom	1=Protection	Other	No
Augustynczyk, A. L. D.	2021	Central Europe	Germany	3=Creation	Maintenance of untouched forest cover	No
Augustynczyk, A. L. D., Yousefpour, R., Rodriguez, L. C. E., & Hanewinkel, M.	2018	Central Europe	Germany	2=Modification	Other	No
Bösch, M., Elsasser, P., Franz, K., Lorenz, M., Moning, C., Olschewski, R., Rödl, A., Schneider, H., Schröppel, B., & Weller, P.	2018	Central Europe	Germany	2=Modification	Restoring degraded forest ecosystems	No
Babí Almenar, J., Petucco, C., Sonnemann, G., Geneletti, D., Elliot, T., & Rugani, B.	2023	Mediterranean/South Europe	Spain	3=Creation	Afforestation	No
Bakhtiari, F., Jacobsen, J. B., Thorsen, B. J., Lundhede, T. H., Strange, N., & Boman, M.	2018	Northern Europe	Denmark	1=Protection	Maintenance of untouched forest cover	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Balkova, M., Kubalíková, L., Prokopova, M., Sedlak, P., & Bajer, A.	2021	Central Europe	Czechia	3=Creation	Afforestation	No
Biasin, A., Masiero, M., Amato, G., & Pettenella, D.	2023	Mediterranean/South Europe	Italy	3=Creation	Afforestation	No
Bont, L. G., Fraefel, M., Frutig, F., Holm, S., Ginzler, C., & Fischer, C.	2022	Central Europe	Switzerland	2=Modification	Other	No
Burke, T., Rowland, C. S., Whyatt, J. D., Blackburn, G. A., & Abbatt, J.	2023	Great Britain and Ireland	United Kingdom	3=Creation	Afforestation	No
Campos, P., Álvarez, A., Oviedo, J. L., Mesa, B., Caparrós, A., & Ovando, P.	2020	Mediterranean/South Europe	Spain	1=Protection	Agroforestry	No
Campos, P., Álvarez, A., Oviedo, J. L., Ovando, P., Mesa, B., & Caparrós, A.	2020	Mediterranean/South Europe	Spain	1=Protection	Agroforestry	No
Campos, P., Mesa, B., Álvarez, A., Oviedo, J. L., & Caparrós, A.	2022	Mediterranean/South Europe	Spain	1=Protection	Agroforestry	No
Capotorti, G. A. O., M. M.; Copiz, R.; Fusaro, L.; Mollo, B.; Salvatori, E.; Zavattero, L.	2019	Mediterranean/South Europe	Italy	2=Modification	Reforestation	No
Castillo-Eguskiza, N. H., D.; Onaindia, M.; Czajkowski, M.	2019	Mediterranean/South Europe	Spain	2=Modification	Afforestation	No
Cervelli, E. P., S.; Allevato, E.; Saulino, L.; Silvestro, R.; Scotto Di Perta, E.; Saracino, A.	2022	Mediterranean/South Europe	Italy	1=Protection	Maintenance of untouched forest cover	No
Czeszczewik, D., Ginter, A., Mikusiński, G., Pawłowska, A., Kałuża, H., Smithers, R. J., & Walankiewicz, W.	2019	Central Europe	Poland	1=Protection	Maintenance of untouched forest cover	No
De Nocker, L.; Liekens, I.; Verachtert, E.; De Valck, J.; Staes, J.; Vrebo, D., & Broekx, S.	2022	Central Europe	Belgium	2=Modification	Restoring degraded forest ecosystems	No
Di Grazia, F. G., B.; Galgani, L.; Troiani, E.; Ferri, M.; Loiselle, S. A.	2021	Mediterranean/South Europe	Italy	2=Modification	Reforestation	No
Dimopoulos, V. T.,	2022	Mediterranean/South Europe	Greece	1=Protection	Restoring degraded forest ecosystems	No

Authors	Year	European region	Country	Typology	NbS action	BCR
C.;Mirasgedis, S.						
dos Santos, M. P. M., T. G.;Domingos, T.;Teixeira, R. F. M.	2022	Mediterranean/South Europe	Portugal	2=Modification	Agroforestry	No
Eggers, J., Holmström, H., Lämås, T., Lind, T., & Öhman, K.	2015	Northern Europe	Sweden	2=Modification	Restoring degraded forest ecosystems	No
Ehrlich, Ü.	2021	Northern Europe	Estonia	1=Protection	Restoring degraded forest ecosystems	No
Ekinci B, Grunewald K, Meier S, Schwarz S, Schweppe-Kraft B, Syrbe R-U	2022	Central Europe	Germany	2=Modification	Restoring degraded forest ecosystems	No
Elsasser, P., Altenbrunn, K., Köthke, M., Lorenz, M., & Meyerhoff, J.	2021	Central Europe	Germany	1=Protection	Maintenance of untouched forest cover	No
Enríquez-de-Salamanca, Á.	2023	Mediterranean/South Europe	Spain	1=Protection	Maintenance of untouched forest cover	No
Ezquerro, M. P., M.;Diaz-Balteiro, L.	2019	Mediterranean/South Europe	Spain	2=Modification	Integrating trees and forests in other sectors	No
Flack, J. L., M.;Todman, L.	2022	Great Britain and Ireland	United Kingdom	2=Modification	Land use conversion from agriculture to forest	No
Gabriels, K. W., P.;Van Orshoven, J.	2022	Central Europe	Belgium	2=Modification	Reforestation	No
Gallay, I., Olah, B., Gallayová, Z., & Lepeška, T.	2021	Eastern Europe	Slovakia	2=Modification	Reforestation	No
Getzner, M. M., J.	2020	Central Europe	Austria	1=Protection	Maintenance of untouched forest cover	No
Getzner, M., Meyerhoff, J., & Schläpfer, F.	2020	Central Europe	Austria	2=Modification	Other	No
González-Díaz, P., Ruiz-Benito, P., Ruiz, J. G., Chamorro, G., & Zavala, M. A.	2019	Mediterranean/South Europe	Spain	1=Protection	Maintenance of untouched forest cover	No
Gren, I. M., & Amuakwa-Mensah, F.	2018	Northern Europe	Sweden	1=Protection	Other	No
Gren, I. M., & Amuakwa-Mensah, F.	2020	Northern Europe	Sweden	1=Protection	Other	No
Hallberg-Sramek, I., Nordström, E. M., Priebe, J., Reimerson, E., Mårald, E., & Nordin, A.	2023	Northern Europe	Sweden	2=Modification	Other	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Heshmatol Vaezin, S.M., Marage, D., Garcia, S.,	2022	Mediterranean/South Europe	France	1=Protection	Restoring degraded forest ecosystems	No
Haara, A. M., J.; Melin, M.; Miettinen, J.; Korhonen, K. T.; Packalen, T.; Varjo, J.	2021	Northern Europe	Finland	2=Modification	Other	No
Iacopo, B. A., M.; Sandro, S.	2019	Mediterranean/South Europe	Italy	1=Protection	Other	No
Iversen, S. V., van der Velden, N., Convery, I., Mansfield, L., Kjeldsen, C., Thorsøe, M. H., & Holt, C. D. S.	2023	Great Britain and Ireland	United Kingdom	2=Modification	Land use conversion from agriculture to forest	No
Johnen, G. S., K.; Rusjan, S.; Zupanc, V.; Vidmar, A.; Bezak, N.	2022	Central Europe	Slovenia	2=Modification	Other	Yes
Juutinen, A. K., M.; Pohjanmies, T.; Tolvanen, A.; Kuhlmeij, K.; Skudnik, M.; Triplat, M.; Westin, K.; Makipaa, R.	2021	Northern Europe	Finland	1=Protection	Restoring degraded forest ecosystems	No
Kaske, K. J. d. J., S. G.; Williams, A. G.; Graves, A. R.	2021	Great Britain and Ireland	United Kingdom	2=Modification	Agroforestry	No
Kozma, Z., Jolánkai, Z., Kardos, M. K., Muzelák, B., & Koncsos, L.	2022	Central Europe	Hungary	2=Modification	Maintenance of untouched forest cover	No
Krzemień, A., Álvarez Fernández, J. J., Riesgo Fernández, P., Fidalgo Valverde, G., & Garcia-Cortes, S.	2023	Mediterranean/South Europe	Spain	3=Creation	Restoring degraded forest ecosystems	No
La Riccia, L., Assumma, V., Bottero, M. C., Dell'Anna, F., & Voghera, A.	2023	Mediterranean/South Europe	Italy	1=Protection	Other	No
Langkilde-Lauesen, C. S., N.; Wilson, K. A.	2022	Northern Europe	Denmark	1=Protection	Maintenance of untouched forest cover	No
Latinopoulos, D.	2019	Mediterranean/South Europe	Greece	1=Protection	Other	No
Likus-Cieślík, J., Leńczuk, D., Woś, B., Lubera, A., Pajak, M., & Pietrzykowski, M.	2023	Central Europe	Poland	2=Modification	Reforestation	No
Lindroos, O., Söderlind, M., Jensen, J., & Hjältén, J.	2021	Northern Europe	Sweden	2=Modification	Other	No
Lorek, A. L., P.	2021	Northern Europe	Poland	2=Modification	Other	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Lorenzo-sáez, E., Oliver-villanueva, J. V., Lerma-arce, V., Yagüe-hurtado, C., & Lemus-zúñiga, L. G.	2021	Mediterranean/South Europe	Spain	2=Modification	Reforestation	No
Mäntymaa, E., Juutinen, A., Tyrväinen, L., Karhu, J., & Kurttila, M.	2018	Northern Europe	Finland	2=Modification	Other	No
Mäntymaa, E., Kaseva, J., Hiedanpää, J., & Pouta, E.	2023	Northern Europe	Finland	1=Protection	Maintenance of untouched forest cover	No
Mäntymaa, E., Pouta, E., & Hiedanpää, J.	2021	Northern Europe	Finland	1=Protection	Maintenance of untouched forest cover	No
Müller, F., Augustynczyk, A. L. D., & Hanewinkel, M.	2019	Central Europe	EU-27	1=Protection	Maintenance of untouched forest cover	No
Mandić, A., & Petrić, L.	2021	Mediterranean/South Europe	Croatia	1=Protection	Maintenance of untouched forest cover	No
Marta-Pedroso, C. L., L.;Gama, I.;Domingos, T.	2018	Mediterranean/South Europe	Portugal	1=Protection	Other	No
Martin Barroso, V., de Castro-Pardo, M., Fernández Martínez, P., & Azevedo, J. C.	2022	Mediterranean/South Europe	Spain	1=Protection	Maintenance of untouched forest cover	No
Mastrorilli, M. R., G.;Verdiani, G.;Tedeschi, G.;Fumai, A.;Russo, G.	2018	Mediterranean/South Europe	Italy	1=Protection	Maintenance of untouched forest cover	No
Mayer, M., & Woltering, M.	2018	Central Europe	Germany	1=Protection	Maintenance of untouched forest cover	No
Nikodinoska, N. P., A.;Pastorella, F.;Granvik, M.;Franzese, P. P.	2018	Northern Europe	Sweden	1=Protection	Maintenance of untouched forest cover	No
Nordén, B., Rørstad, P. K., Magnér, J., Götmark, F., & Löf, M.	2019	Northern Europe	Norway	1=Protection	Restoring degraded forest ecosystems	No
Olmo, V. S., M.;Alberti, G.	2022	Mediterranean/South Europe	Italy	2=Modification	Land use conversion from agriculture to forest	No
Ovando, P. B., S.;Campos, P.	2019	Mediterranean/South Europe	Spain	1=Protection	Maintenance of untouched forest cover	No
Pache, R. G., Abrudan, I. V., & Niță, M. D.	2021	Eastern Europe	Romania	1=Protection	Maintenance of untouched forest cover	No
Pacheco, R. M.	2022	Central Europe	France	1=Protection	Maintenance of untouched forest cover	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Pacheco, R. M.	2022	Mediterranean/South Europe	Portugal	1=Protection	Maintenance of untouched forest cover	No
Paletto, A. P., E.;De Meo, I.;Agnelli, A. E.;Cantiani, P.;Chiavetta, U.;Mazza, G.;Lagomarsino, A.	2021	Mediterranean/South Europe	Italy	1=Protection	Restoring degraded forest ecosystems	No
Pires-Marques, É., Chaves, C., & Pinto, L. M. C.	2021	Mediterranean/South Europe	Portugal	1=Protection	Maintenance of untouched forest cover	No
Ratto, F. B., T. D.;Cole, L. J.;Garraff, M. P. D.;Kleijn, D.;Kunin, B.;Michez, D.;O'Connor, R.;Ollerton, J.;Paxton, R. J.;Poppy, G. M.;Potts, S. G.;Senapathi, D.;Shaw, R.;Dicks, L. V.;Peh, K. S. H.	2022	Great Britain and Ireland	United Kingdom	1=Protection	Maintenance of untouched forest cover	No
Raya, J. M., Martinez-Garcia, E., & Celma, D.	2018	Mediterranean/South Europe	Spain	1=Protection	Maintenance of untouched forest cover	No
Regelmann, C. R., L.;Seintsch, B.;Dieter, M.	2023	Central Europe	Germany	1=Protection	Maintenance of untouched forest cover	No
Ren, W., Wang, X., & Alex, A. M.	2019	Northern Europe	Sweden	2=Modification	Restoring degraded forest ecosystems	No
Riccioli, F. F., R.;Fagarazzi, C.;Cozzi, M.;Vicararo, M.;Romano, S.;Rocchini, D.;Espinosa Diaz, S.;Tattoni, C.	2020	Mediterranean/South Europe	Italy	2=Modification	Other	No
Riccioli, F. F., R.;Marone, E.;Fagarazzi, C.;Calderisi, M.;Brunialti, G.	2020	Mediterranean/South Europe	Italy	1=Protection	Maintenance of untouched forest cover	No
Riccioli, F., Castiglione, F., Casini, L., El Asmar, J.-P., Fratini, R.	2019	Mediterranean/South Europe	Italy	1=Protection	Other	No
Rocchi, L. C., C.;Paolotti, L.;Massei, G.;Fagioli, F. F.;Antegiovanni, P.;Boggia, A.	2019	Mediterranean/South Europe	Italy	2=Modification	Maintenance of untouched forest cover	No
Roggema, R.	2022	Central Europe	Netherlands	2=Modification	Land use conversion from agriculture to forest	No
Sacchelli, S.	2018	Mediterranean/South Europe	Italy	1=Protection	Maintenance of untouched forest cover	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Sacchelli, S., & Bernetti, I.	2019	Mediterranean/South Europe	Italy	1=Protection	Maintenance of untouched forest cover	No
Schenau, S. v. B., J.;Bogaart, P.;Blom, C.;Driessen, C.;de Jongh, L.;de Jong, R.;Horlings, E.;Mosterd, R.;Hein, L.;Lof, M.	2022	Central Europe	Netherlands	1=Protection	Maintenance of untouched forest cover	No
Schirpke, U. S., R.;Da Re, R.;Masiero, M.;Pellegrino, D.;Marino, D.	2020	Mediterranean/South Europe	Italy	1=Protection	Maintenance of untouched forest cover	No
Schou, J. S., Bladt, J., Ejrnæs, R., Thomsen, M. N., Vedel, S. E., & Fløjgaard, C.	2021	Northern Europe	Denmark	2=Modification	Other	No
Silva, E., Naji, W., Salvaneschi, P., Climent-Gil, E., Derak, M., López, G., Bonet, A., Aledo, A., & Cortina-Segarra, J.	2023	Mediterranean/South Europe	Spain	2=Modification	Restoring degraded forest ecosystems	No
Silvestro, R. S., L.;Cavallo, C.;Allevato, E.;Pindozi, S.;Cervelli, E.;Conti, P.;Mazzoleni, S.;Saracino, A.	2021	Mediterranean/South Europe	Italy	2=Modification	Restoring degraded forest ecosystems	No
Sloup, R., Riedl, M., & Machoň, M.	2023	Eastern Europe	Czechia	2=Modification	Other	No
Soliño, M., Yu, T., Alía, R., Auñón, F., Bravo-Oviedo, A., Chambel, M. R., de Miguel, J., del Río, M., Justes, A., Martínez-Jauregui, M., Montero, G., Mutke, S., Ruiz-Peinado, R., & García del Barrio, J. M.	2018	Mediterranean/South Europe	Spain	2=Modification	Other	No
Széchy, A., & Szerényi, Z.	2023	Eastern Europe	Hungary	1=Protection	Maintenance of untouched forest cover	No
Tyrväinen, L., Mäntymaa, E., Juutinen, A., Kurttila, M., & Ovaskainen, V.	2021	Northern Europe	Finland	2=Modification	Other	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Valasiuk, S., Czajkowski, M., Giergiczny, M., Żylicz, T., Veisten, K., Landa Mata, I., Halse, A. H., Elbakidze, M., & Angelstam, P.	2018	Northern Europe	Sweden	1=Protection	Maintenance of untouched forest cover	No
Valatin, G. O., P.;Abildtrup, J.;Accastello, C.;Andreucci, M. B.;Chikalanov, A.;El Mokaddem, A.;Garcia, S.;Gonzalez-Sanchis, M.;Gordillo, F.;Kayacan, B.;Little, D.;Lyubenova, M.;Nisbet, T.;Paletto, A.;Petucco, C.;Termansen, M.;Vasylyshyn, K.;Vedel, S. E.;Yousefpour, R.	2022	Northern Europe	Denmark	2=Modification	Land use conversion from agriculture to forest	No
Vecchiato, D. P., C. B.;Tempesta, T.	2023	Mediterranean/South Europe	Italy	2=Modification	Reforestation	No
Vermaat, J. E. P., M.;Piffady, J.;Putnins, A.;Kail, J.	2021	Central Europe	Germany	1=Protection	Other	No
von Essen, M. d. R., I. T.;Santos-Reis, M.;Nicholas, K. A.	2019	Mediterranean/South Europe	Portugal	1=Protection	Other	No
Warachowska, W., Alvarez, X., Bezak, N., Gómez-Rúa, M., Janeiro-Otero, A., Matczak, P., Vidal-Puga, J., & Zupanc, V.	2022	Central Europe	Germany	3=Creation	Land use conversion from agriculture to forest	No
Widen, A. R., B. M.;Degerman, E.;Wisaeus, D.;Jansson, R.	2022	Northern Europe	Sweden	2=Modification	Implementing forests in riparian buffers	No
Zabala, J. A. A.-G., J. A.;Navarro, N.;Martinez-Paz, J. M.;Alcon, F.	2022	Mediterranean/South Europe	Spain	1=Protection	Reforestation	No
Zachariou, M., & Burgess, D.	2023	Northern Europe	Ireland	2=Modification	Land use conversion from agriculture to forest	No
Zastocki, D., & Kaliszewski, A.	2022	Central Europe	Poland	1=Protection	Other	No
Immerzeel, B.;Vermaat, J. E.;Riise, G.;Juutinen, A., & Futter, M.	2021	Northern Europe	Norway	1=Protection	Other	No
Makrickas, E.;Manton, M.;Angelstam, P., & Grygoruk, M.	2023	Eastern Europe	Lithuania	1=Protection	Other	No

Authors	Year	European region	Country	Typology	NbS action	BCR
Lankia, T.;Neuvonen, M.;Pouta, E.;Sievänen, T., & Torvelainen, J.	2020	Northern Europe	Finland	1=Protection	Other	No

ANNEX G – AGRICULTURE LANDSCAPE STUDIES

Authors	Year	European Region	Country	Typology	NbS action	BCR
Alcon, F. M.-M., C.; Zabala, J. A.; de-Miguel, M. D.; Martínez-Paz, J. M.	2020	Mediterranean/South Europe	Spain	2=Modification	Crop diversification and rotation	No
Asciuto, A. S., E.; Cottone, C.; Borsellino, V.	2019	Mediterranean/South Europe	Italy	3=Creation	Other	Yes
Atkinson, G. O., P.	2022	Great Britain and Ireland	United Kingdom	1=Protection	Other	No
Barrios-Crespo, E. T.-O., S.; Díaz-Simal, P.	2021	Great Britain and Ireland	United Kingdom	2=Modification	Other	No
Bernués, A. A., F.; Clemetsen, M.; Eik, L. O.; Faccioni, G.; Ramanzin, M.; Ripoll-Bosch, R.; Rodríguez-Ortega, T.; Sturaro, E.	2019	Mediterranean/South Europe	Spain	2=Modification	Maintenance of mixed-crop livestock systems	No
Bernués, A. A., F.; Clemetsen, M.; Eik, L. O.; Faccioni, G.; Ramanzin, M.; Ripoll-Bosch, R.; Rodríguez-Ortega, T.; Sturaro, E.	2019	Northern Europe	Norway	2=Modification	Maintenance of mixed-crop livestock systems	No
Bernués, A. A., F.; Clemetsen, M.; Eik, L. O.; Faccioni, G.; Ramanzin, M.; Ripoll-Bosch, R.; Rodríguez-Ortega, T.; Sturaro, E.	2019	Mediterranean/South Europe	Italy	2=Modification	Maintenance of mixed-crop livestock systems	No
Bernués, A. R.-O., T.; Ripoll-Bosch, R.; Alfnes, F.	2014	Mediterranean/South Europe	Spain	2=Modification	Maintenance of mixed-crop livestock systems	No
Biasin, A. M., M.; Amato, G.; Pettenella, D.	2023	Mediterranean/South Europe	Italy	3=Creation	Other	No
Bithas, K. L., D.	2021	Mediterranean/South Europe	Greece	2=Modification	Other	No
Blank, S. G., C. M.; Martínez-Blanco, J.; Muñoz, P.; Coello, J.; Casals, P.; Mosso, A.; Brun, F.	2019	Mediterranean/South Europe	Spain	2=Modification	Agroforestry	No
Bos, F., & Ruijs, A.	2021	Northern Europe	Netherlands	2=Modification	Other	No
Brady, M. V. H., J.; Wilhelmsson, F.; Hedlund, K.	2019	Northern Europe	Sweden	2=Modification	Conservation/regenerative agriculture	No

Authors	Year	European Region	Country	Typology	NbS action	BCR
Campos, F. S.;David, J.;Lourenço-de-Moraes, R.;Rodrigues, P.;Silva, B.;Vieira da Silva, C., & Cabral, P.	2021	Mediterranean/South Europe	Portugal	1=Protection	Other	No
Campos, J. C. R., S.;Sil, A.;Hermoso, V.;Freitas, T. R.;Santos, J. A.;Fernandes, P. M.;Azevedo, J. C.;Honrado, J. P.;Regos, A.	2022	Mediterranean/South Europe	Spain	2=Modification	Other	No
Campos, J. C. R., S.;Sil, A.;Hermoso, V.;Freitas, T. R.;Santos, J. A.;Fernandes, P. M.;Azevedo, J. C.;Honrado, J. P.;Regos, A.	2022	Mediterranean/South Europe	Spain	2=Modification	Conservation/regenerative agriculture	No
Campos, J. C. R., S.;Sil, A.;Hermoso, V.;Freitas, T. R.;Santos, J. A.;Fernandes, P. M.;Azevedo, J. C.;Honrado, J. P.;Regos, A.	2022	Mediterranean/South Europe	Spain	2=Modification	Agroforestry	No
Campos, P. Á., A.;Oviedo, J. L.;Mesa, B.;Caparrós, A.;Ovando, P.	2020	Mediterranean/South Europe	Spain	1=Protection	Agroforestry	No
Campos, P. Á., A.;Oviedo, J. L.;Ovando, P.;Mesa, B.;Caparrós, A.	2020	Mediterranean/South Europe	Spain	1=Protection	Agroforestry	No
Campos, P. M., B.;Álvarez, A.;Oviedo, J. L.;Caparrós, A.	2022	Mediterranean/South Europe	Spain	1=Protection	Agroforestry	No
Castillo-Eguskiza, N. H., D.;Onaindia, M.;Czajkowski, M.	2019	Mediterranean/South Europe	Spain	2=Modification	Conservation/regenerative agriculture	No
Castillo-Eguskiza, N.;Schmitz, M. F.;Onaindia, M., & Rescia, A. J.	2019	Mediterranean/South Europe	Spain	1=Protection	Maintenance of mixed-crop livestock systems	No
Castillo-Eguskiza, N.;Schmitz, M. F.;Onaindia, M., & Rescia, A. J.	2019	Mediterranean/South Europe	Spain	1=Protection	Other	No
Castillo-Eguskiza, N.;Schmitz, M. F.;Onaindia, M., & Rescia, A. J.	2019	Mediterranean/South Europe	Spain	1=Protection	Conservation/regenerative agriculture	No
Collas, L. C. d. S., R.;Finch, T.;Green, R.;Hanley, N.;Balmford, A.	2023	Great Britain and Ireland	United Kingdom	2=Modification	Conservation/regenerative agriculture	No
Czajkowski, M. Z., K.;Letki, N.;Tryjanowski, P.;Wąs, A.	2021	Central Europe	Poland	1=Protection	Conservation/regenerative agriculture	No
Dal Ferro, N. B., M.;Cardinali, A.;Cavalli, R.;Grigolato, S.;Zanin, G.	2019	Mediterranean/South Europe	Italy	2=Modification	Conservation/regenerative agriculture	No
de Groot, R. M., S.;de Vente, J.;De Leijster, V.;Ramos, M. E.;Robles, A. B.;Schoonhoven, Y.;Verweij, P.	2022	Mediterranean/South Europe	Spain	2=Modification	Other	No
De Leijster, V. V., R. W.;Santos, M. J.;Wassen, M. J.;Martínez-Mena, M.;de Vente, J.;Verweij, P. A.	2020	Mediterranean/South Europe	Spain	2=Modification	No or minimum tillage	Yes

Authors	Year	European Region	Country	Typology	NbS action	BCR
De Leijster, V. V., R. W.; Santos, M. J.; Wassen, M. J.; Martínez-Mena, M.; de Vente, J.; Verweij, P. A.	2020	Mediterranean/South Europe	Spain	2=Modification	Mulching and use of cover crops	Yes
De Nocker, L. L., I.; Beckx, C.; Broekx, S.	2023	Central Europe	Belgium	1=Protection	Other	No
Diti, I. L., S. E.; Caffi, T.; Rossi, V.; Canali, G.; Bosso, A.; Cancila, E.; Anelli, S.; Trioli, G.; Kleshcheva, E.; Gatti, M.; Poni, S.	2020	Mediterranean/South Europe	Italy	2=Modification	No or minimum tillage	No
dos Santos, M. P. M., T. G.; Domingos, T.; Teixeira, R. F. M.	2022	Mediterranean/South Europe	Portugal	2=Modification	Maintenance of mixed-crop livestock systems	No
Ekinci B, Grunewald K, Meier S, Schwarz S, Schweppe-Kraft B, Syrbe R-U	2022	Central Europe	Germany	2=Modification	Other	No
Faccioni, G. S., E.; Ramanzin, M.; Bernués, A.	2019	Mediterranean/South Europe	Italy	2=Modification	Agroforestry	No
Fan, F. H., C. B.; Porter, J.	2018	Northern Europe	Denmark	2=Modification	Crop diversification and rotation	No
Faria, N. M., M. B.	2020	Mediterranean/South Europe	Portugal	2=Modification	Other	No
Ferre, M. E., S.; Gsottbauer, E.	2018	Central Europe	Switzerland	2=Modification	Paludiculture or peatland restoration	No
Ferre, M. M., A.; Leifeld, J.; Bader, C.; Muller, M.; Engel, S.; Wichmann, S.	2019	Central Europe	Switzerland	2=Modification	Paludiculture or peatland restoration	No
Flack, J. L., M.; Todman, L.	2022	Great Britain and Ireland	United Kingdom	2=Modification	Other	No
Horák, I. M., P.	2023	Eastern Europe	Czechia	1=Protection	Other	No
Kaske, K. J. d. J., S. G.; Williams, A. G.; Graves, A. R.	2021	Great Britain and Ireland	United Kingdom	2=Modification	Crop diversification and rotation	No
Kaske, K. J. d. J., S. G.; Williams, A. G.; Graves, A. R.	2022	Great Britain and Ireland	United Kingdom	2=Modification	Crop diversification and rotation	No
Kay, S. G., A.; Palma, J. H. N.; Moreno, G.; Rocas-Díaz, J. V.; Aviron, S.; Chouvardas, D.; Crous-Duran, J.; Ferreira-Domínguez, N.; García de Jalón,	2019	More than one European region	EU-27	2=Modification	Agroforestry	No

Authors	Year	European Region	Country	Typology	NbS action	BCR
S.;Măcicășan, V.;Mosquera-Losada, M. R.;Pantera, A.;Santiago-Freijanes, J. J.;Szerencsits, E.;Torralba, M.;Burgess, P. J.;Herzog, F. Kay, S. G., A.;Palma, J. H. N.;Moreno, G.;Roces-Díaz, J. V.;Aviron, S.;Chouvardas, D.;Crous-Duran, J.;Ferreiro-Domínguez, N.;García de Jalón, S.;Măcicășan, V.;Mosquera-Losada, M. R.;Pantera, A.;Santiago-Freijanes, J. J.;Szerencsits, E.;Torralba, M.;Burgess, P. J.;Herzog, F. Kay, S. G., A.;Palma, J. H. N.;Moreno, G.;Roces-Díaz, J. V.;Aviron, S.;Chouvardas, D.;Crous-Duran, J.;Ferreiro-Domínguez, N.;García de Jalón, S.;Măcicășan, V.;Mosquera-Losada, M. R.;Pantera, A.;Santiago-Freijanes, J. J.;Szerencsits, E.;Torralba, M.;Burgess, P. J.;Herzog, F.	2020	More than one European region	EU-27	2=Modification	Agroforestry	No
Kirchweger, S. C., Y.;Kapfer, M.;Steffan-Dewenter, I.;Kantelhardt, J.	2020	Central Europe	Germany	2=Modification	Agroforestry	No
Kozma, Z. J., Z.;Kardos, M. K.;Muzelák, B.;Koncsos, L.	2022	Central Europe	Hungary	2=Modification	Agroforestry	No
Laporta, L. D., T.;Marta-Pedroso, C.	2021	Mediterranean/South Europe	Portugal	1=Protection	Agroforestry	No
Latvala, T. R., K.;Lehtonen, H.	2021	Northern Europe	Finland	3=Creation	Crop diversification and rotation	No
Lehmann, L. M. S., J.;Westaway, S.;Pisanelli, A.;Russo, G.;Borek, R.;Sandor, M.;Gliga, A.;Smith, L.;Ghaley, B. B.	2020	Northern Europe	Denmark	1=Protection	Agroforestry	No
Lehmann, L. M. S., J.;Westaway, S.;Pisanelli, A.;Russo, G.;Borek, R.;Sandor, M.;Gliga, A.;Smith, L.;Ghaley, B. B.	2020	Northern Europe	United Kingdom	1=Protection	Agroforestry	No
Liu, L. D., B.;Mijic, A.	2023	Northern Europe	United Kingdom	3=Creation	Other	No
Liu, L. D., B.;Mijic, A.	2023	Northern Europe	United Kingdom	3=Creation	No or minimum tillage	No
Liu, L. D., B.;Mijic, A.	2023	Northern Europe	United Kingdom	3=Creation	Rainwater harvesting and (re)creation of micro-relief	No

Authors	Year	European Region	Country	Typology	NbS action	BCR
Lopes, L. F. G. d. S. B., J. M. R.; Arede Correia Cristovão, A. F.; Baptista, F. O.	2015	Mediterranean/South Europe	Portugal	1=Protection	Other	No
Marta-Pedroso, C. L., L.; Gama, I.; Domingos, T.	2018	Mediterranean/South Europe	Portugal	1=Protection	Maintenance of mixed-crop livestock systems	No
Martin Barroso, V. d. C.-P., M.; Fernández Martínez, P.; Azevedo, J. C.	2022	Mediterranean/South Europe	Spain	1=Protection	Other	No
Martínez-García, V. M.-P., J. M.; Alcon, F.	2022	Mediterranean/South Europe	Spain	2=Modification	Other	No
Martin-Gorritz, B. M.-V., J. F.; Almagro, M.; Boix-Fayos, C.; Martínez-Mena, M.	2020	Mediterranean/South Europe	Spain	2=Modification	No or minimum tillage	No
Martino, S. M., D.	2018	Eastern Europe	Romania	3=Creation	Maintenance of high mountain traditional practices	No
Morri, E. S., R.	2022	Mediterranean/South Europe	Italy	2=Modification	Other	No
Nikodinoska, N. P., A.; Pastorella, F.; Granvik, M.; Franzese, P. P.	2018	Northern Europe	Sweden	1=Protection	Maintenance of mixed-crop livestock systems	No
Nilsson, L. C., Y.; Smith, H. G.; Alkan Olsson, J.; Brady, M. V.; Hristov, J.; Olsson, P.; Skantze, K.; Ståhlberg, D.; Dänhardt, J.	2019	Northern Europe	Sweden	2=Modification	Crop diversification and rotation	No
Otter, V. L., J.	2020	Central Europe	Germany	2=Modification	Agroforestry	No
Pinke, Z. K., M.; Lövei, G. L.	2018	Eastern Europe	Hungary	1=Protection	Maintenance of mixed-crop livestock systems	No
Pinke, Z. K., M.; Lövei, G. L.	2018	Eastern Europe	Hungary	1=Protection	Agroforestry	No
Pinto, R. A., P.; Blumentrath, S.; Brouwer, R.; Clemente, P.; Santos, R.	2019	Mediterranean/South Europe	Portugal	2=Modification	Conservation/regenerative agriculture	No
Pires-Marques, É. C., C.; Pinto, L. M. C.	2021	Mediterranean/South Europe	Portugal	1=Protection	Other	No

Authors	Year	European Region	Country	Typology	NbS action	BCR
Pires-Marques, É. C., C.;Pinto, L. M. C.	2021	Mediterranean/South Europe	Portugal	1=Protection	Maintenance of mixed-crop livestock systems	No

ANNEX H – MOUNTAIN LANDSCAPE STUDIES

Authors	Year	European region	Country	Typology	NbS Action	BCR
Alcon, F. A.-G., J. A.; Zabala, J. A.; Marín-Miñano, C.; Martínez-Paz, J. M.	2019	Mediterranean/South Europe	Spain	1=Protection	Other	No
Alessandro, P. D. M., I.; Grilli, G.; Notaro, S.	2023	Mediterranean/South Europe	Italy	2=Modification	Other	No
Atkinson, G. O., P.	2022	Great Britain and Ireland	United Kingdom	1=Protection	Other	No
Bednar-Friedl, B. G., B.; Getzner, M.	2009	Central Europe	Austria	1=Protection	Other	No
Bernués, A. A., F.; Clemetsen, M.; Eik, L. O.; Faccioni, G.; Ramanzin, M.; Ripoll-Bosch, R.; Rodríguez-Ortega, T.; Sturaro, E.	2019	Mediterranean/South Europe	Spain	2=Modification	Other	No
Faccioni, G. S., E.; Ramanzin, M.; Bernués, A.	2019	Mediterranean/South Europe	Italy	2=Modification	Other	No
González-Díaz, P. R.-B., P.; Ruiz, J. G.; Chamorro, G.; Zavala, M. A.	2019	Mediterranean/South Europe	Spain	1=Protection	Maintenance of protection forests	No
Marta-Pedroso, C. L., L.; Gama, I.; Domingos, T.	2018	Mediterranean/South Europe	Portugal	1=Protection	Maintenance of protection forests	No
Tempesta, T. V., D.	2018	Mediterranean/South Europe	Italy	1=Protection	Maintenance of protection forests	No

Authors	Year	European region	Country	Typology	NbS Action	BCR
Vecchiato, D. P., C. B.; Tempesta, T.	2023	Mediterranean/South Europe	Italy	2=Modification	Other	No
Vermaat, J. E. P., M.; Piffady, J.; Putnins, A.; Kail, J.	2021	Central Europe	Germany	1=Protection	Other	No
Wuepper, D. H., R.	2022	Central Europe	Switzerland	1=Protection	Other	No
Zabala, J. A. A.-G., J. A.; Navarro, N.; Martínez-Paz, J. M.; Alcon, F.	2022	Mediterranean/South Europe	Spain	1=Protection	Slope stabilisation - reforestation and/or revegetation of mountain areas	No

ANNEX I - STUDIES INCLUDED IN DATA EXTRACTION

- Abramowicz, D., & Stępniewska, M. (2020). Public Investment Policy as a Driver of Changes in the Ecosystem Services Delivery by an Urban Green Infrastructure [Article]. *Quaestiones Geographicae*, 39(1), 5-18. <https://doi.org/10.2478/quageo-2020-0001>
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- Alcon, F., Albaladejo-García, J. A., Zabala, J. A., Marín-Miñano, C., & Martínez-Paz, J. M. (2019). Understanding social demand for sustainable nature conservation. The case of a protected natural space in South-Eastern Spain [Article]. *Journal for Nature Conservation*, 51, Article 125722. <https://doi.org/10.1016/j.jnc.2019.125722>
- Alcon, F., Marín-Miñano, C., Zabala, J. A., de-Miguel, M. D., & Martínez-Paz, J. M. (2020). Valuing diversification benefits through intercropping in Mediterranean agroecosystems: A choice experiment approach [Article]. *Ecological Economics*, 171, Article 106593. <https://doi.org/10.1016/j.ecolecon.2020.106593>
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