ARCADIA

Transformative climate resilience by nature-based solutions in the continental bio-geographical region

Work Package 6
‘Cross-regional support & synthesis’

D 6.1– Comparative report of regional nature-based transformative approaches, visions & pathways

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AUTHORS: Anna Nohed, Kes McCormick, Lisa Blix Germundsson and Misagh Mottaghi

CONTRIBUTORS: Irene Diti, Karla Mlađen, Anna Bonven, Alexis Sancho-Reinoso, Alice Petersson, Fulvio Biddau, Gloria Mozzi and Giada Bastanzi

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TABLE OF CHANGES

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GLOSSARY

Entry	Definition
Nature-based solutions	Nature-based solutions are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience.
Green-blue infrastructure	Green-blue infrastructure are an interconnected network of waterways, wetlands, wildlife habitats, and other natural areas; greenways, parks, and other conservation lands; working farms, ranches, and forests; and wilderness and other open spaces that support species, maintain natural ecological processes, sustain air and water resources, and contribute to the health and quality of life.
Climate resilience	Climate resilience often refers to the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to a changing climate. It focuses on adaptation but with connections to ongoing mitigation efforts.
Biodiversity loss	Biodiversity loss commonly refers to the reduction of any aspect of biological diversity in a particular area through death (including extinction), destruction or manual removal. It can refer to many scales, from global extinctions to population extinctions.
Sustainable development	Sustainable development is considered development that meets the needs of the present, without compromising the ability of future generations to meet their own needs.
Transformative change	There is a diversity of definitions for transformative change and what it entails. In this report, it refers to a fundamental, systemic reorganisation across technological, economic, cultural and social factors, including paradigms, goals and values.
Benefits	Benefits refers to the expected outcomes that flow from NbS as well as the reasons why they are often implemented.
Barriers	Barriers are considered the challenges or obstacles preventing the implementation or scaling of NbS.
Enablers	Enablers are the opportunities and possible drivers for NbS.
Actors	Actors refers to the key stakeholders that are engaged in and affected by NbS. This also includes missing and marginalised actors.

ACRONYMS

Abbreviated	Extended
NbS	Nature-based Solutions
NBEs	Nature-based Enterprises
EC	European Commission
IUCN	International Union for Conservation of Nature
UNEP	United Nations Environment Programme
IPLCs	Indigenous Peoples and Local Communities
SFM	Sustainable Forest Management
PFIT	Forest Land Use Plans
LCA	Life Cycle Analysis
SDGs	Sustainable Development Goals

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EXECUTIVE SUMMARY

The ARCADIA project examines transformative climate resilience through Nature-based Solutions (NbS). Its primary goal is to promote climate adaptation by utilizing NbS in five model regions, including Emilia-Romagna in Italy; Lower Austria; Zagreb and Krapina-Zagorje in Croatia; Skåne in Sweden; and Funen in Denmark.

In this report, we investigate NbS from a regional perspective in the context of Europe. It is widely argued that NbS have the potential to limit the impacts of climate change, enhance biodiversity and improve environmental quality while contributing to economic activities and social well-being.

While NbS are championed as ways to address multiple challenges and produce a plethora of co-benefits for both nature and society, there are also tensions, trade-offs and risks to be navigated and critiques of NbS that need to be acknowledged and addressed across planning, implementing, managing and monitoring stages of NbS projects and initiatives.

From a regional perspective, we are also interested in the interactions and synergies between multiple NbS over a geographic space that often includes a mix of landscapes covering urban, rural and coastal areas as well as social, economic, cultural, economic, environmental, historic and political dimensions.

This report explores the key benefits, enablers, barriers and actors for NbS as well as how visions, approaches and pathways shape outcomes for NbS. An underlying concept that is utilised across this report is governance, and we also place NbS in the context of wider discussions on transformative change.

This report is based on a combination of methods and sources of data collected through the ARCADIA project, including a narrative review of the (academic and grey) literature, regional reporting processes, and a short questionnaire of the five regions. This triangulation of both methods and data provides a robust foundation for understanding and exploring NbS.

The literature review revealed a diversity of benefits that can be connected with NbS as well as a mix of enablers and barriers and key actors for NbS. We also highlight three frameworks on governing NbS from the literature that represent or depict three different approaches for transformative change.

- We categorised the key benefits of NbS as multifunctionality, climate adaptation and mitigation, ecological benefits and ecosystem services, and human health and socio-economic benefits.
- We identified political and institutional issues, economic and market issues, socio-cultural and justice issues, and knowledge and contextual issues as defining factors for both barriers and enablers for NbS.
- We outlined partnerships, engagement, enterprises and risks as key themes to understand in relation to actors or audiences engaged in or impacted by NbS. Here, we can see collaboration and connectivity as key for successful NbS.

This report details experiences and ambitions with NbS from the regions. First, looking at the expected benefits from NbS and visions in regions related to NbS. Second, examining pathways for NbS in terms of barriers and enablers. Finally, exploring the key actors and approaches for realising visions and navigating pathways towards scaling NbS.

The in-case analysis and cross-case comparison combined with the literature review produced a wealth of insights on NbS from research, practice and policy perspectives. We provide four key conclusions and reflections from this report, and the processes of gathering and analysing data.

First, the narrative review of the rapidly growing literature on NbS and the regional assessment are in alignment. But there are also a multitude of areas for expanded research including the project lifecycle perspective for NbS, the hybrid approach of mixing green, blue and grey infrastructure, and NbS implementation in practice.

Second, enhancing collaboration and co-creation processes around NbS projects and initiatives is key to scaling and mainstreaming NbS. The regions hope to achieve several goals simultaneously and address goal conflicts, and they all emphasize multi-actor collaboration and transdisciplinary approaches as important pathways.

Third, regions are positioning NbS in the context of transformative change as is much of the literature. Key topics include the hybrid approach to NbS, missing and marginalised communities, addressing the path dependency of a "grey infrastructure culture", and people-centered planning, multi-actor collaboration, and innovation.

Finally, we present some methodological reflections on strengths and weaknesses, and lessons learned from developing this report. A key challenge for NbS in this research and beyond is the diversity of definitions and understandings of NbS in the literature as well as different interpretations of NbS in practice.

INTRODUCTION AND BACKGROUND

Broadly speaking, nature-based solutions (NbS) are inspired and supported by nature. They have the potential to limit the impacts of climate change, enhance biodiversity and improve environmental quality while contributing to economic activities and social well-being (European Commission, 2015; Cohen-Shacham, et al., 2016; UNEP 2022). It is important to recognise that the term NbS is both flexible and fluid. There are a multitude of definitions that attempt to capture the key elements of NbS (see Table 1), including from the European Commission (EC), the International Union for Conservation of Nature (IUCN), and the United Nations Environment Programme (UNEP).

In this report, we investigate NbS from a regional perspective and explore parameters that are influential in the implementation of NbS in the context of Europe (also see ARCADIA deliverables 1.1, 2.1, 3.1, 4.1 and 5.1). In this respect, we explore NbS over a mix of landscapes covering urban, rural and coastal areas as well as social, economic, cultural, economic, environmental, historic and political dimensions. While NbS are championed as ways to address multiple challenges and produce a plethora of benefits for both nature and society, there are also tensions, trade-offs and risks to be navigated and critiques of NbS that need to be acknowledged and addressed (Chausson et al., 2024; Xie et al., 2020; European Commission, 2015).

Table 1: Definitions for NbS

Sources	Definitions
European Commission (2015)	Actions that are inspired and supported by nature, which are cost-effective; simultaneously provide environmental, social and economic benefits; and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes through locally adapted, resource-efficient and systemic interventions.
International Union for Conservation of Nature (2016)	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.
United Nations Environment Programme (2022)	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 wellbeing, ecosystem services, and resilience and biodiversity benefits.

We use a collection of key terms in this report to analyse and investigate NbS. We consider these terms or topics as a way for unpacking NbS for transformative climate resilience. **Benefits** refer to the expected positive outcomes that flow from NbS as well as the reasons why they are often implemented. **Barriers** are considered the challenges or obstacles preventing the implementation or scaling of NbS. **Enablers** are the opportunities and possible drivers for NbS. **Actors** refer to the key stakeholders that are engaged in and affected by NbS. This also includes missing and marginalised actors. Additionally, we connect these key terms to **visions, pathways, and approaches**, which are elaborated further in the body of this report.

An underlying concept that is utilised across this report is **governance**. While government refers to formal structures or institutions by which a state, a region, or a municipality is organised and governed, governance is often considered as the act of governing. It involves multiple public and private actors as

well as citizens and communities, who engage in debates, contestations, and compete for gaining and maintaining power over an issue that is being governed. Governance can be defined as the system or processes by which entities are directed, influenced, and even controlled. At the same time, different forms of governance offer opportunities to strategically integrate policy instruments, connect different sectors, and engage multiple stakeholders in a dialogue, thereby enhancing collaboration.

The ARCADIA project examines transformative climate resilience through NbS (also see ARCADIA deliverable 7.1). Its primary goal is to promote climate adaptation by utilizing NbS. Hence, we position this report and the exploration of visions, pathways and approaches for NbS in the context of transformative change. **Transformative change** entails not only enhancing climate resilience and implementing sustainability transitions, but also questioning and reformulating existing governance systems and dynamics. It connects localized actions with broader and deeper systemic changes needed for long-term sustainability.

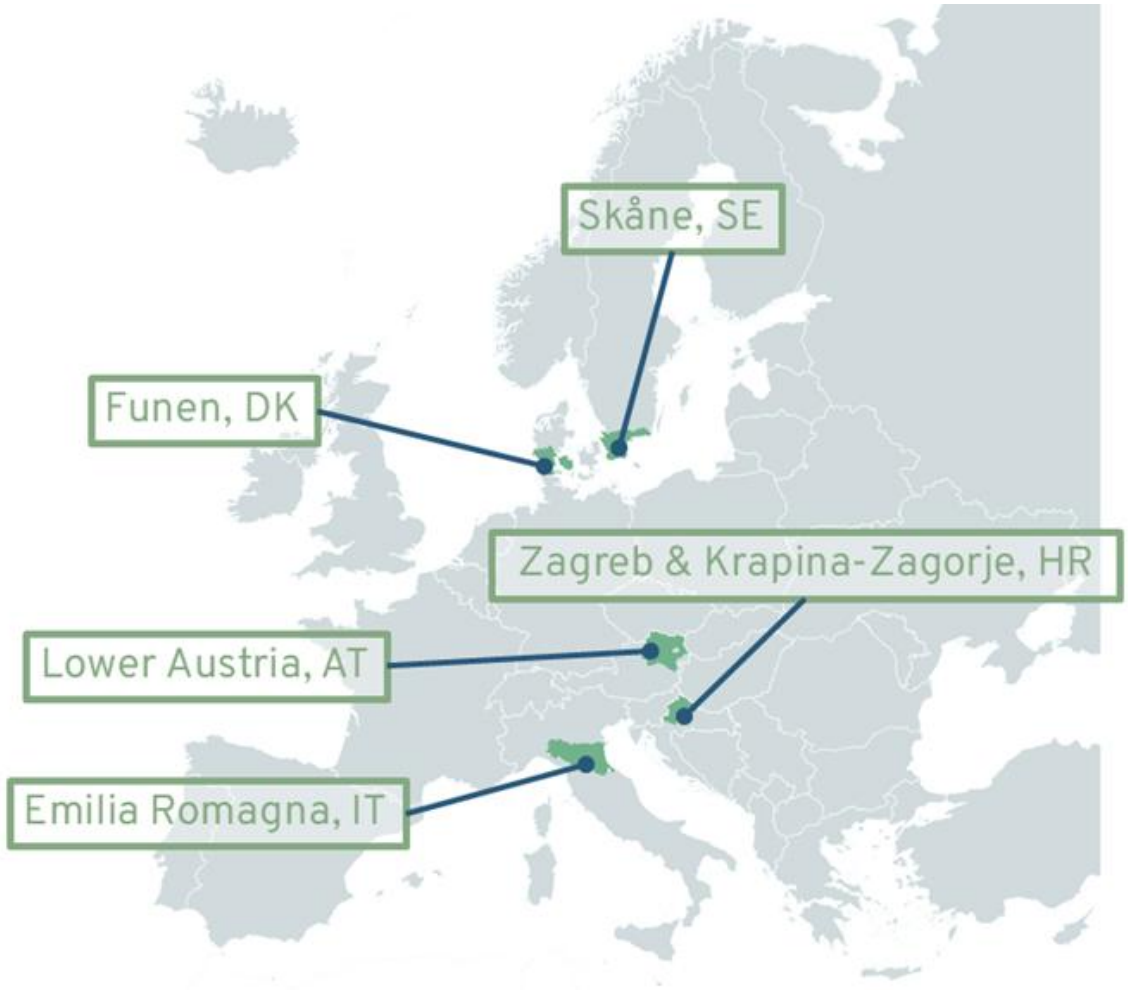
This report focuses on identifying and understanding the benefits, enablers, barriers and actors for NbS in the context of the governance of transformative climate resilience. We place actors in relation to enablers and barriers for NbS, and we also recognise the need to consider NbS in terms of project lifecycles across planning, implementing, managing and monitoring stages. This report aims to help the five model regions in the ARCADIA project as well as regions across Europe to better understand and improve their governance of NbS based on identified potentials and benefits.

This report is structured in six key parts. First, it starts with an introduction and background to NbS from a regional perspective. Second, it outlines the approach and methods used to collect and analyse data. Third, it presents the key insights from the review of both grey and academic literature on governance and NbS, including relationships with transformative change. Fourth, it describes the regional assessment from the five model regions in Europe that are the focus in this report. Fifth, it analyses and discusses the visions, pathways and approaches in terms of the benefits, barriers, enablers and actors in the five regions. Finally, it finishes with key reflections and conclusions from the research processes.

APPROACH AND METHODS

This report is based on a combination of methods and sources of data collected through the ARCADIA project. This triangulation of both methods and data provides a robust foundation for understanding and exploring NbS from a regional perspective. The overall approach builds on a narrative review of the existing and emerging literature on NbS as well as the experiences and ambitions for NbS in the five model regions in Europe who are participating in the ARCADIA project, including Emilia-Romagna in Italy; Lower Austria; Zagreb and Krapina-Zagorje in Croatia; Skåne in Sweden; and Funen in Denmark (see Figure 1).

Figure 1: Map of the five model regions in the ARCADIA project



The narrative review of literature was organised in two parts with a focus on governance of NbS (see Appendix 1 and 2). First, we conducted a review of grey literature with an emphasis on key international and European reports – looking at barriers or challenges and enablers or opportunities for NbS. We used Network Nature as a starting point for identifying key reports (https://networknature.eu/nbs-resources). Second, we engaged in a review of academic literature on NbS and governance. The review of literature embraced a narrative approach to gain an overview of the discussions and findings in the literature on NbS rather than a systematic analysis of all literature. We limited the initial narrative review to 20 key publications selected after a wider reading of the literature. We complemented this with a further 10-15

publications as we developed this report. We used prominence in the literature as criteria for selection. We also applied a geographic focus on Europe to limit the search.

To complement the review of the literature, we conducted a short questionnaire with the five model regions in the ARCADIA project. The short questionnaire focused on a set of key questions, including: the expected benefits from scaling NbS; the key barriers/challenges and enablers/opportunities for NbS; and regional ambitions for NbS. We also analysed and used the reports from the five model regions in the ARCADIA project (see ARCADIA deliverables 1.1, 2.1, 3.1, 4.1 and 5.1) to provide a foundation for this report. In addition, we collected data and insights from the ARCADIA project webinars with all five regions, and utilised the ongoing regional reporting processes to inform this report.

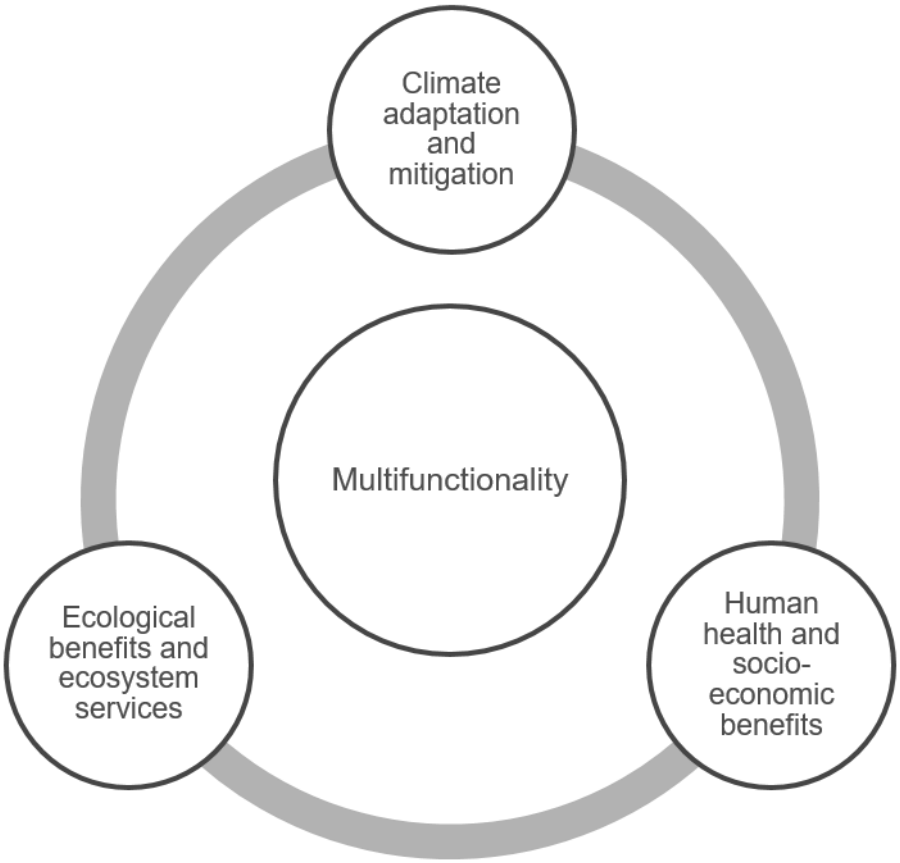
LITERATURE REVIEW

This section presents the outcomes of the literature review on NbS and governance. First, we present an overview of the key benefits, barriers, enablers and actors for NbS as identified in the literature. We conducted an analysis of both grey and academic literature through a narrative review (see Appendix 1 and 2). Second, we explore and highlight three examples of frameworks on governing NbS from the literature in relation to three approaches for transformative change, including: Understanding narratives for NbS; Mainstreaming nature-based enterprises; and Stepping stones for NbS.

Identifying key benefits, barriers, enablers and actors for NbS

There is a diversity of benefits that can be connected with NbS. Based on the literature, we categorised the key benefits of NbS as multifunctionality, climate adaptation and mitigation, ecological benefits and ecosystem services, and human health and socio-economic benefits. Multifunctionality sits at the core of all benefits and connects up and includes climate adaptation and mitigation, ecological benefits and ecosystem services, and human health and socio-economic benefits (see Figure 2). It is consistently highlighted in the literature that the benefits associated with NbS are deeply interconnected.

Figure 2: Benefits of NbS

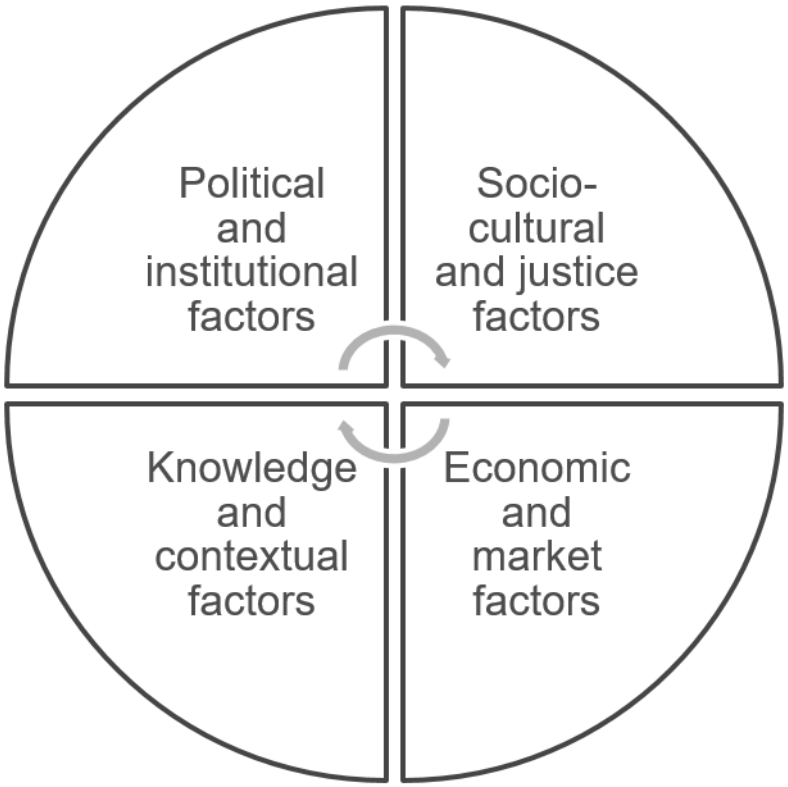


There are a mix of enablers and barriers for NbS across the governance landscape. In the literature, there are also a range of ways used to describe and distinguish between enablers and barriers (Ershad Sarabi et al., 2019; McQuaid et al., 2021; WWF, 2021; Seddon et al., 2020; Wickenberg et al., 2021). For example, in a paper by Ershad Sarabi et al. (2019), focusing on urban settings, barriers and enablers are mapped out across socio-institutional, biophysical and hybrid (both socio-institutional and

biophysical) domains. A further example from McQuaid et al. (2021) explores influencing factors for nature-based enterprises (NBEs) adopting a PESTEL approach with political, economic, social, technical, environmental and legal factors. And finally, in a report by WWF (2021), socio-cultural, institutional and economic areas are used to discuss enabling factors for NbS.

We identify political and institutional issues, economic and market issues, socio-cultural and justice issues, and knowledge and contextual issues as defining factors for both barriers and enablers for NbS. We consider these factors from both the perspective of barriers and challenges as well as enablers and opportunities (see Figure 3). Finally, we outline partnerships, engagement, enterprises and risks as key themes in relation to actors. We position actors in relation to the enablers and barriers, and we also recognise the need to consider NbS in terms of project lifecycles across planning, implementing, managing and monitoring stages.

Figure 3: Barriers and enablers for NbS



Benefits

Multifunctionality is recognized across the literature as the primary benefit and key defining dimension of nature-based solutions (EC, 2023; Seddon et al., 2020; Sarabi et al., 2020). This includes benefits spreading through social, economic, and environmental spheres that NbS can provide simultaneously. The diversity and fluidity of the NbS concept (in theory and practice) are also considered as a key way forward to meet the complexity of achieving the Sustainable Development Goals (SDGs) and societal challenges (Wickenberg et al., 2021).

NbS are predominantly being developed as a response to the challenges of climate adaptation and mitigation. If implemented mindfully, nature-based interventions can also have the potential to support biodiversity and provide ecosystem services (Seddon et al., 2020), which can benefit human physical

and mental well-being (European Commission, 2023). It is also widely acknowledged that NbS can help reduce socio-economic vulnerability and enhance adaptive capacity by addressing economic exposure and sensitivity (Seddon et al., 2020).

Multifunctionality

A key argument for NbS is the ability to provide multiple benefits at once (Sarabi et al., 2020). NbS can provide a range of ecological, social, and economic benefits and they are increasingly positioned as practical solutions for addressing urban sustainability challenges (Naturvation, 2020; Korkou et al., 2023). NbS stem from the recognition that our livelihoods, well-being, and ability to tackle global warming are deeply interconnected with nature. Nature provides humanity with a range of vital services, including clean air and water, food, pollination, support for tourism and recreation, contributions to mental and physical health, and many other essential functions (European Commission, 2023).

It is common for multifunctionality to be used interchangeably with ecosystem services, which are the benefits that nature provides to humans. Furthermore, there is often a need to differentiate between functions and services, which can lead to confusion over these concepts (Korkou et al., 2023). Multifunctionality often refers to the ability of infrastructure to serve multiple functions, which can yield benefits for both people and ecosystems. However, these functions are interconnected with social, economic, and environmental aspects (Korkou et al., 2023). Hansen & Pauleit (2014) define multifunctionality as including various ecological, social, and economic functions that should be intentionally considered rather than relying on chance. This approach also promotes more effective use of space by combining various functions. A service is defined by the direct benefit it provides to people, highlighting the distinction between function and service (Hansen & Pauleit, 2014).

Numerous sources shed light on the potential to address the SDGs and meet multiple societal challenges with the help of NbS (Clever Cities, 2018; Cohen-Shacham et al., 2019; (Cohen-Shacham et al., 2016; Martin et al., 2021; Nesshöver et al., 2017; Seddon, 2022; Seddon et al., 2020; Chausson et al., 2024; UNEP, 2022; Wickenberg et al., 2021). Even though it is not always explicitly emphasized as one of the benefits, NbS even have economic benefits compared to grey-engineered solutions. Martin et al (2021) highlight the multiple co-benefits, not exclusively for ecological resilience but for socio-economic development and the potential to drive new structures of governance. Explicitly stated in many definitions of NbS are the benefits that NbS can provide for human well-being; including physical and mental health benefits, as well as contribute to recreational and cultural values (Martin et al., 2021).

When discussing multifunctionality in relation to NbS, it is important to contrast it with grey infrastructure. Grey infrastructure typically focuses on a single function (Alves et al., 2024), whereas NbS is designed to be multifunctional, offering several benefits simultaneously. However, this multifunctionality needs to be carefully considered during planning to avoid overlooking trade-offs related to various challenges (Alves et al., 2024). There is a need for planning tools that support collaborative processes and enhance the understanding of the multiple functions of NbS and their integration (Alves et al., 2024).

Of great importance for the scalability of NbS is the possibility to be implemented and integrated with existing infrastructure (Cohen-Shacham et al., 2019). The concept is considered appealing to different sectors and organisations due to its simplicity and the intuitive idea of nature offering solutions to complex problems. Hence, NbS are suggested as ways to support collaboration across diverse stakeholder groups, and they are often feasible to integrate into both policy and practice (Cohen-Shacham et al., 2019; Chausson et al., 2024). Overall, the multifunctionality of NbS has the potential to generate short-term multiple benefits while also building long-term resilience (Wickenberg et al., 2021).

Climate mitigation and adaptation

One of the most evident benefits of NbS is the ability to protect against extreme weather events, including flooding and rising temperatures. The literature underlines the potential NbS have for both mitigation and adaptation against climate change (Kabisch et al., 2016; Martin et al., 2021; Sarabi et al., 2020; Seddon et al., 2020; Wamsler et al., 2020; WWF, 2021). First, NbS can protect against climate risks and slow down a warming climate (Seddon et al., 2020) and function as disaster risk reduction (WWF, 2021). Second, NbS also can mitigate climate change and function as a carbon sink (Seddon et al., 2020).

Under the umbrella of NbS, there is a spectrum of solutions that are suitable in both urban and rural environments. For example, green roofs and facades in cities contribute to climate regulation in urban areas (Kabisch et al., 2016), where green spaces and roofs can slow down water flows and protect cities against flooding (Seddon et al., 2020). These qualities can greatly enhance resilience and decrease urban vulnerability (Kabisch et al., 2016; Sarabi et al., 2020).

In rural and mountainous areas, slopes with vegetation help reduce landslide risk, and buffer strips and buffering zones have the potential to reduce erosion. Buffering zones and widening of river beds reduce the risk of flooding and flood water, and afforestation of slopes can mitigate the risk of avalanches and rock falls (Martin et al., 2021). Various NbS measures can protect from coastal erosion and hazards, inland flooding, and sea level rise (Seddon et al., 2020).

Even though adaptation to climate risk is a prominent benefit of NbS, the potential to contribute to mitigating climate change and functioning as a carbon sink is considered just as important. Greenhouse gas (GHG) emissions can be mitigated by advocating for preventative measures. By avoiding deforestation in tropical nations and performing sustainable agricultural practices tons of emissions can be avoided (Seddon et al., 2020).

Both on land and in the sea nature based interventions are beneficial for reducing GHG emissions. By working actively to improve the way activities are managed in different environments there is the potential to improve carbon sequestration and cut emissions (Seddon, 2022). A deeper relationship with nature is also discussed in the literature (Chausson et al. 2024). It is argued that NbS can potentially broaden the focus regarding the fundamental human relationship with nature and thereby create multiple benefits, including significant climate change mitigation efforts (Wamsler et al., 2020).

Biodiversity benefits and ecosystem services

Closely tied to the concept of NbS are ecosystem services, which are benefits or services that ecosystems provide to humans, including regulating (e.g. climate and water), cultural (e.g. recreation), supporting (e.g. soil formation and cycling water) and provisioning (e.g. food) services (Reid, 2005). In fact, ecosystem services are often interpreted in terms of multifunctionality Reid, 2005). However, the benefits of NbS go beyond the conservation and restoration of ecosystems (Sarabi et al., 2020). For example, by sustaining natural resources in drier climates it is possible to enhance ecosystem services, which can help avoid climate shocks (Seddon et al., 2020).

Furthermore, a key way to work with NbS at low risk (and low cost) is to protect already intact ecosystems, which are currently providing ecosystem services for people and biodiversity (Seddon, 2022). Across Europe, protected areas serve as critical refuges for several plant and animal species, providing a sanctuary from habitat destruction and fragmentation induced by human activities (see Box 1). Moreover, they provide critical ecosystem services instrumental in mitigating climate change impacts at both local and regional scales, such as carbon sequestration, water regulation, and soil stabilization.

Box 1: Protected areas as nature-based interventions

Protected areas of already intact ecosystems serve as living laboratories for understanding the intricate interactions between climate, nature, and anthropic activities, offering valuable insights into adaptation. They are vital for climate mitigation as they conserve ecosystems that serve as major carbon sinks, thus lowering atmospheric greenhouse gas levels. Protected areas sequester and store carbon from the atmosphere into natural ecosystems and prevent the release of carbon from vegetation and soils.

Currently, protected areas are preserving high-biomass forests that prevent the release of stored carbon and avoiding emissions of approximately 19.7 ± 1.8 Gt of carbon, which is equivalent to annual global fossil fuel emissions (Duncanson et al., 2023). Therefore, a proper management of these areas can enhance their carbon sequestration ability, and maintain biodiversity, while delivering additional ecosystem services that enhance the capacity to withstand and recover from climate-induced disturbances.

Protected areas contribute to physical protection against disasters predicted to rise with climate change (Mansourian et al., 2009). In the adaptation field, they are important for (at least) three reasons. First, they support species to adapt to changing climate and associated events by providing refuges and migration corridors facilitating autonomous adaptation and maintaining ecosystem processes.

Second, they protect communities from extreme events, regulating local climate and reducing vulnerability to hydro-meteorological extreme events like floods, droughts, storms, and related hazards like landslides, as well as maintaining the provision of those ecosystem services that support livelihoods and human wellbeing. And third, they support economies to adapt by increasing the resilience of inputs and supplies at the core of productive systems like watersheds for irrigation, important gene pools for agriculture, or infrastructure (Mansourian et al. 2009; Belokurov et al., 2016).

There are several existing examples of NbS in our societies today including coastal ecosystems that protect against flooding, sustainable agricultural practices that maintain yields, urban solutions such as green spaces and trees that reduce urban heat and the risk of flooding. Solutions like these underline the idea that working with NbS and integrating nature will benefit both humans and biodiversity. To work with NbS and with ecosystem services is inherently to see communities as a part of nature and how they can help solve societal challenges (Seddon, 2022).

There are several ways to work with NbS in different settings, including agriculture and forestry to coastal, rural and urban areas. For example, sustainable agricultural systems can ensure food security (WWF, 2021). The notion of regenerative agriculture uses various ecosystem functions of trees, plants, and (wild or domesticated) animals while minimizing negative impacts from production as a way to work with nature (Miralles-Wilhelm, 2023). Another way to incorporate NbS into agricultural practices is by using agroecological principles, or climate-smart agriculture. These practices aim to retain or increase available nutrients or improve the microclimate (Miralles-Wilhelm, 2023).

There does not necessarily have to be a contradiction between grey, engineered infrastructure and NbS. There are increasing examples of techniques referred to as hybrid NbS, where grey, blue and green elements are combined to recreate, protect or strengthen natural habitats such as mangroves (PHUSICOS et al., 2023). In fact, integrating green or blue measures with grey infrastructure is often more effective and cost-efficient under certain conditions (Browder et al., 2019). At the same time, there is also a recognition of no tech, low tech and high tech NbS (Snep et al., 2020). This refers to how

technical elements can be embedded in NbS to varying extents. For example, a watering system that is based on sensors monitoring vegetation and rainfall for a green wall.

Human health and socio-economic benefits

The benefits of nature and NbS for human well-being are numerous. Across the literature, it is argued that scaling NbS is a key to protecting human health and enhancing well-being (WWF, 2021). NbS often contribute to improved quality of life, while supporting mental and physical health and provide a sense of belonging (Kabisch et al., 2016). Urban trees, green walls and roofs can improve polluted air and mitigate urban heat island (UNEP, 2022). NbS can also reinforce social cohesion and cultural identities (Kabisch et al., 2016), and improve the health benefits from green spaces through engagement in re-naturalization of community areas (UNEP, 2022).

Our livelihoods, well-being, and our chance to meet the challenge of global warming all depend on nature. Nature provides all sorts of essential services to humanity: clean air and water, food, and pollination, it sustains tourism and leisure activities, it contributes to mental and physical health, and delivers many other functions (European Commission, 2022). NbS have multiple co-benefits for ecological resilience, economic growth, and human health, such as social, recreational, and cultural (Martin et al., 2021). Further, socio-economic benefits from NbS are the opportunities they bring to create new job opportunities and help combat poverty worldwide (UNEP, 2022).

NbS not only provide benefits for human health but also often outperforms grey solutions by being more cost-effective and efficient (European Investment Bank, 2023; Kabisch et al., 2016; Seddon et al., 2020), and more scalable than direct carbon capture (Seddon et al., 2020). Grey engineered infrastructure are more expensive alternatives to NbS, since more investments are required in energy and materials (Nesshöver et al., 2017). The most cost-effective climate mitigation comes from improved management of existing land areas (Seddon, 2022).

Barriers

The literature identifies and discusses a plethora of interconnected barriers and challenges for NbS from a range of different perspectives. Political and institutional challenges include decision-making related to financing, planning and supporting NbS projects and initiatives. Siloed governance is highlighted as a key obstacle hindering effective NbS implementation. Economic and market challenges are tightly connected with limited policy and regulatory frameworks for NbS. The literature highlights a mix of market failures and barriers for investment as well as assessing and valuing the benefits of NbS.

Socio-cultural and justice challenges are increasingly lifted up in the literature from unintended consequences of NbS to greenwashing to limited involvement of Indigenous Peoples and Local Communities (IPLCs). Stakeholder participation is recognized as a vital but also challenging process. An underlying and fundamental barrier to the implementation and scaling of NbS is the current lack of knowledge and awareness. Furthermore, the literature suggests confusion around the concept and its key elements as well as a lack of monitoring and assessment in general, and in particular for social and environmental justice issues.

Political and institutional challenges

Politics can pose several obstacles to NbS including limited support for NbS projects and initiatives. NbS are rarely implemented unless integrated into governance and planning processes (Network Nature, 2023; Seddon, 2022). Interestingly, decision-making around spatial planning is often based on personal backgrounds and preferences, intuition, or financial considerations (Wamsler et al., 2020). This means that where there is a lack of political and financial support for NbS (Clever Cities, 2018) such measures are not considered, which indicates that path dependency and power relations against NbS can greatly influence outcomes (Seddon et al., 2020).

Path dependency in relation to NbS refers to the fact that societies and institutions have developed a "grey infrastructure culture" characterized by established practices, norms, policies, economic structures, and physical infrastructures. These elements can create significant barriers to the adoption of NbS and limit their ability to compete with traditional approaches and technologies, particularly in urban contexts where grey, engineered infrastructure dominates (Linnerooth-Bayer et al., 2023; Davies & Lafortezza, 2019). In this context, the mixing of green, blue and grey elements in hybrid NbS can provide ways to navigate the barriers associated with the path dependency of purely grey infrastructure.

One limitation of working with NbS is that many European and national policies regarding NbS are fragmented and depend on voluntary measures (Martin et al., 2021). The difficulty in mainstreaming NbS often arises from limited tools and guidelines, insufficient coordination, disputed NbS benefits, and a lack of capacities (Network Nature, 2023) and incentives from decision-makers, and conflicting regulations (Seddon et al., 2020). The integration of nature-based climate adaptation into sectoral planning is limited, including the knowledge for mainstreaming NbS, and climate adaptation policies can often fail to translate into action (Wamsler et al., 2020). This may be the result of the long-term benefits that do not align with short-term decision-making (Sarabi et al., 2020; Seddon et al., 2020).

There are political challenges on both regional and national levels since NbS are currently not deeply integrated into policy and regulatory frameworks (Wamsler et al., 2020). Municipalities often have limited control over private land (Wamsler et al., 2020) which contributes to the difficulties in upscaling NbS (Clever Cities, 2018) at the local and regional levels. The lack of formal frameworks for NbS also often leads to inconsistent assessments of solutions and results (Wamsler et al., 2020), hinders NbS adoption (Seddon et al., 2020), and contributes to challenges for monitoring (Clever Cities, 2018), and leads to knowledge and data gaps (El Harrak & Lemaitre, 2023).

Siloed governance is identified as an obstacle hindering effective NbS planning and implementation (Seddon, 2022; Wamsler et al., 2020). Effective climate adaptation requires cross-sector cooperation and coherent regional and national models for NbS (Seddon, 2022) to mainstream climate adaptation. This requires collaborative approaches to unify the efforts of actors (Wamsler et al., 2020). But practical support for collaborating across sectors is needed (Nesshöver et al., 2017). However, the reality is often inadequate governance structures for NbS (Clever Cities, 2018) which favours grey solutions (Seddon et al., 2020). Institutional fragmentation, sectoral silos, and independent departmental operations lead to confusion due to multiple agencies with different responsibilities (Sarabi et al., 2020).

Economic and market challenges

On the economic side, there are significant financial constraints for NbS. Limited climate finance has been recognized as one of several economic challenges for climate adaptation (European Commission, 2022; Seddon, 2022). This is especially significant in low-income countries (Seddon, 2022) but also evident in high-income countries. The cause for this gap can be due to poor financial models and under-investment (Seddon et al., 2020) and insufficient or poorly directed finance (WWF, 2021). To ensure fair benefits from NbS, investment schemes must be long-term (Nesshöver et al., 2017). Currently, the limited direct financial revenues challenge NbS development (WWF, 2021), as well as the lack of dedicated budget for climate adaptation (Wamsler et al., 2020).

A sense of ownership and shared risk over NbS with appropriate financial models can greatly contribute to the development of markets for investing in NbS projects and initiatives (Seddon et al., 2020). Market failures and barriers for investment include information shortfalls (often due to the lack of data on the benefits, tensions and trade-offs of NbS, skills and expertise shortages, and a lack of awareness by the general public), a failure to coordinate across a range of public agencies and organisations, high transaction costs, long timeframes for financial returns and high risk profiles (European Investment Bank, 2023).

There is a challenge in monetizing the benefits of NbS (Seddon et al., 2020) since a majority of ecosystem services do not have financial markets (European Investment Bank, 2023). There is a risk that natural capital is being undervalued (WWF, 2021). When investors and decision makers see high initial costs for NbS it is key to remember that NbS are often cheaper in the long-term (Seddon, 2022). Other reasons for insufficient financial resources for NbS are limited funding opportunities and current short-term investment schemes (Sarabi et al., 2020), which constrain the state of direct financial revenues (WWF, 2021). Municipalities and public authorities often have restricted resources and autonomy, which also contributes to the need for private investments in NbS (Sarabi et al., 2020).

Socio-cultural and justice challenges

A fundamental notion for NbS is to acknowledge it as a way to work with nature, as nature (Chausson et al., 2024). The term NbS may imply that these measures are inherently considered well-intended and harmless (Nesshöver et al., 2017), rather than intrusive. However, the problems that the solutions are meant to solve are not always agreed upon (Nesshöver et al., 2017). Various definitions have taken on the challenge of trying to define what nature means and how we understand it in different ways (Nesshöver et al., 2017). However, Indigenous people and grassroots groups sometimes reject NbS and see this as a form of greenwashing and pulling attention from the urgent problem, which is decarbonization and systemic change (Seddon, 2022). The groups express concerns over the commodification of nature, the violations of human rights, and threats to biodiversity. Not recognizing local voices puts a risk on NbS projects (Seddon, 2022).

In order to avoid misusing the NbS concept (which can cause misunderstanding and unintended consequences), it is important to agree upon the key elements of the definition (Nesshöver et al., 2017). An oversimplification of the concept can lead to unexpected trade-offs (Nesshöver et al., 2017) and increase the risk of greenwashing (El Harrak & Lemaitre, 2023), and overselling the benefits of nature (Nesshöver et al., 2017) can increase the risk of NbS being misused and misinterpreted (UNEP, 2022). Consequently, there is a risk of distraction from the root problem, and ignoring the urgently needed systemic changes combined with rapid and deep decarbonization (Seddon, 2022; UNEP, 2022).

NbS implementation often comes with trade-offs, such as not recognizing how it impacts a diversity of stakeholders. There is a chance that NbS does not take sufficient recognition of rights (WWF, 2021), for example overstepping the rights of IPLCs (UNEP, 2022). Compromised local land rights can lead to land grabs (Seddon et al., 2020) and top-down decision-making can often neglect local rights and knowledge (Seddon, 2022) and as a result NbS can lead to maladaptation and inequity (Seddon, 2022). Social trade-offs may negatively impact the livelihoods of local farmers (Nesshöver et al., 2017) or increase land prices and rent (Kabisch et al., 2016). A common example is *the green paradox*: when the improvement of common green areas leads to displacement processes due to increased rent, hence not benefitting the people who possibly would need it the most (Kabisch et al., 2016).

To avoid maladaptation and social trade-offs, effective citizen involvement can be a way forward (Clever Cities, 2018). A challenge for many NbS incentives is insufficient social inclusion and social acceptance (Clever Cities, 2018). The problem can occur when not all stakeholders are involved or have conflicting goals (Nesshöver et al., 2017). Imperative to the process is the way objective and timing can affect how each stakeholder will be able to engage in the process (Wickenberg et al., 2021), otherwise social incentives can be missed (WWF, 2021). Stakeholder participation is recognized to be challenging due to the misunderstanding or lack of agreement on the NbS concept (Nesshöver et al., 2017). Other challenges to collaboration and citizen involvement can be conservative citizen groups that can hinder the planning of NbS locally (Wamsler et al., 2020; Cousins, 2021).

Knowledge and contextual challenges

A fundamental barrier to the implementation of NbS is the current lack of knowledge (Clever Cities, 2018) about the effectiveness and ability to deliver co-benefits (PHUSICOS et al., 2023). Often research

is focused on urban solutions, and overall there is limited knowledge about the enablers of and opportunities for NbS implementation (Martin et al., 2021). There are also knowledge gaps concerning long-term benefits and the potential ecosystem disservices related to NbS (Kabisch et al., 2016) and uncertainties about the effectiveness of NbS (Seddon, 2022). Evaluating immediate and long-term benefits is challenging due to uncertainties surrounding how these benefits may evolve over time, particularly concerning changes in ecosystems (Wickenberg et al., 2021), indicating that an improved evidence base for understanding long-term ecological and social impacts is essential (Seddon, 2022) as well as comprehensive evidence for cost-effectiveness (Seddon et al., 2020).

It is argued that NbS requires a unified definition, as disagreement surrounding the concept creates confusion (Sarabi et al., 2020). It can become a challenge to find qualified contractors who are experienced and specialized in implementing NbS, as a result of the lack of common standards, technical guidelines, and legal regulations (PHUSICOS et al., 2023). Furthermore, the importance of a common definition and regulatory frameworks and standards for NbS is often highlighted in the literature to enable credibility, clear guidelines, and mainstreaming (Nesshöver et al., 2017; Wamsler et al., 2020), since a loosely defined term can miss opportunities (Nesshöver et al., 2017), and if vaguely defined it loses operational credibility (Cohen-Shacham et al., 2019). Clear definitions and methodologies are therefore essential for the concept to be sustained and to prevent unintended outcomes (Cohen-Shacham et al., 2019).

Throughout the process from strategy to implementation and monitoring of NbS, there is an overall lack of operational clarity, which can create a major obstacle for credibility and applicability (Cohen-Shacham et al., 2016). Selecting the appropriate type of NbS is essential to consider the relative costs and benefits of the NbS options, including the costs for implementation and maintenance and also comparing these against grey options (Wickenberg et al., 2021). Grey solutions are often favoured over NbS, since the effects of NbS take time and the observable efficacy varies between sites and locations (Seddon, 2022), since the implementation always is context-specific (Wickenberg et al., 2021).

As mentioned, framing nature within NbS is also a challenge (Nesshöver et al., 2017), and monitoring and evaluation that is required (European Commission, 2022). However, there are no established targeted indicators (Kabisch et al., 2016) and there is a lack of indicators for enabling monitoring social and environmental justice issues (Kabisch et al., 2016). The uncertainty about implementation concerns lack of information on benefits and effectiveness, and the limited uptake of academic knowledge reduces public acceptance (Sarabi et al., 2020). However, the success of NbS largely depends on the mode of implementation (Wickenberg et al., 2021). This highlights the importance of understanding how frameworks address implementation required for enabling processes (Wickenberg et al., 2021), and stresses that implementation is context-specific (Wickenberg et al., 2021).

Uncertainty and unpredictability are challenging when working with a changing climate and ecosystems. Ecosystems are unpredictable and current NbS principles do not sufficiently address uncertainty or long-term stability (Cohen-Shacham et al., 2019). It is difficult to measure and predict NbS effectiveness (Seddon et al., 2020). Monitoring is essential for long-term stability and adaptive management but it is often overlooked in the principles for NbS (Cohen-Shacham et al., 2019) and the ecological outcomes for NbS are rarely monitored (Seddon, 2022). A clear definition, and principles, and developing evidence-based standards and guidelines for implementing, assessing, and improving NbS is key to scaling up NbS (Cohen-Shacham et al., 2019).

Enablers

As with the barriers and challenges for NbS, the literature also identifies and discusses a plethora of interconnected enablers and opportunities for NbS from a range of different perspectives. Political and institutional opportunities cover shifting policy agendas, collaboration between actors and across sectors, inclusive and multilevel governance, and embedding NbS in local contexts. Economic and

market opportunities include unlocking financing from different sources and institutions as well as the emerging recognition of NbS as a viable and effective response to a changing climate, building resilience, and biodiversity loss.

IPLCs are identified as a key to grasping socio-cultural and justice opportunities associated with NbS. The literature suggests that co-design and knowledge sharing are key to successful NbS, including a diversity of stakeholders and both expert and tacit knowledge (Kabisch et al., 2016; Wickenberg et al., 2021). Finally, the literature highlights that to work successfully with NBS, it is key to connect up planning, implementation, monitoring, and evaluation and learning. Standards, people-centered planning and innovation, and broadly accepted principles for NbS all represent important enablers for scaling NbS.

Political and institutional opportunities

There is a need to mainstream NbS into policy agendas to enable implementation (El Harrak & Lemaitre, 2023). To cut through administrative bodies, polycentric collaboration within institutions is required (Martin et al., 2021). NbS is more likely to be implemented through collaborative efforts to enhance disaster protection, climate adaptation, biodiversity, and human welfare (Martin et al., 2021). Furthermore, NbS can provide opportunities to integrate environmental goals into sectors that typically do not prioritize the environment, thereby improving sustainability in decision-making (Nesshöver et al., 2017). Co-creation of knowledge through collaboration can also lead to a shared understanding, actionable knowledge and informed decision-making (Wickenberg et al., 2021).

To address the challenges of climate adaptation and biodiversity loss on a large scale, innovative and policy-coherent solutions, such as evidence-based NbS frameworks are required (Cohen-Shacham et al., 2019). A detailed formulation of NbS can encourage dialogue, innovation, and collaboration among, policy, science, and practice communities. (Nesshöver et al., 2017) In the effort to incorporate NbS into European research and innovation frameworks, policy-makers have aligned biodiversity and ecosystem services with innovation. This attempt is aimed at promoting growth, creating jobs, and supporting sustainable development simultaneously (Nesshöver et al., 2017). This is an example of how NbS is starting to establish a significant presence in policy, research, and business (Seddon, 2022).

To enable NbS, it is fundamental to work with inclusive governance (WWF, 2021). It is crucial to have supportive and integrated public policies (European Commission, 2022). Preconditions for a fair and successful deployment of NbS are favorable property rights, mandates, legal bases, cross-sectoral collaboration, local champions, clear goals, a common vision, and political support (Martin et al., 2021). Research shows that NbS projects in areas with established land rights and access are more successful (Seddon, 2022). Policies that support collaboration and local empowerment, incentives, and monetization strategies followed by cross-sectoral networking have been identified as drivers for successful NbS.

NbS need to be integrated into all levels of governance. Robust institutions and well-established planning structures are preferable for a broad uptake (Seddon et al., 2020), as well as the creation of multilateral partnerships between companies, communities, governments, NGOs, and financial institutions (Seddon et al., 2020). When working on NbS at regional and national levels, NbS models need to be centered around local conditions, and consider risks like impermanence (Seddon, 2022). A precondition for success is to enable locally-led actions (UNEP, 2022) and funding local institutions (WWF, 2021). Follow-up work needs to be prioritized, and clear leadership is needed, including taking primary responsibility for measurement and evaluation, as well as ensuring that data is open and accessible for public use (European Commission, 2022).

When municipalities work with NbS, there are local challenges, risks and conditions to consider. Municipalities need to actively collaborate with stakeholders and include relevant citizen groups. It is

recommended to internally restructure to accommodate an effective working approach with NbS across departments to better fit NbS development. Policies need to be changed to align with recommendations from science (Wamsler et al., 2020). An individual official within a municipality can be crucial in building trust and establishing connections between the municipality and its residents. A so-called 'municipal champion' is important to identify internally, who can foster long-term relationships, be inclusive, and contribute to learning among stakeholders and residents (Wamsler et al., 2020).

Economic and market opportunities

Several factors indicate that NbS have economic benefits over grey solutions, such as the long-term maintenance costs of NbS often being lower than for engineered alternatives (Seddon, 2022). Even when considering the long-term benefits, NbS often have a better benefit to cost ratio than grey approaches (Seddon, 2022). However, NbS face challenges in financing projects and it is suggested that policy-makers need to enable enhanced investment in NbS by both the private and public sectors (European Commission, 2022).

Funding from public and private sources, bilateral and multilateral, and national and international sources are all opportunities for financing to flow into NbS (Seddon et al., 2020). The relatively new European taxonomy can promote divestment from projects that exploit nature and ecosystems (PHUSICOS et al., 2023) and direct investment into NbS. Regulation and subsidy reforms are needed to create new incentives and remove support for the further erosion of nature, as well as to create new markets and revenues (European Investment Bank, 2023). A more progressive economic and regulated financial system is a foundation to encourage investment in NbS (WWF, 2021).

Successful implementation of NbS requires secure, sustainable financing suited to local conditions and contexts (Seddon, 2022). In low-income countries, where costs are often high, NbS can make a feasible and cost-effective alternative to engineered solutions where NbS can bridge the funding gaps for climate adaptation (Seddon, 2022). For example, in the agricultural sector, there is a clear argument that NbS need to provide economic advantages for both farmers and decision-makers to encourage adoption. A potential benefit of NbS in agriculture can be the emphasis on improvements in agricultural production and socio-economic gains (Miralles-Wilhelm, 2023).

There is a clear need to address a range of challenges through enablers in different market sectors (European Commission, 2022). The literature provides a diversity of recommendations on how to unlock financing for NbS, including: equity-based funding reflecting mutual sharing and less conventional forms of capital (Seddon et al., 2020); long-term investments in ecosystems and strategic, coordinated governance (Seddon et al., 2020); combining marketable and non-marketable ecosystem services (Miralles-Wilhelm, 2023); and novel 'blended' financing to extend the portfolio of bankable NBS projects (PHUSICOS et al., 2023).

Socio-cultural and justice opportunities

Successful implementation of NbS includes engaging with IPLCs and reinforcing local rights as well as ensuring the distribution of co-benefits from NbS to vulnerable areas and groups (Seddon, 2022). It is argued that local citizens and organisations often have essential knowledge about local ecosystems as well as local dynamics, relationships and constraints (Miralles-Wilhelm, 2023) and IPLCs often possess valuable knowledge of how to adapt to external changes and tackle climate and biodiversity crises (Seddon, 2022). A key to successful NbS is therefore knowledge sharing and knowledge valorisation, indicating that by including a diversity of stakeholders both expert, local and tacit knowledge can be shared and used (Kabisch et al., 2016).

NbS are not solely focused on achieving the end result, but rather, the journey to reach that outcome plays a vital role in determining their success. Working with NbS means that the process is guided in an inclusive way, where the needs, knowledge, and desires of local citizens are considered in the design

and implementation (Miralles-Wilhelm, 2023). Furthermore, collaboration between social and natural scientists and Indigenous peoples is crucial for effective NbS (Seddon, 2022), and means that a collaborative transdisciplinary process for implementing NbS necessitates the creation of platforms and spaces for collaboration, identification of relevant stakeholders with diverse knowledge, and a joint approach to formulating problems and understanding challenges (Wickenberg et al., 2021).

Co-design includes participatory processes where all stakeholders are represented (Martin et al., 2021). Effective stakeholder partnerships cultivate trust, instill a sense of ownership over NbS, and inspire active stewardship of our ecosystems. (Ershad Sarabi et al., 2019). Knowledge sharing involves broad stakeholder involvement and facilitates the sharing of ideas (Ershad Sarabi et al., 2019), and through education and training about NbS uncertainties can be reduced and public support increased (Ershad Sarabi et al., 2019). The literature emphasizes the idea of using co-design and participation (Martin et al., 2021; Nesshöver et al., 2017; Seddon, 2022; Wamsler et al., 2020; Wickenberg et al., 2021), to build trust relationships and encourage interest groups of stakeholders to initiate dialogues and develop knowledge and awareness around NbS (Martin et al., 2021; Network Nature, 2023).

There are multiple benefits coupled with NbS in the landscape. They can be ecological corridors that benefit biodiversity (WWF, 2021) or green spaces that provide health benefits to humans (Kabisch et al., 2016). Diverse ecosystems in the urban and rural landscape deliver a wider range of ecosystem services (Seddon et al., 2020). Hybrid solutions are NbS complemented with engineered approaches and they can offer key advantages (Seddon, 2022; Seddon et al., 2020). If NbS is integrated with existing grey structures, the functionality can be enhanced and in parallel public acceptance of the intervention (Ershad Sarabi et al., 2019). It is possible to find synergies between NbS and engineered solutions (Seddon et al., 2020).

The best way to take advantage of ecosystem services is to protect intact ecosystems. Intact ecosystems can offer the highest mitigation potential, the second favourable is to more sustainably manage working lands, and the least effective for mitigation is restoration (Seddon, 2022). Restoration can be beneficial but protecting stored carbon in ecosystems is twice as effective globally as restoration (Seddon, 2022) and the highest carbon sequestration rates naturally occur in older, and diverse forests (Seddon et al., 2020). NbS are living systems, with the capacity to self-repair and naturally adapt to external changes, such as a changing climate (Seddon, 2022).

Knowledge and contextual opportunities

To enable broad uptake of NbS a clear framework is essential. To effectively implement NbS on a significant scale to reverse ecosystem degradation, established coordinated principles are crucial that can create evidence-based standards and guidelines for practitioners and decision-makers (Cohen-Shacham et al., 2019). The process behind NbS is crucial for effectively implementing and maximizing the benefits of these solutions. In other words, planning, implementation, as well as monitoring, and evaluation, are essential steps for a sustainable and effective approach (Nesshöver et al., 2017). International standards for different types of NbS to build a common understanding of the concept are considered important (European Commission, 2022; UNEP, 2022).

Successful NbS projects need to be based on clear and widely accepted principles that balance flexibility with meeting goals on climate, biodiversity and sustainability (Nesshöver et al., 2017). To overcome challenges related to knowledge and financing, co-design, co-creation and co-implementation is key. Frameworks that embrace collaborative approaches can open up and allow for interpretative spaces and inclusion of a diversity of knowledge perspectives (Wickenberg et al., 2021). On the other hand, too narrow knowledge and research interests can act in the opposite direction for NbS (Wickenberg et al., 2021).

When initiating NbS projects and initiatives, people-centered planning and innovation are essential (WWF, 2021). When innovation and experimentation come together, new ideas can be formed, and participants learn from practical experiences (Ershad Sarabi et al., 2019). Even within and between countries, it is necessary to share knowledge and information on NbS to develop and learn from experiences (Kabisch et al., 2016). A transdisciplinary approach to NbS is strongly encouraged so that a broad spectrum of ideas, worldviews, and values can be highlighted. In this way, funding can be directed where it will be most effective (Seddon, 2022).

As suggested, to work successfully with NbS, it is key to connect up planning, implementation, monitoring, and evaluation. Legislation plans and policies can either enable or hinder NbS (Ershad Sarabi et al., 2019). In the design phase, there needs to be a profound ecological and geographical understanding (Seddon et al., 2020) and the implementation of NbS needs to adopt a systems perspective that accounts for the trade-offs that arise concerning multiple ecosystem services (Seddon et al., 2020). Ideally, NbS needs to be able to bridge the gap between research, policy and practice (El Harrak & Lemaitre, 2023).

To be able to assess the success of NbS, there needs to be measurable indicators. With the help of indicators, it is possible to measure and compare interventions and assess effectiveness (Kabisch et al., 2016). It is important to identify these, of which the following are proposed: Integrated environmental performance, human health and well-being, citizens involvement, and transferability (Kabisch et al., 2016). Finally, a standardized system for monitoring and evaluation of NbS is required to improve its effectiveness (Ershad Sarabi et al., 2019), where long-term maintenance needs to be considered (PHUSICOS et al., 2023).

Actors

In the context of actors, four main themes emerge in the literature (see Figure 4). First, building public-private partnerships and facilitating multi-level governance is fundamental to advancing NbS. Second, supporting co-creation and community engagement and working with key stakeholders (like farmers) are key to success with NbS. Third, thriving nature-based enterprises are a foundation for NbS. Fourth, navigating risks with NbS (embedded in barriers and enablers) and unintended social and ecological impacts. Overall, collaboration and connectivity are key for successful NbS.

Partnerships

The role of partnerships in NbS implementation indicates that communication and connections are vital for effective NbS management. Involving internal and external stakeholders is crucial, however, the knowledge base for how to build multi-level governance and engage stakeholders is limited (Wamsler et al., 2020). Stakeholder engagement and internal and external collaboration are often not integrated into policies and governing structures within municipalities. Currently, NbS projects and initiatives often rely on individual champions due to the absence of a mainstream collaborative governing framework (Wamsler et al., 2020). Individual champions can help bring together stakeholders and navigate decision-making processes.

A transdisciplinary approach that spans multiple disciplines, expertise, and sectors is fundamental for NbS (Wamsler et al., 2020). It is an opportunity to bring ideas from relevant actors into NbS planning, as it gains significance in policy (Nesshöver et al., 2017). Measures to build awareness and create partnerships are critically important for all involved stakeholders (European Commission, 2022). The need for decentralization and stakeholder involvement is crucial, emphasizing the importance of considering diverse interests and conflicts. This focus on an inclusive or participatory approach is not always aligned with governing models (Nesshöver et al., 2017).

Five strategies are proposed in the literature to build partnerships and promote multi-level governance within municipalities regarding NbS (Wamsler et al., 2020). Municipal staff and individuals can employ

the following strategies to overcome challenges: 1) targeted collaboration with stakeholders, 2) strategic involvement of citizens, 3) modification of internal cooperation structures, 4) outsourcing, and 5) discrete integration of science and policy (Wamsler et al., 2020). However, stakeholder involvement needs to be conducted fairly. Various groups can be impacted by how a societal issue is addressed. It is essential that all engaged stakeholders feel their participation is meaningful and that their opinions are respected and considered in the design of NbS (Nesshöver et al., 2017). When involving citizens it is vital to raise awareness for initiatives that impact public and private land, and the differing interests associated with how land and space is utilised and governed (Wamsler et al., 2020).

Figure 4: Themes for actors and NbS

Engagement

Effective stakeholder engagement can provide significant benefits when executed properly. These advantages include enhanced planning due to a broader and deeper understanding of the issues, more sustainable management of the solutions, and increased acceptance and support for NbS, which simplifies their maintenance. The legitimacy of NbS needs to be well-established, as the democratic process for their implementation must be conducted respecting all participants (Nesshöver et al., 2017). The literature suggests that the engagement of stakeholders needs to focus on co-creation, community engagement, and working together with stakeholders such as farmers, citizens, and landowners (Nesshöver et al., 2017; Sarabi et al., 2020).

Farmers in particular, as a group, have been studied and may be resistant to adapting their working methods despite seeing benefits in nearby ecosystems, as costs or workload initially increase with a transition to NbS, or because they are resistant to changing accustomed methods. The willingness to alter practices and working methods often depends on the perceived benefits of aligning these methods with NbS. If the compensation is sufficient and of a nature that the farmer considers reasonable, the attitude towards NbS can become more favourable with time (Miralles-Wilhelm, 2023). Farmers

highlight how a segment of society can resist NbS. Ultimately, it is a matter of altering and shifting the attitudes of stakeholders (Sarabi et al., 2020).

Scepticism exists regarding the effectiveness of NbS (UNEP, 2022), which complicates changing individual and social norms and behaviours (Sarabi et al., 2020). For nature conservation, NbS practices often aim to ensure connectivity across various landscapes, connecting patches or a specific percentage of land designated as ecological infrastructure. This requires the involvement of a minimum number of landowners. (Miralles-Wilhelm, 2023). The benefits can be prioritized differently by different groups of people, including land owners, and thus need to be negotiated (Miralles-Wilhelm, 2023).

Active cooperation and coordinated action between diverse stakeholders is crucial (Seddon et al., 2020). The engagement process is relevant for knowledge sharing and learning across and between NbS (Nesshöver et al., 2017). Engaging in NbS processes can help individuals implement a more sustainable lifestyle and contribute to broader systemic changes (Seddon, 2022). It is imperative to adopt a system that emphasizes the importance of quality of life and human-nature interconnections. NbS can facilitate this transition by enhancing resilience and protecting biodiversity (Seddon, 2022). However, some constraints are connected to citizen engagement, for example, when financial resources and structure are scarce, leading to ineffective involvement or stakeholder fatigue. Influential groups can even hinder the planning of NbS (Wamsler et al., 2020).

Enterprises

The importance of Nature-based Enterprises (NBEs) is increasingly recognized in delivering and investing in NbS. NBEs are defined as "private or third sector organizations that place nature at the core of their business" (EC, 2022: 6). The success of NBEs is a foundation to achieve the potential of NbS (European Commission, 2022). Action is required to enable the establishment and growth of NBEs, and enhance their impact both environmentally and socially, alongside an increase in investment in NbS (European Commission, 2022).

In the past, the public sector has been responsible for planning, implementing, and managing many NbS, however today the increasing demand for NbS opens up opportunities and growth of NBEs in the private sector and in third sector organisations (European Commission, 2022). NBEs are enterprises focused on contributing to biodiversity net gain, using nature indirectly or indirectly, through planning, design, and management of NbS or directly by growing, harnessing, restoring, or harvesting natural resources in sustainable ways (European Commission, 2022).

As the demand for NbS is increasing, there are potential bottlenecks in their supply, in particular, due to a lack of enterprises in the private sector, with profound knowledge and long experience of NbS. A nature-positive economy can enhance the delivery of NbS while simultaneously providing several economic benefits, such as innovations, jobs, new knowledge, and more enterprises. Additionally, NBEs can contribute to a just transition toward a more equitable, nature-positive society (El Harrak & Lemaitre, 2023).

The global economy is dependent on healthy ecosystems, as we are facing the extinction of millions of species, which threatens societies and welfare (European Commission, 2022). This calls for steering toward a nature-positive economy and positioning NBEs as a key element in shifting the economy and scaling NbS (European Commission, 2022). Ultimately, we need a dramatic increase in the uptake of NbS and a vast increase in investment in NbS. The demand for NbS is increasing as the public and private sectors realise the benefits and potentials of NbS but it is argued in the literature that NBEs are key to the next steps (European Commission, 2022).

Risks

There are ecological concerns and risks for NbS, and it is imperative to balance ecological and social impacts while considering the multiple goals of NbS (Clever Cities, 2018). If implemented without regard to ecosystem complexity misuse of NbS can potentially harm biodiversity (Seddon, 2022). Monocultures are vulnerable to disease, pests, and climate extremes, and invading plantations can do more harm than good to biodiversity (Seddon et al., 2020). The use of non-native species risks becoming invasive or exacerbating water scarcity (Seddon et al., 2020), ultimately leading to biodiversity loss (Seddon, 2022). Thus, the aim of NbS to conserve biodiversity must be explicitly recognized in all projects and frameworks (Nesshöver et al., 2017).

There is a pronounced uncertainty in ecosystem service provisioning under changing conditions (Seddon et al., 2020), such as climate change. Humans have limited knowledge of ocean carbon fluxes and ultimately the potential for ecosystems to provide cooling since estimates of NbS's potential vary (Seddon, 2022). Under a worst-case scenario, NbS can have negative impacts and reduce albedo, depending on location and vegetation type (Seddon, 2022). Scaling up NbS can come with risks, such as leakage when scaling results in ecosystem damage in other locations (Seddon, 2022). Models may also overestimate the benefits of NbS by not accounting for ecosystem vulnerability, all must be thoroughly assessed and validated through long-term monitoring of social and ecological effects (Seddon, 2022).

It is imperative not to distract with NbS from systemic change that is needed, since the cooling effect of NbS cannot compensate for what is required in cutting greenhouse gas emissions (Seddon, 2022), meaning that ecosystem restoration cannot off-set rapid emissions from deforestation. Further, NbS takes time to establish, and its effectiveness varies with climate conditions (Seddon, 2022). Human stressors and competition over land threaten ecosystems and limit the potential of NbS. Current climate change and increased frequency of extreme weather events are potentially holding back ecosystem recovery (Seddon, 2022). Regrettably, policies may favour afforestation over the protection of valuable ecosystems (Seddon, 2022), when NbS is used for offsetting greenhouse gas emissions.

Emerging perspectives on governing NbS

There are a multitude of perspectives on governing NbS in the literature, often in connection with discussions on transformative change (Palomo et al., 2021; Fransen & Bulkeley, 2024). There is also a diversity of definitions for transformative change and what it means in theory and practice. In this report, it refers to a fundamental, systemic reorganisation across technological, economic, cultural and social factors, including paradigms, goals and values. According to Scoones et al. (2020), there are three interconnected approaches to transformative change, covering a spectrum of shifts from large-scale changes to grass-roots actions. These are structural, systemic and enabling approaches.

Structural approaches refer to fundamental changes in social systems, focusing on deep and systemic changes in the economy, politics, and society to reshape social systems such as norms, regulations, and practices. Systemic approaches refer to intentional changes in specific parts of a system focusing on the connections and interactions between different features of a system such as elements, levels and drivers. Enabling approaches refer to bringing capacity and agency changes, focusing on empowering communities and human actors to deal with uncertainties (Scoones et al. 2020).

Here we highlight three examples from the literature on governance and NBS that fall into the different categories of transformative change as defined by Scoones et al. (2020). First, understanding narratives for NbS (Chausson et al. 2024), which is a structural perspective. Second, mainstreaming nature-based enterprises (European Commission, 2022), which is a systemic perspective. Third, stepping stones for NbS (Xie et al. 2020), which is an enabling perspective. These three examples highlight different

understandings of transformative change and provide insights into the importance of governing NbS as well as ways to navigate tensions, trade-offs and risks.

Understanding narratives for NbS

In the report, entitled "Nature-based Solutions: Narratives, Frames and Future Horizons", the focus is on examining narratives and emerging viewpoints – both supporting and critiquing the rise and potential of NbS. The report argues that proponents present two key narratives. First, the mitigation narrative that "focuses on the climate crisis and increasing emissions, closely followed by the biodiversity crisis" (Chausson et al. 2024: 17). This narrative frames NbS as "global solutions for global issues" (Chausson et al. 2024: 17). Second, the vulnerability narrative that "highlights climate change adaptation as the main concern for NbS" (Chausson et al. 2024: 18). The primary focus is on building resilience to reduce the impacts of climate change.

The report suggests that critics are increasingly challenging "uncritical attitudes among proponents" and highlighting "the need to tackle structural drivers behind climate and biodiversity breakdown" (Chausson et al. 2024: 18). There are also concerns that the NbS concept marginalises IPLCs. Overall, the report argues how the NbS concept can encourage interconnected thinking and acting across climate, biodiversity, and social justice contexts. However, there is a clear need to shape and manage NbS towards meeting global and local goals as well as positive outcomes for IPLCs through critically assessing the potential of NbS (see Table 2).

Table 2: Recommendations for engaging with NbS

Points	Descriptions
Avoid advocacy positions on NbS	Maintain a pluralistic view of solutions for the biodiversity crisis; do not advocate for or against NbS. This approach allows engagement with various perspectives and avoids hindering discussion among different actor groups.
Strengthen capacities for just and transformative implementation	Collaborate with organisations promoting NbS to enhance their ability to implement just and transformative policy and practice. Ensure that actions address power imbalances and drive transformative pathways to just and equitable implementation.
Establish inclusive discussion platforms	Create discussion platforms that accommodate diverse ways of knowing and values, bridging colonial-era power differentials. Enable discussions between Indigenous groups, grassroots organisations, and international nongovernmental organisations, fostering interregional and intergenerational dialogue.
Influence representative policy	Use discussion platforms to shape NbS-related policies that genuinely reflect stakeholders' and rights holders' needs and concerns. This ensures local perspectives are not overshadowed by global knowledge.
Foster collective reflection on NbS	Embrace a systems thinking approach and scenario exploration involving diverse stakeholders to assess NbS potential for transformation. Organise discussions on barriers and opportunities for a just and equitable future for nature, including people.
Engage multilateral and aid funds	Collaborate with multilateral and country aid funds to develop decolonial funding mechanisms that address Global North–South power imbalances. Funding mechanisms should incorporate robust safeguards, empower local communities, and promote inclusive national-level policies.

Foster innovation in policy appraisal	Support the development of innovative valuation methods for policy appraisal that challenge current power asymmetries. Move beyond financial valuation to incorporate diverse values, plural benefits, and well-being considerations in decision-making processes.
Research NbS narratives	Support further research to explore NbS narratives in the biodiversity space. Investigate the association between biodiversity NbS narratives and colonial conservation legacies and examine how narratives frame biodiversity finance and policy integration in relation to NbS.

Source: Chausson et al. (2024).

Mainstreaming nature-based enterprises

In the report, entitled "The Vital Role of Nature-based Solutions in a Nature Positive Economy", the focus is on the role and possibilities for NbS to help shift towards a nature positive economy as well as to highlight the increasing importance of NBEs in delivering and investing in NbS. NBEs are defined as "private or third sector organisations that place nature at the core of their business" (European Commission, 2022: 6). The success of NBEs is of clear importance to achieve the potential of NbS and their opportunities for scaling and mainstreaming is paramount.

A nature positive economy is defined as an economy in which governments and businesses "take action at scale to reduce and remove the drivers and pressures fuelling the degradation of nature, and work to actively improve the state of nature and the ecosystem services it provides" (European Commission, 2022: 6). This report argues that significant action is needed to support the start-up, and mainstreaming of NBEs to increase their impact and in parallel increase financing of NBS. To do so, this report outlines a collection of key roadblocks that are preventing both NBEs and NbS from advancing and expanding, including standards, measurement, policy, investment, markers and awareness (see Table 3).

Table 3: Roadblocks for achieving potential of NbS

Types	Descriptions
Standards	As the concept of NbS matures, increasing concerns are being raised about misuse of terminology, greenwashing, and the quality of NbS. There are calls for transparent and widely accepted standards and codes of practice which can provide greater clarity around what is and what is not NbS and guidance on how NbS can be implemented at planning, delivery, and maintenance phases.
Measurement	Monitoring and reporting are essential elements to avoid greenwashing and loss of biodiversity and to ensure additionality and permanency of the impact of NbS investments. More data and increased data sets are needed to better inform decision-makers and investors about NbS. Mandatory valuation of ecosystem services is a possibility. However, the question of how to value NbS and the pricing of ecosystem services remains a topic of discussion.
Policy	Supportive, integrating public policy is of paramount importance in effecting the paradigm shift required to embed NbS as the bedrock of a nature-positive economy. NbS can only contribute to a nature-positive economy if NbS concepts and approaches are embedded in multi-level, cross-sectoral policy frameworks developed through participatory processes and accompanied by a range of policy instruments and related awareness raising.
Investment	Recent initiatives in Europe hold potential to channel increased financing towards nature-positive investments. Increased recognition

	is needed of the importance of collaborative approaches to project development to ensure the voice of communities is adequately represented in investment decisions. Further research and support actions are needed to address the financing and sustainability of small scale, often community organised NbS projects.
Markets	Many common challenges and enablers affect markets including low levels of awareness and support for NbS among the general public, business sector and in the wider political and public sector environment; a lack of practical, cost-effective methodologies and tools for small businesses to measure the effectiveness of NbS; variation in quality standards and codes of good practice across sectors increasing risk for investors; lack of market research data and support from business innovation ecosystems for market development; skills gaps both technical and related to soft skills such as business development.
Awareness	Measures to increase awareness and build capacity are critically important for all stakeholders - economic policy makers in particular, but policy makers across the board, public sector professionals, businesses across the value chain, innovation ecosystems including investors, third sector organisations and most important, communities and citizens. The potential of technology and platforms to connect complex NbS value chains and to provide information for decision making is clearly recognised.

Source: European Commission (2022).

Stepping stones for NbS

In the report, entitled "Steps for Systemic Integration of Nature-based Solutions", the focus is on the key stepping stones or pivotal actions (see Table 4) that can potentially support the mainstreaming of urban NbS (Xie et al., 2020). Using the examples of climate change and biodiversity, the report examines how stepping stones can be aligned to generate promising pathways for mainstreaming that can contribute to diverse sustainability goals and agendas in cities. Individually, each of the stepping stones can generate change towards the implementation of NbS. The potential effect of stepping stones can be significantly reinforced when they are aligned together, which can enable barriers to be overcome or allow the full range of opportunities to be realised (Xie et al., 2020).

The analysis in this report draws on research in the Netherlands, Sweden, the United Kingdom, Spain, Germany, Hungary and the European Union, focusing on the regulatory, financial and urban development domains of the urban infrastructure regimes that shape the uptake of NbS in cities (Xie et al., 2020). To catalyse and support the mainstreaming of NbS, stepping stones that work across these three domains and that can overcome barriers or make use of opportunities for implementing NbS are critical. Since stepping stones can be aligned in different ways, the report argues that there can be multiple pathways available for mainstreaming NbS (Xie et al., 2020).

Table 4: Types of stepping stones for NbS

Types	Descriptions
Provide a public mandate	The mainstreaming of nature-based solutions can benefit from policy-makers and investors giving a clear mandate for nature-based solutions to be included in urban development through tender and procurement policies, policy instruments (e.g. land use planning guidance), and where possible mandatory regulation.

Regulate for No Net Loss	No-net-loss / net gain regulation for urban nature (biodiversity) has the potential to generate greater interest in nature-based solutions across Europe. Developing harmonised regulation across Europe with strong monitoring and sanctioning to increase effectiveness has the potential to support nature-based solutions mainstreaming.
Include in contractual requirements	Utilities (e.g. water, waste, energy) and network service providers (e.g. road and rail authorities, waterway authorities) are either publicly owned or operate on long-term contracts that are bound by regulatory requirements for service provision. Including nature-based solutions as required for the delivery of mandated functions (e.g. water quality treatment) or for the upkeep of land-holdings (e.g. train sidings, roadside verges) provides an important avenue for mainstreaming.
Align with strategic priorities	Positioning urban nature-based solutions as generating benefits for prioritised policy goals through generating narratives and evidence (i.e. climate change mitigation & adaptation, circular economy and healthy urban living) can widen their relevance and community of practice.
Create intermediaries	In order to overcome institutional silos within both public and private sector organisations, new organisational forms that work across these divisions are required. Intermediary units can either be established within organisations or outside (by external bodies) and provide coordination between departments as well as platforms for innovation.
Generate partnerships	Stimulating partnerships between public, private and third sector organisations for the co-design, development and maintenance of urban nature-based solutions is critical for generating initial action on the ground and increasing support for mandatory urban greening policies.
Establish demonstration projects	Demonstration or pilot nature-based solutions projects, often involving research, can create shared learning and knowledge development as well as providing tangible demonstrations of how nature-based solutions can work in practice, creating confidence amongst partners about their potential.
Engage insurance sector	Engage the insurance sector to support upscaling of urban nature-based solutions based on their risk reduction needs and damage cost expertise.
Facilitate community-based action	Facilitate and support community-based action for local urban nature-based solutions through improving citizen awareness and support.
Provide economic incentives	Provide economic incentives (tax cuts, subsidies) to support the development and uptake of nature-based solutions.
Develop markets	Positioning nature-based solutions as a sustainability solution offering wide societal and reputational benefits can support the development of demand for nature-based solutions projects which in turn can stimulate supply.
Build co-financing arrangements	Build governance arrangements between the public and private sectors to enable co-funding for nature-based solutions development and maintenance.
Work with investment cycles	Integrating urban nature-based solutions into infrastructure projects and renovation cycles increases their (multi)functionality and can save costs by reducing the need for additional outlay and drawing on existing budgets.

Stimulate institutional investment for risk reduction	Institutional investment for urban nature-based solutions is likely to be forthcoming based primarily on their climate risk reduction value (adaptation and mitigation), and specific data/modelling may be required to realise this potential.
Target areas of low land value	Nature-based solutions can face competition from other land-uses which provide a higher return on investment. Using urban space with a lower value can suit some forms of nature-based solutions and provide a more cost effective means of urban greening (e.g. street green, pocket parks and building-integrated green).
Improve data and monitoring	Mainstreaming nature-based solutions will require the development of evidence on their performance in urban nature-based solutions, through the use of 'big data' and new assessment tools that can support effective monitoring, evidence-building and assessments of their effectiveness in addressing key urban goals.

Source: Xie et al. (2020)

REGIONAL ASSESSMENT

In this section, we present in-case analysis from the five model regions in the ARCADIA project, including Emilia-Romagna in Italy; Lower Austria; Zagreb and Krapina-Zagorje in Croatia; Skåne in Sweden; and Funen in Denmark. We organise the regional assessment in this section under a set of key headings including a general description of the regional context, key expected benefits from NbS, key barriers or challenges for NbS, key enablers or opportunities for NbS, and finally, regional ambitions for NbS. This section utilises data from the short questionnaire and the reports (see ARCADIA deliverables 1.1, 2.1, 3.1, 4.1 and 5.1) from the five model regions in the ARCADIA project.

Emilia-Romagna

General description of regional context

The Emilia-Romagna Region is one of the 20 Italian regions. It is located in the Northern-Italy and it covers an area of 22.510 km^2 (sixth in Italy in terms of area). Nearly half of the region consists of plains (47%) while 28% is hilly and 25% mountainous. On the East side the border is represented by the Adriatic Sea coastline. The total population is about 4.460.000 inhabitants (48% male and 52% female), corresponding to 7.5% of the total Italian population. The 18% of the area is classified as medium level of urbanization and average density is 198 inhabs/kmq. The Utilized Agricultural Areas (UUA) covers 46% of the total region. Emilia-Romagna farms represents the 4.7% of the italian farms although in the last decades the number of farms decreased (from more than 170.000 in 1982 to about 53.000 in 2020). Arable lands cover 80% of the total UUA, followed by permanent crops (11%) and meadows and pastures (6%).

Husbandry (mainly cattle, poultry and pigs) are an important part of the regional agricultural sector. The regional forest area, according to the latest data from the National Forests and Forest Carbon Sinks Inventory (INFC2015) covers about 640,000 hectares, corresponding to 28% of the regional territory and 6% of the national forest stock. Only 4% of the regional forests are located in lowlands. State forests have a valuable environmental value and cover about 37.000 ha and are mostly located in the highest Apennines. The regional economy is characterized by world-wide well-known and appreciated products (agriculture, food industry, automotive, chemical and biomedical industry). The tourism sector is well developed both in the hinterland and on the coastline areas. There are a range of climate risks facing Emilia-Romagna (see Box 2).

Box 2: Summary of climate risks in Emilia-Romagna

Climate risk assessment has been carried out as part of the Emilia-Romagna climate change strategy. The main hazards affecting Emilia-Romagna are identified as forest fires, hydrogeological instability (landslides and floods) and subsidence, soil degradation and onset of desertification processes, loss of agricultural production, less availability and lower quality of water, coastal erosion, adverse effects on health, increased energy consumption, loss of biodiversity and ecosystem change, adverse effects on economic activities (industry, commerce and tourism), and saltwater intrusion. These hazards have been linked to the exposed elements and the potential impacts detailed across different sectors and zones. It is worth mentioning that the risk precursor monitoring in the Emilia-Romagna region relies upon several monitoring networks which collect environmental variables that can be used also as indicators of climate-related hazards.

Source: Emilia-Romagna Regional Report for the ARCADIA project (deliverable 1.1)

Key expected benefits from scaling NbS

The action plan for Emilia-Romagna in the ARCADIA project focuses on the implementation of Sustainable Forest Management (SFM) approaches across various forests and parks. The benefits expected are numerous:

Reduction of hydrogeological risk: Following the extreme flood that hit the region, especially the eastern part, in 2023, the need for new territorial safety strategies became evident. This event was not limited to river flooding but included widespread slope failures/landslides in the hills and mountains (Apennines), about 80.000 landslides. An in-depth analysis by a dedicated committee of experts identified the main drivers of the event, classifying the regional territorial system as extremely fragile, particularly in the connection zone between mountains and plains, areas that have typically been transformed from farmland to forestland. Establishing new forest management approaches aimed at supporting water management in river basins has been identified as a strategy to mitigate the increasing hydrogeological risk exacerbated by extreme storms and rainfall events related to climate change.

***Reduction of drought effects*:** Recent years have been marked by severe drought, with limited precipitation in winter and summer, significantly affecting the agricultural and forestry sector. Enhancing water infiltration through SFM and detailed modeling of water demands will support actions to address drought seasons.

Ecosystem and natural resources valorization: SFM will be a pillar in the future Integrated Forest Land Use Plans (PFIT), which have guiding, prescriptive, and operational functions and enable a spatial approach to forest multifunctionality. Forest planning should be based on ecosystem services providing models that will guide policymakers, supported by researchers, in assessing stationary suitability. This will suggest different management models aimed at enhancing ecosystem services and determining forest functions to be conserved, developed, or enhanced accordingly.

***Local stakeholders involvement*:** Local communities will benefit from the valorization of forest resources. Forest owners and supply chain actors will participate in developing mechanisms for how to facilitate payments of ecosystem services, which will support the local economy and revenue.

Key barriers/challenges for NbS

The ARCADIA project in the Emilia-Romagna Region focuses on implementing NbS at the forest level, particularly using Sustainable Forest Management (SFM) to increase forest resilience to climate change. The need for new forest management approaches is driven by the impact of mountainous regions on the water management of plains, which became evident during the extreme flood that hit the region in May 2023. Conversely, recent years have been marked by extreme droughts (low precipitation, heat waves) that have affected regional water reservoirs. Two main challenges for NbS implementation can be identified:

***Local community involvement*:** Implementing NbS in Emilia-Romagna forests requires the involvement of local communities. As mentioned earlier, the valorization of resources through mechanisms of payments for ecosystem services will support the local economy. However, this approach conflicts with the lack of homogeneity in forest ownership forms and types of forest use, resulting in differing interests in the proposed management approaches.

***Lack of a large-scale and shared approach for natural capital value assessment*:** Proposed approaches for assessing forest multifunctional suitability require shared and comparable methods for ecosystem and natural capital assessment. Currently, models are not used at the forest planning level, which sometimes precludes the development of a large-scale vision.

Key enablers/opportunities for NbS

Three main opportunities have been identified in Emilia-Romagna that could support the implementation of NbS, particularly related to SFM:

***Regulations**:* At both national and regional levels numerous regulations support the implementation of NbS. These regulations can serve as guidelines for designing and implementing new forestry management approaches that address the needs for climate change adaptation and mitigation. The upcoming Forest Land Use Plans (PFIT) will be based on the multifunctional role of regional forests, supporting ecosystem services and local communities.

***Knowledge**:* Forest planning requires a multidisciplinary approach. At the regional level, there are high-level research groups that can support the regional authority in defining strategies for natural capital valorization. This will be achieved through specific operational plans and guidelines based on robust assessment methods.

***Funds**:* Currently, multiple funding instruments support the development and implementation of actions addressing climate change effects, such as NbS. Regional funding and resources from the Next Generation EU programs will support the implementation of long-term strategies.

Regional visions and ambitions for NbS

There are five main ambitions for the region in the context of the ARCADIA project (see Box 3 for more details on visions and ambitions). First, promote forest management to mitigate climate change risks (such as floods and landslides). Second, enhance the forest value chain to maximize economic and environmental benefits. Third, valorize regional natural capital by balancing the needs of local communities with effective forest management and biodiversity protection. Fourth, support regional efforts in developing concrete actions for climate change adaptation. Fifth, develop guidelines for policymakers on forest management, based on objective assessments of ecosystem services provided.

Box 3: Summary of visions and ambitions in Emilia-Romagna

Visions in the region

In the Emilia-Romagna Region, NbS are currently mainly oriented towards adaptation to climate change, with a specific focus on strengthening the resilience of the territory with respect to hydrogeological instability, which is a major vulnerability. In addition, it is also crucial to deal with the growing risks related to climate change, including fires, wind damage and frost. The region intends to develop these initiatives in compliance with the guidelines of the National Biodiversity Strategy and the National Forestry Strategy, to ensure an integrated approach aligned with national directives. The Emilia-Romagna Region believes that NbS can be a highly effective tool to increase forest resilience, while mitigating damage and impacts caused by extreme weather events.

To support the dissemination and adoption of NbS, the region has also expressed its commitment through the funding of specific calls and projects. In the framework of the implementation of these strategies, the Emilia-Romagna Region has worked with the development of tools and strategies to quantify and enhance the role of forests in the reduction of CO_2 emissions, through hydrogeological risk mitigation actions and fire and crash risk prevention. Recently, a mandate has been agreed to establish the Regional Register of Forest Ecosystem Services, which represents a fundamental step towards the valorisation and recognition of the ecosystem services generated by sustainable forest management. This tool allows forest owners and holders to access the resources needed to start virtuous paths of planning and active forestry management.

Moreover, communication actions are underway to raise awareness among stakeholders, through the publication of a popular series of six booklets dedicated to the enhancement of Emilia-Romagna woods. Moreover, the region has activated a close cooperation with the University of Bologna to orientate the Territorial Forest Management Plans (PFIT) towards a planning based on NbS, aimed at reducing the risks of hydrogeological instability, increasing biodiversity and enhancing the wood capital, with the ultimate goal of increasing the overall Natural Capital of the region. This academic and institutional cooperation aims at developing a forest management that not only contributes to environmental sustainability, but also enhances the territory in a long-term perspective, increasing the ecological and socio-economic welfare of the Emilia-Romagna Region.

Near and Future Ambitions
One of the main ambitions of the region is to limit the increase in conflicts related to compliance with regulations concerning nature conservation areas, such as Regional Parks and National Parks. In these contexts, there is often a lack of a shared decision-making process with the local populations as a result of proper spatial planning, which should carefully identify the areas intended for integral conservation, those intended for productive purposes and those, equally important, intended for the protection of the cultural traditions of the territory and its populations. The proposed solution envisages a synergetic study to be launched in the coming years, which will integrate the National Forest Strategy with the National Biodiversity Strategy.

To minimise conflicts and find solutions that integrate the two strategies, it is necessary to start with an analysis of the local context, taking into account variables such as climate vulnerabilities, urban pressure, local biodiversity and community needs. Tools such as GIS and environmental simulation models can be used to optimise the distribution of benefits and minimise conflicts between different functions. For example, the interaction between biodiversity conservation (protective function) and forest production (productive function) is considered, with the aim of maximising benefits. In addition, as part of a regional strategic planning policy and in response to the 2023 floods, the region has prioritised the drafting of PFIT for catchment areas, to create a fundamental planning framework for the entire region.

Source: Emilia-Romagna Regional Report for the ARCADIA project (deliverable 1.1)

Lower Austria

General description of regional context

Lower Austria (German: Niederösterreich), is a federal state located in the northeast of Austria. It is the country's largest state by area, covering approximately 20,000 Km^2. Geographically, Lower Austria is diverse, encompassing parts of the Austrian Alps, the Danube corridor, and extensive flatlands and rolling hills in the north and east within the Pannonian Basin. The region features lush vineyards, forests, and agricultural land, making it an important agricultural hub.

The population of Lower Austria is around 1.7 million people. The current administrative capital is St. Pölten, but only since 1986. The historical capital of Lower Austria was Vienna (and also the largest city and economic centre), but since the establishment of the 1st Republic of Austria in 1920, Vienna is a separate federal state surrounded by Lower Austria. Further urban centres include Amstetten (in the west), Krems (centre), as well as Wiener Neustadt and Baden (in the south).

In recent history, Lower Austria has experienced steady economic development, partly due to its proximity to Vienna and its role in agriculture and industry. The state has invested in infrastructure and tourism, promoting its historical sites, natural landscapes, and cultural heritage. The integration of modern industries and preservation of traditional agriculture and viticulture have been key focuses.

Lower Austria is also known for its historical significance, with numerous castles, monasteries, and ruins that reflect its rich past. The region's cultural and natural attractions draw visitors year-round, contributing to its thriving tourism sector.

As for land use, Lower Austria holds a share of around 50% of all arable land in Austria, playing a key role in supplying the Austrian population with agricultural products. Therefore, the protection of the arable land is crucial. Vineyards are both key economic and tourism drivers, particularly in renowned wine regions of Wachau, Wagram, Kamptal, and Weinviertel. Forests cover a substantial portion of the land, particularly in the southern Alpine fringe (which belongs to the mountain biogeographical macroregion, and not to the continental one as the rest of Lower Austria) and in the northwestern part (called Waldviertel, being part of the Bohemian Massif). Like in the rest of the Austrian Alpine regions, there exists a robust timber industry. Lower Austria also hosts industries such as manufacturing and technology, particularly in areas south of Vienna (called Industrieviertel due to the rooted industrial tradition since the Middle Ages).

Not least, Lower Austria hosts two national parks: the Danube Wetlands (*Nationalpark Donau-Auen*) eastwards from Vienna and the Thaya Valley (*Nationalpark Thayatal*) along the borderlands with the Czech Republic. In addition, Lower Austria hosts 20 natural parks stretching over 55,000 hectares, 50 municipalities and home to around 200,000 inhabitants. 70% of the protected area is also protected under Natura 2000. And finally, there are a range of climate risks facing Lower Austria (see Box 4).

Box 4: Summary of climate risks in Lower Austria

In Lower Austria, a comprehensive and systematic climate risk assessment is currently lacking. However, there is a general overview of the main hazards affecting the region, including: Heat stress on human health- Heatwaves can increase the risk of heat-related illnesses and mortality and are expected to become substantially more frequent in the future; Drought in agriculture - Droughts in Lower Austria may worsen, causing crop failures, reduced yields, and shifting harvest times, impacting food security and the economy; Soil erosion due to torrential rain - Torrential rain is projected to become more severe with climate change and can lead to substantial losses in agriculture in Lower Austria; and Multi-risk (cascades/compound) due to extreme weather events (storm, pluvial, fluvial floods) - They can cause damage e.g. on infrastructure (buildings, roads, bridges) and falling trees, flying debris, and roof damage are common consequences of severe storms, leading to disruptions in transportation, communication, and utilities.

Source: Lower Austria Regional Report for the ARCADIA project (deliverable 2.1)

Key expected benefits from scaling NbS

Scaling NbS for climate change adaptation in Lower Austria can offer a range of benefits across environmental, economic, and social dimensions. Here are some key advantages:

Environmental Benefits

1. *Biodiversity conservation*: Implementing NbS such as restoring wetlands, reforestation, and creating green corridors can enhance habitat diversity and support wildlife populations, promoting overall biodiversity.
2. *Climate resilience*: Natural landscapes such as forests and wetlands can absorb and store excess rainfall, reducing flood risks. They can also buffer against extreme weather events, protecting communities and infrastructure.
3. *Improved Ecosystem Services (ES)*: Healthy ecosystems provide essential services like water purification, soil stabilization, and carbon sequestration. Enhancing natural landscapes can improve these functions, mitigating the impacts of climate change.

Economic Benefits

1. *Cost-effectiveness*: NbS can be more cost-effective than traditional engineering approaches. For example, maintaining wetlands for flood control can be cheaper and more sustainable than building artificial structures like levees and dams.
2. *Sustainable agriculture*: Practices such as agroforestry and sustainable land management (e.g. multi use hedges and buffer stripes and/or the combination of various environmentally friendly and humus-increasing or humus-preserving soil management methods in organic farming) can improve soil health and increase yield security in the long run, supporting the region's significant agricultural sector.
3. *Tourism and recreation*: Enhancing natural areas can boost eco-tourism and recreational activities, creating new economic opportunities and supporting local businesses.

Social Benefits

1. *Community well-being*: Green spaces and natural areas provide recreational opportunities and improve mental and physical health. Community-led NbS initiatives can also foster social cohesion and empower local populations.
2. *Educational opportunities*: Implementing and maintaining NbS can provide educational and volunteer opportunities for residents, increasing awareness and engagement with environmental issues.
3. *Cultural heritage*: Many NbS projects can protect and enhance the region's cultural landscapes and heritage sites, maintaining the connection between people and their natural environment.

Key barriers/challenges for NbS

Research indicates that while Austria may not face immediate physical constraints, there are "soft" adaptation limits at the local level. These include constraints in awareness, knowledge, and decision-making processes. To overcome these challenges, involving stakeholders more inclusively in adaptive planning and to integrate disaster risk management with climate change adaptation is needed.

Political

1. *Lack of policy support*: Inadequate integration of NbS into regional and national policies can hinder their adoption. Without strong political will and supportive frameworks, NbS often fail to be prioritized. Nationwide, climate change adaptation (CCA) is considered as a core issue of climate policy by the National Climate Adaptation Strategy. In Lower Austria, however, there is no specific tool for CCA (there exist a Climate and Energy Roadmap, where CCA plays a secondary role), and NbS are not yet present in the regional political jargon.
2. *Inconsistent funding*: Political shifts can result in inconsistent funding and support for NbS projects, making long-term planning and implementation difficult. This is a common concern for Climate Change Adaptation Model Regions (KLAR!). Since KLAR! are not permanent institutions, they can be created and dissolved depending on the political climate.
3. *Bureaucratic hurdles*: Complex regulatory processes and bureaucratic inefficiencies can delay project approvals and discourage stakeholders from pursuing NbS.

Economic

1. *High initial costs*: Although NbS can be cost-effective in the long term, the initial investment for planning, implementation, and maintenance can be a significant barrier. To address this, KLAR! has a dedicated funding program called "KLAR!-Invest".
2. *Uncertain economic benefits*: The economic benefits of NbS, such as ecosystem services and tourism, can be difficult to quantify, making it hard to justify investments to stakeholders and financiers.
3. *Competition with traditional solutions*: Conventional engineering approaches to climate adaptation may be more familiar and perceived as more reliable, diverting resources away from NbS.

Social

1. *Public awareness and perception*: Low awareness and understanding of the benefits of NbS among the public and decision-makers can result in limited support and engagement. The Energy and Environment Agency of Lower Austria offers workshops, lectures, and the "Climate & Me" exhibition to raise awareness and engage municipalities and the public.
2. *Stakeholder conflict*: Competing interests among stakeholders, such as landowners, farmers, and developers, can lead to conflicts that impede NbS projects. One example concerning agricultural practices is the spreading of tree roots of a hedge into the field of a neighbour, which may lead to conflicts because of the root competition with the crops. Further examples are the conflict over land use when parking spaces are de-paved to create green areas, or when areas are required for river restoration as part of flood protection measures. This can lead to disagreements about the best use of space.
3. *Cultural preferences*: Traditional land use practices and preferences for familiar solutions over innovative, nature-based approaches can act as barriers.

Technological

1. *Lack of expertise*: Implementing NbS requires specific knowledge and expertise, which may be lacking in local planning and environmental management sectors.
2. *Monitoring and evaluation*: Effective monitoring and evaluation of NbS impacts can be technologically challenging and resource-intensive, deterring investment.
3. *Innovation gaps*: Limited research and innovation in NbS-specific technologies can slow the development and implementation of effective solutions. The *ecoplus clusters* aim at closing these gaps through connecting the right competencies in the regional Innovation ecosystem.

Environmental

1. *Land availability and quality*: The availability of suitable land for NbS can be a constraint, especially in regions with high land-use competition or degraded environments.
2. *Climate change impacts*: Existing and projected climate change impacts, such as extreme weather events, can affect the viability and success of NbS projects.
3. *Ecological complexity*: Understanding and managing the ecological complexities of NbS can be challenging, requiring comprehensive environmental assessments and adaptive management.

Legal

1. *Regulatory barriers*: Existing regulations and legal frameworks may not support or may even hinder the implementation of NbS, such as restrictive zoning laws or water rights issues. For instance, windbreak hedges are legally classified as forest after several years. If a farmer plants such a hedge, he is not allowed to ever remove it without substitute planting.
2. *Property rights and land tenure*: Unclear or conflicting property rights and land tenure issues can complicate the implementation of NbS, especially in rural areas (see example about root spreading-related conflicts above under social barriers for NbS).
3. *Liability concerns*: Legal liability and risk management issues related to NbS projects can deter investment, as stakeholders may fear potential legal repercussions.

Key enablers/opportunities for NbS

To support NbS investments and initiatives in Lower Austria, a multifaceted approach leveraging political support, economic incentives, community engagement, technological advancements, environmental assets, and supportive legal frameworks is essential. By addressing these areas, Lower Austria can create a robust environment for the successful implementation and scaling of nature-based solutions.

Political

1. *Policy support and integration*: Strong political willingness and commitment to integrating NbS into regional and national policies can drive their adoption. Government initiatives and frameworks that prioritize NbS can create a conducive environment for their implementation. The tool to bring CCA-related challenges into practice in Austria are the so-called KLAR! which result from the voluntary association of municipalities under an umbrella association. By 2024, 29 KLAR! encompassing 271 municipalities (i.e. almost 50% the total no. of municipalities) were active in Lower Austria.
2. *Funding and incentives*: Government funding, subsidies, and incentives for NbS projects can encourage investments. Programs such as grants for sustainable agriculture or tax breaks for green infrastructure can be significant enablers.
3. *International and EU support*: Leveraging support from the European Union and international bodies focused on climate adaptation and biodiversity can provide additional resources and frameworks for NbS implementation.

Economic

1. *Economic diversification*: Diversifying the economy to include eco-tourism, sustainable agriculture, and green technologies can create new markets and opportunities for NbS.
2. *Public-Private Partnerships (PPP)*: Encouraging partnerships between the public sector, private companies, and non-governmental organizations can mobilize resources and expertise for NbS projects.
3. *Economic valuation of Ecosystem Services (ES)*: Developing mechanisms to economically value ecosystem services provided by NbS can help justify investments and attract funding from various stakeholders.

Social

1. *Community engagement and awareness*: Educating and engaging local communities about the benefits of NbS can foster public support and participation. Community-led initiatives can also empower residents and ensure long-term sustainability.
2. *Cultural heritage and identity*: Promoting NbS that enhance and preserve cultural landscapes and heritage sites can strengthen regional identity and support from local populations.
3. *Health and Well-being Benefits*: Highlighting the health and well-being benefits of NbS, such as improved air quality and recreational spaces, can garner public and political support.

Technological

1. *Research and innovation*: Investing in research and innovation related to NbS can improve their effectiveness and scalability. Collaboration with academic institutions and research centres can drive technological advancements. For instance, research about roots showed that the roots of a tree could be found longer than 15 m away from the hedge in the arable land. Root competition and its associated conflict potential among neighbours can therefore be addressed by cutting the roots regularly and planting the hedge in a certain distance to the neighbour.
2. *Monitoring and data Collection*: Advanced monitoring and data collection technologies can help measure the impact of NbS and provide evidence for their benefits, supporting further investments. For instance, temperature effects of hedges are being measured in the business park in the town of Wolkersdorf in the context of the Interreg-project "Plants4Cooling". A thermos-camera has been installed and the cooling effect in the local microclimate is being monitored.
3. *Knowledge sharing platforms*: Creating platforms for sharing knowledge, best practices, and successful case studies can accelerate the adoption of NbS across different regions. This is the central purpose of the biennial meeting of the representatives of the Lower Austrian KLAR! and KEM ("*Klima und Energie Modellregionen*", devoted to CC mitigation) regions.

Environmental

1. *Natural capital*: Leveraging the region's existing natural capital, such as forests, wetlands, and rivers, can provide a strong foundation for NbS projects.
2. *Biodiversity Hotspots*: Protecting and enhancing biodiversity hotspots through NbS can attract funding and support from conservation organizations and environmental groups.
3. *Climate resilience*: Demonstrating the role of NbS in enhancing climate resilience and mitigating risks such as flooding and heatwaves can build a strong case for their implementation. This is precisely the central goal of the ARCADIA Labs in Lower Austria: to showcase successful local solutions and to discuss further potential uses in other areas in this federal state and beyond (national level).

Legal

1. *Supportive legal frameworks*: Developing and enforcing legal frameworks that support NbS can create a favourable regulatory environment. This includes zoning laws, land use regulations, and environmental protection acts.
2. *Land tenure and property rights*: Clarifying and securing land tenure and property rights can facilitate the implementation of NbS, especially in rural and agricultural areas. The legal solution for the hedges problem was the exclusion of multi use hedges (> 50% fruit trees) from legally becoming forest, in contrast to windbreak hedges mentioned above. The land stays legally arable land and, subsequently, more farmers are willing to plant hedges. Municipalities can also set binding requirements for green and blue infrastructure in industrial areas. This is legally possible, but so far rarely implemented in practice.
3. *Liability protections*: Providing legal protections and clear guidelines for liability related to NbS projects can encourage stakeholders to invest without fear of legal repercussions.

Regional visions and ambitions for NbS

The aim is to strive for establishing NbS as a standard when addressing climate impacts in Lower Austria (see Box 5 for more details on visions and ambitions). There are 3 approaches underway in Lower Austria. First, defining a selection of NbS that are most appropriate and highly effective in terms of climate risks. This includes: Taking into account financial, strategic, organizational, temporal, legal, local, spatial planning and social aspects; Referring to climatic aspects, risk-reducing performance and any additional benefits (Ecosystem Services); and Continuing and/or adapting existing solutions as well as including new/innovative ones.

Second. developing the most suitable NbS for local implementation by designing a process that includes analytical and deliberative methods and is accompanied by implementation examples, measurements and visualizations. Third, establishing the featured NbS as standard adaptation measures in Lower Austria by implementing the solutions in strategic, planning and operational instruments, increasing the willingness, acceptance and conviction to implement these NbS, and creating the necessary framework conditions that facilitate and enable broad implementation.

Box 5: Summary of visions and ambitions in Lower Austria

Visions in the region

Up to now, the current official vision of the Lower Austrian Government regarding energy and climate issues does not explicitly include NbS. By the end of 2024, the Climate and Energy Roadmap 2020-2030 is currently under revision. It aims at more stringent goals and targets, and climate change adaptation will be considered to a larger extent. Meanwhile, the current version of the roadmap defines a vision mainly centred on climate change mitigation, and specifically on boosting renewable energy to turn Lower Austria as a forerunner in Europe. Phasing out fossil fuels is a matter of "bearing responsibility" and "exploiting opportunities". The 2050 decarbonisation scenario for Lower Austria

includes a reduction of energy use; the development of renewable energy sources and the long-term withdrawal from fossil fuels.

The Lower Austrian Climate and Energy Program (KEP) is the corresponding tool to implement the Energy and Climate Roadmap. The KEP considers climate change mitigation (Klimaschutz) and adaptation (Anpassung) as two sides of the same coin and underscores the need to find the optimum way to combine both approaches. This tool establishes three overall goals for Lower Austria until 2030 including "to improve adaptation to the consequences of climate change". In accordance with the vulnerability analysis for Lower Austria, the portfolio of measures was selected so that an increase in Lower Austria's resilience with respect to the expected consequences of climate change can be assumed. It is worthy to mention here that every KLAR! Region in the province has a vision concerning climate change adaptation, often based on workshops "Dorf der Zukunft" ("Village of the Future") that are offered to all interested Lower Austrian municipalities.

At the workshops, participants work together to develop how villages and rural regions can be improved through climate mitigation and adaptation measures. After a first interactive input by the organisers, an open yet structured discussion by participants follows. In this second part of the workshop, the aim is to creatively develop ideas for a more sustainable place by using stickers to be placed on maps of the village or town. Together, participants can design a local community supplier, a mobility hub, transport infrastructure such as cycle lanes with e-charging stations, greening surfaces such as flower meadows, and climate-friendly buildings that contribute to a climate-friendly place. The target of these workshops are ordinary citizens as well as local elected representatives. Overall, this kind of network of non-official local visions is stepwise being created across Lower Austrian municipalities.

Near and future ambitions
The Environmental Projects Unit of the Department of Environmental and Energy Affairs of the Office of the Lower Austrian Government has set a mission statement to strive for establishing NbS as the preferred measure when it comes to coping with climate change impacts in Lower Austria. Bearing in mind the climate-related strategies in force at the national and state levels, and assuming that climate change adaptation is one of the two pillars of the Lower Austrian climate policy (together with climate change mitigation), gives an opportunity to elevate the topics of NbS and BGI to the forefront of the Lower Austrian strategy to foster climate resilience ahead of usual solutions based on grey infrastructure.

A particular challenge in the adaptation process, which leads from strategic considerations to concrete implementation, lies in the high level of complexity that results from the different parties involved, different decision-making levels, cross-divisional interactions and dependencies on a diversity of stakeholders. Specifically, this means that climate change adaptation, as an extremely wide-ranging cross-cutting issue, affects many fields of action and actors from a wide range of sectors. Public administration units (from the federal government to municipalities), the business sector and individuals are involved in implementing tasks. In order to take advantage of synergies and in order to avoid misalignment, a cross-sectoral approach and close co-operation between all these actors is required to meet ambitions.

Source: Lower Austria Regional Report for the ARCADIA project (deliverable 2.1)

Zagreb and Krapina-Zagorje

General description of regional context

In the ARCADIA project, both the City of Zagreb and Krapina-Zagorje County are cooperating together to support the implementation of NbS. There are a range of climate risks facing Zagreb and Krapina-Zagorje (see Box 6).

Box 6: Summary of climate risks in Zagreb and Krapina-Zagorje

Climate risk assessment has been carried out for the threat of the most relevant expected climate changes (floods, droughts, storms, heatwaves, fires) for key vulnerable sectors in the City of Zagreb, including: Water management to floods and droughts; Agriculture to floods and droughts; Forestry to fires and storms; Health to heatwaves; Tourism to heatwaves; Biodiversity to temperature increase and changes in precipitation patterns; Building sector to floods and storms; Transport to floods; and Energy sector to heatwaves. Risk assessment has also been carried out for the sectors of particular significance to Krapina-Zagorje County, which are as follows: Building sector; Energy sector; Transport; Water supply and drainage sector; Agriculture; Forestry; Health and safety; and Biodiversity and natural systems.

Source: Zagreb and Krapina-Zagorje Regional Report for the ARCADIA project (deliverable 3.1)

City of Zagreb: Zagreb is the capital of the Republic of Croatia and functions as its economic and administrative hub. It hosts key state institutions - the legislative, judicial, and executive branches - as well as institutions for finance, defense, healthcare, culture, education, transportation, and others. The city comprises 69 settlements and 17 urban districts. According to the 2021 census, the city of Zagreb has 767,131 residents, accounting for 19.8% of the total population of the Republic of Croatia. This is a decrease of 2.9% compared to the 2011 census.

Zagreb is situated in the interior of Croatia, in the Pannonian Basin. To the north, it reaches the southern slopes of Medvednica Mountain, while to the south, it extends to the flatlands along the Sava River. Most of Zagreb is located in a lowland area at an elevation up to 200 meters above sea level. Due to its location, Zagreb enjoys a humid continental climate. However, recent times have witnessed alterations in the Köppen-Geiger climate classification across all meteorological stations within the city.

Agricultural land in the City of Zagreb represents an important economic natural resource. 21,733.1 hectares of the City of Zagreb's area is covered by agricultural land. Therefore, out of the total 64,135.3 hectares that make up the City of Zagreb, 33.89% falls under agricultural land, 35.92% under natural vegetation (forests), 4.56% is maintained vegetation, and 0.93% is water surfaces. In contrast, 24.27% of the area is urbanised.

Krapina-Zagorje County: Krapina-Zagorje County is located in Croatia's northwestern part. It is a distinct geographical unit that stretches from the peaks of Macelj Highlands and Ivančica Mountain in the north to Medvednica Mountain in the southeast. The western border, which is also the national border with the Republic of Slovenia, is marked by the Sutla River. In contrast, the eastern border follows the watershed of the Krapina and Lonja river basins. Krapina-Zagorje County is almost entirely situated in the drainage basins of the Krapina and Sutla rivers.

In terms of area, it is one of the smaller counties (1,229 km²) but has a population density above the national average. According to the 2021 census, Krapina-Zagorje County has 120,942 inhabitants, which is 9% less than in 2011. The territory of Krapina-Zagorje County is divided into 32 local self-government units, specifically 7 towns and 25 municipalities. Agricultural land covers 57.7%, and

arable land 50.4% of the County's total area. Forest land consists of smaller forests, reduced by clearing and conversion to agricultural land, and occupies 35.5% of the County's area.

Key expected benefits from scaling NbS

During the twentieth century, the City of Zagreb experienced exponential demographic growth, which placed significant pressure on the construction sector. In recent decades, the most noticeable pressure has been on the periphery, where, despite planning efforts, continuous urban sprawl occurs due to lower housing market prices. Given the population density of Zagreb, more and more citizens are moving to the surrounding rural areas, which do not have sufficient capacity, leading to urbanisation there as well. This is particularly the case in Krapina-Zagorje County. New neighborhoods and settlements are being built without proper planning, disrupting microclimatic conditions and the functionality of services.

In addition to excessive urbanisation, the City of Zagreb also faces problems with its drainage system. The city's streams, located at the foot of Mount Medvednica, often respond quickly to rainfall in their catchment areas, with a sudden rise in water levels characteristic of torrential streams. Some of these city streams have been integrated into Zagreb's sewage system, significantly burdening it during heavy rains. According to some estimates, their share in the total flow of the sewage system during peak flows exceeds 30%. The sewage system is combined, introducing sanitary and storm waters. With the city's growth, the amount of paved and impermeable surfaces has increased significantly, resulting in increased surface runoff.

Consequently, less precipitation infiltrates naturally into the groundwater, flowing more rapidly to drainage sewer openings, which are often clogged due to lack of maintenance. The drainage system fails in such situations, with pressurised sewage water surfacing and mixing with stormwater in lower areas. For this reason, applying NbS is crucial in Zagreb. Due to the aforementioned urbanisation and concreting, urban heat islands are becoming an increasing problem, the effects of which can also be mitigated by applying NbS. Furthermore, benefits from scaling NbS in Krapina-Zagorje County include mitigating landslides, which are a frequent problem due to the specific relief and geomorphology, especially considering the anthropogenic impact. Additionally, urbanisation and agricultural monocultures compound the risk of landslides. These practices reduce vegetation and biodiversity, both of which are essential for maintaining soil stability.

Key barriers/challenges for NbS

The primary issue is that Croatian legislation does not provide clear answers regarding the definition of NbS. The absence of a clear definition of NbS at the national level results in less utilisation of NbS in the strategies, programs, and plans of local government units. Furthermore, some of the key challenges for NbS in the City of Zagreb and Krapina-Zagorje County, but also in Croatia in general, are:

- There is a lack of technically educated staff in local and regional self-government units, especially in the planning and technical segments of project development and implementation;
- There is a lack of data that would provide baseline frameworks for the implementation of projects based on NbS;
- Lack of standards in planning the appropriate number and type of green spaces according to reference parameters;
- All relevant stakeholders - from planners and designers to maintenance personnel - need to be educated;
- The system's level of technical expertise is low, and the integration rate with other parts of the system where NbS and green infrastructure are presented as desirable is also low;
- There are planning constraints in the design of public spaces (the need for adopting urban development plans and conducting public tenders);

- There is a lack of clear frameworks and standards for planning and designing solutions and green infrastructure;
- Absence of regulations defining the appropriate experts authorised to engage in planning and designing solutions.

Key enablers/opportunities for NbS

When discussing opportunities, a significant prospect for the sustainable application of NbS lies in introducing a methodology and digital system for validating NbS based on financial, spatial planning, environmental, and health indicators and quality-of-life metrics. A comprehensive validation of these proposals allows for a more sustainable and objective selection process, facilitating well-founded approvals for additional (co-)financing from private investors and funds from local government units. Some of the identified opportunities are considering the lifecycle cost of products, project aggregation, reprogramming of used spaces, revitalisation and renewal of unused areas, circular economy, and green public procurement.

Enhancing knowledge levels and leveraging the still underutilised potential of citizen involvement at the local level presents an opportunity for more targeted planning and implementation of NbS. Collaboration among existing projects presents another valuable opportunity. Aligning efforts across initiatives focused on adaptation and planning can amplify impact, optimize resources, and expand outreach through shared knowledge and collective action.

Regional visions and ambitions for NbS

In the City of Zagreb, the focus will be on strategic projects to enhance collaboration and cohesion among city authorities, scientific and professional organisations, civil society groups, the business sector, and citizens. The goal is to improve existing tools and practices for planning, financing, implementing, and monitoring nature-based measures for climate change adaptation. This will be achieved by upgrading the current Energy Atlas to include functionalities for visualising and analysing climate risks and for planning and implementing measures to mitigate these risks. Additionally, the ARCADIA project is an example of increasing biodiversity, reducing the impact of and adapting to climate change, and building resilient communities. Promoting the project and engaging the community will heighten public awareness about climate change issues and the importance of urban sustainability (see Box 7 for more details on visions and ambitions).

Box 7: Summary of visions and ambitions in Zagreb and Krapina-Zagorje

Visions in the region

City of Zagreb: Zagreb increasingly embraces NbS as part of its urban planning and sustainability strategy. Recognising the growing challenges of climate change, urbanisation, and environmental degradation, the city views NbS as a way to increase resilience, biodiversity, and community well-being. The city demonstrates significant potential for implementing NbS, particularly in areas where the capacities of major natural features, such as the Sava River and Medvednica Mountain, both directly connected to the city, can be leveraged. The implementation of NbS varies greatly depending on space characteristics. In the densely urbanised city center, efforts are focused on greening existing "grey" infrastructure. On the city outskirts, especially near rivers and significant forest communities, the priority is to restore disrupted natural processes and connect fragmented areas into a unified network of green spaces.

There are also initiatives that aim to integrate green infrastructure into urban space design. These include intensive planting (8,000 trees are planned), creating new parks, and establishing other green and recreational areas. Furthermore, efforts are directed towards more sustainable spatial planning

and climate adaptation through appropriate landscaping. Zagreb places great importance on engaging in a co-design process. The city adopts a bottom-up approach that prioritises the active participation of users of NbS and local community groups in shaping project activities. For example, the Urban Agenda Partnership for the Sustainable Use of Land and NbS, under which work was developed an NbS Handbook for City Districts and Local Boards that features examples of applicable solutions, also conducted an online survey enabling citizens to suggest locations for these solutions, resulting in over 1,000 submissions.

Krapina-Zagorje County: The strategic vision for the development of Krapina-Zagorje County for the period up to 2027 is states is to develop as “a green and smart county with an inclusive society, sustainable development, and a circular economy that achieves its potential through innovation." (Krapina-Zagorje County, 2023). From this vision, there are five development policy priorities, including being a Green, Preserved, and Safe County. Within this priority it is recognised the goal of promoting sustainable management of natural and built environments, from which measures, activities, and projects have been defined to achieve the goal. The operational part of this strategic framework consists of development projects and activities for which environmental protection measures have also been identified, ensuring that all interventions contribute to improving the state of the environment.

The focus of Krapina-Zagorje County is to try to apply the NbS to the greatest extent possible in implementing development activities and projects. Implementing these activities and projects contributes to improving water bodies and groundwater reserves, more efficient management and preservation of biodiversity and geodiversity, reducing negative impacts on soil characteristics, and consequently, improving the overall natural and built environment. In 2022, Krapina-Zagorje County adopted the Climate Change Mitigation and Adaptation Program for Krapina-Zagorje County, which identified vulnerabilities and risks related to climate change. The program defines adaptation measures to the effects of climate change and increasing the resilience of Krapina-Zagorje County, and NbS has been integrated into the proposed activities.

Near and future ambitions

City of Zagreb: Considering increasingly pronounced climate change challenges, the City of Zagreb is committed to a strategic planning approach that emphasises NbS. It aims to create a more comfortable and sustainable urban environment for its residents, preserve natural resources, and enhance urban ecosystems. The City of Zagreb aspires to build an integrated GBI network. It aims to ensure their integration into a comprehensive network by establishing space planning standards. This approach involves preserving essential green and blue areas, protecting them from repurposing, and adapting their maintenance to enhance urban biodiversity. Plans for public space development include creating new open recreational zones, developing edible landscapes, and establishing green areas that can serve as integral drainage systems.

Special attention is on revitalising abandoned industrial and brownfield sites, which will be integrated into the green infrastructure network and become valuable parts of the urban fabric. An atlas of brownfields for the Zagreb agglomeration already exists, identifying 84 brownfield sites. At the heart of all plans is citizen participation. Through the development of participatory programs, citizens can actively be involved in the planning, managing, and maintaining green and blue areas. A green infrastructure cadastre for the City of Zagreb is already in place, consolidating all public urban green infrastructure into a single resource. For example, an existing publicly accessible application allows citizens to photograph damaged elements of green infrastructure, enabling the city company responsible for maintaining and improving green spaces, parks, gardens, and other public areas, for responding based on citizen reports, and its enhancement is planned for the future.

Krapina-Zagorje County: Krapina-Zagorje County has recognised the need and opportunity to develop its capacities to carry out activities by applying NbS. Krapina-Zagorje County aims to create the conditions for the continuous expansion of NbS application and their inclusion in existing and new activities in areas related to landslide mitigation, biodiversity improvement, stormwater management, environmental quality enhancement, increasing green infrastructure areas, improving environmental aesthetics, and creating new natural spaces for recreation. Furthermore, Krapina-Zagorje County and county organisations will continue to encourage dialogue and promote the importance of NbS within their scope of work, thus enabling interdisciplinary and intersectoral cooperation and a broader perspective on the challenges identified at the local and county levels. This will also be achieved by intensifying the integration of NbS in spatial and strategic planning processes (including climate change adaptation, health, construction and housing, urban planning, and digitalisation).

In this context, the future short-term and medium-term ambitions of Krapina-Zagorje County related to intensifying the application of NbS are: conducting activities to raise awareness of the local community about the need and ways to preserve natural values and biodiversity through promotional activities, workshops, and education about NbS; development of a Green Infrastructure Development Strategy; creation of a catalogue of NbS for Krapina-Zagorje County; mapping of locations with potential for the application and establishment of NbS; encouraging citizen involvement in programs and projects for sustainable management of the natural environment with integrated NbS; promoting the concept of green cities and the renaturalisation of urban areas through applying NbS.

Source: Zagreb and Krapina-Zagorje Regional Report for the ARCADIA project (deliverable 3.1)

Skåne

General description of regional context

Skåne County is the southernmost county of Sweden. It covers around 3% of Sweden's total area, while its population of 1.3 million comprises 13% of Sweden's total population. Skåne County is administered by Region Skåne, one of the 20 county councils of Sweden. Its main responsibilities are for the public healthcare system and public transport. Skåne County contains 33 municipalities, the largest by population being Malmö Municipality (340,000 inhabitants), Helsingborg Municipality (145,000), and Lund Municipality (130,000 inhabitants). Although the county is of only moderate size, it is of great importance as a food producer in Sweden, which is why it is often called the “granary of Sweden.” Among the chief crops are wheat, barley, potatoes, rapeseed, vegetables, and sugar beets. There are a range of climate risks facing Skåne (see Box 8).

Box 8: Summary of climate risks in Skåne

Climate risk assessment Sweden operates through a multi-level approach coordinated by the national government and state agencies, with local and regional collaboration. Due to the vulnerable position of Skåne, bordered by coastline on three sides and with large parts of the region being low-lying, many of the climate risks in Skåne are related to sea-level rise and flooding. Flooding can result from heavy rainfall or direct and indirect effects of rising sea levels. Various areas, societal functions, and industries are at risk of being affected by flooding, including infrastructure, urban areas, transportation, the release of pollutants, saltwater intrusion, and increased disease transmission. Thus, heavy rainfall events pose a risk to the drinking water supply in Skåne. Extreme heat and heatwaves are also a challenge that affects public health. Changes in temperature and precipitation patterns will also impact agriculture and natural environments. In Skåne, it is particularly important to address

how climate change may affect agriculture and the unique ecosystems and species in the region. High temperatures and drought can also affect the quantity and quality of drinking water.

Source: Skåne Regional Report for the ARCADIA project (deliverable 4.1)

Key expected benefits from scaling NbS

Current infrastructure often cannot handle the expected increase in floodings and 100-year rains, which will flood basements and streets and cause large damages. Furthermore, grey infrastructure is not enough to handle all the water and flooding that cities and the countryside expect in Skåne's future. NbS is a way to handle these challenges on a larger scale, while also providing spaces for recreation and ecosystem services. NbS provide a method to handle climate change risks in a way that can gain local support and motivate investments – by adding value, not taking away value.

The same applies to increased problems with so-called heat islands during heat waves where sensitive infrastructure such as nursing homes and preschools need to be protected against high temperatures where NbS such as increased abundance of trees in our urban areas can be a suitable solution. The changing climate will also increase the risk of long dry periods where NbS regarding water management can reduce drought problems in the agricultural sector.

Skåne is the breadbasket of Sweden with the most fertile soils in the country. At the same time, it also harbours the greatest biodiversity and constitutes the second most densely populated region (after Stockholm) in Sweden. This poses a particular challenge since both biodiversity and food production are predicted to decline due to climate change. At the same time biodiversity is considered a key feature to continued ecosystem functioning under altered climatic conditions.

Meanwhile cities in Skåne continue to attract new citizens and industries. Together this results in a space problem, which is exacerbated by climate change. We need to figure out together where best to give space to what and to use the limited space most efficiently and prepare Skåne for climate change. NbS are the best tools to master this challenge. Also, if we succeed in Skåne with the stated challenges, we can succeed across Sweden.

Key barriers/challenges for NbS

Many solutions are yet to be implemented on a wider scale in the region due to issues with financing, lack of space in the cities, and competing interests in the highly populated landscape with highly fertile farmlands. The same applies to our cities where the political will to build densely to reduce the use of the valuable agricultural land leads to a lack of space for NbS. Heat as a climate risk has yet to be mainstreamed into urban planning. Here Skåne has much to learn from other partners within ARCADIA.

There is currently a lack of agreement in Sweden on who should finance risk reduction related to climate change. For example, it is the house owner's legal responsibility to invest in coastal anti-erosion measures to protect one's home, but inhabitants often expect this to be the responsibility of municipalities. Meanwhile, municipalities may struggle to motivate expensive investments in risk reduction measures, which are typically financed locally rather than nationally. Finally, climate adaptation is typically a shared responsibility rather than belonging to a specific unit or department in municipalities and in the region – further complicating who should pay attention to the issues and carry the costs of preventive measures.

Sweden suffers from a lack of coordination when it comes to environmental issues. For example, following the EU water framework directive is a national task, which is supposed to be facilitated by largely independent municipalities who may or may not seriously work towards the aims (good ecological status in all water bodies) of the directive. Governmental incentives are erratic and far below

what would be required to achieve good status in the given timeframe. There are no sanctions for municipalities who don't do their part. Some requirements to receive benefits from state agencies are directly counterproductive to the establishment of NbS.

Unlike other European countries, streams and their banks are owned by landowners and not the municipality, which makes implementation of NbS more difficult in Sweden. Landowners and their associations are weary of erratic government initiatives. Municipalities are unwilling to pay market prices to acquire the necessary land for NbS. Farmers are conservative and unwilling to change traditional practices. Mutual mistrust between farmers and the public sector exists, and this is an enduring challenge.

Key enablers/opportunities for NbS

There are four main enablers for NbS in Skåne. First, there is existing expertise and projects in the region – we have know-how and success stories, particularly with NBS and water. Second, there are growing ambitions in cities – we work together with healthy competition, which drives us further towards innovation. Third, our local politicians generally understand that we need to work innovatively with NbS to protect our cities and landscapes. However, there is a significant challenge to open up financing for NbS. And there remains a need to increase knowledge and understanding of local politicians as well as municipal administrators. Finally, in the regional development strategy – "The Open Skåne 2030" – the stakeholders of the region have set a target of a climate neutral and fossil fuel free Skåne by 2030.

Awareness of water and climate adaptation related issues is higher than ever. Many NbS initiatives are going in this direction. Skåne has tested, experimented with, and implemented NbS in relation to water over the last 30 years. Detailed plans for real estate include calculations for water management. Unfortunately, certain ambitions are sometimes set against objectives for an increased number of homes. For example, ideas of 3-30-300 are on the agenda but difficult to fully implement. The 3-30-300 rule offers benchmarks for cities and suggests that individuals should see 3 trees from their dwelling, have 30 % tree canopy in their neighbourhood, and live within 300 metres of a high quality green space.

To fully capture opportunities with NbS in Skåne, three key actions are necessary. First, we need to creatively explore financing solutions and ways to make space for NbS in cities and rural landscapes. Second, we need to think in new ways by learning from other regions in terms of financially, organizationally, democratically, and strategically. Third, we need to establish public and private alliances in the region, to gain support and build momentum for a larger strategic effort towards NbS in Skåne.

Regional visions and ambitions for NbS

There are four main ambitions for the region in the context of the ARCADIA project (see Box 9 for more details on visions and ambitions). First, developing solutions for NbS where nature and the city come together. Second, finding innovative ways to scale up successful approaches in the landscape. Third, learning new ways to gain support for NbS through inclusive citizen participation, smart financing solutions and innovative design that strengthens the region's resilience. Fourth, joining hands with the private sector and other NbS actors, to widen the implementation of nature-based climate adaptation across sectors in the region.

Box 9: Summary of visions and ambitions in Skåne

Visions in the region
The vision for climate adaptation and NbS in Skåne is developed through a multilevel process

involving two key regional actors, the County Administrative Board and the Regional Authority, along with the region's municipalities. The County Administrative Board coordinates adaptation efforts through regional action plans, while the Regional Authority integrates climate adaptation into regional development and crisis preparedness through the Regional development plan. Additionally, Sweden's planning monopoly grants municipalities exclusive authority over land use and physical planning within their territories. Consequently, municipalities are responsible for integrating climate adaptation into their planning processes (Sveriges Riksdag, 2010). A cross-regional process between Denmark and Sweden also influences the development of a regional vision for Skåne.

Nationally, the Swedish Agency for Marine and Water Management is a national authority working to protect marine and freshwater environments. Its climate adaptation action plan envisions Sweden as having "Living seas, lakes, and bodies of water that bring joy and benefit to us all" (Havs- och Vattenmyndigheten, 2018). Regionally, Climate adaptation is a central element in the County Administrative Board of Skåne's action plan for Sweden's environmental goals. It is included in the goals for Sustainable Cities and Societies, as well as for Sustainable Land and Water Use (Länsstyrelsen Skåne, 2021). The County Administrative Board of Skåne will also develop and update the regional action plan for climate adaptation in Skåne during 2024–2025.

The Regional Authority is reviewing and updating the current regional development plan, emphasizing the need for measures to underscore the importance of future climate adaptation actions. Cross-regionally, the Danish-Swedish political collaboration, Greater Copenhagen, is actively working on climate adaptation. Its Green Charter outlines a vision and goal for the region, including Skåne, to become an "internationally leading metropolis-region in the green transition." This vision involves cross-sector collaboration, stimulating the market for green solutions, and fostering partnerships between companies, institutions, universities, and innovation spaces (Greater Copenhagen, 2022).

Near and future ambitions
The County Administrative Board and the Regional Authority have complementary roles in addressing climate-related issues at the regional level. The County Administrative Board coordinates adaptation efforts through regional action plans, while the Regional Authority incorporates climate adaptation into regional development through the Regional Development Plan. Both documents are currently being revised, with updated versions expected to be published in the coming years. In particular, the Regional Development Plan will outline future ambitions. Skåne has ambitious municipalities and regional goals, three universities, companies, many years of experience working with NbS, and public-private partnerships. By connecting the right actors and working together, actors in Skåne can develop their capacities and set a foundation for a more unified vision for NbS in Skåne.

The ambition is to realise this call to action through collaboration and capacity building **(**By working with stakeholders in water catchment areas to implement NbS in cross-municipal and regional collaborations, inviting private actors and public authorities to set new ambitions, and sharing progress and knowledge with actors throughout the region); financial solutions and opportunities (By initiating and showcasing tests, pilots, and opportunities for financing in the region, supporting stronger public-private collaboration in NbS, and mapping financing solutions for public and private actors); and awareness and support networks for private businesses (Developing a nature-based, innovative sector with large companies and SMEs is crucial for progress in regional climate adaptation, and through developing competencies in NbS and showcase innovative solutions in Skåne and in the European arena to increase awareness and share knowledge about NbS).

Source: Skåne Regional Report for the ARCADIA project (deliverable 4.1)

Funen

General description of region context

Approximately 246,000 inhabitants live in the Odense Fjord catchment area, of which approximately 182,000 live in Odense city, the third largest city in Denmark. Odense has grown significantly since the Second World War. Many construction projects both inside the old city centre and outside the city limits have significantly changed the city's space, and the city has gone from being an industrial city to a service and university city.

Approximately 90% of the population in the catchment area discharge their wastewater to a municipal treatment plant. The remaining 10% of the population live in unsewered areas outside urban centres. In total, there are approximately 6,900 residential properties located in the open countryside outside urban centres and sewered catchment areas. The catchment area of Odense Å/Fjord is approx. 1046 km2 and includes approx. 1100 km of open watercourses and 2600 lakes and ponds (>100 m2). The catchment area of Odense Fjord makes up about 1/3 of Funen and the fjord flows into Kattegat through a relatively narrow strait, known as "Gabet", in the northern part of the fjord.

The last ice age 11,500-100,000 years ago created the landscape of Funen as we know it today. Most prevalent in the landscape are moraine surfaces covered by moraine clay. The meltwater that flowed away from the ice formed meltwater valleys. One example is Odense valley was formed by a meltwater river that had much the same general course as the river has today. Clay soil types are slightly dominant and cover about 51%, while sandy soil types cover about 49% of the area. Funen's moraine soil is particularly suitable for growing agricultural crops. Agriculture has therefore left its mark on the landscape. Deep ploughing, liming and the like have made the surface soil more uniform.

As in the rest of Denmark, land use in the catchment area of Odense Fjord is dominated by agricultural production. Agricultural land accounts for 68% of the catchment area. The remaining area is made up of approximately 16% urban areas/roads, 10% forest and 6% natural areas (meadows, bogs, pastures, lakes, and wetlands). There are a range of climate risks facing Skåne (see Box 10).

Box 10: Summary of climate risks in Funen

In Denmark, climate risk assessment has so far primarily focused on water management for flooding due an existing abundance of water, which will be exacerbated with the additional projected precipitation. Climate adaptation in Funen is primarily focused on managing increasing amounts of water. The risks are specifically related to flooding caused by rising groundwater and storm surge. Additionally rising temperatures and droughts can alter the extent of flooding events, and hence have also become a focus of climate adaptation in recent years. In Denmark and Funen, there are higher temperatures, but also quite a bit more water. coming from all sides. From above there is more precipitation. Groundwater rises from below. From behind, the water comes from the catchment and down through streams and in front is the Odense Fjord, where the surface water disappears, but where seawater also comes in as a result of rising sea levels and not least in connection with storm surges.

Source: Funen Regional Report for the ARCADIA project (deliverable 5.1)

Key expected benefits from scaling NbS

Odense is a city surrounded by large suburban areas with one-family houses, roads, and hard surfaces. With the estimated growth of the city, urban development is expected to reach municipal borders in 2050. The space for water management, nature, biodiversity, and many other objectives is highly limited and there is a need for a multifunctional approach to lift the ambitions of the many different agendas.

NBS can be a way to handle these challenges by incorporating more values and tackling water management issues in synergy with green solutions rather than in pipes and grey solutions.

In the catchment area of Odense Fjord, NbS is an important method to support a focus on the connection between challenges between water quality and quantity. Like many other Danish fjords and coastal areas, Odense Fjord suffers from a poor aquatic environment but the solutions to reduce the risk of flooding from the upland can have a beneficial impact on the fjords' condition. These connections need to be highlighted to plan and utilize funding as well as space in the best way possible.

Key barriers/challenges for NbS

The approach to nature-based solutions should be cross-cutting and holistic, but within the fields of public administration, legislation and project development, the approach is often highly sectoral. Water management is divided by sectors for wastewater, groundwater, surface water, coastal management, aquatic environment, etc. which inhibits the identification of synergies across the water cycle. Beyond this, there is an urgent need to streamline the sectoral legislation related to climate adaptation, as many areas of authority and grant opportunities are not synchronized and very often work against each other.

It can be EU vs Danish legislation, e.g. climate adaptation projects vs Water Framework Directive or Habitats Directive etc. or agricultural policy that often constitutes a barrier to climate adaptation. With no national plan for climate adaptation, a lack of prioritisation results in a fragmented response and ambiguous responsibility. Currently, there is no agreement on who should finance risk reduction related to climate change. For example, it is the house owner's legal responsibility to invest in coastal protection measures, but inhabitants often expect it to be the responsibility of the municipality. Meanwhile, municipalities may struggle to motivate expensive investments in risk reduction measures, which are typically financed locally rather than nationally.

A discussion on the need for a national or regional approach to managed retreat in high-risk areas has been ongoing within technical fields and research. However, on a political level, there is a lack of willingness/courage to put this topic on the agenda. Existing funding measures are similarly sector-divided and do not promote multifunctionality. Urban heat is increasingly becoming a challenge, however the appropriate measures and considerations to be made have not been considerably recognized yet. Here, it will be necessary to work with water storage and greening of urban spaces.

Key enablers/opportunities for NbS

Odense municipal development strategy targets climate neutrality in 2030 and climate resilience in 2050. These aims set a common political goal for municipal development focused on climate reduction, nature, and water management. Over the years, a productive collaboration between stakeholders has been supported by initiatives such as the Odense Fjord Collaboration, where private and public stakeholders along the fjord have a common ambition to reach good water status before 2027. The University of Southern Denmark has a dedicated research effort focused on NbS with the Climate Cluster and AquaNbS projects. The local water utility company, VandCenter Syd, have been working extensively with urban local water drainage and local water management on the terrain for many years.

There is a political interest in climate adaptation, especially in the Climate and Environmental Committee in Odense Municipality, but the funds allocated to climate adaptation continue to be limited. Political awareness can be raised, especially with attention to multifunctional solutions. Climate adaptation and water management is a political priority, but it follows from the other agendas like nature/biodiversity and is often mentioned as an added value in nature projects. Life Cycle Analysis (LCA) has been identified as a tool that may be able to highlight the connections between climate mitigation and adaptation. With further development, an existing LCA tool of VandCenter Syd could be a part of facilitating political dialogue.

Regional visions and ambitions for NbS

In the context of the ARCADIA project, for the region, the ambition for NbS is to create solutions that are inspired and supported by nature to provide values for both people and nature (see Box 11 for more details on visions and ambitions). This means a systemic approach that mimics natural processes - as we know that nature is the best at making nature. The approach must be multifunctional as funding and space is limited but the challenges are numerous. As a basis for working with NbS, there is a need to zoom out and look at larger systems and across sectoral divides. This includes the connections in the water cycle from the upland to the fjord where multiple synergies should be incorporated and exploited further.

Box 11: Summary of visions and ambitions in Funen

Visions in the region

The Climate Adaptation Plan for the Odense Municipality sets the ambitions for the initiatives in Odense to create a robust and resilient metropole. Odense Municipality is the largest city on the island of Funen and it is situated at the outlet of the Odense River from which considerable water from Funen drains through. Odense Municipality shares the catchment to the fjord with Nordfyn, Faaborg-Midtfyn and Kerteminde municipalities. The Climate Adaptation Plan sets the vision for a climate-adapted city of Odense in 2050 and onwards. The initiatives set targets to be developed with multifunctional purposes and creating synergies for biodiversity, nature and community as a continued foundation in the plan. NbS are mentioned explicitly in projects related to nature restoration and generally as an element to consider in all projects to support the interaction with nature.

The Climate Adaptation Plan includes potential climate adaptation projects prioritized according to a risk assessment. It lists a set of principles that climate adaptation in the municipality needs to comply with. Climate Adaptation planning in Odense strives to create sustainable solutions and each project in the Climate Adaptation Plan is scored in several parameters of potential added value: biodiversity, community, health, traffic safety, water environment, and multi-functionality. Through these principles and potential added values Odense Municipality aims to ensure that climate adaptation projects are multifunctional and beneficial for nature, society and the climate. The Climate Action Plan also mentions climate adaptation as an element to be considered in relation to climate mitigation measures such as afforestation, rewetting of low-lying areas and peatlands, and sustainable urban development and construction.

The Odense Fjord Collaboration was founded in 2021 and is currently revisiting its vision together with its partners. The foundation, however, remains: What started as a bottom-up initiative by a local agricultural organisation, the largest Danish nature conservation NGO (Danmarks Naturfredningsforening) and relevant stakeholders, is a robust partnership between 17 local partners around the Odense Fjord. During the initial years, focus has primarily been on accumulating existing and new data to gain a holistic definition of the issues at hand. In the new vision statement, primary focus is set on action. NbS are mentioned explicitly as a relevant tool on land, alongside marine restoration in the Odense Fjord. The Odense Fjord Collaboration is always searching to create connections between its partners, with increased focus on water quality and climate adaptation also on a national scale.

Near and future ambitions

An aim in the region is to promote NbS and GBI as a driver for climate adaptation with the potential to manage multiple challenges with solutions that also supports biodiversity and quality of life for humans. Working with NbS and GBI, the region is inspired by natural dynamics in technical water management solutions supporting multiple functions, including urban greening, biodiversity and social/recreational wellbeing. The region aims to raise the level of data on NbS and GBI to promote

a stronger implementation. Better data can provide both politicians and managers with a better understanding of NbS and GBI and help promote a solid foundation of knowledge when they discuss adaptation plans, allocation of funding and incorporate NbS and GBI into projects that will turn ambitions to action.

Furthermore, the plan is to undertake a comprehensive assessment of a selected urban area looking at possibilities within hydrology, nature and quality of life as a basis for describing synergies and creating a clear picture of a project that can promote fundraising and political decision-making. This work can form the basis for a three-step process that focuses on sustainable urban drainage systems with NbS. Part of the innovation consists of facilitating collaboration between stakeholders. To establish new ways to have continuous fruitful dialogues about NbS and GBI there is a need to practice this collaboration. The ambition is to use this project as a driver of transformation in the region by developing and practising this approach. The collaboration will challenge the traditional organizational silo-thinking and promote re-structuring and path-shifting towards commitment to working towards a common goal or cause.

Source: Funen Regional Report for the ARCADIA project (deliverable 5.1)

ANALYSIS AND DISCUSSIONS

In this section, we combine insights from the literature review and regional assessment (based on the short questionnaire and the reports from the five model regions in the ARCADIA project) to discuss cross-case similarities, differences and lessons. We organise this section under three key headings. First, looking at the expected benefits from NbS and overall visions and ambitions in the regions related to NbS. Second, examining pathways for NbS in relation to barriers and enablers. Finally, exploring the key actors and approaches for implementing visions and navigating pathways towards scaling NbS in the regions.

Benefits – Visions

The geographic and societal contexts in the five model regions in the ARCADIA project, and thus the expected benefits of promoting NbS, span a wide spectrum (see Table 5). While Emilia-Romagna focuses on the highland forested areas in the region, Zagreb and Krapina-Zagorje have a significant focus on the city and built-up areas. While Skåne and Funen mainly focus their actions on cities and built-up areas, Skåne also highlights actions in agricultural landscapes, and Funen emphasizes effects in coastal areas. Lower Austria has a broad focus on both urban and rural areas. The literature on NbS is increasingly exploring different contexts (WWF, 2021), particularly cities and built-up areas (Sarabi et al., 2020).

Table 5: Benefits and ambitions in the five model regions in the ARCADIA project

Regions	Benefits to ambitions
Emilia-Romagna	**Benefits:** Reduction of hydro-geological risk, reduction of drought effects, ecosystems and natural resources valorization, local stakeholder involvement. **Ambitions:** Promote forest management to mitigate climate change risks (such as floods and landslides). Enhance the forest value chain to maximize economic and environmental benefits. Valorize regional natural capital by balancing the needs of local communities with effective forest management and biodiversity protection. Support regional efforts in developing concrete actions for climate change adaptation. Develop guidelines for policymakers on forest management, based on objective assessments of ecosystem services provided.
Lower Austria	**Benefits:** Environmental: Biodiversity conservation, climate resilience, and improved ecosystem services Economic: Cost-effectiveness, sustainable agriculture, tourism and recreation Social: Community well-being, educational opportunities, cultural heritage. **Ambitions**: Establishing NbS as a standard when addressing climate impacts. Three approaches: Defining a selection of NbS that are most appropriate and highly effective in terms of climate risks; Developing the most suitable NbS for local implementation and designing a process for it; and Implementing the solutions in strategic, planning and operational instruments, and creating the necessary framework conditions that facilitate and enable broad implementation.
Zagreb and Krapina-Zagorje	**Benefits:** NBS are needed to address new neighborhoods and settlements being built without proper planning, resulting in increased surface runoff. The city's

	drainage systems are combined with sewage systems and are significantly burdened during heavy rains, leading to drainage system failures in lower areas. NBS are also needed to mitigate urban heat islands, mitigating landslides in rural areas, and maintaining soil stability. **Ambitions:** The goal is to improve existing tools and practices for planning, financing, implementing, and monitoring nature-based measures for climate change adaptation, by improving visualising and analysing climate risks and for planning and implementing measures to mitigate these risks. The focus is on strategic projects to enhance collaboration and cohesion among city authorities, scientific and professional organisations, civil society groups, the business sector, and citizens. Additionally, promoting the ARCADIA project and engaging the community will heighten public awareness about climate change issues and the importance of urban sustainability.
Skåne	**Benefits:** Improved capacity to handle flooding and heat islands in cities. Handle the space problems of increasing population, agricultural land, and high biodiversity values, and provide space for recreation and ecosystem services. Improved water management and reduced drought problems in rural areas. Handle climate change risks in a way that gains local support and motivates investments by adding value. **Ambitions:** Develop solutions for NbS where nature and the city come together. Find innovative ways to scale up successful approaches in the landscape. Learn new ways to gain support for NbS through inclusive citizen participation, smart financing solutions and innovative design that strengthens the region's resilience. Join hands with the private sector and other NbS actors, to widen the implementation of nature-based climate adaptation across sectors in the region.
Funen	**Benefits:** Improve water quality and quantity of the Odense Fjord catchment area. The space for water management, nature, biodiversity, and many other objectives is highly limited and there is a need for a multifunctional approach to lift the ambitions of the many different agendas. NBS can be a way to handle these challenges by incorporating more values and tackling water management issues in synergy with green solutions rather than in pipes and grey solutions. **Ambitions:** Create solutions that are inspired and supported by nature to provide values for both people and nature, by using a systemic approach that mimics natural processes. The approach must be multifunctional as funding and space is limited but the challenges are numerous. Incorporate and exploit further synergies by zooming out and looking at larger systems and across sectoral divides in the water cycle from the upland to the fjord.

The common denominator for these five regions is that by implementing NbS, they hope to achieve several goals simultaneously. It is not only technical and ecological problems that need to be addressed, but also economic, organizational, and democratic challenges. Furthermore, they also wish to address competing goals by using the NbS concept. The regions highlight several types of conflicts or tensions

such as different interests claiming the same limited spaces in the city, and between groups of stakeholders with competing interests. According to Sarabi et al. (2020) space is often a limiting factor in urban areas and makes it challenging to find sufficient space for NbS (Sarabi et al., 2020).

The regions see great opportunities to use NbS as a unifying concept, which can bring stakeholders together and encourage new ways of solving problems. The regions are convinced that achieving the technical and ecological solutions requires new approaches to collaboration among stakeholders and financing. The literature repeatedly highlights the aspect of a collaborative approach in all stages of the NbS process (Wickenberg et al., 2021; Nesshöver et al., 2021; Martin el al., 2021; Cohen-Shacham, et al., 2016; Wamsler et al., 2020). Therefore, although the regions have slightly different focuses in terms of various technical and ecological issues in cities, built-up areas, forested uplands, or agricultural landscapes, they see similar opportunities when it comes to the need to find new ways to solve the problems, involving stakeholders and new organizational and financial solutions.

The regions have significant visions for their work with NbS and the ARCADIA project. For example: "develop solutions for NbS where nature and the city come together" (Skåne); "create solutions that are inspired and supported by nature to provide value for both people and nature" (Funen); "establishing NbS as a standard when addressing climate impacts" (Lower Austria); and "improve existing tools and practices for planning, financing, implementing, and monitoring" (Zagreb and Krapina-Zagorje). The view of the benefits of NbS is guided by the regional visions and ambitions, but also brings insights into the broad and multifaceted work required to realize them.

Barriers and Enablers – Pathways

The varying regional contexts (including cities, coastlines, forested and agricultural areas) implies that the barriers and enablers mentioned by the regions are equally numerous and multifaceted, which also entails a diversity of pathways towards scaling NbS. The barriers range from technical and ecological, such as struggles with technical solutions and biodiversity monitoring, to organizational and financial, such as how to organise local community involvement and tackle inconsistent funding. Enablers span from supportive policies and funding to coalitions of stakeholders coming together to support NbS projects and initiatives.

But there is no doubt that challenges are not lacking in regards to implementing NbS on the ground as the regions mention political and regulatory hurdles, competition for physical space in cities and rural areas, and existing and potential stakeholder conflicts. Administrative barriers, such as lack of coordination between national, regional and local levels of public authorities and organisations, and a strictly sectoral approach in public administration impeding interdisciplinary solutions, are frequently mentioned in the literature (Matin et al., 2021; Sarabi et al., 2020; Seddon, 2022; Nesshöver et al., 2017).

In addition, the regions describe how implementing NbS is a matter of education, knowledge and attitudes among the involved stakeholders. Even the lack of a clear definition and consistent use of the NbS concept is considered to be a barrier to effective implementation, which finds support in the literature as a common barrier for NbS (Sarabi et al., 2020; Wamsler et al., 2020; Nesshöver et al., 2017; Cohen-Shacham et al., 2019). In fact, the literature is engaging significantly with exploring and critiquing the concept of NbS in many ways and working towards typologies, frameworks and explanations to further NbS implementation (Wickenberg et al., 2021; Seddon 2022).

The regions also see many positive and enabling factors that can act as drivers for managing barriers and finding pathways forward. Among the examples mentioned are increased political interest in new solutions, improved collaboration between stakeholders, building public-private partnerships, as well as the possibility of engaging the community in issues related to local environments and personal health

and well-being. These are also highlighted in the literature (Wamsler et al., 2021; Sarabi et al., 2020). While many of the barriers and enablers are similar across regions (see Table 6), the viable pathways towards implementing NbS need to be developed and tested in the different contexts.

Table 6: Barriers and enablers in the five model regions in the ARCADIA project

Regions	Barriers and Enablers to Pathways
Emilia-Romagna	**Barriers:** Local community involvement, lack of a large-scale and shared approach for natural capital value assessment. **Enablers:** Regulations, knowledge, funds
Lower Austria	**Barriers:** Political: Lack of policy support, inconsistent funding, bureaucratic hurdles. Economic: High initial costs, uncertain economic benefits, competition with traditional solutions. Social: Public awareness and perception, stakeholder conflict, cultural preferences Technological: Lack of expertise, monitoring and evaluation, innovation gaps. Environmental: Land availability and quality, climate change impacts, ecological complexity. Legal: Regulatory barriers, property rights and land tenure, liability concerns. **Enablers:** Political: Policy support and integration, funding and incentives, international and EU support. Economic: Economic diversification, public-private partnerships (PPP), economic valuation of ecosystem services. Social: Community engagement and awareness, cultural heritage and identity, health and well-being benefits. Technological: Research and innovation, monitoring and data collection, knowledge sharing platforms. Environmental: Natural capital, biodiversity hotspots, climate resilience. Legal: Developing supportive legal frameworks, clarifying and securing land tenure and property rights, providing legal protection and clear guidelines.
Zagreb and Krapina-Zagorje	**Barriers:** Lack of clear definition of NbS results in less utilisation of NbS in the strategies, programs, and plans at local level. Lack of technically educated staff at local and regional level. Lack of data providing baseline frameworks for the implementation of projects based on NbS. Lack of standards for green spaces in planning. Educational need for all relevant stakeholders, from planners and designers to maintenance personnel. Low level of technical expertise, slow integration rate with other parts of the infrastructure system. Lack of clear frameworks and standards for planning and designing solutions and green infrastructure. Absence of regulations defining the appropriate experts authorised to engage in planning and designing solutions.

	Enablers: Professionals such as urban planning experts, landscape architects, engineers, are needed to prepare and implement projects. Development and energy agencies, sectoral agencies need to support and promote the development of projects. Non-profit organizations need to be involved in the co-creation process, project implementation, and raising awareness. Local and regional governments need to work with project implementation, best practice examples, and raise awareness. National ministries need to create policy frameworks and raise awareness. Private sector can develop and implement projects. Universities, schools and kindergartens can implement projects and raise awareness. Financial institutions and banks can finance projects Citizens can be involved in co-creation processes, project implementation and raising awareness.
Skåne	**Barriers:** Lack of financing and lack of space in the cities. Competing interests in rural areas between housing and industrial construction and highly fertile farmlands. The political will to build densely to reduce the use of the valuable agricultural land leads to a lack of space for NbS. Heat as a climate risk has yet to be mainstreamed into urban planning. Lack of agreement on who should finance climate risk reduction. Climate adaptation is typically a shared responsibility between organisational units – further complicating who should pay attention to the issues and carry the costs of preventive measures. Lack of coordination between national and local level. Mutual mistrust between farmers and the public sector. **Enablers:** Existing expertise and projects in the region – we have know-how and success stories, particularly with NBS and water. Growing ambitions in cities – we work together with healthy competition, which drives us further towards innovation. Local politicians generally understand that we need to work innovatively with NbS to protect our cities and landscapes. The regional development strategy sets a target of a climate neutral and fossil fuel free Skåne by 2030. Awareness of water and climate adaptation related issues is higher than ever. Three key actions needed: Creatively explore financing solutions and ways to make space for NbS in cities and landscapes. Think in new ways by learning from other regions in terms of finance, organisation, democracy, and strategy. Establish public and private alliances in the region, to gain support and build momentum for a larger strategic effort towards NbS in Skåne.
Funen	**Barriers:** The fields of public administration, legislation and project development are dominated by a highly sectoral approach, which inhibits the identification of synergies across the water cycle.

	An urgent need to streamline the sectoral legislation related to climate adaptation, as many areas of authority and grant opportunities are not synchronized and very often work against each other. Lack of a national plan for climate adaptation results in a fragmented response and ambiguous responsibility. Lack of agreement on who should finance risk reduction related to climate change. Lack of political interest in a national or regional approach to managed retreat in high-risk areas. Existing funding measures are similarly sector-divided and do not promote multi-functionality. Lack of consideration of appropriate measures for urban heat, such as water storage and greening of urban spaces. **Enablers:** Odense municipal development strategy targets climate neutrality in 2030 and climate resilience in 2050, setting a political goal for municipal development focused on climate reduction, nature, and water management. Collaboration between private and public stakeholders, such as the Odense Fjord Collaboration, with a common ambition to reach good water status before 2027. The University of Southern Denmark has a dedicated research effort focused on NbS with the Climate Cluster and AquaNbS projects. The local water utility company, VandCenter Syd, have been working extensively with urban local water drainage and local water management on the terrain for many years. The LCA tool may help highlight the connections between climate mitigation and adaptation.

Actors – Approaches

Actors and approaches are a central theme in the reporting from all five model regions in the ARCADIA project. The actors most frequently mentioned by the regions are policy-makers and authorities or public bodies. Policy-makers are considered as powerful enablers of NbS, as they can lead and establish political visions, plans, and strategies in climate and sustainability. They can also influence laws and regulations in a direction that supports the effective implementation of NbS, as well as dedicate public budget funds to appropriate measures.

Although, policy-makers exist at several levels, from the European level to national, regional, and local levels, and the regions point out that coordination and cooperation between these levels is not always working. For example, both Skåne and Funen highlight a lack of coordination regarding environmental issues between the different policy-making levels. In Sweden, there is no agreement which level is responsible for financing risk reduction in climate issues, and in Denmark, a national plan for climate adaptation is missing. Lower Austria highlights the lack of policy support as a main barrier to NbS implementation. Lack of policy support is also mentioned as a key barrier for NbS by Wamsler et al (2020). The Zagreb and Krapina-Zagorje region calls for better policy support and frameworks for physical planning in general in Croatia.

Authorities and other public bodies, such as national agencies and local municipalities, are highlighted as central enablers in all regions. They can provide existing expertise and success stories, and influence laws and regulations in a favorable direction for NbS. Nevertheless, in most cases, authorities or public bodies can represent potential barriers and challenges for NbS, as they maintain regulatory obstacles and have bureaucratic processes, as in Lower Austria, or have low staff education levels and lack

knowledge about NbS in physical planning, as in Zagreb and Krapina-Zagorje. These barriers are also identified in the literature (Martin et al., 2021; Wamsler et al., 2020).

The main shortcoming is often the lack of competence and inability to cooperate between and within authorities and public bodies. The need for better competence and cooperation is illustrated by for example the Funen region, who calls for improved cooperation between the sectorally divided fields of public administration for wastewater, groundwater, surface water, coastal management and aquatic environment. The sectoral divisions in the public administration inhibits the identification of synergies across the water cycle, according to the Funen region, which is supported by the literature (Sarabi et al., 2020; Wamsler et al., 2020; and Seddon, 2022).

Other actors that are frequently mentioned are local communities. For example, the Emilia-Romagna region highlights their ambition of *"*balancing the needs of local communities with effective forest management and biodiversity protection*"*. Lower Austria highlights that NbS, in collaboration with local communities, can strengthen tourism and recreation, thus contributing to the local economy. They emphasize that NbS can improve health and well-being, enhance cultural landscapes and heritage sites, and, not least, foster social cohesion and empower local communities. Therefore, education, engagement, and awareness within local communities are considered a central factor in NbS implementation (Wickenberg et al., 2021).

Landowners such as farmers and foresters play important roles in contributing to the development of payment schemes for ecosystem services, according to Emilia-Romagna and Lower Austria. In the Funen region, the productive cooperation between stakeholders around Odense Fjord is highlighted. However, there is a risk of conflicting interests between urban development, climate change mitigation, agriculture and forestry (Miralles-Wilhem, 2023). Lower Austria and Skåne highlight that issues such as property and tenure rights, as well as liability concerns, need to be addressed with reasonable solutions. Actors in the supply chains connected to forestry and agriculture are also mentioned by Emilia-Romagna and Lower Austria.

The public and NGOs are described as important actors, although less frequently than the other actors already mentioned. For example, Lower Austria emphasizes the significance of public awareness and perceptions of NbS in developing supportive legal frameworks. Zagreb and Krapina-Zagorje highlight the roles of the public and NGOs in contributing to co-creation processes and project implementation. Skåne aims to advance citizen involvement in NbS to increase public support for NbS, which is also recommended in the literature (Wamsler et al., 2020; Miralles-Wilhelm, 2023; Kabisch et al., 2016).

Researchers and research organisations are primarily mentioned in the role of providing data, modelling and suggesting strategies that can support policy-makers and decision-makers, as noted by regions such as Funen, Emilia-Romagna, and Lower Austria. To a limited extent, the role of research in educating and collaborating with public and private actors is mentioned. Lower Austria mentions innovation ecosystems and knowledge-sharing platforms organised by research organisations. The literature clearly emphasises the importance of knowledge sharing between actors and stakeholders (Kabisch et al., 2016; Nesshöver et al., 2017).

Banks and financial institutes are mentioned as vital for supporting the development of financial solutions for NbS (Palomo et al. 2021; Fransen & Bulkeley, 2024), as mentioned by Skåne, and for project financing, in Lower Austria and Zagreb and Krapina-Zagorje. In sum, exploring, improving, and further developing collaboration between actors is central for all five regions in the ARCADIA project (see Table 7). For example, the Zagreb and Krapina-Zagorje region identifies it as a key regional ambition in terms of enhancing collaboration and cohesion among city authorities, scientific and professional organisations, civil society groups, the business sector, and citizens.

Table 7: Actors and approaches in the five model regions in the ARCADIA project

Regions	Actors to Approaches
Emilia-Romagna	**Actors**: Policy makers, local stakeholders, local communities, forest owners, forest supply chain actors, researchers. **Approaches:** Local stakeholder and community involvement, balancing the needs of local communities with forest management and biodiversity protection.
Lower Austria	**Actors:** Policymakers, politicians, regulating authorities, the general public, landowners, farmers, developers, local planning and environmental management sectors, local communities, research and innovation, knowledge sharing platforms. **Approaches:** Involve actors more inclusively to overcome barriers. A multifaceted approach leveraging political support, economic incentives, community engagement, technological advancements, environmental assets, and supportive legal frameworks.
Zagreb and Krapina-Zagorje	**Actors:** Professionals such as urban planning experts, landscape architects, engineers, - preparation and implementation of projects Support institutions (development and energy agencies, sectoral agencies) - promotion and development of projects Non-profit organizations - involvement in the co-creation process, project implementation, raising awareness Local and regional government (counties, cities, municipalities) - project implementation, best practice examples, raising awareness Decision-makers (ministries) - policy creation, raising awareness Private sector (companies, craftsmen) - project development and implementation Educational institutions (universities, schools, kindergartens) - project implementation, raising awareness Financial institutions (banks) - project financing Citizens (general public) - involvement in the co-creation process, project implementation, raising awareness **Approaches:** Enhance collaboration and cohesion among city authorities, scientific and professional organisations, civil society groups, the business sector, and citizens. Promoting the project and engaging the community will heighten public awareness about climate change issues and the importance of urban sustainability.
Skåne	**Actors:** Authorities, municipalities, politicians, house owners, landowners, farmers, citizens, public-private partnerships.

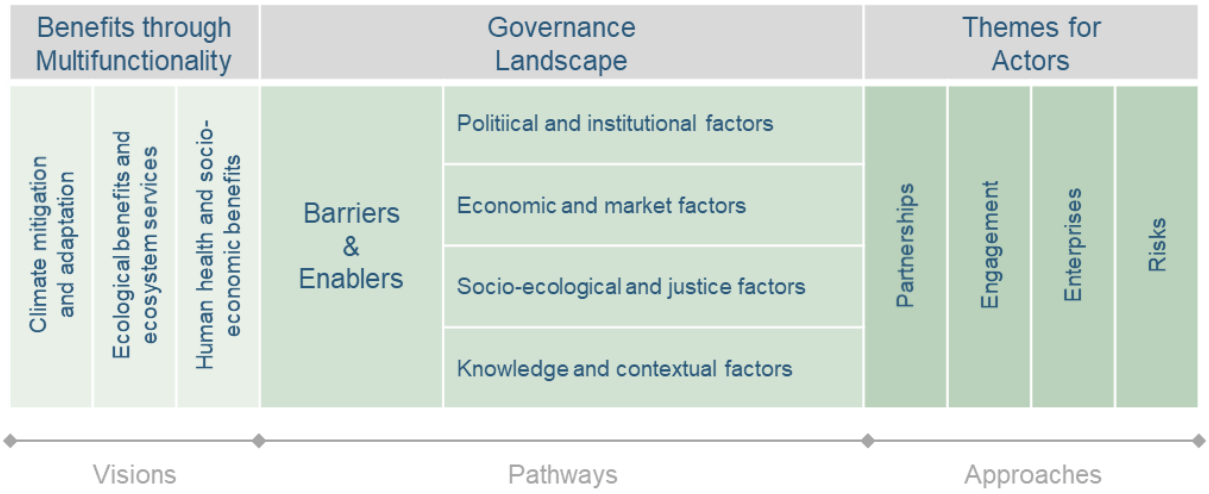
	Approaches: Creatively exploring financing solutions and ways to make space for NbS in cities and rural landscapes. Learning from other regions in terms of finance, organization, democracy, and strategy. Establishing public and private alliances in the region, to gain support for NbS.
Funen	**Actors:** Public administration, regulatory authorities, and politicians at various levels. Private and public stakeholders. House owners. The local water utility company. **Approaches:** A systemic and multifunctional approach, as funding and space is limited but the challenges are numerous. Zoom out and look at larger systems and across sectoral divides, to enable incorporation and exploitation of multiple synergies.

CONCLUSIONS AND REFLECTIONS

This report explores the key benefits, enablers, barriers and actors for NbS as well as how visions, approaches and pathways shape outcomes for NbS (see Figure 5). First, we considered the benefits of NbS through the lens of multifunctionality. We also placed benefits in relation to visions. Second, we explored the governane landscape of barriers and enablers for NbS, and broader pathways. And third, we discussed the key themes of partnerships, engagement, enterprises and risks in the context of actors, and we positioned actors in relation to approaches. An underlying concept that across this report is governance, and we also place NbS in the context of wider discussions on transformative change.

In this section, we provide key conclusions and reflections from this report and the processes of gathering and analysing data. First, the narrative review of the rapidly growing literature on NbS and the regional assessment are in alignment. But there are also a multitude of areas for expanded research. Second, enhancing collaboration and co-creation processes around NbS projects and initiatives is key to scaling and mainstreaming NbS. Third, regions are positioning NbS in the context of transformative change as is much of the literature. Finally, we present some methodological reflections on strengths and weaknesses, and lessons learned from developing this report.

Figure 5: Overview of approach



Growing literature and assessment from regions are in alignment on NbS

This report finds a significant degree of alignment across the literature and the reporting from the five model regions in the ARCADIA project on identified benefits, barriers, and enablers for NbS. The common challenges and opportunities that various regions face, reinforce the need for collaborative approaches to effectively implement and scale NbS. Multifunctionality is the benefit most associated with NbS and functions as an umbrella under which the benefits for biodiversity, climate adaptation, mitigation, human well-being, and economy fit. When preventative measures are adopted, a benefit, such as disaster risk reduction, can also become a driver for NbS, for example when there is extreme heat or water scarcity. Due to preventative actions, NbS can save resources and avoid loss and damage.

It is important to note the grey area between enablers and barriers for NbS. It is not a sharp categorization. In practice meaning that an enabler for NbS can become a barrier depending on the context or perspective. For example, a common enabler for a successful NbS project is often collaboration with the local community, and that governance is inclusive and reflective throughout the entire process. While an inclusive dialogue is not to be underestimated, collaboration can also become

a barrier to progress when local groups hold opinions that oppose NbS or when a group gains influence over the outcome. The same is true for legislation. Legislation and policy can either benefit or hinder the development of NbS. Navigating the pathway towards NbS can therefore be bumpy and messy.

Geography and context matters when understanding barriers and enablers for NbS. But a key challenge for NbS across Europe is the lack of funding, which is frequently mentioned in the regional reports and the literature. To meet current and future needs and policies, both private and public funding needs to significantly increase. Since NbS is a long-term endeavor, funding needs to encompass the entire process and not overlook the need for project maintenance and evaluation. Put simply, plans and strategies for NbS with limited funding and authority do not create significant or lasting impacts or produce the range of benefits discussed in this report.

The aspects reported by the regions are well reported in the literature, which suggests that similar research is not needed to facilitate action. However, there are a multitude of areas for expanded research. Here we highlight three topics. First, an under-developed area in the literature is applying a project lifecycle perspective across design, implementation and maintenance, and connecting in monitoring, evaluation and feedback to the NbS processes. Second, another interesting area appearing in the literature is the hybrid approach of mixing green, blue,and grey infrastructure as well as exploring the no tech, low tech, and high tech approaches to NbS. And third, there is an overwhelming need for further research on the area of implementation of both single and multiple NbS projects looking at synergies and connections between NbS across landscapes.

Collaborating between actors on NbS is key argues both the regions and literature
The regions and the literature reflect gaps between political visions for climate adaptation and resilience, and the actions and experiences of actors. As described by the regions, they hope to achieve several goals simultaneously and address goal conflicts, and they all emphasize multi-actor collaboration and transdisciplinary approaches as important pathways to success. This implies that the practical pathways forward are linked to involving actors in both established and new approaches. Thus, involving actors is key to implementing and scaling NbS. If organised consciously, it has the potential to influence the involved actors and bring about changes on many and different levels, and lead to truly positive outcomes.

The actors most commonly mentioned by the regions are authorities and public bodies, in various sectors and ranging from the local level to the European level. The regions call for improved cooperation and alignment between policy-makers, authorities and public bodies to facilitate NbS planning and implementation. Furthermore, local communities, landowners, NGOs and civil society stakeholders are frequently mentioned as key actors. The desired collaboration with such actors would probably be greatly simplified if the public actors were more in alignment.

Researchers and research institutions are mentioned by the regions primarily in the role of providers of knowledge and models to support policy-making. At the same time, most regions call for increased knowledge building and sharing among several groups of professionals, as well as local communities and stakeholders. In such knowledge building and sharing, researchers and research institutions can play a pivotal role, in arranging opportunities for education and training, and facilitating processes of knowledge building and sharing between multiple actors. This can also, for example, include joint efforts of the commonly called for monitoring and evaluation of NbS.

Furthermore, while many actors are mentioned, there can still be actors who are not engaged or overlooked in processes of NbS planning or implementation; so-called missing and marginalised actors. The questions of how to identify and involve such actors are vitally important, as they can help to enhance enablers, navigate barriers and influence potential pathways if they are involved.

Thus, the Zagreb and Krapina-Zagorje region set significant goals for increased collaboration and cohesion among various actors, which is expected to help develop a broad range of issues. Similarly, Lower Austria emphasizes that involving stakeholders more inclusively in adaptive planning and disaster risk management is necessary to overcome main barriers and challenges. Skåne, for its part, highlights the need to "creatively explore financing solutions" for NbS, and learn regarding financial, organizational, and democratic strategies and solutions.

The literature underlines the importance of collaboration between actors and stakeholders as well as knowledge sharing, for planning and implementation of NbS (Seddon, 2022; Wichenberg et al., 2021; Wamsler et al., 2020). All regions call for the formation and strengthening of public-private partnerships or alliances. All regions thus emphasize multi-actor collaboration and transdisciplinary approaches as important pathways to success.

Regions and the literature are positioning NbS in context of transformative change

The five model regions in the ARCADIA project are positioning NbS in the context of transformative change as is much of the literature. There are a range of topics related to transformative change and NbS. First, mixing green, blue and grey infrastructure as a hybrid approach. Second, specifically working with ensuring benefits from NbS flow to missing and marginalised communities. Third, directly addressing the path dependency of a "grey infrastructure culture" to open up opportunities for NbS. And finally, people-centered planning, multi-actor collaboration, and innovation are essential to connecting NbS with transformative change.

As suggested, mixing green, blue and grey infrastructure is on the rise. Integrating green or blue measures with grey infrastructure is even being suggested as more effective and cost-efficient under certain conditions (Browder et al., 2019) as well as potentially more likely to drive transformative change. This hybrid approach offers several advantages, including that it can be implemented in areas with limited space, leverages the complementary strengths of natural and built solutions, fosters innovation in designing adaptation, and provides an increased level of confidence compared to relying solely on green or blue approaches (Sutton-Grier et al., 2015).

While NbS projects aim to deliver positive environmental and socio-economic outcomes, there remains a limited understanding of how they can specifically benefit vulnerable and marginalized communities (Boyland et al., 2022). To enhance their effectiveness, NbS approaches can be more impactful when combined with broader and deeper thinking on transformative change (Riera-Spiegelhalder et al., 2023). Moreover, active stakeholder participation in identifying the benefits of NbS implementation is crucial for ensuring that these projects and initiatives effectively address the specific needs of communities and stakeholders (Moraes et al., 2022; Davies et al., 2021).

The concept of path dependency refers to the fact that societies and institutions have developed a "grey infrastructure culture" characterized by established practices, norms, policies, economic structures, and physical infrastructures. These elements can create significant barriers to the adoption of NbS and limit their ability to compete with traditional approaches, particularly in urban contexts. Designers and decision-makers often prefer conventional grey infrastructure due to their familiarity with it from technical, financial, and legislative perspectives. In contrast, NbS are often perceived as "black boxes," requiring navigation through uncharted territory (Linnerooth-Bayer et al., 2023).

When initiating NbS projects and initiatives, people-centered planning and innovation are essential (WWF, 2021). When innovation and experimentation come together, new ideas can be formed, and participants learn from practical experiences (Ershad Sarabi et al., 2019). Even within and between regions, it is necessary to share knowledge and information on NbS to develop and learn from experiences (Kabisch et al., 2016). A transdisciplinary approach to NbS and transformative change is

strongly encouraged so that a broad spectrum of ideas, worldviews, and values can be highlighted and joined up.

Methodological reflections on investigating NbS

There are a diversity of definitions and understandings of NbS in the literature as well as different interpretations of NbS in the five model regions in the ARCADIA project. This allows considerable flexibility but also creates challenges to what is included or not included in research on NbS in the regions. The literature on NbS is rapidly expanding and the narrative approach focused on providing an overview of the discussions and findings in the literature on NbS rather than a systematic analysis of all literature. This narrative approach provided a robust foundation for the report but it is also limited in not being systematic. The short questionnaire and regional reporting provided a wealth of data on the regions but it is also limited to the partners engaged in the ARCADIA project.

REFERENCES

Alves, A., van Opstal, C., Keijzer, N., Sutton, N., & Chen, W.-S. (2024). Planning the multifunctionality of nature-based solutions in urban spaces. *Cities*, *146*, 104751. https://doi.org/10.1016/j.cities.2023.104751

Belokurov A., Baskinas L., Biyo R., Clausen A., Dudley N., Guevara O., Lumanog J., Rakotondrazafy H., Ramahery V., Salao C., Stolton S., Zogib L. 2016 Climate Adaptation Methodology for Protected Areas (CAMPA): Coastal and Marine. WWF, Gland, Switzerland.

Boyland, M., Tuhkanen, H., Green, J., & Barquet, K. (2022). Principles for just and equitable nature-based solutions. In Principles for Just and Equitable Nature-Based Solutions. Stockholm Environment Institute Stockholm.

Browder, G., Ozment, S., Rehberger Bescos, I., Gartner, T., and Lange, G.-M.: Putting Nature to Work: Integrating Green and Gray Infrastructure for Water Security and Climate Resilience, World Bank Group and World Resources Institute, https://doi.org/10.46830/wrirpt.18.00028, 2019.

Chausson, A., Bugre, A., Spiegelenberg, F., Welden, E. A., & Melanidis, M. (2024). *New Report on Narratives, Frames and Future Horizons of Nature-based Solutions*. Unearthodox. https://unearthodox.org/2024/06/new-report-on-nature-based-solutions/

Clever Cities. (2018). *Barriers and Success Factors for Effectively Co-creating Nature-based Solutions for Urban Regeneration.* https://networknature.eu/nbs-resource/24855

Cohen-Shacham, E., Andrade, A., Dalton, J., Dudley, N., Jones, M., Kumar, C., Maginnis, S., Maynard, S., Nelson, C. R., Renaud, F. G., Welling, R., & Walters, G. (2019). Core principles for successfully implementing and upscaling Nature-based Solutions. *Environmental Science & Policy*, *98*, 20–29. https://doi.org/10.1016/j.envsci.2019.04.014

Cohen-Shacham, E, Janzen, C, Maginnis, Stewart, & Walters, Gretchen. (2016). *Nature-based solutions to address global societal challenges* (978-2-8317-1812–5). IUCN. https://iucn.org/resources/publication/nature-based-solutions-address-global-societal-challenges

Cousins, J. (2021) Justice in NbS: Research and Pathways. Ecological Economics, 180, 1-11. https://doi.org/10.1016/j.ecolecon.2020.106874

Davies, C., Chen, W. Y., Sanesi, G., & Lafortezza, R. (2021). The European Union roadmap for implementing nature-based solutions: A review. *Environmental Science & Policy*, *121*, 49–67. https://doi.org/10.1016/j.envsci.2021.03.018

Davies, C., & Lafortezza, R. (2019). Transitional path to the adoption of nature-based solutions. *Land Use Policy*, *80*, 406–409. https://doi.org/10.1016/j.landusepol.2018.09.020

Duncanson, L., Liang, M., Leitold, V., Armston, J., Krishna Moorthy, S. M., Dubayah, R., Costedoat, S., Enquist, B. J., Fatoyinbo, L., Goetz, S. J., Gonzalez-Roglich, M., Merow, C., Roehrdanz, P. R., Tabor, K., & Zvoleff, A. (2023). The effectiveness of global protected areas for climate change mitigation. *Nature Communications*, *14*(1), 2908. https://doi.org/10.1038/s41467-023-38073-9

El Harrak, M., & Lemaitre, F. (2023). *European Roadmap to 2030 for Research and Innovation on Nature-based Solutions*. Network Nature. https://networknature.eu/product/29557

Ershad Sarabi, S., Han, Q., L. Romme, A. G., de Vries, B., & Wendling, L. (2019). Key Enablers of and Barriers to the Uptake and Implementation of Nature-Based Solutions in Urban Settings: A Review. *Resources*, *8*(3), Article 3. https://doi.org/10.3390/resources8030121

European Commission. (2015). *Towards an EU research and innovation policy agenda for nature-based solutions & re-naturing cities: Final report of the Horizon 2020 expert group on 'Nature based solutions and re naturing cities' : (full version)*. Publications Office of the European Union. https://data.europa.eu/doi/10.2777/765301

European Commission. (2022). *The vital role of nature-based solutions in a nature positive economy*. Publications Office of the European Union. https://data.europa.eu/doi/10.2777/307761

European Commission. (2023). *TrAnsformative climate ResilienCe by nAture-baseD solutions in the contInentAl bio-geographical region | ARCADIA Project | Fact Sheet | HORIZON*. CORDIS | European Commission. https://cordis.europa.eu/project/id/101112737

European Investment Bank. (2023). *Investing in nature-based solutions. State-of-play and way forward for public and private financial measures in Europe*. https://climate-adapt.eea.europa.eu/en/metadata/publications/investing-in-nature-based-solutions-state-of-play-and-way-forward-for-public-and-private-financial-measures-in-europe

Fransen, A., & Bulkeley, H. (2024). Transnational Governing at the Climate–Biodiversity Frontier: Employing a Governmentality Perspective. *Global Environmental Politics*, *24*(1), 76–99. https://doi.org/10.1162/glep_a_00726

Hansen, R., & Pauleit, S. (2014). From Multifunctionality to Multiple Ecosystem Services? A Conceptual Framework for Multifunctionality in Green Infrastructure Planning for Urban Areas. *AMBIO*, *43*(4), 516–529. https://doi.org/10.1007/s13280-014-0510-2

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., Haase, D., Knapp, S., Korn, H., Stadler, J., Zaunberger, K., & Bonn, A. (2016). Nature-based solutions to climate change mitigation and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action. *Ecology and Society*, *21*(2). https://www.jstor.org/stable/26270403

Korkou, M., Tarigan, A. K. M., & Hanslin, H. M. (2023). The multifunctionality concept in urban green infrastructure planning: A systematic literature review. *Urban Forestry & Urban Greening*, *85*, 127975. https://doi.org/10.1016/j.ufug.2023.127975IUCN. (2016). *Nature-based solutions to address global societal challenges* [Resource]. https://iucn.org/resources/publication/nature-based-solutions-address-global-societal-challenges

Linnerooth-Bayer, J., Martin, J., Fresolone, A., Scolobig, A., Aguilera Rodriguez, J. J., Solheim, A., Grimsrud Olsen, S., & Hoffstad Reutz, E. (2023). *Learning from NBS implementation barriers*. Université de Genève. https://www.phusicos.eu/publication--results/

Mansourian, S., Belokurov, A., & Stephenson, P. J. (2009). The role of forest protected areas in adaptation to climate change. *Unasylva*, *60*(231–232), 63–69.

Martin, J. G. C., Scolobig, A., Linnerooth-Bayer, J., Liu, W., & Balsiger, J. (2021). Catalyzing Innovation: Governance Enablers of Nature-Based Solutions. *Sustainability*, *13*(4), Article 4. https://doi.org/10.3390/su13041971

McQuaid, S., Kooijman, E. D., Rhodes, M.-L., & Cannon, S. M. (2021). Innovating with Nature: Factors Influencing the Success of Nature-Based Enterprises. *Sustainability*, *13*(22), Article 22. https://doi.org/10.3390/su132212488

Miralles-Wilhelm, F. (2023). Nature-based solutions in agricultural landscapes for reducing tradeoffs between food production, climate change, and conservation objectives. *Frontiers in Water*, *5*. https://doi.org/10.3389/frwa.2023.1247322

Moraes, R. P., Reguero, B. G., Mazarrasa, I., Ricker, M., & Juanes, J. A. (2022). Nature-based solutions in coastal and estuarine areas of Europe. Frontiers in Environmental Science, 10, 829526.

Nesshöver, C., Assmuth, T., Irvine, K. N., Rusch, G. M., Waylen, K. A., Delbaere, B., Haase, D., Jones-Walters, L., Keune, H., Kovacs, E., Krauze, K., Külvik, M., Rey, F., van Dijk, J., Vistad, O. I., Wilkinson, M. E., & Wittmer, H. (2017). The science, policy and practice of nature-based solutions: An interdisciplinary perspective. *Science of The Total Environment*, *579*, 1215–1227. https://doi.org/10.1016/j.scitotenv.2016.11.106

Palomo, I., Locatelli, B., Otero, I., Colloff, M., Crouzat, E., Cuni-Sanchez, A., Gómez-Baggethun, E., González-García, A., Grêt-Regamey, A., Jiménez-Aceituno, A., Martín-López, B., Pascual, U., Zafra-Calvo, N., Bruley, E., Fischborn, M., Metz, R., & Lavorel, S. (2021). Assessing nature-based solutions for transformative change. *One Earth*, *4*(5), 730–741. https://doi.org/10.1016/j.oneear.2021.04.013

PHUSICOS, Martin, Fresolone-Caparrós, A., Scolobig, A., & Reutz, E. H. (2023). *Learning from NBS implementation barriers* [Other]. Deliverable 5.4 of the PHUSICOS project. https://phusicos.eu/

Reid, W. V. (2005). *Millennium Ecosystem Assessment: Ecosystems and Human Well-being*. Island Press. https://www.wri.org/research/millennium-ecosystem-assessment-ecosystems-and-human-well-being

Riera-Spiegelhalder, M., Campos-Rodrigues, L., Ensenado, E. M., Dekker-Arlain, J. D., Papadopoulou, O., Arampatzis, S., & Vervoort, K. (2023). Socio-economic assessment of ecosystem-based and other adaptation strategies in coastal areas: a systematic review. Journal of Marine Science and Engineering, 11(2), 319.

Sarabi, S., Han, Q., Romme, A. G. L., de Vries, B., Valkenburg, R., & den Ouden, E. (2020). Uptake and implementation of Nature-Based Solutions: An analysis of barriers using Interpretive Structural Modeling. *Journal of Environmental Management*, *270*, 110749. https://doi.org/10.1016/j.jenvman.2020.110749

Scoones, I., Stirling, A., Abrol, D., Atela, J., Charli-Joseph, L., Eakin, H., Ely, A., Olsson, P., Pereira, L., Priya, R., van Zwanenberg, P., & Yang, L. (2020). Transformations to sustainability: Combining structural, systemic and enabling approaches. *Current Opinion in Environmental Sustainability*, *42*, 65–75. https://doi.org/10.1016/j.cosust.2019.12.004

Seddon, N. (2022). Harnessing the potential of nature-based solutions for mitigating and adapting to climate change. *Science*, *376*(6600), 1410–1416. https://doi.org/10.1126/science.abn9668

Seddon, N., Chausson, A., Berry, P., Girardin, C. A. J., Smith, A., & Turner, B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *375*(1794), 20190120. https://doi.org/10.1098/rstb.2019.0120

Snep, R. P., Voeten, J. G., Mol, G., & Van Hattum, T. (2020). Nature Based Solutions for Urban Resilience: A Distinction Between No-Tech, Low-Tech and High-Tech Solutions. *Frontiers in Environmental Science, 8*. https://doi.org/10.3389/fenvs.2020.599060

Sutton-Grier, A. E., Wowk, K., & Bamford, H. (2015). Future of our coasts: The potential for natural and hybrid infrastructure to enhance the resilience of our coastal communities, economies and ecosystems. Environmental Science & Policy, 51, 137-148.

UNEP. (2022, December 10). *Nature-based Solutions: Opportunities and Challenges for Scaling Up | UNEP - UN Environment Programme*. https://www.unep.org/resources/report/nature-based-solutions-opportunities-and-challenges-scaling

Wamsler, C., Wickenberg, B., Hanson, H., Alkan Olsson, J., Stålhammar, S., Björn, H., Falck, H., Gerell, D., Oskarsson, T., Simonsson, E., Torffvit, F., & Zelmerlow, F. (2020). Environmental and climate policy integration: Targeted strategies for overcoming barriers to nature-based solutions and climate change adaptation. *Journal of Cleaner Production*, *247*, 119154. https://doi.org/10.1016/j.jclepro.2019.119154

Wickenberg, B., McCormick, K., & Olsson, J. A. (2021). Advancing the implementation of nature-based solutions in cities: A review of frameworks. *Environmental Science & Policy*, *125*, 44–53. https://doi.org/10.1016/j.envsci.2021.08.016

WWF. (2021). *Powering Nature: Creating the conditions to enable nature-based solutions.* https://www.wwfca.org/en/powering_nature

Xie, L., Bulkeley, H., & van der Jagt, A. (2020). *Pathways for Systemic Integration of Nature-Based Solutions*. https://networknature.eu/product/22735

ANNEX

Appendix 1 - Overview of reports on NbS

Appendix 2 - Overview of articles on NBS

Appendix 1 - Overview of reports on NbS

Benefits = the reasons why NBS is considered important
Barriers = the challenges/obstacles/barriers preventing the implementation and scaling of NBS
Enablers = the opportunities and possible drivers for NBS
Audience = the key actors/audience focused on in the report
Methods = the data collection and analysis behind the report

Publication	Benefits – why?	Barriers – what?	Enablers – how?	Audience/Actors – who?	Methods
WWF (2021) Powering Nature: Creating the Conditions to Enable Nature-based Solutions	Protecting human health Disaster risk reduction Safeguarding access to clean water Ensuring food security Mitigating and adapting to climate change	SOCIOCULTURAL Insufficient recognition of rights. Missing social incentives. INSTITUTIONAL Conflicting policy frameworks. Limited government capacity and corruption. ECONOMIC Undervaluing natural capital. Insufficient or poorly directed finance. Limited direct financial revenues.	INCLUSIVE GOVERNANCE Legal rights Investing in local institutions Fair benefit sharing SMART SPATIAL PLANNING Leads to resilient communities People-centred planning Ecological corridors Climate-smarting interventions PROGRESSIVE ECONOMIC AND FINANCIAL REGULATION Subsidy reform Natural capital accounting and beyond income measures Regulated finance	By identifying structural barriers, policy levers and systemic enablers, this report provides governments, decision-makers, civil society and the private sector with a practical basis for integrating nature-based solutions into planning decisions at different scales and in multiple sectors.	The systemic enabling framework presented in the report is informed by the evidence and ideas from 10 case studies to unleash the power of nature to help solve key societal challenges at local to global scales, while maximising its positive nature-people-climate contribution.
Cleaver Cities (2018) Barriers and success factors for effectively co-creating nature-based solutions for urban regeneration	The potential positive interactions of environmental, economic and social systems lie at the heart of NBS.	The limited knowledge base for nature-based solutions; the inadequate governance structures for NBS; the balancing of the multiple goals NBS can deliver; effective citizen involvement; insufficient social inclusion and social acceptance; lack of political and financial support; the challenges for monitoring NBS; and, the difficulties in upscaling NBS.	Solutions show that interactions of environmental, economic and social systems have to be considered at all stages of co-creation, implementation, evaluation and upscaling.	Focus is to guide city governments to transform NBS beyond single interventions into city-wide planning processes.	This report draws on the experiences of past and ongoing projects in the field of nature-based solutions and urban regeneration. Evidence was gathered not only from sources explicitly focused on nature-based solutions, but also from those dealing with the related topics of urban regeneration, ecosystem services, green (and blue) infrastructure and climate adaptation in cities more broadly.

European Commission (2022) The vital role of Nature-Based Solutions in a Nature Positive Economy	Our livelihoods, well-being, and our chance to meet the challenge of global warming all depend on nature. Nature provides all sorts of essential services to humanity: clean air and water, food, and pollination, it sustains tourism and leisure activities, it contributes to mental and physical health and delivers many other functions.	Standards Measurement and valuation Public policy Investment in NBS Specific market sectors NBS awareness and capacity building	International and European standards for different types of NBS are urgently needed. Decisive action and leadership is needed on measurement and valuation, including an independent NBS open-source observatory. Supportive, integrating public policy is of paramount importance. Need to address a range of challenges and enablers in different market sectors. Policy makers need to enable accelerated investment in NBS by both the public and private sector. Measures to increase awareness and build capacity are critically important for all stakeholders.	Focus on economic policy makers but is of high relevance for policy makers across multiple domains, public sector institutions and agencies, researchers, civil society and NGO representatives, investors and financial institutions, industry and Nature-Based Enterprises (NBE) in delivering NBS.	The objective of this report is to highlight the vital role of Nature-Based Solutions (NBS) in the shift towards a nature-positive economy and to raise awareness of the increasingly important role of Nature-Based Enterprises (NBE) in delivering NBS. This report is based on extensive consultations with 170 diverse stakeholders.
Unearthodox and Nature-based Solutions Initiative. (2024) Nature-based Solutions: Narratives, frames, and future horizons.	The NBS concept has been promoted in research, policy, and practice as an integrated approach to address interlinked societal challenges in biodiversity, health, and climate.	NBS and the human–nature binary. Neoliberal frames sideline justice and equity in NBS governance.	Relational and more-than-human epistemologies Embracing plural valuation through NBS Transformation towards just NBS Transforming international governance as a path to decolonisation	This report acknowledges a diversity of actors in the NBS context. Actors represented in the document analysis span a wide range of areas, with most from international non-governmental organisations (NGOs), academia, multilaterals, and research institutes.	A mixed methods approach was used to explore frames and narratives and the actors underpinning them, consisting of an analysis of 55 documents and 10 key informant interviews.
Naturvation (2020) Steps for Systemic Integration of Nature-based Solutions.	NBS can provide a range of ecological, social and economic benefits and are increasingly positioned as practical solutions for addressing urban sustainability challenges.	Seven general dimensions were identified that serve as conceptual categories for identifying structural barriers (and enablers). Core mission, guiding principles and values. Stakeholder landscape and organisational forms. Knowledge paradigms and key expertise. Funding structure and key resources.	This report identifies and elaborates the key stepping stones – pivotal actions– that can unlock the potential for mainstreaming urban NBS. Using the examples of climate change and biodiversity, we examine how stepping stones can be aligned to generate promising pathways for mainstreaming NBS that can contribute to diverse sustainability agendas in cities.	In total, 20 stepping stones were identified as pivotal for mainstreaming urban nature-based solutions. The report targets urban infrastructure regimes, which are shaped by regulatory, financial and urban development domains.	The analysis which underpins this report drew on research undertaken in the Netherlands, Sweden, the United Kingdom (UK), Spain, Germany, Hungary and the European Union (EU), focusing on the regulatory, financial and urban development domains of the urban infrastructure regimes that shape the uptake of NBS in cities.

		Policy paradigms and key regulations. Dominant technologies.			
United Nations Environment Programme (2022) Nature-based Solutions: Opportunities and Challenges for Scaling Up.	NBS works with nature to address a range of important social, economic and environmental challenges. These challenges include climate change, land degradation, food security, water availability as well as urban development, poverty, unemployment, and biodiversity loss.	Four important concerns or barriers to wider uptake of NBS are discussed in this report. NBS could infringe on the rights of indigenous peoples and local communities (IPLCs) and other actors. NBS could distract or detract from other urgently needed actions such as decarbonization. NBS can be misinterpreted and misused. Scepticism about the effectiveness of NBS.	Build a common understanding of NBS. Adopt integrated approaches to scale up NBS, combining policy, finance, and safeguard measures. Apply appropriate safeguards, standards, and guidelines for NBS. Enable locally-led actions on NBS.	This report aims to inform NBS-related initiatives and discussions on NBS at global, regional, and national levels, with a focus on how NBS can be scaled up to more effectively address social, economic, and environmental challenges.	This report provides an overview of NBS, a set of recommendations for achieving the scaling up and replication of NBS, and ways to recognize and respond to concerns about NBS.
European Investment Bank (2023) Investing in nature-based solutions: State-of-play and way forward for public and private financial measures in Europe.	NBS are both a means of addressing socio-economic challenges through biodiversity conservation and restoration and building resilience to the consequences of climate change through mitigation and adaptation using natural processes. NBS are considered cost effective and produce multiple benefits.	The main challenge of financing the increased uptake of NBS is that the majority of the benefits currently have no financial market value. Market failures and barriers include information shortfalls (due to the lack of data on the benefits and trade-offs of NBS, skills and expertise shortages, and a lack of awareness in the general public), a failure to coordinate across public agencies, high transaction costs, long timeframes for financial returns and high risk profiles than other comparable investment options.	Regulation and subsidy reforms will be needed to create new incentives and remove support for the further erosion of nature, as well as to create new markets and revenues. Systemic and strategic issues, such as competition for land and water resources, will also need to be addressed. The need for climate resilience will become both an important driver and design parameter for NBS.	NBS projects are largely fostered and financed by the public sector, and this report targets private sector involvement and suggests a range of funding and financing mechanisms.	This report, by the EIB, is the culmination of a key strategic partnership with the European Commission, aimed at fostering NBS. It assesses the current state of deployment of NBS in Europe. The analysis is based on publicly available sources of information, supplemented by access to key databases of active NBS projects in Europe and extensive consultations with a range of stakeholders.
Network Nature (2023) European Roadmap to 2030 for Research and Innovation on Nature-based Solutions.	The term NBS emerged in the late 2000s as a concept to address and mitigate societal, economic, and ecological challenges simultaneously.	This report highlights 9 challenges for NBS including knowledge and data gaps, risks of greenwashing, lack of integration, limits on mainstreaming NBS, limited tools and guidelines, insufficient coordination, NBS benefits disputed, and lack of capacities	Advancing NBS knowledge and data on NBS Closing the NBS research-implementation gap Mainstreaming NBS in policy Building awareness, capacities, and dialogues on NBS	This report identifies core action areas for European research and innovation on NBS that are essential to achieve EU goals for NBS development and deployment.	This report on NBS draws on the results of several streams of work by Network Nature, including Mapping the EU Research, Innovation, and Implementation landscape on NBS and Collecting and synthesising knowledge gaps on NBS.

		and incentives for decision-makers.			
International Union for Conservation of Nature and Natural Resources (2016) Nature-based Solutions to address global societal challenges.	NBS are actions to protect, sustainably manage and restore natural or modified ecosystems, which address societal challenges (climate change, food and water security or natural disasters) effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits.	A lack of operational clarity presents a major obstacle to the credibility and applicability of new concepts in the fields of conservation and development. Several parallel exercises are currently underway to develop operational parameters for specific NBS approaches.	By unifying NBS approaches under a single operational framework, it becomes possible to scale up implementation and strengthen impact. Five preliminary parameters are proposed: ecological complexity, long-term stability, scale of ecological organisation, direct societal benefits and adaptive governance. Lessons learned from the 10 case studies include local governance, community engagement, collaboration, ecosystem approach, livelihoods benefit and risk management.	The term NBS has been used mainly in communications targeting policy makers. The NBS concept is increasingly being developed and applied by IUCN and other organisations, such as the European Commission.	This report provides an overview on the NBS concept and its application as well as presents 10 case studies of NBS implementation.
PHUSICOS (2023) Learning from NBS implementation barriers.	There is a continuum between fully 'grey' infrastructure, which are engineered projects constructed with little consideration of their impacts on biodiversity, climate and other ecological consideration (e.g., concrete dams or seawalls), to projects that re-create or strengthen the naturally occurring habitat (e.g., mangroves to lessen storm surge). There are ways of 'greening' 'grey' infrastructure and hybrid NBS projects that combine both grey and green elements.	This report highlights two key barriers: i) lack of knowledge about the effectiveness of NBS and their ability to deliver co-benefits and ii) the lack of qualified contractors who have specialized experience on constructing NBS compounded by a lack of standards, technical guidelines and legal norms.	Key lessons or enablers include: innovative co-generation stakeholder processes; smart uses of CBA that account for long-term impacts; novel 'blended' financing to extend the portfolio of bankable NBS projects; the EU taxonomy that can promote divestment from nature-negative projects; mechanisms to transfer infrastructure risk; and whole-of-life contracts that include long-term maintenance and monitoring.	In the implementation of NBS, contractors play a crucial but often overlooked role. Contractors include a wide range of private sector companies, who are tasked with the design, construction and/or maintenance of solutions following a bidding process initiated by the project initiators or owners (usually public entities).	The methodologies include: a systematic literature survey and meta-analysis of 'grey' infrastructure implementation,; the analysis of the 12 'grey' barriers compared with their NBS counterparts; 13 semi-structured interviews with public-sector entities across Norway, including municipalities, county governors and national directorates; and 20 semi-structured interviews with private-sector professionals working in the provision of NBS services.

Appendix 2 - Overview of articles on NBS

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Publication	Benefits – why?	Barriers – what?	Enablers – how?	Audience/Actors – who?	Methods
Kabisch et al., 2016, Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action	Decrease vulnerability and enhance the resilience of cities Mitigate climate change-induced impacts and serve as proactive adaptation options for municipalities Improved quality of life Mental and physical health Supporting a sense of belonging Reinforce cultural identities More cost-effective and efficient than "grey" approaches Green facades and roofs can enhance climate regulation and counteract urban heat island	Knowledge gaps of long-term benefits No established targeted indicators Potential ecosystem disservices Lack of indicators addressing social and environmental justice issues Increases in land prices and rent "The green paradox" – those for which the green spaces would be most beneficial don't always profit from the natural area because of displacement processes.	Knowledge sharing and learning, from existing approaches and experiences within and between countries Case studies can address the added values of NbS Development indicators to increase measurability comparability and improve assessment of effectiveness Communication and decision-making – using indicators to communicate benefits to inform decision-making and provide convincing arguments for NbS. Indicators for Integrated environmental performance, human health and well-being, citizen's involvement, and transferability Health indicators measure health benefits from proximity to green spaces. Knowledge valorization and sharing - exploiting existing tacit and expert knowledge of various stakeholder Establishing collaborative governance approaches	Trans-disciplinary workshops with experts from research, municipality and the public.	Insights from interdisciplinary and trans-disciplinary workshops with experts from research, municipality, and society.
Martin et al., 2021. Catalyzing innovation: Governance Enablers of Nature-based solutions	Contribute to disaster risk reduction, climate change adaptation, and sustainable development. This paper focuses on risk reduction in mountainous areas including: - Vegetating slopes to reduce landslide risk.	In many European and national NbS policies, the application of NbS is fragmented, hence relying on voluntary measures. There is little research on the Enablers of and opportunities for NBS implementation. Studies focus mainly on urban solutions.	Two groups of enablers. They are distinguished by when they occur: as a precondition for NbS or during the initiation, planning, design, and implementation. Four subcategories are used for grouping of enablers in each group: 1. SOCIO-CULTURAL: Environmental and risk awareness, opposition to grey	China, Italy and Germany, civil society actors and other stakeholders in mountainous areas.	Case studies from Germany, China, and Italy, and interviews with representatives from cases.

	- Buffer strips and buffering zones to reduce erosion and contain flood water. - Widening riverbeds to reduce flood risks. - Afforestation of slopes to mitigate avalanche and rockfall risks. NbS have multiple co-benefits for ecological resilience, economic growth, and human health, such as social, recreational, and cultural. Drive new and innovative governance structures.		measures, interest groups, stakeholder engagement, and trust relationships. 2. LEGAL/INSTITUTIONAL/POLITICAL: Favourable property rights, mandates, legal bases, cross-sectoral collaboration, local champions, clear goals, common vision, and political support. 3. HUMAN RESOURCES: Expert knowledge, development programs, communication strategy, and co-designed plans. 4. FINANCIAL RESOURCES: Availability of funds, additional funding sources, cost-effectiveness There is a need for mainstreaming NbS into policy agendas which can be made through polycentric collaborations that cut through administrative bodies. Co-design: Stakeholder participatory processes. Organized advocacy groups for NbS. Funding community-based implementation and monitoring. Drivers: 1. Policies supporting collaboration and local empowerment. 2. Incentives and monetization strategies. 3. Cross-sectional networking. Preconditions for Success: 1. Mainstreaming into Policy: Facilitated by polycentric administration. 2. Synergies: Disaster protection, climate adaptation, biodiversity, and human welfare through concerted efforts.		
Ershad Sarabi et al., 2019. Key enablers of and barriers to the Uptake and Implementation of Nature-based solutions in Urban Settings	Benefits beyond conservation and restoration. Delivers ecosystem services. Enhance Urban Resilience Multifunctionality: Provides multiple simultaneous benefits.	Socio-Institutional: 1. Knowledge Gaps: - Limited practical understanding and fragmented knowledge.	1. Stakeholder Partnerships: Builds trust and encourages ecosystem stewardship. 2. Knowledge Sharing: Facilitates idea sharing and stakeholder involvement.	Public-private partnerships in urban settings.	Systematic review, selected papers between 2015-2019.

	Three types of benefits that partnerships with stakeholders can bring to the NBS development process: 1. Substantive: Local perspectives improve planning. 2. Instrumental: support for the plans 3. Normative: Increases legitimacy of the process Shared Vision: Consensus is created through partnerships and dialogue. Open dialogue promotes acceptance for NbS.	- Lack of consensus on definitions. 2. Financial Constraints: - Limited funding opportunities and short-term schemes. - Municipalities' restricted resources and autonomy. - Need for private investment. 3. Path Dependency: - Resistance to change and altering stakeholder mindsets. - Difficulty changing individual and societal behaviors. 4. Institutional Fragmentation: - Sectoral silos and independent departmental operations. - Confusion due to multiple agencies with different responsibilities. 5. Inadequate Regulations: - Scattered regulations focused on grey infrastructure. - Legislation may not cover all environmental components. Hybrid Barriers: 6. Implementation Uncertainty: - Lack of information on benefits and effectiveness. - Limited diffusion of academic knowledge reduces public acceptance. Biophysical Barriers: - Limited space, especially in urban areas. - Long-term benefits not aligning with short-term local agendas.	3. Economic Instruments: Incentivizes adoption through price, quantity, and fiscal measures. 4. Legislation, plans, and Policies: Can enable or hinder NbS based on their design. 5. Education and Training: Reduces uncertainties and builds public support. 6. Monitoring and Evaluation: Standardized systems to assess and enhance NbS effectiveness. 7. Innovation and Experimentation: Promotes innovation and learning from practical experiences. 8. Integration with Grey Infrastructure: Combines NbS with existing structures for enhanced functionality and public acceptance. Typology of enablers: 1. Socio-Institutional 2. Hybrid 3. Biophysical		

Seddon et al., 2020. Understanding the value and limits of nature-based solutions to climate change and other global challenges	1. Climate Change Mitigation and Adaptation: - Protecting against climate impacts and slowing warming. - CO2 mitigation through ecosystem stewardship and agriculture improvements. - Avoiding deforestation in tropical nations to mitigate emissions. 2. Biodiversity and Ecosystem Services: - Supporting biodiversity. - Securing ecosystem services. 3. Environmental Protection: - Protecting from erosion, inland flooding, coastal hazards, and sea-level rise. - Moderating urban heat waves and managing urban storm-water and flooding. - Creating green roofs and spaces to mitigate heat waves and regulate water flow in urban areas. 4. Resource Sustainability: - Sustaining natural resources in drier climates. - Enhancing ecosystem services to buffer communities from climate shocks. 5. Socioeconomic Benefits: - Supporting governance reform and access to resources. - Reducing socio-economic exposure and sensitivity. - Supporting socioeconomic adaptive capacity. 6. Advantages Over Other Carbon Removal Options: - More cost-effective and scalable than direct air capture,	1. Ecological Concerns: - Risk of monocultures vulnerable to disease, pests, and climate extremes. - Non-native species becoming invasive or exacerbating water scarcity. 2. Social and Ethical Issues: - Compromising local land rights and potential land grabs. - Harm to biodiversity from encroaching plantations. 3. Policy and Measurement Challenges: - Difficulty in measuring and predicting NbS effectiveness. - Poor financial models and under-investment. - Inflexible governance favouring grey infrastructure. 4. Economic and Financial Barriers: - Insufficient climate finance for NbS. - Challenges in monetizing NbS benefits. - Short-term decision-making in the public and private sectors. - Lack of ownership, risk-sharing, and appropriate finance models. 5. Regulatory and Incentive Issues: - Conflicting regulations and lack of supportive incentives. - Regulatory frameworks hindering NbS adoption. - Path dependency and power relations against NbS. 6. Knowledge and Evidence Gaps:	1. Ecological and Scientific: - High carbon sequestration rates in naturally regenerating, older, and diverse forests. - Diverse ecosystems delivering a wider range of ecosystem services. 2. Systemic and Interdisciplinary Approaches: - Grounding NbS in robust ecological and geographical understanding. - Implementing NbS within a systems-thinking framework that accounts for multiple ecosystem services and trade-offs. - Major systemic changes in interdisciplinary research, institutional organization, and communication. 3. Economic and Financial Support: - Funding from public and private, bilateral and multilateral, national and international sources - Payments for ecosystem services (PES) programs, including carbon credits. 4. Governance and Partnerships: - Creating multilateral groupings of partnerships between companies, communities, governments, NGOs, and financial institutions. - Active cooperation and coordinated action between diverse stakeholders. - Strong institutions and well-established planning structures. 5. Integration with Engineered Solutions: - Finding synergies between NbS and engineered approaches. - Hybrid solutions combining grey infrastructure with NbS. 6. Economic Incentives and Alternative Incomes: - Agroforestry providing alternative income sources and reducing exposure to environmental risks. 7. Supportive Frameworks and Long-term Planning:	Academia, policy, finance, and local governance.	Review article.

	BECCS, and enhanced weathering. - Effective forest restoration and management, especially in tropical regions. 7. Agricultural and Urban Benefits: - Enhancing agricultural yields through agroforestry.	- Lack of comprehensive evidence and knowledge gaps in cost-effectiveness. - Uncertainty in ecosystem service provision under changing conditions.	- Equity-based funding reflecting mutual sharing and less conventional forms of capital. - Long-term investments in ecosystems and strategic, coordinated governance. 8. Sustainable Development Goals: - NbS enables sustainable development within planetary boundaries when implemented effectively.		
Wickenberg et al., 2021. Advancing the implementation of nature-based solutions in cities: A review	1. Seen as a promising way forward in urban and rural contexts to meet several of the sustainability challenges and SDGs. 2. Can help tackle climate change and advance urban sustainability by using nature to deliver social, ecological and economic benefits. 3. Have the potential to generate short term multiple benefits while also building in long-term resilience. 4. Benefits and co-benefits relate to NBS provision of different ecosystem services, i.e. cultural, regulating, provisioning, supporting, or disservices, e.g. related to safety, aesthetics or health	1. Challenges for implementation: - success largely depend on implementation - the paper highlights the importance of understanding how frameworks address implementation and synthesize key elements and conditions required for enabling the implementation process. Implementation is context-specific. 2. the type of collaboration, its objective and timing in the process, are important in that they affect how each collaboration partnership will be able to engage in the process. 3. selecting the appropriate type of NBS is essential to consider the relative costs and benefits of the NBS options including the costs for implementation and maintenance and also comparing these against grey options. 4. Assess immediate and future benefits are difficult due to uncertainty depending on how the benefits may	Collaboration and Co-creation of knowledge lead to a shared understanding, actionable knowledge and informed decision-making. COLLABORATION: A transdisciplinary and collaborative process to build knowledge for NBS implementation requires: spaces and platforms for collaboration; specification of relevant actors with different types of knowledge; joint formulation of problems and understanding of challenges. CO-CREATION OF KNOWLEDGE: Analysis of NbS options and benefits: types of solutions (green/blue/grey); immediate and future benefits; trade offs negotiation. Identification of key policies and actors: policy processes. institution/actors, responsibilities. iii) Exploration of financial options: a) business models, b) funding schemes. c) public private partnerships. should preferably occur through a collaborative process: co-creation of knowledge . To overcome challenges related to knowledge, financing and land ownership, co-design, co-creation and co-implementation. Frameworks can open up and allow for interpretative space and inclusion of diverse knowledge perspectives, which has been called for in the discourse on NBS. On the other hand, too narrow knowledge and research interests could act in	Focus on policy, local governance, and research. For NBS to be meaningful in terms of delivering positive impacts in cities, we need a better understanding of how implementation is embedded in NBS frameworks. Key elements and steps that can inform the NBS implementation process and the resulting outputs to build capacity for implementation.	Review article.

		change over time (e.g. due to changes in ecosystems). 4. weighing short and long term effects against each other	the opposite direction.		
Seddon (2022) Harnessing the potential of NbS for mitigating and adapting to climate change	1. NbS involves working with nature as a part of nature to tackle societal challenges, benefiting both people and biodiversity. 2. Examples include restoring ecosystems to protect against flooding, sustainable land management to maintain crop yields, and creating green spaces in cities to reduce heat and flood risks. 3. NbS reduces GHG emissions and enhances carbon sinks on land and in the sea. 4. Improved land and sea management cuts emissions and boosts carbon sequestration. 5. NbS generally increases carbon storage. 6. Restoring ecosystems reduces climate impact exposure, like floods and landslides. 7. Green infrastructure in cities moderates heatwaves and reduces flooding. 8. NbS lower sensitivity to climate impacts, sustaining agriculture in unpredictable climates. 9. Protecting intact ecosystems benefit biodiversity and communities, with low risk. 10. Most land for cost-effective CO2 mitigation comes from better management of existing lands.	1. Grassroots and Indigenous groups reject NbS as a distraction from systemic change and emission cuts. 2. Uncertainties about NbS effectiveness fuel pushback. 3. Concerns over greenwashing, human rights violations, and threats to biodiversity. 4. Varied estimates on NbS cooling potential; limited knowledge on ocean carbon fluxes. 5. Negative impacts of NbS include reduced albedo depending on location and vegetation type. 6. Models may overestimate NbS benefits by not accounting for ecosystem vulnerability. 7. Scaling up NbS can cause ecosystem damage elsewhere (leakage). 8. NbS's cooling effect is smaller than what's needed from emission cuts. 9. Lack of climate finance for low-income countries. 10. High initial costs for NbS but cheaper long-term. 11. NbS takes time to establish, and effectiveness varies with climate threats. 12. Restoration's slow carbon accumulation can't offset rapid deforestation emissions. 13. Land competition limits NbS potential.	1. High estimates assume society is willing to pay a high price for carbon. 2. NbS can bridge funding gaps for climate adaptation, especially in low-income countries where costs are high; they are cheaper than engineered solutions. 3. NbS can complement engineered approaches, offering key advantages. 4. As living systems, NbS can self-repair and adapt to changing climates, like oyster reefs and mangroves tracking sea level rise. 5. Long-term maintenance costs of NbS may be lower than engineered alternatives. 6. NbS, when considering long-term benefits, can have a higher benefit/cost ratio than engineered solutions. 7. Protecting intact ecosystems offers the highest mitigation potential, followed by managing working lands and then restoration. 8. Protecting stored carbon in ecosystems is twice as effective globally as restoration. 10. NbS have gained prominence in policy, research, and business. 11. Ecosystems are adapted to natural disturbances and may require them to thrive. 12. Adaptive management of NbS can reduce climate-related threats and boost resilience. 13. Successful NbS implementation requires secure, sustainable financing suited to local contexts.	Global and local governance.	Review of the field.

		14. Human stressors threaten available ecosystems. 15. increased frequency of extreme events may hinder ecosystem recovery. 16. Pollution and deforestation compound climate impacts on ecosystems. 17. Siloed governance hinders NbS, requiring cross-sector cooperation. 18. NbS is rarely implemented unless integrated into planning. 19. Greenwashing by large emitters distracts from necessary systemic change. 20. NbS as carbon offsets allow harmful business-as-usual practices. 21. Top-down NbS often neglect local rights and knowledge. 22. Imposed strategies can cause maladaptation and inequity. 23. Ignoring local voices makes projects unethical and unsustainable. 24. Concerns over commodifying nature push back against NbS. 25. Misuse of NbS can harm biodiversity. 26. Policies may favour afforestation over ecosystem protection. 27. NbS investments can lead to biodiversity loss via non-native plantations. 28. Need to align NbS with Indigenous and local values, avoiding nature commodification.	14. NbS projects are more successful in areas with established land rights and access. 15. Indigenous and local communities possess valuable knowledge for adapting to change and tackling climate and biodiversity crises. 16. Successful NbS must involve Indigenous and local communities, reinforcing local rights and delivering benefits. 17. NbS should support biodiversity by protecting, restoring, and connecting native habitats, with monitoring of outcomes. 18. Guidelines should prioritize protecting intact ecosystems and consider adaptive restoration strategies, including using species suited to new conditions. 19. Regulation should restrict NbS-related offsets to organizations with robust plans to phase out fossil fuels. 20. NbS should be rigorously assessed and validated through long-term monitoring of social and ecological impacts. 21. Regional and national NbS models need to be grounded in local contexts, considering risks like impermanence and leakage. 22. Participation in NbS can promote sustainable lifestyle choices, aiding systemic change. 23. Collaboration between social and natural scientists and Indigenous peoples is crucial for effective NbS. 24. Interdisciplinary efforts can ensure NbS reflect diverse values and direct investment where it's most needed. 25. NbS can contribute to net-zero carbon emissions when combined with other climate solutions and drastic GHG cuts. 26. Systemic change towards valuing quality of life and connection with nature		

		29. NbS ecological outcomes are rarely monitored. 30. Directing finance toward effective NbS without delaying decarbonization is challenging. 31. Improved evidence base for long-term social and ecological solutions needed. 32. Engineered solutions are quick but NbS takes time and varies in efficacy. 33. Regional and national models of NbS for climate mitigation are urgently needed. 34. The default remains engineered solutions, missing opportunities for resilience in low-income nations.	is essential, with NbS accelerating this transition while building resilience and protecting biodiversity.		
Nesshöver et al., (2017) The science, policy and practice of NbS: an interdisciplinary perspective	1. Defined by the European Commission: [NBS] 'aim to help societies address a variety of environmental, social and economic challenges in sustainable ways 2. Alternatives to engineered infrastructure that require large investments in materials and energy. 3. Improved ability to understand, manage, and balance multiple objectives within complex socio-ecological systems could unlock new opportunities to address interconnected societal challenges.	1. NbS should be developed in relation to existing concepts to clarify their value. 2. Avoid relabeling or misusing NbS to prevent misunderstandings and unintended consequences. 3. NbS should not be expected to be cheap or easy in the short term. 4. The broad framing of NbS can make the concept seem vague and unclear. 5. A loosely defined term like NbS risks missing opportunities for better resource management. 6. Oversimplification and misuse of NbS can lead to unforeseen trade-offs. 7. If NbS aims to conserve biodiversity, this must be explicitly recognized in projects.	1. NbS should be developed in relation to existing concepts to clarify their added value. 2. The European Commission's framing of NbS encourages transdisciplinary research and challenges short-term, narrow-focused development approaches. 3. The strength of NbS lies in its integrative, systemic approach, preventing it from being just another "green communication tool" for traditional resource exploitation. 4. NbS must involve all relevant stakeholders to ensure they contribute to all dimensions of sustainability. 5. In Europe, policymakers have integrated NbS into the 'Horizon 2020' framework, aligning biodiversity and ecosystem services with innovation for growth, job creation, and sustainable development. 6. A comprehensive formulation of NbS would stimulate discussion, innovation, and communication among science, policy, and practice communities.	Funders, researchers, policymakers, and practitioners.	Review of the field.

		8. The term "solutions" may imply that problems are clear and agreed upon, which isn't always the case. 9. Reflection, dialogue, and negotiation are essential to ensure socio-environmental justice in NbS. 10. A key challenge for NbS is defining what is considered "nature" or "natural." 11. The European Commission's definition of NbS is broad and inclusive. 12. Different interpretations of NbS are acceptable if each case is explicit about its rationale. 13. Framing nature within NbS is challenging. 14. NbS should consider both benefits and potential risks, such as health impacts. 15. Systemic problems with multiple trade-offs can't be reduced to simple solutions. 16. NbS must ensure all stakeholders are involved and reconcile conflicting goals. 17. Trade-offs may negatively impact local farming livelihoods. 18. Stakeholder participation is difficult due to the fuzziness of the NbS concept. 19. Transdisciplinary science is challenging and not yet mainstream. 20. Practical support is needed for cross-sectoral collaboration in NbS. 21. There is a risk of overselling the benefits of nature.	7. NbS can facilitate "outside the box" thinking in addressing complex socio-environmental problems, though careful facilitation is needed to manage conflicts productively. 8. NbS offers opportunities to mainstream environmental targets into sectors that may not traditionally value the environment, enhancing sustainability in decision-making. 9. NbS can significantly contribute to the broader concept of a 'green economy,' though its sustainability perspective remains debated. 10. Successful NbS projects should be based on clear, widely accepted principles that balance flexibility with sustainability across different focus areas. 11. Developing an integrated 'innovation' perspective on NbS will create a framework for evaluation and monitoring, ensuring no aspect of sustainability is overlooked. 12. NbS provides an opportunity for sustainability science to gain greater recognition in policy, projects, and practice, bringing together ideas from all relevant actors.		

		22. Long-term investment is required to ensure equitable benefits from NbS.			
Cohen-Shacham et al., Core principles for successfully implementing and upscaling NbS	1. NbS can be implemented independently or integrated with other solutions, ideally at a landscape scale, and should be central to the design of policies and actions addressing societal challenges. 2. Its widespread adoption is due to the simplicity and logical appeal of nature providing solutions, making it accessible for non-specialists and encouraging uptake in policy, practice, and the private sector, while fostering collaboration across diverse sectors and stakeholders. 3. NbS can significantly contribute to the 2030 Agenda for Sustainable Development, directly supporting SDGs like food security, health, clean water, sustainable cities, climate action, and ecosystem conservation.	1. Without clear evolution, definition, and principles, developing evidence-based standards and guidelines for implementing, assessing, improving, and scaling up NbS globally will be impossible. 2. NbS risks being vague without operational rigor. 3. Clear definitions and methodologies are needed for concepts to endure and avoid unintended consequences. 4. Current NbS principles don't adequately address uncertainty or long-term stability, as ecosystems are unpredictable. 5. Monitoring is essential for long-term stability and adaptive management but is often overlooked in NbS principles. 6. Scaling up and integrating small-scale interventions into broader, impactful actions is a key challenge and opportunity for NbS.	1. Innovative approaches to ecological restoration, nature conservation, and addressing global societal challenges are urgently needed. 2. To tackle these challenges on a large scale, we must develop innovative, policy-coherent solutions, such as an evidence-based Nature-based Solutions (NbS) framework. 3. For effective large-scale implementation of NbS to reverse ecosystem degradation, clear and coordinated principles are essential for creating evidence-based standards and guidelines for practitioners and decision-makers.	Presents frameworks that serve as a foundation for future development of NbS standards and guidelines for improved conservation and development. Systemic approach Mentions institutions and stakeholder groups Provides guidelines for practitioners and decision-makers	Review of the field.
Wamsler et al., (2020). Environmental and climate policy integration: Targeted strategies for overcoming barriers to nature-based solutions and climate change adaptation	Hopefully NbS can broaden the focus regarding the fundamental human relationship with nature and create multiple benefits, including climate change	1. Requires transdisciplinary approaches to unite actors' efforts. 2. NbS is not integrated into current policy and governance structures. 3. Knowledge about governance processes to support NbS and stakeholder involvement is fragmented. 4. Targeted stakeholder involvement: - Institutional: Siloed sectoral work hampers NbS/CCA.	1. Five strategies to overcome NbS development challenges in municipalities: i) Stakeholder collaboration ii) Strategic citizen involvement iii) Outsourcing iv) Internal structure adjustments v) Science-policy integration. 2. Relational approaches rely on municipal champions to build trust, communicate inclusively, and promote learning while handling complex environments.	Policy recommendations for future research and local governance.	Established a city-to-city learning lab to systematically analyse selected urban development projects step-by-step, the entire chain from idea to follow up, for selected NbS projects. specifically, in Skåne. This paper is based on an applied participatory analysis of Skåne municipalities in order to explore, compare and learn from the integration of nature-based approaches into their daily planning practice and

		- Policy/legal: No regulatory framework ensures NbS/CCA in planning. - Financial: Internal financial constraints. - Knowledge: Lack of local expertise on climate impacts. 5. Lack of formal frameworks for NbS/CCA leads to inconsistent assessments. 6. Strategic citizen involvement: - Institutional: Lack of resources and structures makes citizen involvement ineffective. - Knowledge: Influential groups hinder planning processes. 7. Strong conservative citizen groups are a barrier to NbS/CCA planning. 8. Alteration of internal structures: - Institutional: Departments work in silos; developers have limited responsibility. - Financial: Complex structures make internal cooperation difficult, leading to outsourcing. - Knowledge: High staff turnover and lack of monitoring limit knowledge retention. 9. Larger municipalities face more power struggles and siloed work, though they may have NbS/CCA capacities. 10.Outsourcing: - Policy/legal: Municipalities have limited control over private land. - Human/financial: No dedicated budget for	3. Effective urban development requires understanding NbS management for climate adaptation and integrating it into urban planning at the municipal level. 4. Targeted stakeholder involvement, including collaboration with private companies and academia, is crucial for NbS/CCA development. 5. Outsourcing and collaboration with external experts help municipalities implement NbS, with Malmö known for externally funded flagship projects. 6. Strategic citizen involvement helps raise awareness and gain support for urban measures affecting private land. 7. Internal cooperation has improved through cross-sector efforts, including joint work between departments. 8. Outsourcing NbS/CCA implementation reduces financial burdens and increases property values. 9. Science-policy integration is supported through national policies, with many municipalities employing staff to focus on NbS/CCA. 10. City-to-city learning facilitates ecological compensation integration, as seen in Lomma, helping share best practices. 11. Relational approaches and municipal champions are essential in overcoming planning constraints and addressing ‘wicked’ urban problems.		associated governance mechanisms.

		NbS/CCA, leading to stakeholder fatigue. 11. Concealed science-policy integration: - Institutional: No regulatory framework for systematic NbS/CCA integration. - Policy/legal: Lack of clear guidelines for mainstreaming. 12. NbS/CCA is a low priority, with economic development and housing taking precedence. 13. Mechanisms to integrate climate considerations into sectoral planning are limited. 14. Mainstreaming knowledge is scarce, and adaptation policies often don't translate into action. 15. NbS/CCA implementation relies heavily on individual champions due to the lack of mainstreaming mechanisms. 16. Decisions are often based on personal backgrounds, intuition, or monetary considerations. 17. More research is needed on how living labs can be used to address deep leverage points to support NbS and CCA.	12. Applied learning labs encourage collaboration and build networks to support NbS and climate adaptation work.		
Miralles-Willhelm (2024) Nature-Based Solutions in Agricultural Landscapes for Reducing Trade-offs between Food Production, Climate Change, and Conservation Objectives	Regenerative/ conservation agriculture uses multiple ecosystem functions of trees, plants and (wild or domesticated) animals, while minimizing negative prod. impacts Agroecological principles, or climate-smart agriculture, aim at retaining or increasing available nutrients or improving the microclimate. Agroforestry and silvopasture	For conservation, NbS practices often aim to ensure connectivity across larger landscapes, to connect patches or a certain percent of land set aside as ecological infrastructure, which requires involvement of a minimum number of landowners. Farmers' willingness to adopt NbS practices depends on their perception of benefits of NbS implementation, compensation	Combining marketable and non-marketable ecosystem services, relevant economic, attitudinal and farm structural factors NbS benefits will be prioritized differently by different groups of people, e.g. landowners and others in society, and thus need to be negotiated. Many locals have vital knowledge about local ecosystems. NbS design should be guided by inclusiveness, local needs, knowledge and aspirations as part of the solutions.	Farmers, landowners, locals, decision-makers, society at large.	Surveys of scientific and grey literature. Groups co-benefits provided by NbS into 1) ag-production, 2) conservation, 3) climate, 4) socioeconomic factors.

	practices provide food, fodder, shade, timber, biodiversity, pollination etc. Grass strips, buffer zones, for erosion control can provide fodder, pollination, mulch etc. Crops can provide carbon storage, root structure, soil organic matter, nutrient cycling, water management, N-fix legumes, etc.	levels, forms of compensation etc. Farmers may not adopt NbS practices despite having witnessed ecosystem benefits, because of increased initial costs, labour inputs, or customs and preferences	NbS needs to make an economic argument for adoption for both farmers and decision makers; however, the literature here is scarce (except carbon storing). NbS in agriculture needs to emphasize gains in agricultural production and socioeconomic benefits to farmers; this is an area of opportunity for future analytical work on the general topic of NbS.		