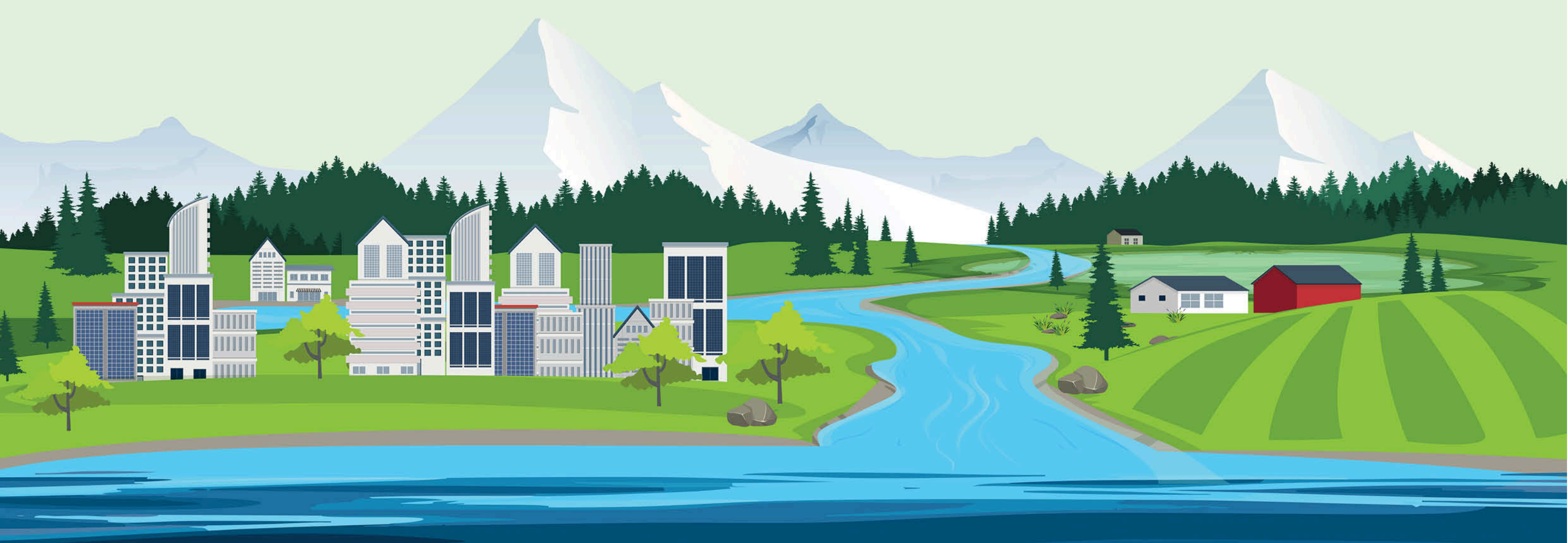
Nordic Council of Ministers

A GUIDE FOR NATURE-BASED SOLUTIONS IN THE NORDICS

Implementing NbS to solve societal challenges in different ecosystems



Authors

Tessa Bargmann[1], Annette Baattrup-Pedersen[2,3], Line Barkved[4], Helena Hanson[5], Kolbrún í Haraldsstovu[6], Ekaterina Shorohova[7], Daniele Stefàno[8], Johanna Alkan-Olsson [5], Georg Andersson[5], Caroline Enge[4], Sigrid Engen[1], Ingvild Skumlien Furuseth[4], Eli Rinde[4], Ruben Roos[1], and Leonard Sandin[1]

1. Norwegian Institute for Nature Research (NINA), Norway
2. Aarhus University (AU), Denmark
3. NIRAS A/S, Denmark
4. Norwegian Institute for Water Research (NIVA), Norway
5. Lund University (LU), Sweden
6. Faroe Islands National Museum (FINM), the Faroe Islands
7. Natural Resource Institute (LUKE), Finland
8. Agricultural University of Iceland (AUI), Iceland

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Nature-based solutions, Nordic countries, guide, handbook, societal challenges, implementation, ecosystems.

Contents

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Foreword

Nature-based solutions (NbS) offer a powerful approach to addressing the interlinked challenges of biodiversity loss, climate change and other societal challenges by protecting, restoring, and sustainably managing ecosystems. In the Nordic region, NbS initiatives focus on solutions that strengthen biodiversity, contribute to climate adaptation and mitigation, and improve human well-being. Examples include the restoration of peatlands, forests, and grasslands, sustainable farming practices, and blue-green infrastructure in urban and coastal areas. These approaches not only enhance ecosystems but also strengthen food security, health and resilience, especially in the light of climate change.

The Nordic Council of Ministers' Vision 2030 foresees the Nordic region as the most sustainable and integrated in the world by 2030. In support of this goal, the council funded a thematic programme on NbS that spanned six projects from 2021 to 2024. The programme's focus was to mainstream NbS for biodiversity and climate resilience.

This report marks the final phase of the programme, aimed at delivering best practices and practical guidance for implementing NbS at local levels across the Nordic countries. The aim is to support policymakers and practitioners alike, within and beyond the Nordic region, in leveraging NbS for sustainable development, conserve and restore biodiversity, and climate resilience.

Jan-Petter Huberth Hansen, Leader of the Steering Group, Project Leader at the Norwegian EPA (Miljødirektoratet)

Jóna Ólavsdóttir, Programme Coordinator, Nordic Council of Ministers, The Faroese EPA (Umhvørvisstovan), Faroe Islands

Thanks to the steering committee:
Jan-Petter Huberth Hansen (The Norwegian EPA (Miljødirektoratet), Norway), Irene Lindblad (Ministry of Climate and Environment, Norway), Anna Planke (Ministry of Climate and Environment, Norway), Bo Storrank (Ministry of the Environment, Finland), Eva Juul Jensen (The Danish EPA (Miljøstyrelsen), Denmark), Kolbrún í Haraldsstovu (The National Museum (Tjóðsavnið), Faroe Islands), Lise Lykke Steffensen (NordGen), Lotta Manninen (Ministry of the Environment, Finland), Lovisa Lagerblad (Swedish Environmental Protection Agency).

Thanks also to the reference group:
Elisa Keeling Hemphill (The Norwegian EPA (Miljødirektoratet), Norway), Fia Niclasen (The Faroese EPA (Umhvørvisstovan), Faroe Islands), Linda Dalen (The Norwegian EPA (Miljødirektoratet) Norway), Marit Finnland Troite (The Norwegian EPA (Miljødirektoratet) Norway), Aaron Tuckey (The Swedish EPA (Naturvårdsverket) Sweden).

Hartvig Christie and Sondre Meland (Norwegian Institute for Water Research (NIVA)), and Ulrika Jansson, Jenni Nordén and Evert Mul (Norwegian Institute for Nature Research (NINA)) have contributed to and reviewed parts of the report. Internal quality control of the report was performed by Lajla Tunaal White from the Norwegian Institute for Nature Research (NINA).

Executive Summary

The world is currently facing a biodiversity and climate crisis which are globally interlinked. Nature-based solutions (NbS), defined as "as "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" is part of the solution to these challenges. Nature-based solutions (NbS) offer a powerful approach to addressing the interlinked challenges of biodiversity loss, climate change and other societal challenges by protecting, restoring, and sustainably managing ecosystems. In the Nordic region, NbS initiatives focus on solutions that strengthen biodiversity, contribute to climate adaptation and mitigation, and improve human well-being. Examples include the restoration of peatlands, forests, and grasslands, sustainable farming practices, and blue-green infrastructure in urban and coastal areas. These approaches not only enhance ecosystems but also strengthen food security, health and resilience, especially in the light of climate change.

This report (guide) is a shortened and adapted version of the Nordic online guide for Nature-based solutions implementation[1] where the online guide includes a larger set of NbS applications across the six ecosystems included in the project as well as the main societal challenges and how these could be dealt with using NbS. Nature-based solutions encompass many different actions spanning protection, sustainable use, and restoration of ecosystems to solve societal challenges such as biodiversity loss, food security, and climate change mitigation and adaptation. As such, nature-based solutions are highlighted by both the UN, IPBES and IPCC as a cost-effective way of meeting the Sustainable Development Goals. The Kunming-Montreal Global Biodiversity Framework (GBF) recognises the need for action and goals to address the hazardous loss of biodiversity and restoring natural ecosystems including through NbS.

There is no one-size-fits all approach to planning NbS, because each project is dependent on the type of NbS that is chosen, combined with the context (i.e. country, ecosystem type, local conditions) in which it is applied. NbS implementation should therefore be tailored to each location's individual characteristics, using place- and context-specific assessments. The IUCN standard for NbS is designed to guide the practical implementation of NbS, as well as support conservation and policy development and is described in this report. We also list existing guidance and tools for NbS implementation, which are important for well executed NbS projects. This also includes information regarding standards,

1. https://nbsguide.org

policies and laws, cost-benefit analysis, and monitoring and evaluation of NbS projects.

One of the main points of NbS is that they are implemented to meet societal challenges. In this report we focus on several societal challenges and how they can be addressed by NbS: biodiversity enhancement, climate change mitigation and adaptation, disaster risk and preparedness, economic development, food security, human health and wellbeing, social justice and capacity building, and water management. Monitoring and evaluation of NbS efficiency are therefore essential to determine whether implemented NbS respond effectively to these challenges across ecosystems and land use types. The IUCNs global standard for NbS requires that NbS are managed adaptively and are based on evidence. This means that in practice, NbS need to be monitored and evaluated to make sure that the implemented actions continue to deliver the benefits, and effectively address the societal challenges that they were implemented for.

The report focusses on six ecosystem types and how NbS can be implemented in these: coastal, cultural landscapes, forests, mountains, urban, and freshwater ecosystems including rivers, lakes and wetlands. We give examples of NbS implementations for different ecosystems including creation and restoration of marine gardens, crop rotation, deadwood enrichment, revegetation and restoration of terrestrial vegetation, green and blue-green roofs, rewetting of wetlands, and restoration.

Norwegian summary

Verden står for tiden overfor et biologisk mangfold og klimakrise som er globalt sammenkoblet. Naturbaserte løsninger (NbL), definert som "tiltak for å beskytte, bærekraftig forvalte og gjenopprette naturlige eller modifiserte økosystemer, som effektivt og tilpasningsdyktig samfunnsutfordringer, samtidig som de gir menneskelig velvære og biodiversitetsfordeler" er en del av løsningen på disse utfordringene. Naturbaserte løsninger tilbyr en kraftig tilnærming til å møte de sammenkoblede utfordringene med tap av biologisk mangfold, klimaendringer og andre samfunnsutfordringer ved å beskytte, gjenopprette og forvalte økosystemer på en bærekraftig måte. I Norden fokuserer NbL-initiativene på løsninger som styrker biologisk mangfold, bidrar til klimatilpasning og -reduksjon og forbedrer menneskers velvære. Eksempler inkluderer restaurering av myr, skog og gressmark, bærekraftig jordbrukspraksis og blågrønn infrastruktur i by- og kystområder. Disse tilnærmingene forbedrer ikke bare økosystemene, men styrker også matsikkerhet, helse og motstandskraft, spesielt i lys av klimaendringer.

Denne rapporten (veilederen) er en forkortet og tilpasset versjon av den nordiske nettbaserte guiden[2] for implementering av naturbaserte løsninger, der den elektroniske guiden inkluderer et større utvalg av NbL-applikasjoner på tvers av de seks økosystemene som inngår i prosjektet, samt de viktigste samfunnsutfordringene, og hvordan disse kan håndteres ved hjelp av NbL. Naturbaserte løsninger omfatter mange ulike tiltak som spenner over beskyttelse, bærekraftig bruk og restaurering av økosystemer for å løse samfunnsutfordringer som tap av biologisk mangfold, matsikkerhet, og begrensning av og tilpasning til klimaendringer. Naturbaserte løsninger fremheves derfor av både FN, IPBES og FNs klimapanel som en kostnadseffektiv måte å nå bærekraftsmålene på. Kunming-Montreal Global Biodiversity Framework (GBF) anerkjenner behovet for handling og mål for å håndtere tapet av biologisk mangfold og gjenopprette naturlige økosystemer, inkludert gjennom NbL.

Det finnes ingen one-size-fits-all-tilnærming til planlegging av NbL, fordi hvert prosjekt er avhengig av hvilken type NbL som velges, kombinert med konteksten (dvs. hvilket land, økosystemtype, lokale forhold) det brukes i. NbL-implementering bør derfor skreddersys til hvert steds individuelle egenskaper, ved hjelp av steds- og kontekstspesifikke vurderinger. IUCN-standarden for NbL er utformet for å veilede den praktiske implementeringen av NbL, samt støtte bevaring og politisk utvikling, og er beskrevet i denne rapporten. Vi lister også opp eksisterende veiledning og verktøy for NbL-implementering, som er viktige for godt gjennomførte

2. https://nbsguide.org

NbL-prosjekter. Dette inkluderer også informasjon om standarder, retningslinjer og lover, kost-nytte-analyser og overvåking og evaluering av NbL-prosjekter.

Et av hovedpoengene med NbL er at de gjennomføres for å møte samfunnsutfordringer. I denne rapporten gir vi eksempler på disse samfunnsutfordringene og hvordan de kan løses av NbS for forbedring av biologisk mangfold, reduksjon og tilpasning til klimaendringer, katastroferisiko og beredskap, økonomisk utvikling, matsikkerhet, menneskers helse og velvære, sosial rettferdighet og kapasitetsbygging og vannforvaltning. Overvåking og evaluering av NbL-effektivitet er derfor avgjørende for å avgjøre om implementert NbL svarer effektivt på disse utfordringene på tvers av økosystemer og arealbrukstyper. IUCN sin globale standard for NbL krever at NbL håndteres adaptivt og er bevis-basert. Dette betyr at NbL i praksis må overvåkes og evalueres for å sikre at de implementerte tiltakene fortsetter å levere de fordelene de ble implementert for.

Rapporten har fokus på seks økosystemtyper og hvordan NbL kan implementeres i disse: kyst, kulturlandskap, skog, fjell, urbane og ferskvannsøkosystemer inkludert elver, innsjøer og våtmarker. Vi gir eksempler på NbL-implementeringer for ulike økosystemer, inkludert opprettelse og restaurering av marine hager, vekstskifte, anrikning av død ved, revegetering og restaurering av terrestrisk vegetasjon, grønne og blågrønne tak, restaurering av våtmark, og restaurering på et overordnet nivå.

1. Introduction

As part of the 2030 vision for a greener Nordic region, the Nordic Council of Ministers has funded a four-year programme on nature-based solutions in the Nordic Region. Nature-based solutions (NbS) are defined by the United Nations and IUCN as "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" IUCN (2016). Nature-based solutions encompass many different actions spanning protection, sustainable use, and restoration of ecosystems to maintain and re-establish their services to solve societal challenges such as climate change adaptation, food security, biodiversity loss and climate change mitigation. As such, nature-based solutions are highlighted by both the UN, IPBES and IPCC as a cost-effective way of meeting the Sustainable Development Goals.

More recently, the NbS concept has gained traction in policy and economy, resulting in the development of a global standard designed to guide the implementation of NbS, but also to support a common understanding of NbS in the global user community. Since the NbS concept is becoming increasingly relevant in science, policy and society, there is a need to keep track of and learn from existing solutions, so that future implementation of NbS can maximise benefits across the globe.

The Kunming-Montreal Global Biodiversity Framework (GBF) adopted by the UN convention CBD in 2022 recognises the need for action and sets goals to address the dangerous loss of biodiversity and restoring natural ecosystems including through NbS, where NbS are named explicitly in target 8 and 11. In a declaration from the Ministerial meeting in Helsinki in November 2022, the Nordic Ministers of Climate and Environment have committed to “upscale and mainstream nature-based solutions in terrestrial, freshwater, coastal and marine ecosystems in the Nordic Region and to apply nature-based solutions as a viable and beneficial alternative to technological solutions or to be integrated into these, to promote more robust, comprehensive and cost-effective actions” as well as urging “actors in the Nordic countries to make use of the information and reports produced by the Nordic programme for nature-based solutions and apply nature-based solutions actively in the green transition”.

The S-ITUATION project (Sandin et al., 2022) made three main recommendations in order to upscale NbS in the Nordics. First, that there is a need to support capacity-building among practitioners, especially in municipalities. Second, that it is important to create arenas for knowledge exchange and experiences on NbS across the Nordics and globally. Finally, that there is a need to develop more practical guidance on how to plan, design, implement and operationalize NbS, as such arenas and guidance are currently lacking in the Nordics. The completed NCM funded projects (Sandin et al. 2022, Barkved et al. 2024) have paved the way to help develop such practical guidance through the evaluation, mapping, and synthesis of NbS in the Nordic countries, as well as following and learning from eight NbS pilot projects funded by the NCM. The goal has been to make the information and guide operational and available to a wide range of stakeholders, such as practitioners, local authorities, and the public.

The Nordic Council of Ministers (NCM) has, based on these earlier reports and experiences, initiated the GuideNbS project in order to produce a practical online handbook and best-practice toolbox for the practical implementation of NbS in the Nordics (see below). The guide we have produced is based on the previous NCM funded S-ITUATION, S-UMMATION and eight pilot NbS projects. This report summarizes guidance's and best practices for the practical implementation of NbS across the main societal challenges and across six ecosystem types (coastal areas, cultural landscapes, forests, mountains, urban areas, and freshwater ecosystems, including rivers, lakes and wetlands).

Glossary

Biodiversity – entirety of genes, species and ecosystems of a region.

Conservation – the care and protection of natural resources so that they are available for future generations. This includes maintaining diversity of species, genes, and ecosystems, as well as functions of the environment, such as nutrient cycling.

Drainage – wetland and forest drainage for agricultural and silvicultural purposes, for example, which use surface ditches, subsurface permeable pipes, or both, to lower the groundwater depth. Excess water from the plant root zone and underlying soil can enter the pipes through perforations and flow away from the field to a ditch or another outlet.

Ecosystem – a community or group of living organisms that live in and interact with each other in a specific environment.

EEA – European Environment Agency

Grey literature - materials and research produced by organizations outside of the traditional commercial or academic publishing and distribution channels. Common grey literature publication types include reports, working papers, government documents, white papers and evaluations.

IPBES – The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IPCC – Intergovernmental Panel on Climate Change

IUCN – The International Union for Conservation of Nature

Nature-Based Solutions (NbS) – The United Nations Environment Assembly of the United Nations Environment Programme from 2022 defines NbS as "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits". This builds on the IUCN definition which is "actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature".

NCM – Nordic Council of Ministers

Nordic countries – the Nordic countries include the sovereign states of Denmark, Finland, Iceland, Norway and Sweden and the autonomous territories of the Faroe Islands and Greenland; and the autonomous region of Åland.

Peatland – terrestrial wetland ecosystems, also named "mires", where waterlogged soil conditions prevent the full decomposition of plant material. The thickness of the peat layer is defined to be at least 0.3 m, but this strict definition does not apply in all European countries.

Restoration – management measures that aim to restore the original form and function of different ecosystem habitats to favourable conservation status.

Rewetting – measures to raise water levels back to the soil surface, to recover anaerobic soil conditions and/or to recover the natural hydrological dynamics/hydraulic connectivity. These processes are important for the growth of natural wetland vegetation, while simultaneously halting carbon emissions from oxidation. Due to subsidence, rewetting of peat soils by closing pumping stations and/or drain systems might also cause inundation.

Sustainable use – methods and rates of resource use that do not lead to the long-term degradation of the environment, thereby maintaining its potential to meet the needs and aspirations of present and future generations.

UNEA – The United Nations Environment Assembly

UNEP – The United Nations Environment Programme

Vegetation – A collection of plants that can be found in a particular area or habitat. In this report, we use this word to mean *native* vegetation, because NbS using non-native plants conflict with biodiversity enhancement that is an essential part of NbS.

2. How to use the guide

The goal of this report and the online handbook has been to develop an online handbook and best-practice toolbox which can be used as a knowledge base for NbS practitioners across the Nordic countries. This report is a shortened and adapted version of the Nordic online guide for Nature-based solutions implementation[3] where the online guide includes a larger set of NbS applications across the six ecosystems included in the project as well as the main societal challenges, and how these could be dealt with using NbS. Chapter 3 explains what NbS are, summarizes a number of online guidances for NbS, including existing standards, policies and laws, the cost-benefits of NbS, and gives advice on the monitoring and evaluation of NbS outcomes. Chapter 4 gives examples of societal challenges and how they can be addressed by NbS. Chapter 5 describes the six ecosystem types included in the guide and gives examples of NbS that can be implemented in these ecosystems. Chapter 6 provides examples of different types of NbS that can be found in the online handbook; creation and restoration of marine gardens, crop rotation, deadwood enrichment, revegetation and restoration of terrestrial vegetation, green and blue-green roofs, rewetting of wetlands, and restoration. Chapter 7 offers some conclusions on the implementation of NbS in the Nordics.

The NbS examples that are covered in this report include a description of:

- how to apply this NbS
- outcomes of this NbS
- important considerations

When implementing NbS, is it important to follow the mitigation hierarchy (see e.g., chapters 4.2 Climate change adaptation and mitigation, and 6.5 Revegetation and restoration of terrestrial vegetation). The priority is to protect and conserve non-degraded ecosystems including natural functions and processes and avoid the loss of these ecosystems. In areas where nature and ecosystems have already been degraded, restoration actions should be used. As a last resort, and if none of these options are available, re-creation of nature or solutions based on elements of nature and natural processes can be implemented.

3. https://nbsguide.org

3. What are nature-based solutions?

The United Nations Environment Assembly of the United Nations Environment Programme from 2022 defines NbS as "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits". This builds on the IUCN definition which is "actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature". These solutions harness the power of nature to tackle various environmental, social, and economic issues, such as climate change, food and water security, disaster risk reduction, pollution mitigation and sustainable urban development (Figure 1).

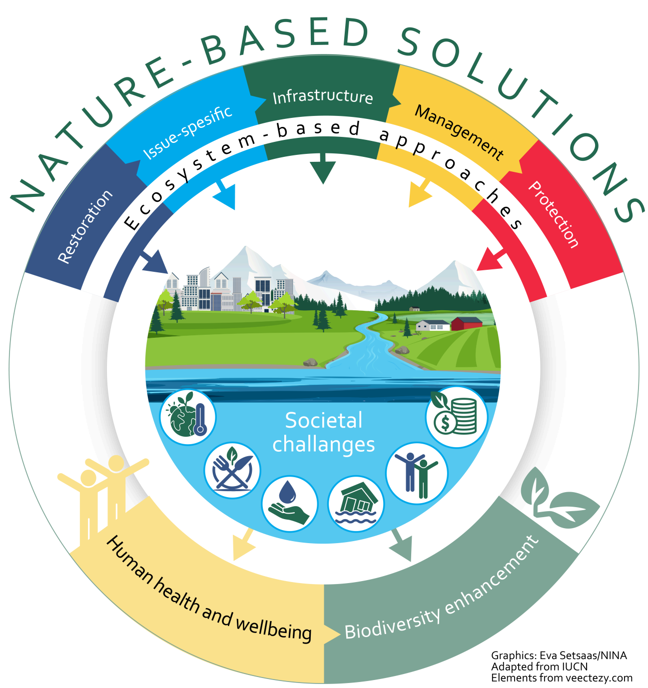

Figure 1. NbS must address human health and well-being, and biodiversity enhancement, along with other societal challenges.

NbS are:

- highlighted by the UN, IPBES and IPCC as a cost-effective way of meeting SDGs (address societal challenges while safeguarding benefits to biodiversity and human well-being)
- vital in addressing climate change and biodiversity loss
- tackle societal challenges using opportunities and models created by ecosystem elements and processes
- an umbrella concept incorporating already established approaches (e.g. ecological engineering, ecological restoration, blue-green infrastructure, ecosystem-based adaptation, ecosystem-based management, area-based conservation)

Nature-based solutions encompass many different actions spanning protection, sustainable use, and restoration of ecosystems to solve societal challenges such as climate change adaptation, food security, biodiversity loss and climate change mitigation and adaptation. As such, nature-based solutions are highlighted by both the UN, IPBES and IPCC as a cost-effective way of meeting the Sustainable Development Goals. The Kunming-Montreal Global Biodiversity Framework (GBF) recognises the need for action and goals to address the hazardous loss of biodiversity and restoring natural ecosystems including through NbS, where NbS are named explicitly in target 8 and 11.

NbS should have:

i. measurable targets for their expected benefits ii) solid documentation that these benefits are achieved through monitoring, and
ii. if monitoring shows that the initial targets are not fulfilled, adaptive management should be considered to improve their functions.

This forms part of the IUCN global standard for the implementation of NbS (IUCN, 2020; see below), which encompasses eight criteria and associated indicators that focus on biodiversity conservation, ecosystem integrity, and societal benefits. These criteria aim to ensure that NbS deliver benefits for both nature and people, address societal challenges effectively, are economically viable, and are governed by inclusive and equitable processes. To avoid greenwashing it is necessary to have clear and explicit requirements for when and how the term NbS should be used, including the necessity to strictly use the term as defined by the UN and IUCN focusing on actions that have a positive effect on biodiversity. It is also important to be aware that the term NbS has being misused to "sell" concepts that are harmful to nature and society.

Traditionally, NbS can be divided into actions targeting a range of specific ecosystem services which address a variable number of ecosystem functions focusing on biodiversity. In this handbook, we will focus on NbS which address multiple ecosystem functions, processes, and societal problems there are no examples of highly constructed or "grey-green" infrastructure included.

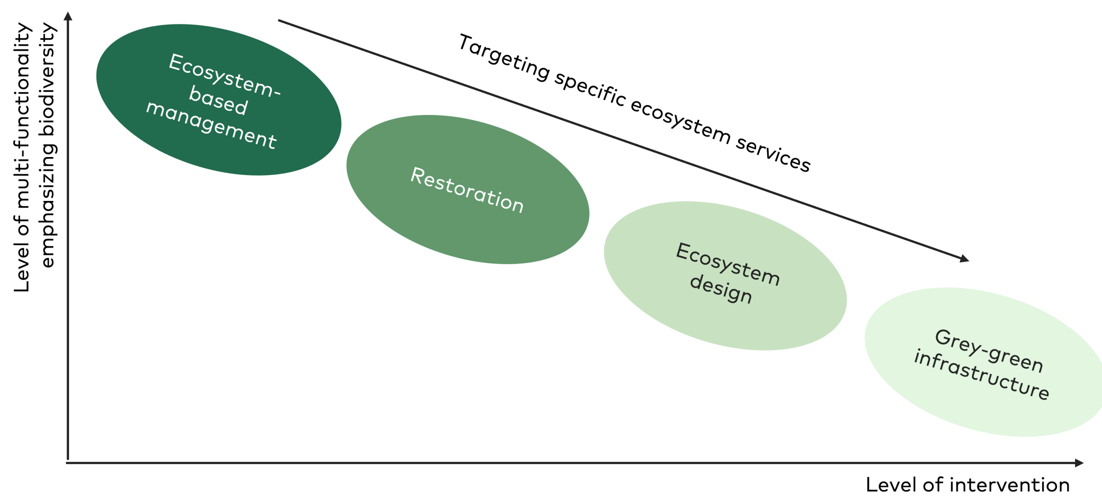

Figure 2. The schematic diagram shows how NbS can differ in their level of intervention, their level of ecosystem service delivery including a focus on biodiversity, and their targeting for specific ecosystem services. Adapted from Cohen-Shacham et al. (2016).

3.1 General guidance for NbS

Recently, NbS have become more visible in policy and economy, resulting in the development of a global standard (IUCN, 2020). This standard is designed to guide the practical implementation of NbS, as well as support conservation and policy development. The standard can also help to establish a common understanding of what NbS are amongst NbS practitioners and stakeholders.

The IUCN Global Standard for NbS identifies eight criteria to ensure full realization of the potential of NbS (Figure 3). All NbS should follow a general set of principles to adhere to these standards:

1. NbS effectively address societal challenges
2. The design of NbS is informed by scale
3. NbS result in a net gain to biodiversity and ecosystem integrity
4. NbS are economically viable
5. NbS are based on inclusive, transparent and empowering governance processes

6. NbS equitably balance trade-offs between achievement of their primary goal(s) and the continued provision of multiple benefits
7. NbS are management adaptively, based on evidence
8. NbS are sustainable and mainstreamed within an appropriate jurisdictional context

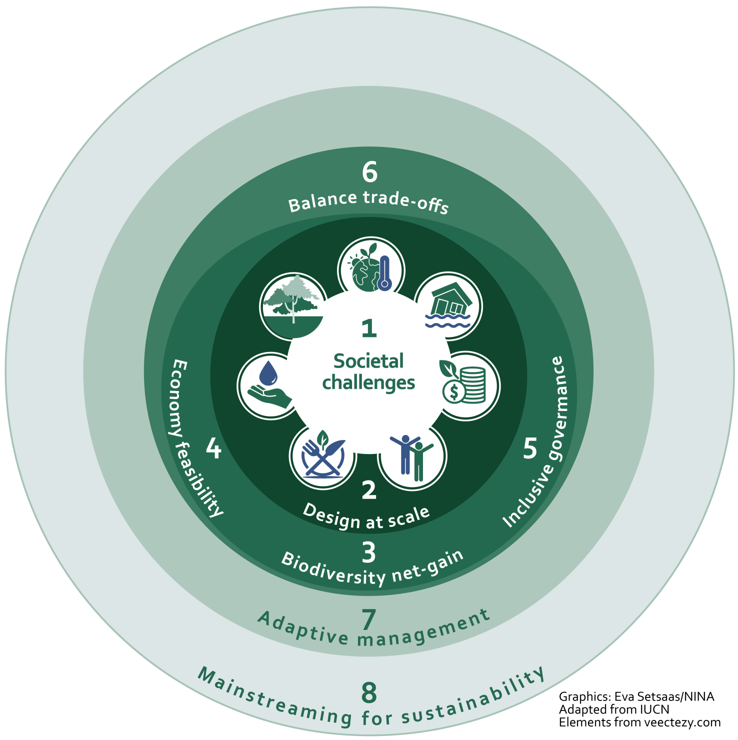

Figure 3. Eight assessment criteria of the IUCN Global Standard for NBS.

How to plan an NbS

There is no one-size-fits all approach to planning NbS, because each project is dependent on the type of NbS that is chosen, combined with the context (i.e. country, ecosystem type, local conditions) in which it is applied. NbS implementation should therefore be tailored to each location's individual characteristics, using place- and context-specific assessments. However, there are helpful steps that can be followed when implementing NbS projects, also known as the NbS project cycle (Figure 4).

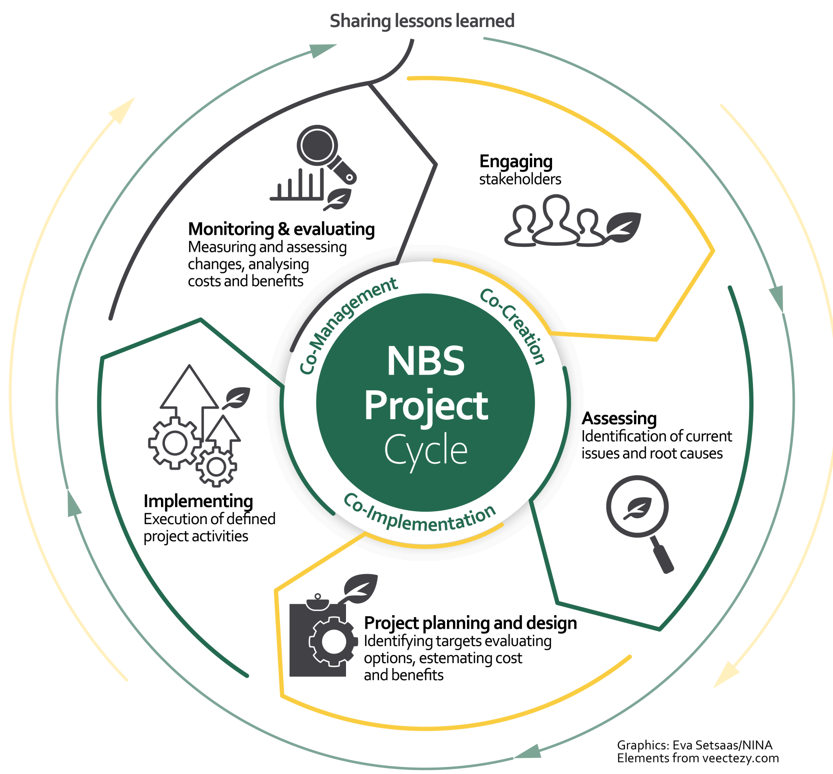

Figure 4. The NbS Project cycle: Engaging stakeholders, Assessing, Project planning and design, Implementing, Monitoring and evaluation, and Sharing lessons learned.

General Guidance for NbS in the Nordics

A previous Nordic Council of Ministers project on implementation processes in eight Nordic pilot projects identified some common key aspects which affect the success of NbS project planning and implementation in a Nordic context (Barkved et al. 2024). Many of these aspects are also in line with leading frameworks on NbS and can be related to the IUCN standard for NbS.

Why do we need guidance for NbS?

- Aid a common understanding of NbS, fast-track policy development and transformative societal change
- Equip users with a robust framework for planning and design of NbS
- Ensure actions help solve societal challenges
- Assess outcomes and success of NbS
- Ensure NbS are effective, scalable, and sustainable
- Mainstream nature-based approaches in policy and practice through increasing scale and impact

- Help preventing negative outcomes or misuse (greenwashing)
- Help funding agencies, policymakers and other stakeholders assess the effectiveness of interventions

3.2 Existing guidance and tools for NbS

There is a wide range of guidance material for NbS, from general guidance on how to think about planning an NbS project, to specific guidance on how to apply a defined NbS in a specific country, ecosystem, or context. The following is a non-exhaustive list of NbS guidance, focusing on more general guidance in a Nordic context.

Global General Guidance

- Guidance for using the IUCN Global Standard for Nature-based Solutions: A user-friendly framework for the verification, design and scaling up of Nature-based Solutions.[4]
- Standards of practice to guide ecosystem restoration.[5]
- Natural climate solutions Handbook: A technical guide for assessing nature-based mitigation opportunities in countries.[6]
- Handbook of Nature-Based Solutions to Mitigation and Adaptation to Climate Change.[7]
- Voluntary guidelines for the design and effective implementation of ecosystem-based approaches to climate change adaptation and disaster risk reduction and supplementary information.[8]

European General Guidance

- EU NAIAD project – Handbook for the Implementation of Nature-based Solutions for Water Security[9]
- Evaluating the impact of nature-based solutions. A handbook for practitioners[10]
- Nature-based solutions handbook[11]
- Phusicos project – according to nature – NbS guidebook[12]

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5. https://www.fao.org/documents/card/en/c/cc5223en
6. https://www.nature.org/content/dam/tnc/nature/en/documents/TNC_Natural_Climate_Solutions_Handbook.pdf
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8. https://www.cbd.int/doc/publications/cbd-ts-93-en.pdf
9. https://networknature.eu/new-handbook-implementation-nature-based-solutions-water-security
10. https://op.europa.eu/en/publication-detail/-/publication/d7d496b5-ad4e-11eb-9767-01aa75ed71a1
11. https://oppla.eu/product/19999
12. https://www.phusicos.eu/publication--results/

- National guidance on the implementation of NbS. A tool for climate adaptation and other societal challenges (Sweden)[13]
- A national guide for municipalities to evaluate when to use NbS, focusing on climate related risks (Norway)[14]

European guidance for freshwater & wetland NbS

- EU MERLIN Project – New framework for monitoring systemic impacts of freshwater and wetland restoration actions[15]

European guidance for urban areas

- NbS catalogue – a catalogue of nature-based solutions for urban resilience [16]
- UNALAB technical handbook of nature-based solutions[17]
- NATWiP Handbook – A handbook for practitioners to promote and inspire implementation of nature-based solutions in peri-urban areas[18]
- UrbanGreenUP – tools and resources for selection of nature-based solutions [19]

Guidance from other countries

- Nature-based solutions resource guide. Compendium of federal examples, guidance, resource documents, tools, and technical assistance (USA).[20]

3.3 Standards, policies and laws

A good knowledge of local, regional and national policies is important when planning NbS. This is because existing policies may prevent or support NbS projects.

Examples of policies that may influence the success of NbS implementation:

- Existing legislation – how strong are laws related to biodiversity protection, climate adaptation and water quality?
- Governance system – how adaptive is the management and policies in response to a rapidly changing environment?

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13. https://www.naturvardsverket.se/4acc16/globalassets/media/publikationer-pdf/7000/978-91-620-7074-8.pdf
14. https://www.miljodirektoratet.no/ansvarsomrader/klima/for-myndigheter/klimatilpasning/veiledning-til-statlige-planretningslinjer-for-klimatilpasning/vurdere-naturbaserte-losninger/
15. https://project-merlin.eu/files/merlin/downloads/deliverables/MERLIN_D1.2_Monitoring_Handbook_Sept2024.pdf
16. https://www.felixx.nl/projects/nbs-catalogue.html
17. https://unalab.eu/en/documents/d55-nbs-implementation-handbook
18. https://www.iis-rio.org/en/publications/natwip-handbook-a-handbook-for-practitioners-to-promote-and-inspire-implementation-of-nature-based-solutions-in-peri-urban-areas/
19. https://www.urbangreenup.eu/
20. https://www.whitehouse.gov/wp-content/uploads/2022/11/Nature-Based-Solutions-Resource-Guide-2022.pdf

- Rights of the landowner – how can local or national authorities collaborate with private landowners for the implementation of NbS?
- Existing incentives – are there incentives for citizens, private landowners, farmers, companies and municipalities to contribute to nature-positive measures?

The governance systems in the Nordic countries have many similarities, but there are also differences in how the implementation of NbS can be supported through policies. When working with policy development to mainstream and upscale the use of NbS, this is both related to creating new policies, such as strategies and incentive programs, to strengthen existing policies that are already supporting NbS, such as nature protection and restoration initiatives, and to change policies that may not incentivize NbS. There are several standards and criteria suggested for NbS, and these can also be applied when working with policy development, such as the IUCN global standard. Key elements that policies supporting NbS should also consider, are education and capacity building, financing, stakeholder involvement, knowledge-based management and cross-sectoral collaboration.

3.4 Cost-benefit of NbS

One of the main challenges when planning and implementing Nature-based solutions (NbS) is to be able to weigh the costs of the solutions against their benefits. Cost-benefit analyses are traditionally focused on one single, or a few selected issues, and do not always include impacts on nature or the ecosystem services provided by nature. This makes it difficult to assess the costs and benefits of NbS in comparison to more traditional, technical, or "grey" solutions.

The lack of information and uncertainty about the costs and benefits of NbS makes it difficult to calculate reliable revenue streams and to develop investment plans for NbS. To help to address this issue, the following recommendations were made in NbS workshops with Nordic stakeholders (Sandin et al., 2022):

- The strength of NbS is that they can address multiple societal problems at the same time, but this is not reflected in most current cost-benefit analyses. To account for the benefits of NbS, there is a pressing need for proper monetary valuation studies focusing on the ecosystem services of different NBS to allow for value transfers from one study area to other locations and cases.
- Current cost-benefit analyses of NbS often do not properly consider the long-term benefits of NbS (as these benefits could increase over time, depending on how they were built/secured and managed). This leads to the impression that NbS are more expensive compared to traditional or "grey" solutions, even when they are not. Comprehensive cost-benefit analysis can help potential investors choose NbS over other more technical solutions.

- Current thinking is often focused on single ecosystem service delivery – for example water companies focus on delivering drinking water and cleaning wastewater using traditional infrastructure, thus missing the additional services NbS could provide. In order to direct existing funding to test and create NbS, including ecosystem service delivery, it is necessary with creative, proactive, and holistic thinking.
- There is a lack of coordinated public and private funding for NbS. The many benefits that NbS can deliver for different societal needs should also be reflected in the funding the solutions receive. Incentive systems may help to attract private investors, coordinate public funding, and mainstream NbS.
- Public funding is partly dependent on awareness and understanding of the importance of NbS. If governments should prioritize NbS over other types of solutions, one route would be to increase awareness and knowledge about NbS among the general public to change the views of politicians.
- Changing mindsets towards the acceptance of more holistic solutions is necessary to embrace NbS in order to upscale such solutions.

3.5 Monitoring and evaluation

At the core of NbS are the societal challenges that these solutions will help solve (IUCN, 2020). Monitoring and evaluation of NbS efficiency are therefore essential to determine whether implemented NbS respond effectively to these challenges across ecosystems and land use types. The IUCNs global standard for NbS require that NbS are managed adaptively and are based on evidence. This means that in practice, NbS need to be monitored and evaluated to make sure that the implemented actions continue to deliver the benefits that they were implemented for. It is therefore very important that in the start-up phase of a new NbS project (such as a restoration project) that measurable "scope, vision, target, goals, and objectives" are identified, and that adequate funding are allocated for monitoring and evaluation as part of the NbS implementation (Gann et al. 2019).

Unfortunately, proper monitoring is not often done in NbS in the Nordics (see Sandin et al. 2022; Barkved et al., 2024). If no proper monitoring and evaluation is done, it will result in the following problems:

- a lack of initial data for proper project planning
- missing monitoring and assessment schemes for evaluating NbS
- a lack of information regarding the effects of NbS on social and ecological values across different spatial scales and on long-term effects

The European Commission has developed a handbook for practitioners for the evaluation of impact of NbS with the goal to "to support the adoption of common indicators and methods for assessing the performance and impact of diverse types of NbS" (European Commission, 2021). Other frameworks developed to assess NbS includes the integrated valuation of a nature-based solution for water pollution control (Liquete et al., 2016); the assessment of the effectiveness and co-benefits of nature-based solutions in urban areas including NbS design, implementation and evaluation (Raymond et al., 2017); the assessment of the regulation of urban run-off (Zölch et al., 2017); and a 'dynamic' assessment framework explicitly incorporating climate change (Calliari et al., 2019).

Regarding the evaluation of the impact of NbS, important questions remain regarding how to assess NbS within and across societal challenges (Raymond et al., 2017), but it is clear that the monitoring and evaluation of NbS impacts should include both observations (monitoring) as well as analysis (assessment of the results). This includes both measuring and assessing change, as well as costs and benefits of the NbS. Including a monitoring scheme with the NbS project will support and enhance the evidence base for new and established NbS as well as provide important information regarding performance, effectiveness, implementation and costs (European Commission 2021). When doing so it is important to include appropriate, unbiased, and robust methods for the monitoring and evaluation to be effective (Chrysoulakis et al 2021). Most current studies on the impact of NbS are limited to single cases, limited in terms of the impacts considered or have focused on a specific type of NbS (Dumitru et al. 2020). Most attention has focused on assessing the environmental aspects without paying enough attention to economic, social and health impacts (Brink and Wamsler, 2018; Raymond et al., 2017).

4. Societal challenges

One of the main points of NbS is that they are implemented to meet societal challenges. In this chapter we give examples of these societal challenges and how they can be addressed by NbS for biodiversity enhancement, climate change mitigation and adaptation, disaster risk and preparedness, economic development, food security, human health and wellbeing, social justice and capacity building, and water management.

4.1 Biodiversity enhancement

Biodiversity enhancement refers to actions and strategies aimed at increasing the variety of life in all its forms, including species diversity, genetic variation, and ecosystem diversity.

Addressing biodiversity in nature-based solutions

Evaluating biodiversity net-gain when implementing a NbS requires a thorough understanding of the characteristics of the ecosystem in question before biodiversity targets can be set. A so-called baseline assessment must include information about the ecological state, the main drivers for biodiversity loss, and potential for improvement. This information should have a scientific basis while also making use of local knowledge. Working at the landscape and/or the catchment scale, considering ecological principles (e.g., bottlenecks and founder events, sink habitats, ecological traps, population dynamics, trophic cascades, large-scale ecological processes) can help to maximize the positive ecological and biodiversity impact on local ecosystems and enhance long-term sustainability.

The evaluation of biodiversity enhancement is not always as straightforward as it sounds, and the following factors should always be considered when evaluating biodiversity enhancement in NbS:

- **Scale**: NbS implementation may cause a species increase locally, but without considering this increase in a wider regional or even global context, it is difficult to evaluate the biodiversity benefit. For example, if the NbS favors common species at the expense of uncommon, or endemic species, an increase in species richness cannot be considered a benefit for biodiversity as a whole. The implementation of NbS should therefore consider potential conflicts associated with the protection of species or habitats of special interest (e.g., species listed in the annexes to the Habitats Directive; IUCN red listed species).

- **Target species**: It is important to consider which species are and are not desired as an outcome of an implemented NbS. A lower number of desired target species (e.g. species being typical for the ecosystem, red-listed species, or keystone species) may often be a more desirable outcome than a large number of undesirable species. A large number of species that are common everywhere, or even worse, invasive to the region, are not generally a desirable outcome for biodiversity.
- **Context dependency** (ecosystem type/local legislation): The evaluation of biodiversity enhancement for the same NbS may differ depending on the region. For example, rewetting of former wetlands can mediate both an increase and a decrease in species richness, depending on the characteristics of the area and the rewetting approach. If an area has potential to regain characteristics of a poor fen (low productivity), an increase in species richness may not be considered a biodiversity enhancement if this is a result of a high amount of nutrients in the water used for rewetting. Local legislation may help set goals for the desired biodiversity outcomes, for example if there are existing management plans for specific species or habitat types.
- **Connectivity**: To ensure the long-term persistence of the identified target species, it is important to consider landscape connectivity. If a population of species is isolated and unable to move to other areas to feed or reproduce, it is less likely to be able to survive over time. It is therefore always better to have the whole landscape in mind – e.g. are areas available nearby that can serve as corridors for dispersal or as foraging areas? Are barriers existing that may hinder species dispersal, feeding and/or reproduction? Ideally, NbS should improve biodiversity over the long term and across a large area by linking conservation efforts with more specific NbS measures within the region.

To ensure that the NbS is meeting its goals for biodiversity enhancement, it is also essential to have monitoring in place to follow up on these goals. Better monitoring will help us to learn more about the efficacy of different NbS in the Nordic region and inform management plans to halt biodiversity declines.

4.2 Climate change adaptation and mitigation

Climate change is a long-term change in temperature and weather patterns and is currently one of the biggest challenges for life on earth. The Intergovernmental Panel on Climate Change (IPCC) defines climate change mitigation as an "intervention to reduce the sources or enhance the sinks of greenhouse gases" (Edenhofer, et al. 2014). Climate change adaptation, on the other hand, involves adjustments and changes by humans and natural systems in response to actual or anticipated changes in climate. The ultimate goal of climate change adaptation and mitigation is to limit the negative impacts or maximize the potential benefits caused by climate change.

Together, climate change mitigation and adaptation are key components of climate resilience. By reducing future climate risks through mitigation and preparing for existing and anticipated impacts through adaptation, we can build a more resilient foundation for dealing with current and future climate change. In this context it should also be noted that while adapting to a changing climate is essential, it should not overshadow our efforts in climate change mitigation.

Addressing climate change adaptation and mitigation with nature-based solutions

NbS can be highly effective in supporting both climate change adaptation and mitigation and for building climate resilience (Dumitru and Wendling, 2021). For example, NbS can help to decrease greenhouse gas emissions related to land use change, capture and store carbon dioxide from the atmosphere (i.e. mitigation), or improve the ability of ecosystems to withstand the effects of climate change, such as flooding, sea-level rise, drought and heatwaves (i.e. adaptation).

- Land use (agriculture, forestry etc.) results in a large proportion of global emissions of greenhouse gases such as carbon dioxide, methane and nitrous oxide – better land management and conservation can help reduce these emissions.

- Healthy ecosystems can act as natural carbon sinks by absorbing carbon dioxide – conservation, restoration and sustainable management of wetlands, forests and oceans can contribute to improved carbon storage.

- Intact ecosystems can also help communities become more resilient to extreme weather events and climate-related disasters.

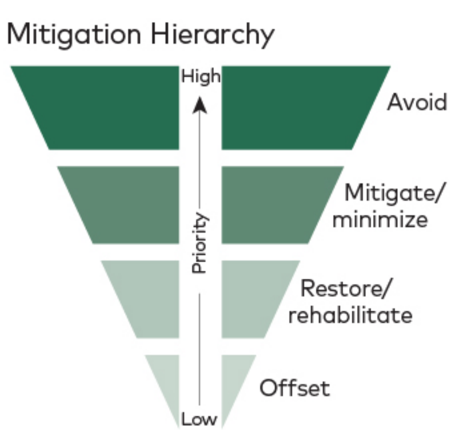

Figure 5. Mitigation hierarchy for NbS

Measuring the efficacy of a NbS for climate change mitigation can be difficult and will be dependent on the starting point before the NbS is implemented. Also, the effectiveness of NbS can vary depending on the specific ecosystem type and implementation approach, which needs to be considered. Some examples of possible indicators for evaluating the success of an NbS related to climate mitigation and climate resilience can be:

- total carbon removed or stored in vegetation and soil per unit area per unit time
- avoided greenhouse gas emissions from reduced building energy consumption
- monthly mean value of daily maximum/minimum temperature
- heatwave incidence: Days with temperature above the 90^{th} percentile threshold value for that specific site

For NbS related to climate mitigation, quantifying carbon storage in soils, vegetation, or wetlands, is a key indicator (Dumitru and Wendling, 2021), as it provides direct evidence of carbon dioxide mitigation benefits. In urban areas, looking at reduction in urban heat island effects through monitoring temperature changes in areas with NbS interventions compared to areas without can also provide information on mitigation effects. Such cooling effects can help reduce energy use for cooling and mitigate emissions indirectly (if fossil energy sources are used).

Examples of effects of NbS related to climate change adaptation and climate resilience can be e.g., reduction in flood hazards. Measuring the change in flood-prone areas or flood intensity after implementing NbS can serve as an indicator of their effectiveness. NbS aimed at improving drought resilience, could be traced by looking at changes in water availability during dry periods, soil moisture retention, or crop yields in drought-prone areas (Dubo et al., 2021). NbS being implemented to address heatwaves, particularly in urban areas, could be documented by looking at changes in urban heat island effects or reductions in peak temperatures during heatwaves.

As mentioned, the effectiveness of NbS can vary depending on the local context, and a combination of indicators may be necessary to fully assess their impacts related to climate change. As is the case for any NbS, when addressing climate change adaptation and mitigation, cross-sector involvement is very important. To ensure that the NbS is meeting its goals for climate change adaptation and mitigation, it is also essential to have monitoring in place. Also see Chapter 4.3 below – NbS with a focus on disaster risk and preparedness.

Examples of NbS with a focus on climate change adaptation and mitigation

Many of the NbS described in the handbook have the potential to address climate change adaptation and mitigation. The following is a selection of these:

- No tillage: No, or reduced, tillage refers to the practice of sowing or planting the new crop, after harvest, without first tilling the soil.
- Closer-to-nature forest management: multipurpose forest management that addresses global societal challenges.
- Restoration and revegetation: restoring vegetation where vegetation has completely disappeared or restore degraded vegetation.
- Rain gardens and swales: Rain gardens and swales can mitigate the effects of frequent rainfall and snowmelt by slowing and filtering stormwater runoff. These structures can help prevent flooding, reduce pollution entering waterways, and recharge groundwater.
- Rewetting: Former wetlands that have been drained for human activities are rewetted applying different types of NbS that restore the natural hydrology of the area.
- Floodplain reconnection: Floodplain can be reconnected to its surrounding by applying different types of NbS that reconnect the hydrological connectivity between the river and the floodplain.

4.3 Disaster risk and preparedness

Disaster risk refers to the potential loss of life, injury, or destruction and damage from a disaster in a given time period. Disaster risk is usually expressed as a function of three key components: **Disaster Risk = Hazard x Exposure x Vulnerability.**[21]

- **Hazards**: a process, phenomenon or human activity that may cause a loss of life, injury, or other negative impacts.
- **Exposure**: the presence of people, assets, systems, or other elements in hazard-prone areas.
- **Vulnerability:** the conditions determined by physical, social, economic, and environmental factors that increase the susceptibility to the impacts of hazards.

21. https://www.undrr.org/

Some examples of disaster risks in Nordic countries are hazards such as extreme weather events, storms, forest fires, and landslides. Disaster risks are not limited to natural or ecological hazards. They can also involve risks related to technology failure, dam ruptures, pandemics or other infrastructure failures, power outages, or water supply disruptions.

Disaster preparedness refers to the knowledge and capacities developed by governments, response and recovery organisations, communities, and individuals to anticipate, respond to, and recover from the impacts of likely, imminent, or current disasters (European Commission, n.d.). Preparedness activities aim to build the capacities needed to manage all types of emergencies effectively and achieve orderly transitions from response to sustained recovery.

Key aspects of disaster preparedness include:

Contingency planning: developing arrangements in advance of potentially hazardous events	*Capacity building:* increasing knowledge and abilities of various actors to manage risks and emergencies	*Early warning systems*: implementing systems to provide timely alerts about potential hazards
Resource management: stockpiling equipment and supplies and arranging for their coordination and distribution	*Training and exercises*: conducting drills and simulations to test and improve response capacities	*Public information*: developing arrangements for communication and evacuation

Nordic countries are working to enhance their resilience to various disaster risks and improve their preparedness and ability to respond. An example is the Nordic Group for Public Health Preparedness, known also as the Svalbard Group.[22] Here the countries share information, skills, and knowledge about emergency preparedness, crisis and disaster management related to public health and social services. Countries also conduct national risk assessments to identify and analyze potential hazards, as well as extensive coordination exercises across sectors. Countries also provide self-preparedness guidance and recommendations for household emergency kits. Municipalities and county administrative boards often also have specific responsibilities within their geographical areas during crises.

22. https://nordichealthpreparedness.org/

Addressing disaster risk and preparedness with nature-based solutions

Nature-based solutions can play a role in disaster risk management (IFRC, n.d.; IUCN, 2017). In terms of *hazards*, NbS can help prevent or mitigate natural hazards. For example, forests and vegetation can stabilize slopes and reduce the risk of landslides. In terms of *exposure*, NbS can limit people's exposure to the hazards, for example protecting and restoring coastal vegetation and sand dunes can provide protection from storm surges and strong winds to coastal communities. In terms of *vulnerability*, NbS can help reduce overall vulnerability to disasters through supporting community well-being and generating environmental benefits.

Internationally, the concept of comprehensive disaster and climate risk management (CRM) now includes NbS as an integral part of planning for disaster risk reduction and climate change adaptation.[23] NbS have the potential to enhance disaster preparedness in several ways:

- By protecting and restoring ecosystems, communities can build resilience against future disasters.
- Providing cost-effective solutions to reducing disaster risks, complementing conventional measures .
- Providing multiple benefits as nature-based solutions aim to address various societal challenges simultaneously, such as disaster risk, climate change, food security, and water security.

To ensure that the NbS is meeting its goals for disaster risk and preparedness, it is essential to have systems for long-term monitoring and assessment in place.

Examples of NbS with a focus on disaster risk and preparedness

NbS for disaster risk management in a Nordic context can be adapted to the Nordic climate and landscape. They can leverage the natural landscape and biodiversity to mitigate the risks of floods, landslides, and coastal erosion. Such NbS can also provide co-benefits such as enhancing biodiversity, improving water quality, and contributing to human well-being. Some examples are:

- Revegetation and restoration of vegetation in mountain ecosystems: In steep terrains, reforestation and sustainable forest management practices can help reduce the risk of landslides. Tree roots can help stabilise the soil and prevent erosion, particularly after heavy rain or snowmelt.
- Reducing grazing pressure allows vegetation to recover, promoting stronger root systems that help stabilize the soil and prevent erosion. This can be particularly effective in areas prone to landslides, flooding, or wind erosion, as healthier vegetation creates a natural barrier to these risks.

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23. https://www.undrr.org/

- Prescribed burning: can reduce the risk of uncontrolled forest fires.
- Restoration and management of drained forested and afforested wetland and peatlands: can by acting as natural sponges absorbing excess water from heavy or prolonged rainfall and snowmelt help decreasing peak flows and downstream flooding risks. Rain gardens and swales or other nature-based stormwater structures: can help slow down and retain urban stormwater during heavy rain, which can overwhelm the urban drainage systems and cause urban flooding while also contributing to urban biodiversity and air quality improvements.
- Green and blue-green roofs: can help mitigate local stormwater flood risks and damages while also contributing to urban biodiversity and air quality improvements.
- River daylighting byremoving pipes and closing of artificial channelscan help mitigate flooding.
- Restoring natural waterways: can provide flood protection and enhance aquatic ecosystems.
- Reconnecting rivers to floodplains: can protect downstream areas from flooding by providing additional storage capacity for waters when inundating.
- (Re-)establishment of shallow lakes and ponds: can protect downstream areas from flooding in periods with high levels of precipitation, because of their capacity to store water.

4.4 Economic development

Economic development can be defined in many ways, but it involves the transformation of an economy in a country, region or community which improves the well-being and quality of life of the population. This typically involves increasing income levels, reducing poverty, creating jobs, improving access to education and healthcare, and improving living standards and environmental conditions.

Addressing economic development with nature-based solutions

Economic and social development is one of the most understudied societal challenges when it comes to how it can be addressed with nature-based solutions (Dunlop et al., 2024). However, NbS can support economic development in several ways.

Securing good environmental conditions is important for any economic sector, as all sectors are dependent on the provision of natural capital assets either directly or through their supply chains (World Economic Forum, 2020). Protecting and restoring ecosystems are therefore crucial to reduce financial risks caused by nature and biodiversity loss and provide sustainable jobs. A nature-based approach to climate change adaptation and disaster risk preparedness can also create more resilient landscapes, hence reducing damage to society and the economy (Lafortezza et al., 2018).

In an urban setting, investing in NbS can improve the urban environment and living conditions, which in turn can boost local property values, job creation and public health. Working with nature-based solutions can furthermore provide jobs, from planning to implementation and on-going maintenance and care. A recent study found that the demand for nature-based enterprises is on the rise (Tedeschini et al., 2024). Nature-based enterprises are driven by a mission to work with and for nature to address societal challenges and biodiversity loss. These enterprises use nature as a core element of their services.

Nature-based solutions should, by definition, address societal challenges while providing benefits for human well-being, ecosystem services and biodiversity. However, when working with NbS, one can easily forget to accommodate for ecosystem service provision that benefits human well-being and the economy. It is therefore important to pay attention to these aspects and make trade-offs when needed. Moreover, while improving the urban environment can boost the local economy, it can also cause "green gentrification" due to increased desirability to live in greener urban areas, with resulting increases in property prices, but this varies with proximity to city center, type and size of green space (Quinton et al., 2024).

Urban greening requires careful consideration and planning strategies for the improvement to benefit the targeted area without excluding or displacing population groups (Anguelovski et al., 2022; Bressane et al., 2024). For more information, see chapter 4.7 on social justice and capacity building. While NbS offer several opportunities for economic development, it can also, in some cases, pose challenges for certain sectors, such as forestry and agriculture, where profitability might be affected. Recognizing and addressing such potential impacts is essential to ensure a balanced approach.

To ensure that the NbS is meeting its goals for economic development, it is also essential to have monitoring in place. Monitoring of economic development can include indicators to monitor property values, number of new businesses and jobs created, retail and commercial activity, gross value added to local economy, recreational monetary value, or overall economic, social and health wellbeing in proximity to NbS.

4.5 Food security

Food should be accessible to all, safe and locally appropriate, and reliable through time and across space (IUCN, 2017).

Addressing food security with NbS

There are many conventional solutions that can address food security, such as improving access to food and improving incentives for local food production. However, food security is best addressed by combining conventional solutions with NbS that make better use of existing ecosystems, such as wetland restoration, agroforestry, and other NbS commonly used in cultural landscapes. NbS should be multi-faceted and use a holistic view to adapt food production to environmental and climate change, as well as keep in mind local issues that lead to reduced food security.

There are many ways to address food security issues, for example:

- Protecting or restoring ecosystems that can deliver ecosystem services that help ensure food security in case of natural disasters, political instability, or because of climate change.
- Protecting wild genetic resources.
- Protecting food crops from pests and diseases.
- Managing wild species.
- Managing water used for irrigation of crops.
- Addressing land tenure issues that can lead to food insecurity.
- Reducing reliance on imported food staples.

Examples of NbS with a focus on food security

- Crop rotation and intercropping: Crop rotation is the change of crops between harvests. This can be from one year to another or, depending on climate and crop type, several times over a season. Intercropping refers to when two or more crops are grown at the same time on the same piece of land. This may reduce soil and nutrient run-off through reduced exposed soil and improve soil health.
- No tillage: No, or reduced, tillage refers to the practice of sowing or planting the new crop after harvest without first tilling the soil. This reduces soil run-off, greenhouse gas emissions and improves soil health.
- Perennial crops: Perennial crops are crops that are not tilled after harvest but planted and then harvested year after year without replanting the crop. Most used examples are fruit trees and berry bushes. Soil health, pollinator and bird habitat can be potential nature benefits of such practice. Perennial cereal crops have not yet been fully developed.

- Mulching: Mulching is a collection of NbS that focuses on covering the soil and adding nutrients and organic matter to it. This can be compost, chopped plant material, or even living mulch in form of intercropping plants that grow under the main crop. This may reduce watering requirements, improve soil health and enable better waste management and nutrient recycling.

4.6 Human health and wellbeing

The World Health Organization defines human health as "...a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (Schramme, 2023).

Addressing human health and wellbeing in nature-based solutions

Healthy ecosystems, climate and biodiversity have been recognized as important determinants of human health and wellbeing. For instance, natural environments provide noise and heat regulation, promote physical activity, lower stress and give faster psychological recovery, improve air and water quality, provide cultural ecosystem services such as social interactions, aesthetics, recreation, spiritual values, and a sense of place. Natural areas are also a source of medicines and other pharmaceutical products which directly contribute to improved human health.

Human health and well-being is underrepresented in the research on NbS. Research tends to be skewed towards urban environments, and few studies assess the full range of human well-being benefits. Implementation of NbS should thus be followed up with monitoring of a broad range of human health and well-being outcomes. Documenting the specific well-being benefits of NbS would likely increase public support for such initiatives and can fall within the remit of a "one health" approach to ecosystem services. The World Health Organisation (WHO) describes One Health as "an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems."[24]

Though there are often many indirect ways in which NbS can improve human health, there are a variety of considerations that should be made when planning NbS addressing human health and wellbeing specifically. The IUCN and the WHO have made ten recommendations for ensuring human health and wellbeing in NbS:

1. Biodiversity, healthy ecosystems, and a stable climate are essential to achieving good health outcomes.
2. Educate and empower health professionals to engage in NbS.
3. Redesign food systems to be nature-positive, resilient and to sustain healthy communities.

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24. https://www.who.int/health-topics/one-health#tab=tab_1

4. Use nature-based solutions to support access to safe water, sanitation, hygiene, and waste management.
5. Integrate urban ecosystems with public health planning.
6. Redesign energy and transport systems to integrate green-gray infrastructure to support health.
7. Place equity at the centre of the design, governance, and implementation of nature-based solutions for health.
8. Empower Indigenous Peoples and under-resourced communities to safeguard human health and well-being.
9. Support/enable youth leadership and innovation in nature and health decision-making.
10. Finance inclusive NbS that prioritize health outcomes.

4.7 Social justice and capacity building

Social justice is to have a fair and equitable distribution of resources, benefits and costs, and the power to make decisions in all parts of society (Abbott, 2014). Key elements are transparency and inclusive participation with particular attention to the needs of vulnerable and marginalised communities.

Capacity building is about developing skills, knowledge, and resources with and for different actors – communities, organisations, and institutions to effectively plan, design, implement, and maintain NbS (UN, n.d.). This includes strengthening local expertise, fostering partnerships and creating supportive governance structures.

In NbS, social justice means ensuring fair access to natural resources and their benefits for all people. This includes inclusion in conservation and restoration activities or other measures. It also addresses inequalities related to who is affected by environmental degradation, for example different levels of exposure to air pollution among different socio-economic settings (Strandell et al., 2024). The aim of capacity building is to ensure fair, inclusive, and empowering processes that provide diverse actors with the opportunities and tools needed to participate in and benefit from NbS while addressing existing inequalities and enhancing resilience (World Bank, 2023).

Addressing social justice and capacity building in nature-based solutions

NbS can support equitable access to clean water and disaster resilience, which, depending on the socio-economic context may disproportionately affect vulnerable communities. In flood-prone areas or areas in risk of droughts, marginalized populations often suffer the most, and nature-based interventions can mitigate these effects, ensuring more inclusive and fair access to natural resources.

Community engagement and empowerment: NbS can involve local communities in planning and implementation, fostering a sense of ownership and empowering them to manage their natural resources sustainably, but again, this will depend on the socio-economic context. However, a participatory approach generally reduces inequality by giving all stakeholders, including underrepresented groups, a voice in decision-making processes.

It is therefore important to pay attention to who will benefit from the NbS. It should be identified if vulnerable or marginalized groups may be affected by barriers to participating in or benefiting from the NbS project. Barriers to inclusion physical, financial, informational, attitudinal, institutional. The project should carefully consider how benefits from the NbS will be distributed and take actions to ensure that all, marginalized groups in particular, can access them equitably. This may involve targeted outreach, tailored program design, or setting specific inclusion targets.

NbS can involve local communities in planning and implementation, fostering a sense of ownership and empowering them to manage their natural resources sustainably, but this also depends on the socio-economic context. However, a participatory approach generally reduces inequality by giving all stakeholders, including underrepresented groups, a voice in decision-making processes.

Local engagement can ensure that the NbS is aligned with local priorities and complement existing programs or services. Cross-sector partnerships can contribute to this by leveraging diverse expertise and resources for implementation.

Capacity building measures can ensure participation and enhance empowerment. Such measures need to be tailored to the socio-economic context of the NbS initiative. Working with local experts and leaders is relevant when developing and delivering training, but local power relations should also be considered. Ongoing support can be provided by offering a range of resources and communication channels to support engagement and skill development beyond one-off training.

It is particularly relevant to equip practitioners with knowledge and skills to select, adapt, implement and evaluate NbS in their specific context. Improving awareness, providing resources, and creating mechanisms for local action and ownership and supporting bottom-up initiatives is key. The resource limitations of community organizations need to be considered when designing capacity-building efforts. It is important to be considerate of the existing power dynamics and work towards an equitable distribution of power in co-design processes.

4.8 Water management

Water management involves the processes of planning, developing, distributing, and managing the use of water resources. It involves a range of practices to control water availability, quality, and distribution to meet human and environmental needs, balancing competing demands such as domestic use, agriculture, industry, and ecosystem conservation.

NbS are increasingly recognized as integral to a sustainable water management, as multiple objectives such as flood and drought mitigation, water quality improvement, biodiversity conservation, and climate resilience can be addressed that will create a more resilient and balanced water cycle. Sound water management can therefore support and provide a wide range of ecosystem services including provisioning services (food, fuel, genetic material), regulating services (flood regulation, water purification, erosion regulation), supporting services (nutrient cycling) and cultural services (recreational, educational and aesthetic).

Addressing water management in nature-based solutions

Water management and NbS are closely linked, as NbS leverages natural processes to address water-related challenges in sustainable ways. By utilizing or restoring natural ecosystems, NbS offer alternative or complementary solutions to traditional, engineered approaches in water management. These methods enhance resilience, promote biodiversity, and provide cost-effective, adaptable solutions to water-related issues. For example, NbS like restoring wetlands and floodplains absorb and slow floodwaters, reducing the risk of floods in downstream areas and enhance the infiltration of water to the groundwater thereby increasing the recharging of aquifers. At the same time these areas can treat and retain pollutants from runoff before it reaches the rivers or groundwaters thereby enhancing water quality. To effectively address water management through NbS, it is essential to adopt large-scale, catchment-level planning, as many benefits will naturally manifest downstream of the NbS implementation area.

Predicting the efficacy of different NbS for water management can be challenging, as outcomes depend on the project area's initial characteristics and the scale of the challenges the NbS aims to address. Therefore, it is recommended to use modeling tools or similar approaches before implementation to assess whether the NbS can achieve sufficient impact and to set realistic goals. These could involve goals related to for example:

- capacity to store and retain precipitation water relative to the dynamics of the precipitation events (duration and magnitude)
- capacity to purify water which will depend on the quality and quantity of the water entering the area and local characteristics of the soil including the infiltration capacity
- nitrogen and phosphorus concentration or load
- metal concentration or load

Examples of NbS with a focus on water management

- Remeandering: A previously straightened or channelized stream is returned to a more natural, meandering (curving) planform.
- Raising riverbed level: The stream bed level of a previously cut down stream is elevated to reconnect the river with the surrounding area.
- Ditch and drain blocking and filling: Man-made drainage ditches and drains that were originally constructed to lower the water table for purposes like agriculture are obstructed or filled completely.
- Disconnect functioning drainpipes: Artificial drainage systems are disconnected to prevent the water from entering directly into the stream.
- Rewetting: Former wetlands that have been drained for human activities are rewetted applying different types of NbS that restore the natural hydrology of the area.
- Floodplain reconnection: Floodplain can be reconnected to its surrounding by applying different types of NbS that reconnect the hydrological connectivity between the river and the floodplain.
- (Re-)establishment of shallow lakes and ponds: Small, shallow bodies of water are created in areas where they have been lost, degraded, or were not previously present.

5. Ecosystems

Here we describe six ecosystem types (coastal, cultural landscapes, forests, mountains, urban, and freshwater ecosystems including rivers, lakes and wetlands) and give examples of NbS that can be implemented in these ecosystems. In the earlier S-ITUATION project we also developed facts sheets for agricultural landscapes,[25] coastal and marine,[26] forest,[27] urban,[28] and wetland ecosystems.[29]

5.1 Coastal

Coastal ecosystems include areas affected by the tide (intertidal zone) as well as those further out on the continental shelf. They also include adjacent land areas. The Nordic coastal region includes the Northeast Atlantic coasts of Norway, Denmark, the Faroe Islands, Iceland and Greenland along with the Baltic Sea coasts of Denmark, Sweden, Åland and Finland. Key coastal habitats here include soft bottom habitats, blue mussel beds, seagrass meadows, kelp forests and seaweeds.

Coastal ecosystems as nature-based solutions

Well-functioning coastal ecosystems provide a range of benefits to humans. These include i) climate change mitigation and adaptation through, for instance, carbon storage, erosion control, wave attenuation, ii) economic development from, for instance, harvesting marine resources and tourism, iii) food security from sustainable fisheries and aquaculture, iv) human health and well-being through a myriad of cultural ecosystem services such as aesthetics, recreation, social relationships, spiritual values, along with resources to tackle medical societal challenges through marine bioprospecting.

25. https://nordicsituation.com/wp-content/uploads/2022/12/s-ituation-factsheet-agriculture.pdf
26. https://nordicsituation.com/wp-content/uploads/2022/12/s-ituation-factsheet-coast-and-marine.pdf
27. https://nordicsituation.com/wp-content/uploads/2022/12/s-ituation-factsheet-forests.pdf
28. https://nordicsituation.com/wp-content/uploads/2022/12/s-ituation-factsheet-urban-nbs-1.pdf
29. https://nordicsituation.com/wp-content/uploads/2022/12/s-ituation-factsheet-wetlands.pdf

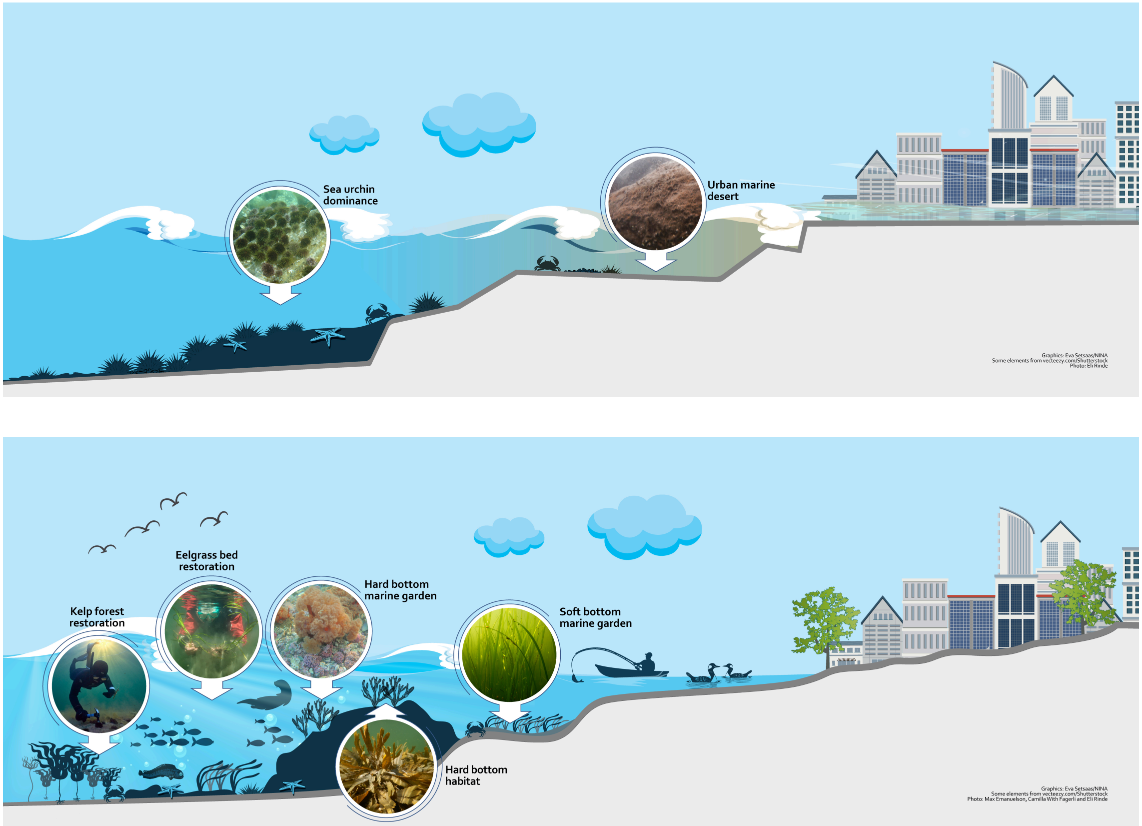

Figure 6. Infographic for coastal ecosystems, before and after NbS

NbS that can be implemented in coastal areas

- **Eelgrass meadow restoration**: the restoration of eelgrass meadows. Example in Horsens Fjord in Denmark.[30]
- **Artificial blue forests**: the active cultivation of kelp forest. For example, North Sea Farm 1: a pilot project to cultivate seaweed within an offshore wind farm.[31]
- **Sea urchin removal**: sea urchin removal for passive kelp forest restoration. For example, in Norway, Troms County, there is a project that is using sea urchin removal as a tool to connect people with nature conservation, and science with the rest of society, facilitating regenerative travelling.[32]
- **Soft and hard bottom marine gardens**: constructing underwater landscapes and terrain to allow for the restoration of diverse and robust marine habitats and communities.

30. https://www.sdu.dk/en/nyheder/endelig-breder-aalegraesset-sig
31. https://www.northseafarmers.org/projects/nsf1
32. https://wildlabprojects.org/project/snorkel-&-restore-kelp-forests-around-troms%C3%B8/PP0RLU/

Examples of coastal and marine NbS from the S-ITUATION project can be found here[33] and in the online handbook.[34]

5.2 Cultural landscapes

Cultural landscape is a term used to describe the interaction between human activity and the environment and falls into three main categories according to the World Heritage Committee:[35]

1. "a landscape designed and created intentionally by man"
2. an "organically evolved landscape" which may be a "relict (or fossil) landscape" or a "continuing landscape"
3. an "associative cultural landscape" which may be valued because of the "religious, artistic or cultural associations of the natural element."

Cultural landscapes are found throughout the Nordic countries. In highland, stony, and mountainous areas you can find mainly low-productive grassland areas used for animal husbandry. In the lowlands you tend to find more intensively managed agricultural fields, with crops such as wheat, rapeseed and sugar beets.

Cultural landscapes as nature-based solutions

The main purpose of cultural landscapes is to provide food; hence they are essential for the societal challenge food security. Nature-based solutions within the cultural landscape are meant to counteract negative impacts of agricultural activities. This includes biodiversity protection by supporting flora and fauna, for example meadow flowers, birds, and insects, as well as reduced eutrophication, greenhouse gas emissions, soil erosion and degradation.

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33. https://nordicsituation.com/wp-content/uploads/2022/12/s-ituation-factsheet-coast-and-marine.pdf
34. https://nbsguide.org
35. https://en.wikipedia.org/wiki/World_Heritage_Site

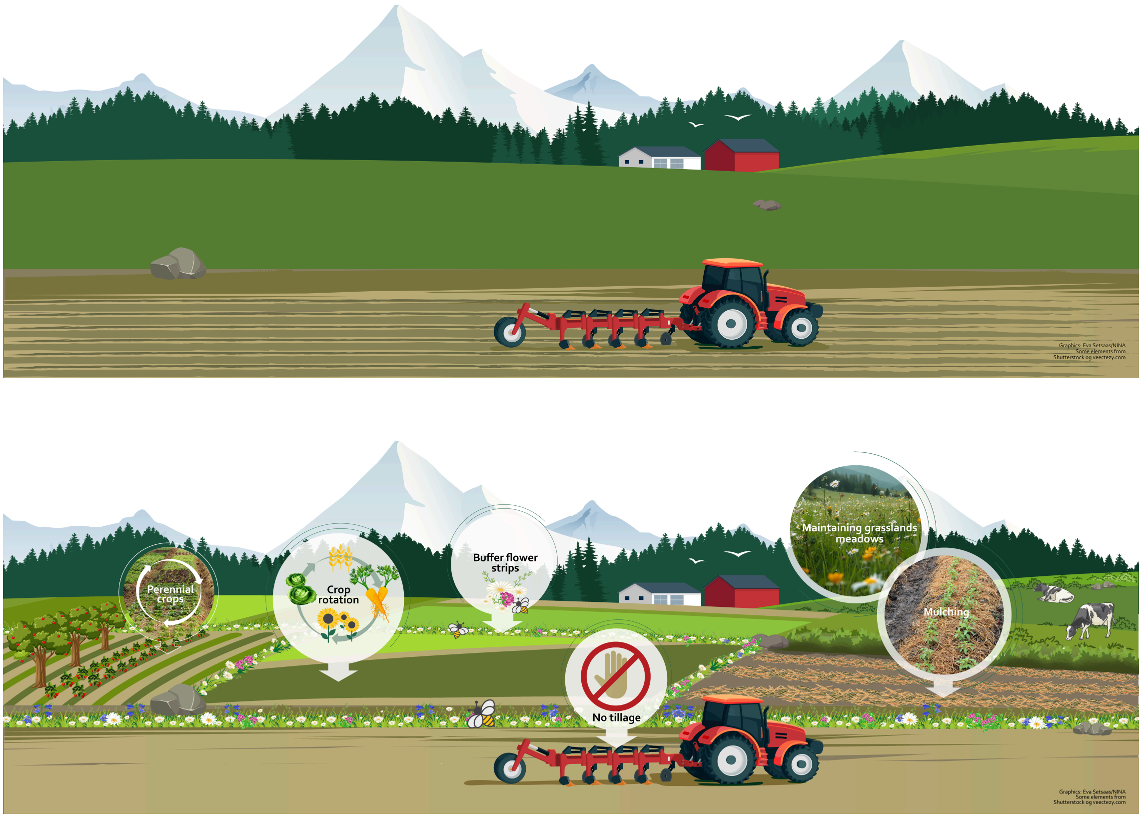

Figure 7. Infographic for cultural landscapes, before and after NbS

NbS that can be implemented in cultural landscapes

- **Flower strips/buffer zones**: Buffer zones and flower strips are types of vegetation structure planted to serve a specific purpose. This can be, for example, to protect a water course by taking up excess phosphor from field run-off, provide floral resources to insects, provide food and shelter to animals, or protect against soil erosion.
- **Maintaining grasslands and meadows**: Maintaining and creating grasslands and meadows is an important conservation measure for semi-natural and natural ecosystems in the cultural landscape.
- **Crop rotation and intercropping**: Crop rotation is the change of crops between harvests. This can be from one year to another or, depending on climate and crop type, several times over a season. Intercropping refers to when two or more crops are grown at the same time on the same piece of land.
- **No tillage**: No, or reduced, tillage refers to the practice of sowing or planting the new crop after harvest without first tilling the soil.

- **Perennial crops**: Perennial crops are crops that are not tilled after harvest but planted and then harvested year after year without replanting the crop. Most used examples are fruit trees and berry bushes. Perennial cereal crops have not yet been fully developed.
- **Mulching**: Mulching is a collection of NbS that focuses on covering the soil and adding nutrients and organic matter to it. This can be compost, chopped plant material, or even living mulch in form of intercropping plants that grow under the main crop.

Examples of NbS in the agricultural landscape can be found here[36] and in the online handbook.[37] There are also many water-related NbS that can be implemented in agricultural landscapes (see Chapter 5.6 Rivers, lakes and wetlands).

5.3 Forest

A forest is a complex ecological system where trees are the dominant life-form. Forests can develop under various conditions, with various soil types, plant and animal species.

Forests and other wooded land cover 55% of the Nordic countries. In Finland and Sweden, this figure exceeds two-thirds, making them the most forested countries in Europe. The percentage of forested land in Norway and Denmark is 38% and 15%, respectively. Forest cover in Iceland is approximately 0.5% of the total land area.

Coniferous species dominate Nordic forests, with pine and spruce accounting for 78% of the standing stock. Pine is the dominant species in Finland and Sweden, while spruce is the most common species in Norway. Seventy-one percent of the broad-leaved species are birch, with the remaining 29% being smaller volumes of aspen, alder, maple, oak, and beech. Forests in Denmark and Iceland are dominated by broad-leaved species.

Forests as nature-based solutions

Nordic forest is a significant player in the combat against climate change, both as a carbon sink and as a provider of substitutes to fossil-based products. Forests are also home to thousands of species, some unique to the Nordic region, and provide a popular recreation area for people.

Afforestation or forest-related NbS can be located in forests, but also urban areas or abandoned agricultural lands, for example. Forest NbS can address multiple societal challenges: biodiversity enhancement (creating habitat for forest species),

36. https://nordicsituation.com/wp-content/uploads/2022/12/s-ituation-factsheet-agriculture.pdf
37. https://nbsguide.org

climate change mitigation and adaptation (via carbon sequestration), economic development (timber production and other services), food security (a source of local berries, mushrooms, medicinal plants etc.), human health and wellbeing (e.g. recreational areas, fresh air, medicinal plants), and water management (restored or improved hydrology and better water quality).

Seventy-five percent of the Nordic countries' forestland is privately-owned. Finland has the highest share of publicly owned forests (31%), and Norway has the smallest percentage (20%).

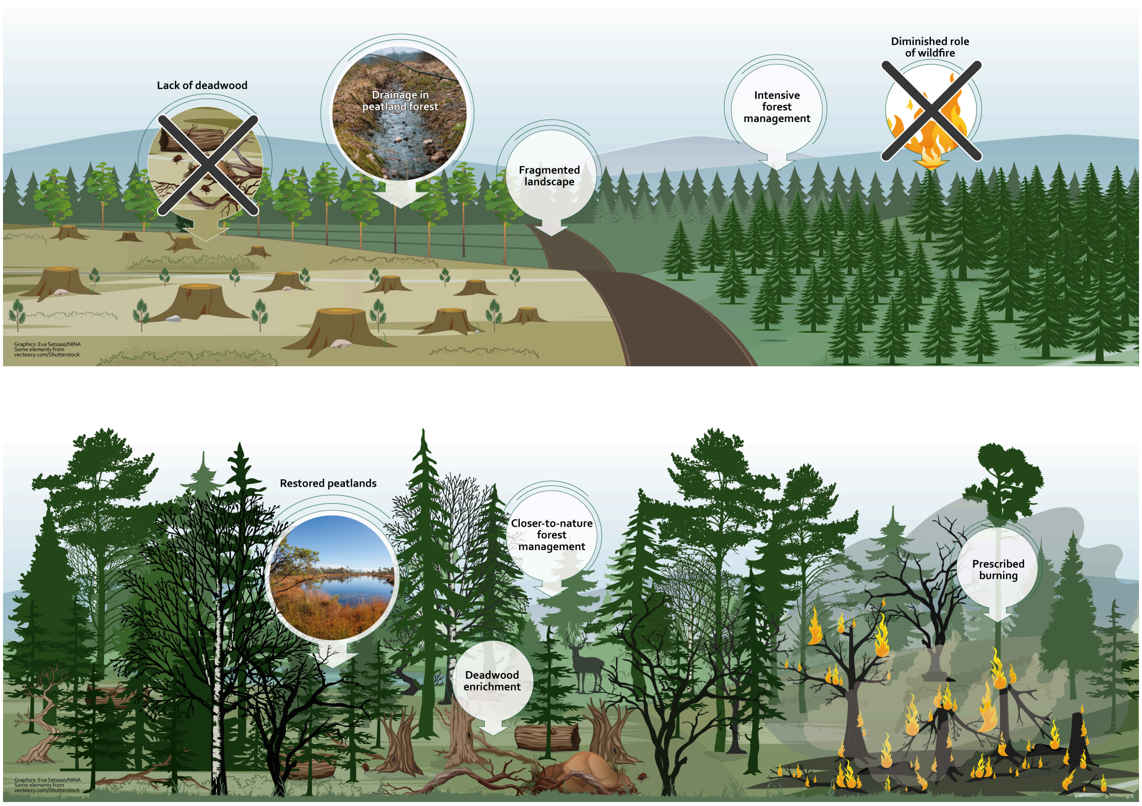

Figure 8. Infographic for forests, before and after NbS.

NbS that can be implemented in forests

- **Closer-to-nature forest management**: multipurpose forest management that addresses global societal challenges.
- **Deadwood enrichment**: retaining and creating deadwood as a part of closer-to-nature management and ecological restoration. For example, the EVO experiment in southern Finland, which focuses on the effects of prescribed burning, tree retention and downed deadwood creation on the deadwood profile in managed boreal Norway spruce forest stands over a 16-year period (Shorohova et al, 2024).

- **Prescribed burning**: an intentional and controlled burning of an area for ecological restoration or silvicultural purposes (in Nordic countries).
- **Restoration and closer-to-nature management of drained forested and afforested peatlands:** rehabilitation of forested peatlands' nature and ecosystem functions and services. For example, see the best practice report on ecological restoration in drained peatlands from Finland (Similä et al 2014)

Examples of NbS in forests can be found here[38] and in the online handbook.[39]

5.4 Mountains

Mountain or "montane" ecosystems are found on the slopes of mountains. Because the climate gets colder with elevation, the composition of the flora and fauna depends on elevation. As such, bands or zones of similar vegetation can be distinguished at similar elevations. These zones were already observed by early explorers such as Alexander von Humbolt and described as similar across the globe, although species identities differ regionally. At moderate elevations forests dominate, while small-stature plants are the only ones that endure the harsh conditions at high elevations. The ecosystems above the tree line are referred to as "alpine". The very highest regions of the alpine are permanently covered by snow and ice.

A variety of ecosystems covered elsewhere in this handbook can occur in steep terrain, for example **forests** and **lakes**. Mountains can also include wetlands and mires, as well as cultural landscapes. Mountains in the Nordic countries are used extensively as grazing areas for reindeer, sheep and cattle.

The Scandinavian mountains stretch from southern Norway to Northern Finland and include the western and northern parts of Sweden. Mountains up to an elevation of 880 m a.s.l. are also found on the Faroe Islands.

Mountains as nature-based solutions

Mountain ecosystems provide a wide range of ecosystem services[3] and thereby contribute to the societal challenges biodiversity enhancement (e.g., creating habitat for species), climate change adaptation (e.g., carbon storage), disaster risk and preparedness (e.g., landslides, floods), and water management (e.g., access to drinking water). Where mountain areas are used for grazing or hunting, they contribute to the societal challenge of improving food security.

38. https://nordicsituation.com/wp-content/uploads/2022/12/s-ituation-factsheet-forests.pdf
39. https://nbsguide.org

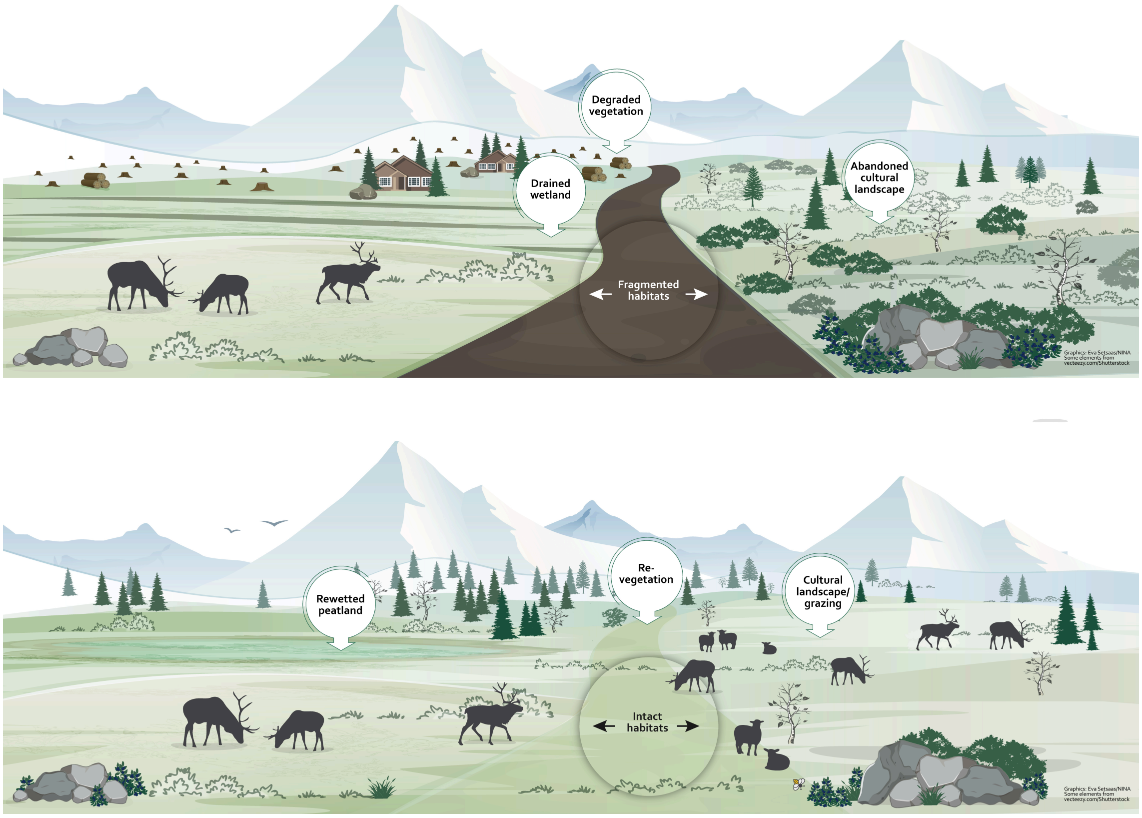

Figure 9. Infographic for mountains, before and after NbS.

NbS that can be implemented in mountains

- **Restoration and revegetation**: restoring vegetation where vegetation has completely disappeared or restore degraded vegetation. See for example the restoration project at the shooting range in Hjerkinn, Dovrefjell in Norway,[40] or the Lendisbati project on the Faroe Islands.[41]
- Other NbS can also be implemented in mountain ecosystems, for example: remeandering of rivers, rewetting of mires, maintaining grasslands and meadows and closer-to-nature forest management.

Further examples on NbS can be found in the online handbook.[42]

40. https://www.nina.no/english/Sustainable-society/Restoration-Ecology/Hjerkinn-military-training-area
41. https://networknature.eu/pilot-project-first-large-land-restoration-initiative-faroe-islands
42. https://nbsguide.org

5.5 Urban

An urban ecosystem refers to the interaction between natural processes and human activities within a city or urbanised area. In the Nordic region, urban ecosystems are shaped by a unique blend of cultural and environmental factors, including seasonal variations and proximity to natural landscapes such as forests, lakes, streams and fjords. Urban ecosystems are strongly influenced by human activities that have modified the once natural environment. The interplay and mosaics between built infrastructure and natural spaces creates habitats to species that can adapt to such urban environments. However, the species composition may differ from those in more natural environments.

Urban ecosystems in the Nordics face challenges such as air and water pollution, as well as noise and light pollution, from transportation, industry, burning of wood for heating and other human activities. As cities and urban areas expand, natural habitats are often replaced by buildings, roads, and parking lots, fragmenting ecosystems and impacting biodiversity. However, urban environments also offer unique opportunities for nature-based solutions. Making nature a part of cities through parks, green rooftops, community gardens and blue features like ponds, streams and raingardens has become increasingly important.

Urban ecosystems and nature-based solutions

Integrating NbS into urban areas can enhance biodiversity, reduce pollution, and help adapt to climate change, while also improving the quality of life for urban communities. Urban biodiversity is essential for the resilience of cities. Green spaces, urban forests, and rain gardens provide ecosystem services crucial for humans and wildlife. For example, trees can provide shade that help regulate temperature and absorb stormwater and, in some cases, contribute to air quality, but this is more uncertain (Venter et al. 2024).

Rain gardens play a vital role in managing stormwater by retaining and treating runoff, for example from roads, and reducing pollutants such as heavy metals and nutrients before they enter urban waterways. Cities are also increasingly recognizing the physical and mental health benefits of access to nature. Incorporating NbS into urban planning and development can improve livable environments.

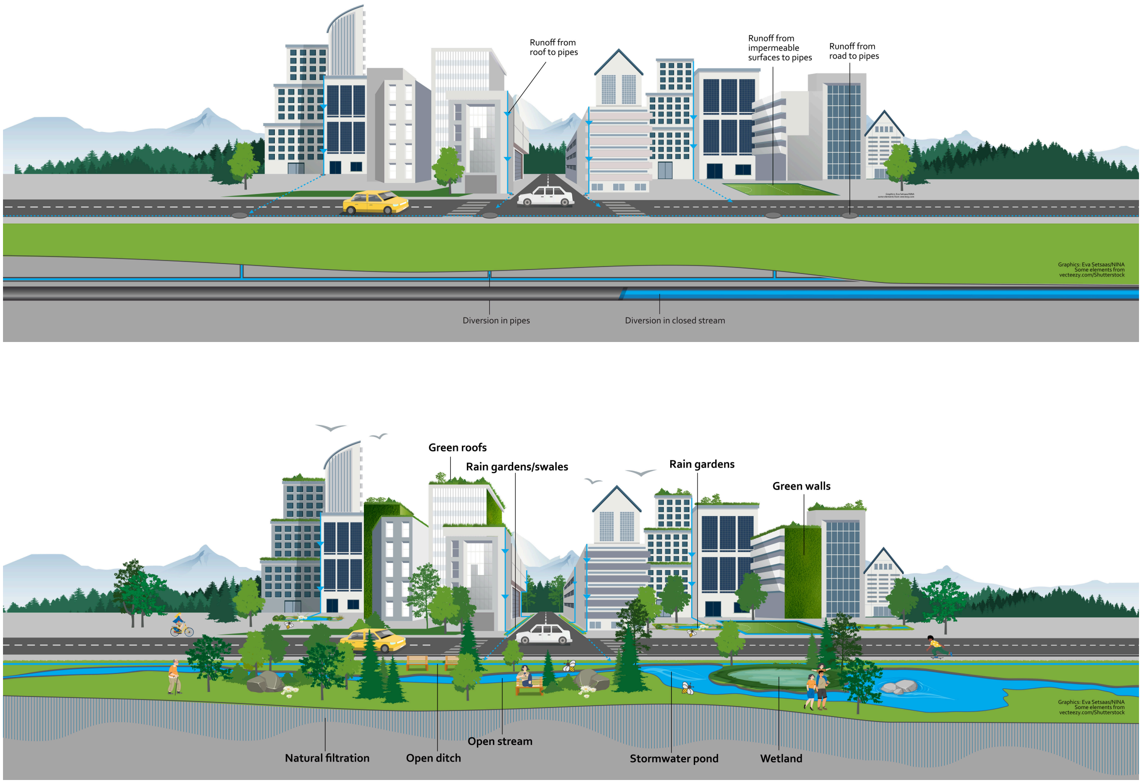

Figure 10. Infographic for urban areas, before and after NbS.

NbS that can be implemented in urban areas

- **Green roofs and walls:** Green roofs can help reduce stormwater and regulate local temperatures to reduce urban heat island effects, improve air quality, and create habitats for local species including birds and bees, butterflies, beetles and other invertebrates. Green and blue-green roofs (e.g. Blue-green roof on Vega Scene in Oslo[43]), as well as green walls, are particularly beneficial in densely built environments with limited ground-level green space.
- **Rain gardens and swales:** In the Nordic region, where frequent rainfall and snowmelt can lead to significant stormwater runoff on hard surfaces, rain gardens and swales offer solutions to manage stormwater, reduce flooding risks, and retain and treat pollutants from the urban environment. These structures can help prevent flooding by slowing runoff, reduce pollution entering waterways, and recharge groundwater. Care needs to be taken for these structures to be beneficial for biodiversity, for example in thinking about which plants and vegetation are used in the solutions.

43. https://www.bergknapp.no/vegascene

- **River daylighting and urban wetlands restoration**: Restoring or creating urban rivers, lakes, and wetlands can help improve water quality, reduces flood risks, and provides critical habitats for aquatic and terrestrial species. For example, see the river reopening example at Hovinbekken, Oslo.[44] Wetlands also play a role in carbon sequestration and can contribute to climate change mitigation.
- **Urban trees and forests:** Planting street trees and protecting or restoring urban forests can help cool down city areas and reduce the impact of heat waves as well as protect against wind. Trees can also absorb stormwater and offer habitats for birds and other species while also contributing to the aesthetic and recreational value of urban spaces.

Examples of NbS in urban areas can be found here[45] and in the online handbook.[46]

5.6 Rivers, lakes and wetlands

Rivers, lakes and wetlands are saturated with freshwater, either permanently or seasonally, creating unique habitats for a variety of aquatic plants and animals. These ecosystems are typically characterized by vegetation adapted to waterlogged, oxygen-poor soils, and can include marshes, swamps, and bogs. Freshwater wetlands are especially valuable for their role in filtering water, reducing flood impacts, and providing habitat for biodiversity. In the Nordics, rivers, lakes and wetlands are diverse and ecologically significant, playing a crucial role in supporting biodiversity, regulating water flow, and sequestering carbon. Wetlands in the Nordics range from small streams, over large lakes to peatlands, and they are integral to the region's natural landscape and cultural heritage. As such, wetlands are also an important ecosystem in agricultural systems, which are dependent on water availability and are also often the source of degradation of these ecosystems. Below is a list of some of the main types of wetlands:

- **Peatlands – bogs**: Common across the Nordic region, especially in Finland and Sweden. Bogs are acidic, nutrient-poor wetlands dominated by sphagnum mosses. They often form in cool, humid climates and accumulate thick layers of peat.
- **Peatlands – fens**: Found throughout the Nordics, fens are less acidic and more nutrient-rich than bogs. They are often fed by groundwater and support a diverse array of plant life, including sedges, grasses, and various flowering plants.

44. https://hovinbekken.org/
45. https://nordicsituation.com/wp-content/uploads/2022/12/s-ituation-factsheet-urban-nbs-1.pdf
46. https://nbsguide.org

- **Marsh**: A marsh is a type of wetland that is dominated by herbaceous plants rather than woody vegetation like trees and shrubs. It typically has shallow, standing or slow-moving freshwater or brackish water and is characterized by waterlogged, nutrient-rich soils. These wetlands often occur along the edges of rivers, lakes, and estuaries, serving as transition zones between aquatic and terrestrial ecosystems.
- **Shallow Lakes and Ponds**: The Nordic region is dotted with thousands of lakes and ponds, many of which are surrounded by wetland areas. These water bodies support a variety of aquatic life and are important for migrating birds and amphibians, for example.
- **Riverine/floodplain wetlands**: These wetlands are found along rivers, particularly in Sweden and Finland. They play a crucial role in flood management and provide habitats for species like beavers, otters, and a wide range of birds.
- **Forested Wetlands/swamps**: Forested wetlands, particularly those dominated by pine or spruce, are common in the Nordic countries. These swamps often occur in conjunction with peatlands and are important for species like moose and various bird species.

Rivers, lakes and wetlands as nature-based solutions

Nature-based Solutions in wetlands address a range of societal challenges by leveraging the inherent capabilities of these systems. Below are some of the main societal challenges that can be effectively addressed applying NbS in rivers, lakes and wetlands:

Disaster risk and preparedness – Flood Risk Management:

Challenge: Increasing frequency and intensity of floods due to climate change and urbanization.

NbS Application: Restoring rivers, lakes and wetlands help absorb and slow down floodwaters, reducing the risk and severity of floods in downstream areas.

Water Management – Water Quality Improvement:

Challenge: Pollution and nutrient runoff from agricultural and urban areas degrading water quality.

NbS Application: Wetlands act as natural filters, trapping sediments, nutrients, and pollutants. Restoration of wetlands can reduce nutrient overload, prevent sedimentation, and treat and retain contaminants from water sources. This not only improves the ecological balance of rivers, lakes, and coastal areas but also contributes to e.g. cleaner drinking water. In this way, wetland restoration is a cost-effective strategy for enhancing water quality and protecting both environmental and human health.

Biodiversity enhancement – Biodiversity Loss:

Challenge: Habitat destruction and fragmentation leading to declines in species populations and loss of biodiversity.

NbS Application: Rivers, lakes and wetlands provide critical habitats for a diverse array of species. By protecting and restoring these ecosystems, biodiversity can be enhanced by supporting the survival of both aquatic and terrestrial species.

Climate Change Mitigation:

Challenge: Rising greenhouse gas emissions contributing to global warming.

NbS Application: Wetlands, particularly peatlands, are critical carbon sinks that play a vital role in mitigating climate change. By preserving and restoring these ecosystems, large amounts of carbon dioxide can be sequestered and at the same time the release of greenhouse gases can be prevented. This is especially important, as disturbed wetlands, such as drained peatlands, can emit significant quantities of carbon, methane and nitrous oxide.

Climate Change Adaptation:

Challenge: Increasing temperature and changing precipitation patterns affecting communities and ecosystems.

NbS Application: By protecting and restoring rivers, lakes and wetlands it is possible to help communities adapt to climate change by providing natural buffers against extreme weather events, stabilizing local climates, and maintaining water availability during dry periods.

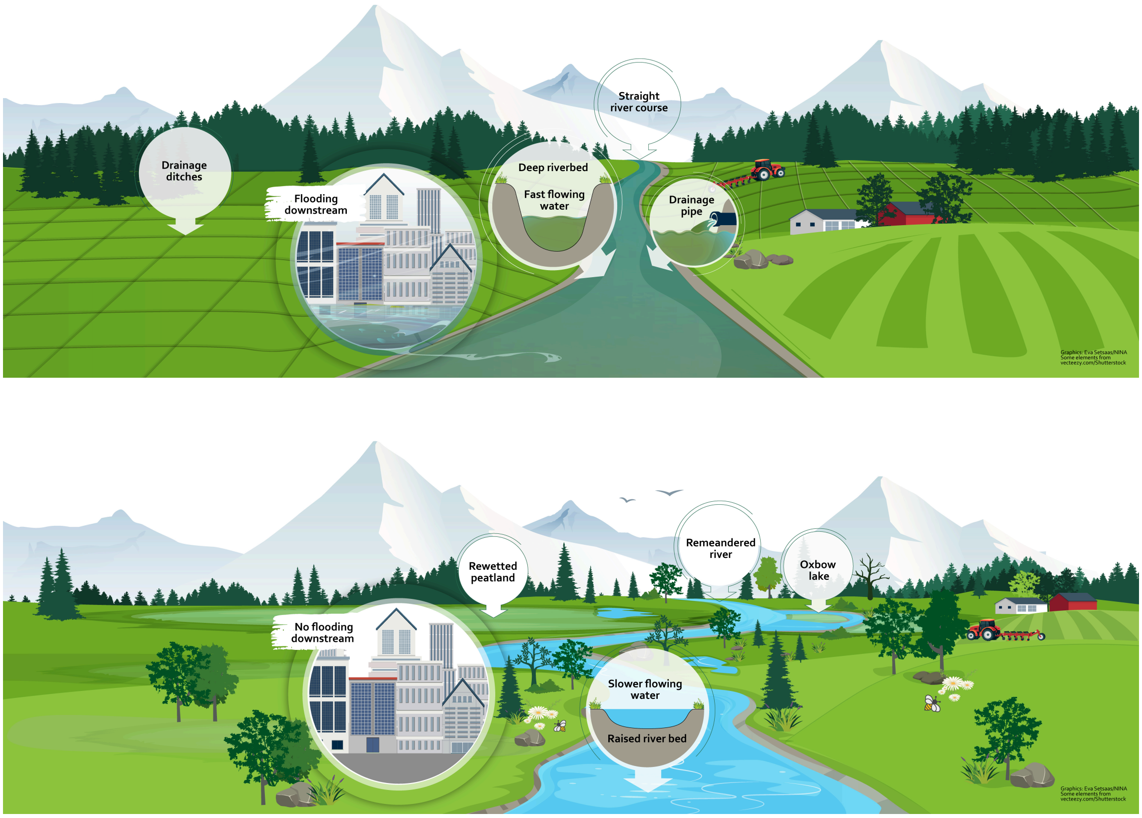

Figure 11. Infographic for wetlands, before and after NbS.

NbS that can be implemented in rivers, lakes and wetlands

- **Remeandering**: A previously straightened or channelized stream is returned to a more natural, meandering (curving) planform.
- **Raising riverbed level**: The stream bed level of a previously cut down stream is elevated to reconnect the river with the surrounding area.
- **Ditch and drain blocking and filling**: Man-made drainage ditches and drains that were originally constructed to lower the water table for purposes like agriculture are obstructed or filled completely. For example, the Kylldal catchment of the Kyll river near Steinebruck (Nauta et al., 2024).
- **Disconnect functioning drainpipes**: Artificial drainage systems are disconnected to prevent the water from entering directly into the stream. For example, Kvorning, the river valley to Nørreåen in central Jutland.[47]
- **Rewetting**: Former wetlands that have been drained for human activities are rewetted applying different types of NbS that restore the natural hydrology of the area.

47. https://naturstyrelsen.dk/ny-natur/klimalavbundsprojekter/klima-lavbundsprojekt-ved-kvorning-i-noerreaadalen

- **Floodplain reconnection**: Floodplain can be reconnected to its surrounding by applying different types of NbS that reconnect the hydrological connectivity between the river and the floodplain.
- **(Re-)establishment of shallow lakes and ponds**: Small, shallow bodies of water are created in areas where they have been lost, degraded, or were not previously present.

Examples of NbS in wetlands can be found here[48] and in rivers, lakes, and wetlands the online handbook.[49]

48. https://nordicsituation.com/wp-content/uploads/2022/12/s-ituation-factsheet-wetlands.pdf
49. https://nbsguide.org

6. Examples of NbS

Here we give examples of different types of NbS that can be found in the online handbook, one from each ecosystem, and one more general NbS: creation and restoration of marine gardens, crop rotation, deadwood enrichment, revegetation and restoration of terrestrial vegetation, green and blue-green roofs, rewetting of wetlands, and restoration. More details, including case studies can be found in the online guide.

6.1 Restoration

Ecological restoration is a highly variable group of nature-based solutions (NbS) where the main aim is to assist the recovery of natural structures, functions and processes of an ecosystem that has been degraded, damaged or destroyed.

Any ecosystem can be restored, but the degree of restoration success depends on many factors, such as how much the original ecosystem has been degraded, which natural processes have been disrupted, if there is intact nature near the area that is to be restored, how suitable the restoration plan is regarding restoration methods and goals.

Any societal problem can be addressed by restoration actions, and the degree to which the societal problem is addressed is dependent on the restoration goals of the project. Ideally, your restoration project should address multiple societal problems.

Restoration has been highlighted by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) as a crucial tool to prevent and reverse landscape degradation, protect climate, promote biodiversity enhancement, ecosystem services, and to achieve the UN Sustainable Development Goals. The Intergovernmental Panel on Climate Change (IPCC) also states the need for restoration to reduce carbon emissions and to support climate change adaptation and mitigation.

How to apply this NbS

The easiest way to restore nature is to use local nature as a template for your NbS. You may want to restore key biotopes, a specific vegetation type or habitat, or remove a specific invasive alien species. Thus, the methods used for different restoration actions in different ecosystems and contexts are highly variable. There are, however, some general principles and guidelines for ecological restoration. This handbook also covers existing Guidance and tools for NbS which may be of interest to help you plan your restoration project.

The UN Decade on Ecosystem Restoration's Best Practices Task Force, the International Union for Conservation of Nature's Commission on Ecosystem Management (IUCN CEM) and the Society for Ecological Restoration (SER) have suggested ten principles of ecological restoration, which can be used to guide restoration throughout the UN Decade on Ecosystem Restoration 2021–2030. The ten principles state that good ecosystem restoration:[50]

1. Contributes to global policy frameworks.
2. Promotes fair and inclusive engagement.
3. Includes a continuum of restorative activities.
4. Aims at the highest recovery possible to benefit nature and people.
5. Addresses the causes of degradation.
6. Incorporates all types of knowledge.
7. Sets ecological, cultural and socio-economic goals.
8. Tailors activities to local and land/seascape contexts.
9. Measures results and adapts actions.
10. Integrates policies and measures for lasting impacts.

Regardless of the type of societal problem that you wish to address with your restoration action, you should have a plan for how you wish to enhance biodiversity. Biodiversity encompasses the variety of life in all its forms, including species diversity, genetic variation, and ecosystem diversity and setting clear biodiversity targets that can be followed over time.

Important considerations

Restoration science and practice is a field with a long history, but there are still many new concepts and theories that are needed to understand potential conflicts arising from an upscaling of restoration activities. Ecosystem restoration involves diverse activities with large variation in restoration targets, value considerations, spatial and temporal scale. The level of degradation, as well as environmental conditions, available resources, and socio-economic factors, is essential for deciding on restoration targets and interventions needed to achieve them. Restoration to compensate for habitat loss, within the no-net-loss context, has recently become more explicit, along with the need for evidence for improved ecological conditions in ecologically degraded sites.

50. https://openknowledge.fao.org/items/fb87513e-cd4d-42dd-a78d-48fd29afd4ca

The costs of restoration vary greatly and are dependent on the ecosystem type, level of intervention (i.e. full restoration of all ecosystem functions, or specific ecosystem functions), and the degree to which the original ecosystem has been degraded.

6.2 Creation and restoration of marine gardens

Marine urban rewilding focuses on restoring lost habitats such as kelp forests, seagrass beds and saltmarshes, while also creating novel ecosystems that have no natural equivalent. This NbS focuses on shaping urban coastal and constructed landscapes as well as implementing necessary actions to enhance environmental conditions in the marine urban areas. The goal is to create or restore diverse, resilient marine habitats that support native species. While similar landscape approaches are commonly applied in the planning of green spaces on land, they are often overlooked in marine environments. This NbS aims to rewild so-called "marine deserts", devoid of life, and prevent the degradation of ecosystems when developing new structures in coastal waters.

Figure 12. Illustration of an urban landscape with no facilitation of soft and hard bottom marine gardens, and what a marine garden can look like. Design/photo Eli Rinde, NIVA.

This NbS is applicable to urban areas, industrial parks and other locations where artificial structures are built into the sea. The NbS can be used to repair or restore lost marine habitats and biodiversity in coastal cities, and as a guideline to minimize habitat and biodiversity loss in new development projects. Urban structures that typically need biodiversity enhancing measures include concrete walls and floors and constructed hard shorelines. It can also be used as a measure to improve water quality. The NbS is relevant for shallow coastal areas in all Nordic countries.

Rewilding urban seascapes aims to enhance marine life and biodiversity, while supporting human health and wellbeing. By providing a varied and diverse land-sea ecosystem, this approach offers opportunities for enriching nature experiences, fostering a deeper connection between people and the marine environment. This NbS also addresses intertwined challenges of the biodiversity and climate crises. It promotes the use of low carbon materials in coastal infrastructure and designs structures that promote the colonisation and growth of native marine species, such as kelp, seagrass and oysters. These species play a critical role in climate regulation and adaptation by storing carbon and reducing shoreline erosion.

Restoring lost habitats or creating new ones, not only benefits local biodiversity, but also promotes critical ecosystem services, including improved water quality. Kelps and seagrass absorb nutrients and trap sediments, while oysters and blue mussels act as natural filters removing plankton and other particles. In addition to its environmental benefits, this NbS has the potential to enhance ocean literacy by serving as an educational tool, promoting awareness of marine ecosystems and the need to protect them.

How to apply this NbS

The creation or restoration of soft and hard bottom marine gardens is one of several NbS options for rewilding urban or constructed coastal areas (FAO, 2023). Landscape construction must be nature-inclusive, deliberately creating space for geological and biological diversity, using the local landscape and habitats as templates, shaped to meet the needs of key local species.

Rinde & Sørensen (2023) recommend choosing habitat-forming species that facilitate other species, driving "facilitation cascades" between marine habitats. This approach promotes mutual benefits between habitats, causing positive feedback loops and community resilience and persistence. The selected native species should be robust and capable of providing important ecological functions. Identifying target species requires site-specific knowledge of native species and their habitat requirements (e.g. substrate type, terrain attributes, wave exposure, light, temperature, salinity, oxygen). These requirements will inform the design of soft and hard bottom gardens.

The habitat forming species may include plants (seagrass), macroalgae (kelp, rockweed, maerl) or animals (e.g. filtering animals such as blue mussels, flat oysters, ascidians). The gardens can be planned at different scales, from small tidal pools to larger ecosystems such as kelp and rockweed forests, maerl and seagrass beds, and saltmarshes. In areas with sea urchin overgrazing, removal of urchins from artificial structures in shallow water will aid the recovery of kelp and rockweed. The design of the gardens on the upper shores should be amphibious and future climate proof, capable of withstanding flooding and extreme weather events, like heavy rainfall and heat waves. These climate-smart designs will be more durable and adaptable than current coastal infrastructure. Using marine-life friendly materials is crucial when constructing marine gardens.

The rewilding manual provides a step-by-step approach from planning through implementation and monitoring, ensuring the success of urban marine rewilding efforts. While, focused on coastal areas, the approach is general and can be applied to rewilding of other ecosystems. A key factor for success is providing sufficient room for nature and allowing natural processes to unfold over time. In addition, innovative design, management plans, and adaptive management are essential for long-term success.

Outcomes of the creation and restoration of marine gardens

- Healthier and more diverse habitats: promoting diversity improves ecosystem resilience and the well-being of humans and other organisms.
- Improved mental health: Access to urban nature helps reduce depression, anxiety and stress.
- Improved ecosystem service provision: successful rewilding of urban seascapes provides recreational opportunities, climate adaptation, and improved water quality.

The direct ecological benefits of a restored or newly built soft or hardbottom garden include:

- Increased production of plant and animal biomass: Enhanced biomass from vegetated habitat-forming species in the gardens (e.g. maerl, seagrass, kelp, rockweed and other macro algae), along with diverse fauna living on and among the plants/algae.
- Increased biodiversity and more complex food webs: Increased biodiversity supports more intricate food webs compared to the "urban deserts", incorporating more trophic levels, and improving land-sea connectivity such as birds using the gardens for feeding.

- Recovery of lost ecological functions: recovered functions provided by vegetation (examples provided above) and filtering animals (e.g. mussels or ascidians), providing cleaner water, erosion control, food and recreational opportunities.
- Creation of habitat corridors: New or restored habitats offer vital corridors for species within systems that have lost most of their historic natural ecosystem extent, enhancing connectivity and resilience.

Important considerations

In general, the landscape, including depth, terrain attributes, and substate type, must be shaped and chosen to meet the environmental needs of the target habitat-forming species. Similarly, efforts to enhance environmental conditions should prioritise the well-being of marine life in the same manner as for humans. This involves addressing habitat and living conditions throughout the entire life cycle of the species. This includes sufficient light for plants and algae, and oxygen for animals. Oxygen levels depend on urban water treatment and solutions that promote sufficient water circulation. Due to limited experiences with marine rewilding, it is essential to test, adapt and refine solutions as needed.

As with green parks on land, maintenance of the blue gardens is essential. Measures such as removing invasive species, waste, and filamentous algae should be part of ongoing management. A holistic and long-term approach is needed for success, involving cross disciplinary collaboration from planning through implementation, monitoring, and adaption.

The costs will depend on scale, habitat type(s), region, and context. Costs to facilitate for an eelgrass meadow in an urban area includes planning and preparing the terrain that should hold the meadow, as well as material costs. Preparation of the terrain can involve just setting off sufficient suitable space for the meadow, and to add sand or mud if needed to form a suitable substrate for the plants. However, it can also involve reconstructing the landscape and to form a suitable site for the meadow. Reconstructing the landscape involves costs such as removing material (natural as well as constructed), and costs of new material and the construction work. In a reconstructed landscape, soft substrate is prevented from being flushed away by currents and waves (e.g. by forming a sheltered basin). In both cases, the site needs to receive sufficient light for the eelgrass plants photosynthesis (i.e. the site cannot be placed too deep, or in the shadow of high buildings).

6.3 Crop rotation

Crop rotation is the change of crops between harvests. This can be from one year to another or, depending on climate and crop type, be several times over a season. In contrast, if the same crop is used all the time, no crop rotation is used. A crop rotation system can also include crops which main purpose is not to produce food or fiber directly, but to e.g. improve soil or reduce emission of climate gases. These include *cover crops, green manure and intercropping*.

How to apply this NbS

Cover crops and green manure

In agriculture, cover crops are grown to improve the soil. They are planted between the harvests of cash crops to cover what would otherwise be bare soil and protect it from erosion and nutrient loss. Cover crops are chosen to be easy to incorporate into the soil before the main crop is planted. Usually, annuals, which are taken away before they set seed.

Green manure crops are used to bind nitrogen and add organic matter to the soil, improve soil life, and make other micro-nutrients available. The green manure crops usually consist of legume plants which improve soil when they decompose in the soil, thus releasing the nutrients.

Intercropping

There is also intercropping, which is not a crop rotation system per se, but makes use of increasing diversity of crops over space not time as for cover crops and green manure. For example, growing two different crops together can benefit their viability through, for example keeping moisture in the soil or making use of the space more efficient but also to increase variation in the field to strengthen the existence of natural enemies to pests. This is an extensively used method in, for example, agroforestry practices and in several agroecological practices.

Intercropping works with both annual and perennial crops, or a mixture of annual and perennial crops, one example of intercropping is agroforestry. Agroforestry is one of the relatively rarely used NbS in western agriculture. One reason could be that harvesting may demand more manual labour as the different crops are grown close together and cannot be harvested in the same way as with machinery. Globally the proportion of cropped land using inter-cropping varies widely from around 20% to as high as 94%.

Intercropping can be planned to facilitate harvesting, for instance by planting different crops with enough distances to enable machine harvesting of each crop separately.

Crop rotations of different kinds can be used in all ecosystems where crops are grown. What crops to use and how often to rotate is heavily dependent on regional and local climate, market, availability and farmer preference.

Outcomes of crop rotations

Crop rotations have the potential to counteract societal challenges mainly related to food security, biodiversity enhancement and disaster risk and preparedness. This is done through the following pathways:

- Reduced pest and weed build up for a certain crop.
- Reduced erosion of soil between cultivation of food crops.
- Reduced greenhouse gas emissions.
- Improved nutrient availability in soils.
- Improved soil biodiversity.
- Increased diversity of resources for different organisms both below and above ground.
- Pull pollinators or natural enemies into the crops and/or push pest species from the crops.

Important considerations

Altering the crop rotation system needs a restructuring of the farming practices as well as agro-market structures, which can be both time consuming and costly, but it may have benefits in both the short and the long term. A new crop rotation system can increase the number of crops used on the farm, not only temporally but also spatially. This comes from the fact that not all fields on the farm are at the same stage in the crop rotation system, which means that neighboring fields usually differ in what is grown on them a single year. Growing cover crops between the harvest and the sowing next year, covers the soil and store nutrients that can be used more by the following crop.

Inter-cropping combines two or more crops close to each other. This can be done in different ways. For example, by having a mixture of two or more crops without any distinct separation within the field, or by growing different crops in every other row, or by growing two or more crops together for some part of the time, e.g. sowing a second crop a bit before the first is harvested.

Most farmers use some type of crop rotation already, but there are added benefits of increasing it further. Potential benefits of crop rotation of some sorts include the increase of soil biodiversity and soil organic matter and carbon content, this is especially true if legumes are included in the rotation. Further benefits are reduction of soil erosion. Crop rotation also helps reduce the built-up pest load in the field and surrounding areas and can improve resource use as different crops have different needs of soil resources. Inter-cropping can have benefits for the total yield and resilience to pest species and weather variability if chosen carefully. Perhaps the best-known example of this is the Central American milpa where maize, beans and squash are grown together. Here, the maize is offering support for the climbing beans, the beans fix nitrogen in the soil for next year, and the squash covers the ground and reduces weeds. This maximizes the use of space, and potentially resources, and can also suppress weeds and reduce water loss. In Europe the mix of, for example, oats and peas is a common way of producing fodder high in nutrients.

The intercropping can also be used in a type of push-pull system where some plants attract pollinators and natural enemies, or repel and push away pest species, which in turn is beneficial for the main crop.

This NbS necessitates new cultivation practice which can be demanding for the farmer in terms of new knowledge and management. Sometimes it can require operation and purchases of new machinery as well as identification of new markets if it concerns crops that are harvested and not only soil improving.

Some cover crops are treated with herbicides before the main crop is planted, which can negatively affect either other living organisms, or if you make a mistake, damage the crop you plant afterwards. The cover crops are sometimes mandatory for farmers to use to reduce emissions of greenhouse gases from bare soil.

There are several studies on crop rotation but not all point in the same direction and the certainty of this NbS is of medium strength. How well it delivers in relation to the societal challenges heavily depends on the rest of the farming practices, the soil type and the local climate.

There can be added cost to management in terms of both time, seed purchase and fuel for machinery. However, the main point of this NbS and sub NbS is not only to be beneficial to the environment but also to improve or maintain yield while decreasing external inputs including irrigation.

6.4 Deadwood enrichment

Standing and downed deadwood in the form of snags, logs, branches and stumps is retained during various management activities and/or created, with the objective to increase the quantity and diversity of this essential component in forests and other ecosystems.

The deadwood enrichment can be a NbS in the forest and urban ecosystems as a part of closer-to-nature management and ecological restoration. Deadwood enrichment can also be used in wetlands and cultural landscapes.

In Nordic forest ecosystems, timber harvesting, fire suppression and salvage logging reduce deadwood abundance and diversity, and climate change is expected to change input (through natural disturbances) and output (through decomposition) rates of deadwood in space and time. Around 7,500 forest species in the Nordic countries are associated with deadwood, and hundreds of species are threatened because of the shortage in availability of deadwood. The importance of deadwood for biodiversity, carbon sequestration and ecosystem functioning has been recognised not only in forests, but also in aquatic ecosystems, such as rivers and streams, as well as wetlands and coastal areas. In urban ecosystems and cultural landscapes, deadwood benefits biodiversity and ecosystem services, as well as can be important for environmental education.

How to apply this NbS

The cheapest and simplest solution is retention of all existing deadwood. Creation of new deadwood is beneficial especially if the quantity and diversity of existing deadwood is low. The objective is to ensure a continuous presence of a diverse deadwood in different stages of decomposition and thereby a range of niches for deadwood-associated biodiversity.

In forest ecosystems, a short-term enrichment of deadwood can be achieved by careful sparing of existing deadwood and creation of new deadwood (Figure 13) by

- mapping of existing deadwood in order to avoid destroying it during management operations,
- creating snags and high tree stumps – future downed deadwood, and
- killing of targeted trees by girdling, felling or pulling, inoculating with fungal pathogens or combination of these techniques.

Figure 13. Girdled tree and high stumps. Photo: Erkki Oksanen

Long-term solutions aiming at enabling a continuum of a diverse deadwood include:

- creation of deadwood in mature forests to accelerate development towards near-natural state,
- the retention of single trees or groups of living trees in final and intermediate fellings,
- partial or complete retention of damaged and dead trees in connection to or instead of salvage logging after natural disturbances such as windthrows, insect outbreaks or fires, and
- prescribed burning.

In cultural landscapes and gardens, the deadwood habitats can be retained or created in form of individual, preferably large, standing or downed dead trees, log piles, wood stacks, stumperies, and wooden fences. In urban ecosystems, the deadwood can be spared and created in parks and other urban green spaces, and used in green roofs, built ponds, basins, artificial wetlands, and creeks including cased streams. Moreover, it can attract people in art exhibitions, eco-trails etc. Deadwood art is an education material and source of inspiration for different nature-based solutions.

Outcomes of deadwood enrichment

Restoring a continuous supply of diverse deadwood is vital to reverse the negative trends in decreasing biodiversity and the ecosystem's ability to adapt to change. The NbS – deadwood enrichment – addresses a range of societal challenges:

- enhances biodiversity by means of providing ecological niches and food for a range of living organisms,
- addresses the societal challenge of climate change mitigation and adaptation through carbon sequestration for decades or hundreds of years in large-diameter deadwood in particular, and through increased carbon sequestration in forest soil by carbon inputs from deadwood into the soil,
- reduces the risks of diseases through the diversity of deadwood associated species that enhance an ecological resilience to pests, thus promoting ecosystem health (Disaster risk and preparedness), and
- promotes ecosystem productivity and timber production of forest ecosystems by improving soil fertility through organic matter and nutrient inputs from deadwood, as well as through providing a seedbed for natural tree species regeneration, thus promoting economic development.

Important considerations

Major points worth bearing in mind when considering deadwood management (Figure 14).

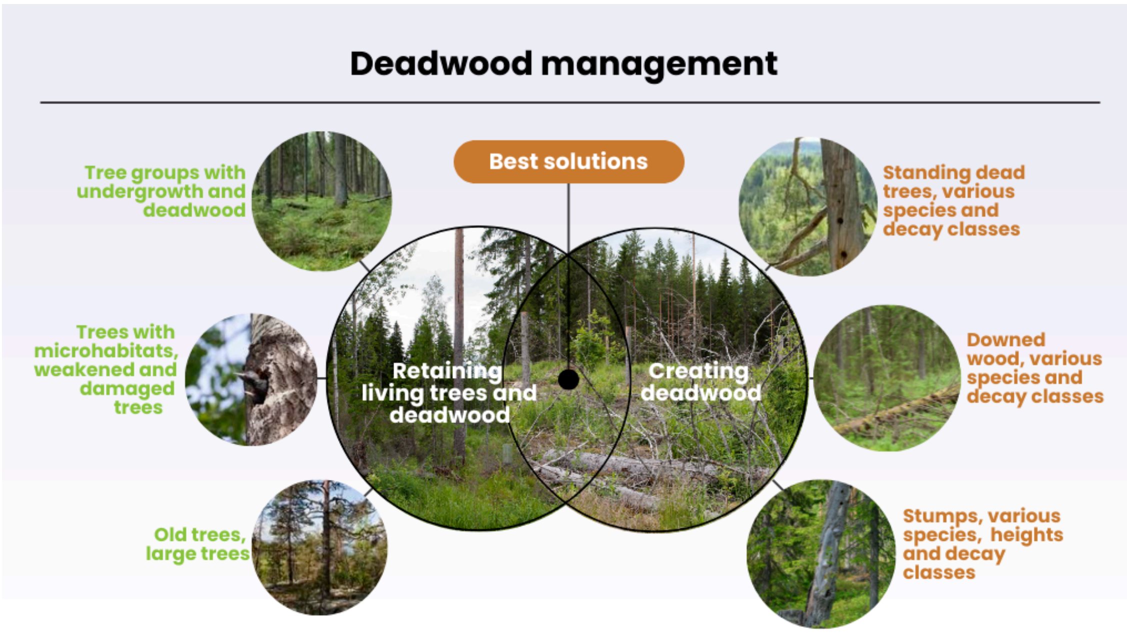

Figure 14. Best nature-based solutions in deadwood management

- In forest ecosystems, retained habitat trees (trees with microhabitats such as nesting cavities) as well as fresh logs and snags can be a source of pests in the case of susceptible species (e.g. Norway spruce and bark beetle). This can bring economic losses to forest owners.
- Girdled living trees can be an entry point for unwanted tree pests and diseases.
- In urban ecosystems, retained habitat trees and snags can cause possible safety risk to the public if close to roads, paths, etc.
- Prescribed burning should be performed with caution to avoid fire risk. The NbS needs to be negotiated with private forest owners.
- People's safety should be kept in mind when creating deadwood or performing prescribed burning.

There are no extra costs associated with retaining living trees or tree groups and/or deadwood. However, there is a potential loss of financial revenue as the retention of individual trees or tree groups preferably involves trees of larger diameters desirable for timber extraction.

- Costs for deadwood creation are not high if the treatment is made at the same time as timber harvesting.
- Burnings (link to prescribed burning) are laborious and expensive. In Finland, for example, the costs of burnings are €1500–2500/hectare. Financial support for private landowners is available in some Nordic countries.

6.5 Revegetation and restoration of terrestrial vegetation

Revegetation and restoration of terrestrial vegetation (vascular plants and other non-vascular primary producers such as lichens and bryophytes) can be used to revegetate areas where vegetation has completely disappeared or to restore degraded vegetation.

Revegetation and restoration can be applied in any ecosystem where vegetation is present naturally but has disappeared or been degraded. To be successful, knowledge of the living (biotic) and non-living (abiotic) components of the ecosystem is required. The combination of biotic and abiotic conditions, as well as financial considerations, will determine restoration aims, appropriate methods, and species.

Vegetation is an integral component of almost any terrestrial ecosystem and essential for ecosystem functioning and ecosystem services. Revegetation of barren land and restoration of degraded vegetation have positive effects on biodiversity, will reduce the risk of soil erosion by water or wind, improve soil quality, contribute to carbon cycling and storage both above and below ground, and may positively affect human health.

Protect rather than restore:
Avoiding the degradation and loss of vegetation should always be top priority (Figure 1). If impacts on vegetation are unavoidable however, impacts should be reduced as much as possible. Restoring vegetation should never be an after-thought, but rather be incorporated from the start of any project that may induce a need for restoration of vegetation. As such, measures that will benefit restoration efforts may be taken as the project proceeds: local topsoil can be collected and put in place at the final phase of the project, seeds of native plants can be collected before vegetation is removed, nursery beds can be established to temporarily store native plants which can later be placed back. These measures may be hard to implement when revegetation or restoration is not planned in advance. Compensating loss of nature or vegetation elsewhere is lowest on the priority list (Figure 15).

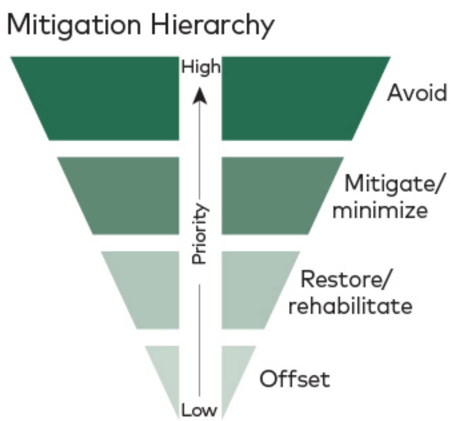

Figure 15. Mitigation hierarchy for impacts on biodiversity and nature. Avoidance is top priority, followed by minimization of damage, restoration and compensation.

How to apply this NbS

Site assessment and setting a reference state:

Before restoration is started, site conditions (including but not limited to climate, biodiversity, geology, pollution) at the restoration site should be surveyed. In addition, the drivers of ecosystem degradation should be identified.

To set a restoration goal, a reference ecosystem should be chosen. Choice of reference ecosystem is not always obvious. The reference state can be either based on historical accounts of what the ecosystem looked like before drivers of degradation became effective, or an intact ecosystem in a location with similar conditions. In some cases, a part of the area to be restored has good condition and can serve as a reference state for the rest of the area. If no reference ecosystem can be found, a theoretical ecosystem state can be used for example based on species prediction models.

When the current conditions and drivers of degradation, as well as the reference ecosystem are known, restoration goals can be formulated. Large and long-term projects will benefit from an adaptive process, where goals are evaluated and adjusted as the project progresses. Sub-goals can be formulated to check if progress is on schedule or if additional measures are required to meet the final restoration goals. Clearly defined goals allow for the evaluation of revegetation and restoration efforts and are helpful to established whether the planned actions meet the best-practice guidelines for NbS.

Removing sources of degradation:

Before revegetation or restoration is attempted, the drivers of degradation of vegetation should be identified and eliminated. It is unlikely to achieve restoration goals while degradation continues. Examples of such drivers include (road) construction, mining, overharvesting, overgrazing, eutrophication, pollution, or invasive species. In case the drivers of degradation are temporary and can be planned for, for example during construction works, the project should be adjusted such that initialized restoration actions are not negatively affected by other activities. For example, tracks from heavy vehicles can cause soil compaction and thereby negatively affect the establishment of flower meadows or damage the roots of set-aside trees. Relevant actors such as contractors and machine operators should be informed and educated about where, when, and how restoration efforts will be carried out.

Restoration by emulating natural dynamics and disturbance:

In some cases, natural succession (i.e., the natural change of vegetation species composition over time) is a viable restoration option once disturbing factors have been neutralized. Without a need for active measures, costs associated to this method are usually low. Downsides may be that erosion worsens soil conditions, that natural processes may act slower than desired, that naturally established vegetation may not match the reference state, that non-native species establish before native species do, or that natural revegetation is interpreted as neglect by the public.

Restoration of natural dynamics:

Many ecosystems depend on disturbances on different scales and such dynamics should be considered when establishing the reference state. These disturbances may occur naturally but, in many cases, require active management. An example of a disturbance that acts at a local scale is the death of an individual tree which provides light to understorey vegetation. Forest fires and floods are examples disturbances that typically manifest at a larger scale. Disturbance can also be caused by herbivores such as deer and cattle. In some cases, restoring the natural ecosystem dynamics is sufficient for restoration to achieve the desired ecosystem state.

Restoration of abiotic conditions:

Abiotic conditions are an important driver of vegetation composition. For vegetation, climate, soil conditions, and hydrology are particularly important. Terrain features such as slopes, depressions, and outcrops should be restored as these drive variation in soil and microclimate. For wetland vegetation, restoring hydrology is an important prerequisite. On-site treatment and improvement of soil may in some cases be possible. In other cases, soil needs to be transported to the restoration site from elsewhere. In case of eutrophication, nutrient rich topsoil may need to be removed. Heterogeneity in landscape features and soil conditions will allow diverse plant communities to co-exist.

Restoration and establishment of vegetation:

In many cases, active revegetation such as transplantation of patches of vegetation or individual plants is desirable. In some cases, some initial planting is needed to stabilize soil before further revegetation is allowed to occur more naturally. Seeds can be sown directly, or seedlings can be planted out. Seed and seedling should be sourced locally to preserve genetic variation. Some plants may be propagated vegetatively, but such plants are clones and may have lower genetic diversity than desired. The transplantation of entire turfs from intact vegetation to the restoration site may in some cases be an option. When turfs are transplanted, vegetation is likely to survive. The downside is that turf transplants require some logistics and that a hole is left behind at the donor site. Large projects may incorporate trials to establish the most effective method of revegetation.

Monitoring, maintenance, and an adaptive process:

Monitoring before, during and after restoration is important because it is impossible to determine whether restoration goals have been reached without monitoring. Monitoring should be planned for at project start, so that a baseline condition can be established. An adaptive process, where monitoring drives decision making, is beneficial especially to large-scale or long-term projects. After initial restoration, regular maintenance actions may be required, for example mowing or grazing of wildflower meadows. The length of the monitoring period depends on the vegetation type but is almost always more than 10 years.

Figure 16. Road removal and restoration of a shooting range at Hjerkinn, Dovrefjell in Norway. Photo: Dagmar Hagen.

Outcomes of vegetation restoration

Potential outcomes:

- Increased vegetation cover restores ecological functioning and ecosystem services.
- Increased biodiversity.
- Reduced risk of soil erosion.
- Restored vegetation may have subsequent positive effects on other organism groups such as insects, mammals, birds, etc.
- Increased recreational value and associated health benefits.
- Climate change mitigation e.g., through increased carbon storage in vegetation and soils.

Undesirable outcomes:

Restoration actions may not result in the nature type local communities have grown accustomed to. For example: while restoring a mire, forest may disappear which strongly impacts how people experience the landscape.

Important considerations

- Machinery used for restoration may itself lead to damage to vegetation and may promote soil erosion – impacts should be minimized.
- Use of soil and plant material from outside the restoration area may increase the risk of introducing non-native, invasive species or cause genetic contamination (introduction of non-local genetics).
- Soil and vegetation that contains non-native species should be disposed of appropriately.
- Restoration and revegetation efforts will benefit from the involvement of local communities.

The associated costs strongly depend on the methods used and the size of the area to be restored. Allowing vegetation to recover by natural processes can reduce costs. Landscaping (restoring slopes, terrain, etc), and any removal and treatment of contaminated soils comes with considerable costs. Monitoring is an important part of restoration projects and require funding years/decades after the actual restoration effort is complete.

6.6 Green and blue-green roofs

Green roofs are layers of vegetation planted over a waterproofing cover installed on flat or sloped roofs, serving to absorb rainwater, provide insulation, and create habitats for wildlife. There are several types of green roofs, the two main groups are extensive and intensive green roofs.[51]

Extensive green roofs are designed for minimal maintenance, covered with a lightweight layer of soil and drought-resistant plants such as sedums or meadow. They are typically not accessible for recreational use and are used for covering large areas or buildings unable to support heavier loads. Extensive green roofs are often possible to retrofit buildings. Extensive green roofs can, in principle, be installed at all roof angles, but costs increase for steeper roof angles. For example, the city of Copenhagen mandates green roofs in most local plans with a roof angle below 30 degrees.[52]

Intensive green roofs are thicker, can support a wider variety of plants, including shrubs and trees, and require more maintenance. They are often designed to be accessible and also serve as social spaces and can include features like walkways, benches and areas for urban farming.

Blue-green roofs extend the concept by incorporating water storage and management systems beneath the vegetative layer to handle excess rainwater more efficiently, combining the benefits of green roofs with extended stormwater management capabilities (Andenæs et al., 2020). Investigations on how to adapt such roofs to Nordic conditions are ongoing (see e.g. Thodesen et al., 2018).

Figure 17. The blue-green roof at Vega Scene in down-town Oslo. Photo: Bergknapp

51. https://worldgreeninfrastructurenetwork.org/key-definition-green-roof/
52. https://weadapt.org/knowledge-base/adaptation-decision-making/circle-2-adaptation-inspiration-book/

How to apply this NbS

Green and blue-green roofs as a stormwater measure are often applied in urban ecosystems. Their specific design and plant selection can vary to adapt to local climates, building regulations, and ecological goals. Beyond their direct impact on the buildings they cover, such roofs can positively influence surrounding ecosystems by reducing runoff into local waterways and regulating local temperature.

Implementation involves ensuring a waterproof membrane and a root barrier if needed, followed by a drainage system, soil layer, and appropriate vegetation. Blue-green roofs may include additional layers for water retention and controlled release. The choice of plants is critical and varies by climate; in cooler climates, sedum and hardy grasses are common, whereas in warmer climates, a broader range of plants can be supported. Choices of plants also depend on the soil layer available. In the context of NbS it is important to be mindful of the vegetation choice for biodiversity effects. Negative side-effects can occur if invasive species are used on the roofs that can spread to the ground. Technical considerations include roof load-bearing capacity and access for maintenance.

Outcomes of green and blue-green roofs

Green and blue-green roofs address environmental challenges such stormwater runoff and can also provide food for birds and insects in urban areas. They can also contribute to reducing energy consumption by regulating the temperature of the buildings and providing aesthetically pleasing and social green spaces for urban residents.

Blue-green roofs add significant stormwater management capacity, potentially reducing the need for traditional, ground-level stormwater infrastructure.

Important considerations

Key considerations involve structural capacity of existing buildings, climate and local vegetation suitability, maintenance requirements, and water management needs. Social acceptability and integration into local and national green infrastructure policies are also important for implementation success. Financial incentives, regulatory frameworks, and public awareness can significantly influence project viability.

The implementation costs of green and blue-green roofs can vary widely, influenced by factors such as roof size, system complexity, and local labour and material costs. The added weight may also necessitate structural reinforcements, especially in older buildings. Operational costs include maintenance and, for blue-green roofs, management of the water storage system.

Green and blue-green roofs also present potential challenges and uncertainties. One concern is that nutrients, due to fertilization of the vegetation, can leach into stormwater runoff and contribute to eutrophication in nearby water bodies. Additionally, the long-term performance and effectiveness of green roofs can vary based on factors such as plant selection, local climate conditions, and maintenance practices. These considerations highlight the importance of thorough planning and ongoing management to maximize the benefits of green and blue-green roofing systems.

There are numerous case studies demonstrating the effectiveness of green and blue-green roofs in urban environments, including in Nordic cities.[53] These examples show the versatility and adaptability to different climates and urban settings, from dense city centres to suburban developments.

6.7 Rewetting of wetlands

Rewetting refers to the process of restoring the hydrological conditions in former wetlands, peatlands, and other waterlogged ecosystems that have been drained and hydrologically altered.

Rewetting can restore near-natural or natural hydrological conditions in riparian zones, wetlands (such as swamps and floodplains), and peatlands (such as bogs and fens). Peatlands, characterized by their accumulation of peat, are especially significant targets for rewetting due to their role in carbon storage and biodiversity. By re-establishing natural water levels, rewetting promotes ecological recovery and supports essential ecosystem functions.

How to apply this NbS:

Different measures can be used to rewet an area. The most important measures that can be implemented in freshwater ecosystems are:

1. Ditch and drain blocking and filling.
2. Disconnect functioning drainage pipes.
3. Raise stream/riverbed levels.
4. Remeander the course of the stream/river.

By combining all measures, it is possible to fully restore the natural hydrology of the ecosystem, but depending on the possibilities these can also be applied individually.

Ditch and drain blocking or filling can be done either by excavating the entire drainpipe or by cutting/crushing the pipes at intervals to stop water flow. Existing

53. https://lucris.lub.lu.se/ws/portalfiles/portal/99737064/2021_BOOK_MALM_Augustenborg_Bok_180x235mm_ENG_Webb.pdf

ditches within the area should be filled along their entire length or at selected intervals to rewet the landscape. When disconnecting drainage pipes that lead from outside areas, such as agricultural land, it's important to ensure that drainage water infiltrates below the root zone in the restored area and does not flow onto the surface, as has commonly been done in the past. This is crucial because nutrient-rich drainage water from agricultural fields can hinder biodiversity restoration if it reaches the surface or root zone in the restored area. (Baumane et al., 2021). When elevating the riverbed as a way to restore natural flow patterns it's important to consider the natural width-to-depth ratio of the river to ensure that this measure does not create overly wide and shallow sections. The material used for raising the riverbed should be a mixture of sand, gravel, and stones to resemble the natural substrate composition of the river at the intervention site. Similarly, when remeandering a stream, restoring natural curves and bends should follow key principles in fluvial geomorphology. For example, spacing between riffles areas of shallow, faster-flowing water should ideally be 5–7 times the width of the undisturbed channel to support natural stream dynamics, sediment transport, and diverse habitats. This guideline, however, should be tailored to local conditions, including the stream's width, slope, sediment dynamics, and surrounding geomorphology, to achieve optimal ecological and hydrological function.

Outcomes of wetland restoration:

Rewetting drained ecosystems, such as wetlands and peatlands, can address several significant societal challenges, particularly in the context of environmental sustainability, climate change, and biodiversity. The success of rewetting efforts depends on factors such as the degree to which natural processes are restored, the size of the rewetted area, the site's spatial location relative to flood-prone areas, and other characteristics including terrain and soil properties.

Rewetting peatlands can significantly reduce emissions of greenhouse gases, particularly carbon dioxide and methane, which are released when peat is drained and exposed to oxygen. By rewetting these areas, emissions are lowered, contributing to climate change mitigation. The reduction in emissions will be highest in areas where organic soil contents are high (>6%) and where the water level in the river is as close as possible to the surface of the terrain over a large part of the project area. This creates oxygen-free conditions that slow down the decomposition of the organic matter in the soil thereby mediating the largest reduction in emissions. Rewetting can also enhance carbon sequestration by restoring the carbon storage capacity of the ecosystem.

Rewetting may also protect downstream areas from flooding in periods with high levels of precipitation, because rewetted areas can absorb and store excess water like a sponge. This can be highly beneficial if downstream areas should be protected from flooding like urban or cultivated areas. The efficiency of raising the riverbed level or remeandering for flood protection depends on the exact measures that are implemented, the discharge of the river and the characteristics of the surrounding land, since these parameters will all affect the amount of water that can be retained. The significance of rewetting for flood protection will depend on the size of the rewetted areas and terrain conditions. The efficiency will be highest in low-laying project areas that are sufficiently large to retain large quantities of water.

In agricultural landscapes, rewetting drained areas can enhance water retention, which can be highly advantageous in periods of drought and contribute to a more sustainable agricultural practice.

Rewetting can also stimulate denitrification in rewetted areas and help reduce the transport of nitrate to streams and downstream coastal areas. Overall, denitrification acts as a natural filter, removing excess nitrates from drainage water entering the area thereby reducing the risk of nutrient pollution of downstream ecosystems. Nitrate is reduced through denitrification, which is a natural process by which bacteria convert nitrate and nitrite into nitrogen gas, which is released into the atmosphere. This process only occurs under anaerobic conditions, meaning in the absence of oxygen, and water saturation is therefore a prerequisite for this process to occur. Organic matter should also be present in the soil to serve as an energy source for the denitrifying bacteria.

Important considerations:

When rewetting there may be a risk of methane emissions. Anaerobic conditions create favourable conditions for the formation of methane gas through anaerobic decomposition and, as methane is a greenhouse gas, just like carbon dioxide, methane emission may counteract the positive effect of less-carbon dioxide emission. Therefore, it is very important to maintain a water level just below the surface to minimize this risk. Similarly, when former agricultural land with high contents of phosphorus is flooded there is a risk that the phosphorus is mobilized from the soil that can enter the river and cause eutrophication of downstream river reaches, lakes and coastal areas. Therefore, mitigation measures to reduce this risk should be considering before the intervention. There can also be a risk of altering the hydrology outside the project area. When the groundwater level is raised in a rewetted area, there can be a risk of affecting water level in upstream reaches, drainage pipes and ditches that discharge into the project area. Therefore, the project boundary should be defined so only low-lying areas are included in the project, while higher-lying areas are excluded. This will diminish the risk of negatively affecting drainage conditions outside the project area.

To ensure biodiversity enhancement within the project area it is important to be aware that high inputs of nitrate can be critical for many plant species and therefore that biodiversity may not respond positively within the area if nitrate-rich drainage water percolates into the root zone of the plants. This will affect interspecific competition and favour species that compete effectively at high levels of nutrients. These species are not in general species that are associated with positive developments in biodiversity. Instead, disconnected drainpipes should be placed below the root zone to ensure that the outflowing nutrient-rich water does not come into contact with the root zone, but instead into the layers below where denitrification can occur.

The cost for rewetting includes implementation (manpower, technology, costs of buying land etc.), operational costs, maintenance, and monitoring costs.

7. Conclusions

The world is currently facing a biodiversity and climate crisis which are globally interlinked. Nature-based solutions, defined as "as "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" is part of the solution to these challenges. Nature-based solutions offer a powerful approach to addressing the interlinked challenges of biodiversity loss, climate change and other societal challenges by protecting, restoring, and sustainably managing ecosystems. In the Nordic region, NbS initiatives focus on solutions that strengthen biodiversity, contribute to climate adaptation and mitigation, and improve human well-being. Examples include the restoration of peatlands, forests, and grasslands, sustainable farming practices, and blue-green infrastructure in urban and coastal areas. These approaches not only enhance ecosystems but also strengthen food security, human health and well-being, and resilience, especially in the light of climate change. This report is a shortened and adapted version of the Nordic online guide for Nature-based solutions implementation[54] where the online guide includes a larger set of NbS applications across the six ecosystems included in the project, as well as the main societal challenges and how these could be dealt with using NbS.

Nature-based solutions encompass many different actions spanning protection, sustainable use, and restoration of ecosystems to solve societal challenges such as biodiversity loss, food security and climate change mitigation and adaptation. As such, nature-based solutions are highlighted by both the UN, IPBES and IPCC as a cost-effective way of meeting the Sustainable Development Goals. The Kunming-Montreal Global Biodiversity Framework (GBF) recognises the need for action and goals to address the hazardous loss of biodiversity and restoring natural ecosystems including through NbS.

There is no one-size-fits all approach to planning NbS, because each project is dependent on the type of NbS that is chosen, combined with the context (i.e. country, ecosystem type, local conditions) in which it is applied. NbS implementation should therefore be tailored to each location's individual characteristics, using place- and context-specific assessments. The IUCN standard for NbS is designed to guide the practical implementation of NbS, as well as support conservation and policy development and is described in this report. We also list existing guidance and tools for NbS implementation, which are important for well executed NbS projects. This also includes information regarding standards,

54. https://nbsguide.org

policies and laws, cost-benefit analysis, and monitoring and evaluation of NbS projects.

One of the main points of NbS is that they are implemented to meet societal challenges. In this report we focus on several societal challenges and how they can be addressed by NbS for biodiversity enhancement, climate change mitigation and adaptation, disaster risk and preparedness, economic development, food security, human health and wellbeing, social justice and capacity building, and water management. Monitoring and evaluation of NbS efficiency are therefore essential to determine whether implemented NbS respond effectively to these challenges across ecosystems and land use types. The IUCNs global standard for NbS require that NbS are managed adaptively and are based on evidence. This means that in practice, NbS need to be monitored and evaluated to make sure that the implemented actions continue to deliver the benefits that they were implemented for.

The report focuses on six ecosystem types and how NbS can be implemented in these: coastal, cultural landscapes, forests, mountains, urban, and freshwater ecosystems including rivers, lakes and wetlands. We give examples of NbS implementations for different ecosystems including creation and restoration of marine gardens, crop rotation, deadwood enrichment, revegetation and restoration of terrestrial vegetation, green and blue-green roofs, rewetting of wetlands, and restoration.

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Tessa Bargmann, Annette Baattrup-Pedersen, Line Barkved, Helena Hanson, Kolbrún í Haraldsstovu, Ekaterina Shorohova, Daniele Stefàno, Johanna Alkan-Olsson, Georg Andersson, Caroline Enge, Sigrid Engen, Ingvild Skumlien Furuseth, Eli Rinde, Ruben Roos, and Leonard Sandin

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The Nordic Council of Ministers
Nordens Hus
Ved Stranden 18
DK-1061 Copenhagen
pub@norden.org

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