MASTER THESIS

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„The role of biodiversity, ecosystems and ecosystem-based disaster risk reduction: a critical analysis of the Austrian disaster risk reduction policy approach“

verfasst von / submitted by

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I. Expression of thanks

First of all, I would like to thank my supervisor, Dr. Benni Thiebes, for his support in mastering this thesis. Also a big thanks goes to my family, particularly to my mother, for the many helpful remarks that improved the linguistic form of this work.

However, most of all I would like to extend a huge thanks to my master course colleagues, who unknowingly got me through a very difficult time for me personally– not to mention managing to get through the master course itself. I have great faith that they will continue to make a difference in this world.

Last but not least, I dedicate this thesis to my dad, who would have laughed his head off and rightly so. Missing you dearly, our WLü.

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V. List of Abbreviations

CBD	Convention on Biological Diversity
EbA	Ecosystem-based adaptation
Eco-DRR	Ecosystem-based disaster risk reduction
EEA	European Environmental Agency
EU	European Union
FAO	Food and Agriculture Organization of the UN
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
NbS	Nature-based solutions
OECD	Organization for Economic Cooperation and Development
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	UN Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WEF	World Economic Forum

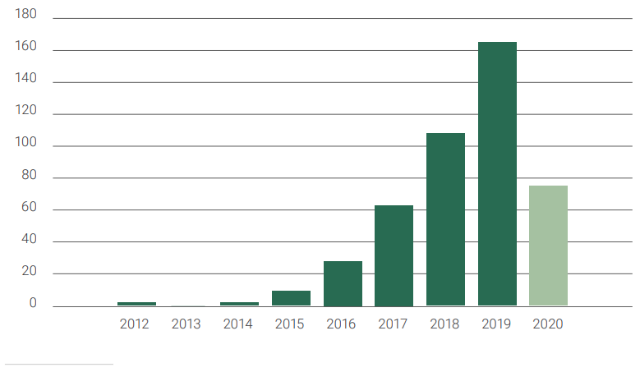
1. Introduction

Not only in recent years has it very much apparent become, and continues to at an alarming rate, that biodiversity loss and ecosystem degradation are continuously and increasingly progressing on a global scale. Together with climate change, this signifies a highly complex, systemic threat to human kind and the planet in general. Therefore, these two issues, en par with climate change, have increasingly risen to the attention of the scientific community and political decision makers, with the need to address these issues becoming more and more urgent every year. There is also an increasing recognition of the need to address these issues in the spheres of climate change adaptation and disaster risk reduction in order to address the risk of increasingly aggravated natural hazards due to climate change and biodiversity loss and ecosystem degradation, as this thesis will outline. At the same time, there is a growing recognition that biodiversity and ecosystems also offer enormous potential for disaster risk reduction and climate change adaptation efforts.

In light of this recognition, the concept of so-called ecosystem-based approaches to climate change adaptation and disaster risk reduction, i.e. ecosystem-based adaptation (EbA) and ecosystem-based disaster risk reduction (Eco-DRR), have been developed and increasingly promoted in the academic community as well as the policy discourse in various international multilateral fora.

There is growing acknowledgement by policy-makers and practitioners that the two approaches can generate multiple benefits and address multiple hazards, can be implemented in a variety of sectors, and in addition generate ecosystem service benefits that increase resilience, offer economic benefits, and so on, as this thesis will highlight.

Even though Eco-DRR and EbA are fairly new concepts, there is an ever growing volume of academic research on the one side (around issues such as cost-effectiveness, sectoral approaches, governance and stakeholder engagement, monitoring and evaluation etc.), as well as a growing body of supportive material developed by international stakeholders to increase awareness around and support policy-makers and practitioners in the on-the ground implementation of these two approaches (figure 1 below provides a snapshot of the increase in mentioning of the term “nature-based solutions” in recent years in the academic discourse).



Source: UNDRR 2021: 46, figure 2.6

Note: For 2020, period analysed is January to April.

Figure 1: Number of mentions of nature-based solutions in title, abstract or keywords in the Scopus database

There is also an increasing number of guidance documents that have been developed for policy makers and practitioners, aiming to raise awareness, enhance the uptake, and support the on the ground implementation, see e.g. MATTHEWS AND OCAMPO DELA CRUZ 2022, UNDRR 2021, EEA 2021, COMMISSION 2021, UNDRR 2020, TRÉMOLET AND KARRES 2020, IUCN FRENCH COMMITTEE 2019, SUDMEIER-RIEUX ET AL. 2019, LO 2016, MONTY ET AL. 2016, UNEP 2015, to name only a few. Furthermore, IUCN in 2020 developed the IUCN Global Standard for Nature-based Solutions, which lists criteria and indicators and was adopted by the 98th Meeting of the IUCN Council.[1]

In light of the continuously declining state of biodiversity and ecosystems, as well as the increasing need for climate change adaptation and enhanced disaster risk reduction in response to climate change, this thesis will outline that there is growing recognition in the policy and academic discourse of the need for:

- Increased awareness of the importance of biodiversity loss and environmental degradation as risk drivers,
- Tackling biodiversity loss and environmental degradation also in the context of disaster risk reduction,
- The need for enhanced synergies between adaptation and disaster risk reduction, and an acknowledgement of
- The usefulness of EbA and Eco-DRR in achieving the above.

As the thesis has been prepared in the context of a master course on risk prevention and disaster management, its focus will naturally be mainly on Eco-DRR, which should not be perceived as an attribution of less significance to the issue of climate change adaptation. On the contrary, not only recent events in the summer of 2022 have shown the urgent need for climate change adaptation on a global scale.

The aim of the thesis is to, in a first step, reflect the policy and academic discourse around the above-mentioned issues, and to provide an overview of EbA and Eco-DRR,

[1] More information available at: https://www.iucn.org/resources/publication/iucn-global-standard-nature-based-solutions-first-edition (accessed 12.8.2022).

including with regard to benefits of said approaches, but also current challenges surrounding them.

In a second step, this thesis aims to examine whether or not there is a recognition of these issues in the current Austrian policy approach to disaster risk reduction. This will be achieved by analysing high-level policy documents pertaining to various sectors of relevance (e.g. disaster risk reduction, adaptation, forest management, water management, land-use, infrastructure, etc.). However, this thesis will not examine the current regulatory and legal framework in Austria, budget/funding approaches and activities in the various sectors, nor current on the ground practice, as this would exceed the scope of this thesis.

In doing so, the thesis will aim to address the following hypotheses and research questions.

Hypothesis 1: Biodiversity loss and ecosystem degradation increasingly constitute significant risk drivers, whilst at the same time biodiversity and ecosystems offer great potential in preventing and mitigating natural hazards, therefore protection of biodiversity and ecosystems should be at the forefront of disaster risk reduction efforts. However, current disaster risk reduction approaches in Austria so far do not consider the threat posed by biodiversity loss and environmental degradation, nor the opportunities that biodiversity and ecosystems offer to the extent possible and necessary.

Research question 1: Is there a recognition of biodiversity loss and environmental degradation as risk drivers on the one side, as well as the opportunities that particularly ecosystems offer in terms of disaster risk reduction on the other side in current high-level policies relevant to disaster risk reduction in Austria?

Hypothesis 2: In light of the increasing risks caused by climate change, there is a need for enhanced linkages between adaptation and disaster risk reduction. Eco-DRR and EbA play an increasingly important role in discussions and efforts on an international level and in the context of international cooperation and sustainable development efforts. The two approaches offer enormous potential for addressing numerous threats and challenges disaster risk reduction and adaptation practitioners and policy makers are faced with.

Research question 2: What are the advantages/potential and disadvantages/challenges of Eco-DRR and EbA and in how far can they be used for addressing disaster risk reduction and climate change adaptation?

Hypothesis 3: Eco-DRR and EbA are still underused concepts in the overall disaster risk reduction approach in Austria.

Research question 3: What is the status of mainstreaming of Eco-DRR and EbA, i.e. the integration of ecosystem considerations in current disaster risk reduction related policies/strategies in Austria?

In order to provide the relevant context and particularly to address research questions 1 and 2, a literature review was conducted, based on a keyword search and making use of various online catalogues and platforms (such as https://usearch.univie.ac.at/, https://www.preventionweb.net/knowledge-base, https://www.researchgate.net/, and https://scholar.google.com/). In doing so, various key words, including a combination thereof, was made use of in the context of the literature review (i.e. ecosystem-based disaster risk reduction, ecosystem-based adaptation, nature-based solutions, biodiversity / ecosystem AND disaster risk reduction, biodiversity / ecosystem AND Austria). In addition, the most recent authoritative, i.e. multilaterally agreed, reports on the subjects of climate change and biodiversity have been reviewed, such as the reports by Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC), as well as the latest decisions, reports, etc. of the relevant international negotiating bodies, with special emphasis on the Convention on Biological Diversity (CBD).

Chapter 2 of this thesis will therefore provide a snapshot of the current state of biodiversity and ecosystems in general, and in Austria in particular. This will be followed by a depiction of biodiversity loss and environmental degradation as risk drivers, as well as of the reflection of those two issues in national risk assessment in general, and in Austria in particular. A short introduction will be given to the link between climate change adaptation and disaster risk reduction and related approaches. Ensuingly, opportunities of biodiversity and ecosystems for disaster risk reduction will be discussed.

Based on this, chapter 3 will provide an introduction to the concepts of EbA and Eco-DRR, as well as a discussion of opportunities and challenges thereof.

In order to address research question 3, i.e. regarding the status of mainstreaming of Eco-DRR and EbA in the relevant Austrian disaster risk reduction policy approach, a number of high-level policy/strategy documents were screened in order to identify whether, and if so in how far said documents support ecosystem-based approaches. The selection of the high-level documents was made on the basis of various pieces of guidance that have recently been developed. The assessment of the status of mainstreaming was conducted based on a methodology which aimed at rating the various policies/strategies in terms of their level of support of ecosystem-based approaches. Chapter 4 will outline the methodological approach taken in this regard. Chapter 5 will provide a review of the state of mainstreaming of EbA and Eco-DRR in the current Austrian disaster risk reduction policy approach, which will be followed by a critical analysis of and reflection on the insights gained in chapters 6 and 7.

Chapter 8 will draw relevant conclusions with regard to the underlying hypotheses and research questions, based on the findings of chapters 2 to 7.

Last but not least, an outlook will be provided in chapter 9, pertaining to e.g. areas for possible enhancements of mainstreaming of Eco-DRR and EbA in the disaster risk reduction approach in Austria.

2. Biodiversity and ecosystems in the context of disaster risk reduction

The following section will explore the importance of biodiversity and ecosystems in the context of disaster risk reduction approaches. For this, in a first step, an overview will be provided of the status of biodiversity ecosystems globally, and in Austria in particular. In a second step, the importance of biodiversity loss and environmental degradation as risk drivers will be pointed out, thereby showcasing the importance of tackling biodiversity loss and ecosystem degradation also in the context of disaster risk reduction, both as an underlying risk, as well as a possible solution. In a third step, it will be examined whether this is reflected national risk assessment in general, and in Austria in particular. This will be followed by a short introduction of the link between climate change adaptation and disaster risk reduction and related approaches. The chapter will conclude with an overview of opportunities that biodiversity and ecosystems offer in terms of disaster risk reduction.

2.1. Status of biodiversity and ecosystems

The problematic and continuously deteriorating state of biodiversity and ecosystems has in recent years been increasingly acknowledged by relevant international actors and in the relevant international fora, as reflected also in recent authoritative, i.e. multilaterally agreed reports.

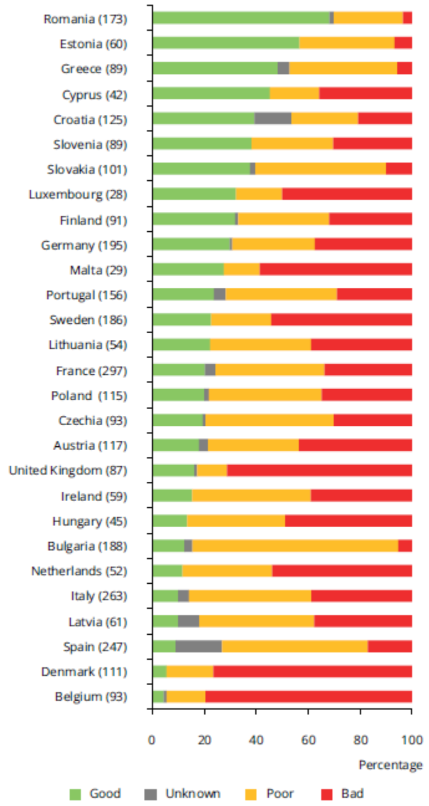
For example, in 2019, the global assessment report on biodiversity and ecosystem services prepared by IPBES, the equivalent of the IPCC but for the issue of biodiversity and ecosystems, clearly highlights the deteriorating state of biodiversity and ecosystems on a global scale: "Nature and its vital contributions to people, which together embody biodiversity and ecosystem functions and services, are deteriorating worldwide. (…) While more food, energy and materials than ever before are now being supplied to people in most places, this is increasingly at the expense of nature's ability to provide such contributions in the future, and frequently undermines nature's many other contributions, which range from water quality regulation to sense of place. The biosphere, upon which humanity as a whole depends, is being altered to an unparalleled degree across all spatial scales. Biodiversity – the diversity within species, between species and of ecosystems – is declining faster than at any time in human history." (IPBES 2019: A) The IPBES report also makes reference to direct and indirect drivers of change having accelerated during the past 50 years and being unprecedented in human history, with the direct drivers of change with the largest global impact having been the following: changes in land and sea use, direct exploitation of organisms, climate change, pollution, and invasion of alien species. (IPBES 2019: B) The report also highlights the linkage between biodiversity and ecosystem functions and services on the one hand, and the achievement of several of the Sustainable Development Goals on the other hand. (IPBES 2019: C23)

Similarly, the 2019 UNDRR Global Assessment Report points out that, overall, the pressures on exposed biodiversity and ecosystems lead to an irreversible and continuing decline of genetic and species diversity, and ecosystem degradation at all scales. Inter alia, it indicates that freshwater biodiversity and ecosystem services are threatened globally more than any others, with two thirds of all rivers being highly degraded, along with the freshwater habitat they support, this in turn affecting nearly 5 billion people living in highwater-threat areas. It also points out that marine biodiversity is at risk from overfishing, ocean warming and acidification, melting of sea-ice with the loss of under-ice biota, oil and gas development, shipping, coastal habitat destruction, loss of coral reefs, eutrophication and pollution. Similarly, it points out that terrestrial biodiversity is at risk from rising temperatures, loss of grasslands to deserts and drylands, deforestation and degradation of tropical forests, and melting of glaciers. (UNDRR, 2019, p. 145f)

The 2020 report of the EEA on the state of nature in the EU, which is based on reports from EU Member States under the Birds (2009/147/EC) and the Habitats (92/43/EEC) directives and on subsequent assessments at EU or EU biogeographical levels, also highlights that, despite significant efforts and some improvements, biodiversity in the EU continues to decline, facing deteriorating trends from changes in land and sea use, overexploitation and unsustainable management practices, as well as water regime modification, pollution, invasive alien species and climate change. It indicates that, while improvements have been observed with regard to some species and habitats, progress has been insufficient to meet the objectives of the EU Biodiversity Strategy to 2020[2], which aimed to halt the loss of biodiversity and ecosystem services in the EU by 2020, and to restore them as far as possible, while also helping to curb global biodiversity loss. (EEA, 2020, p. 17)

The EEA 2020 report also allows for insights with regard to the conservation status of habitats and species in Austria, as well as conversation trends. The report indicates that significant variations in terms of the conservation status of habitats can be observed. Most Member States, including Austria report a good conservation status for only less than 40% of their habitat assessments, with Austria having reported a bad conservation status for slightly over 40% of the habitats in its territories (see figure 2 below). Figure 3 below also provides a snapshot of the spatial distribution of habitats' conservation status in Austria.

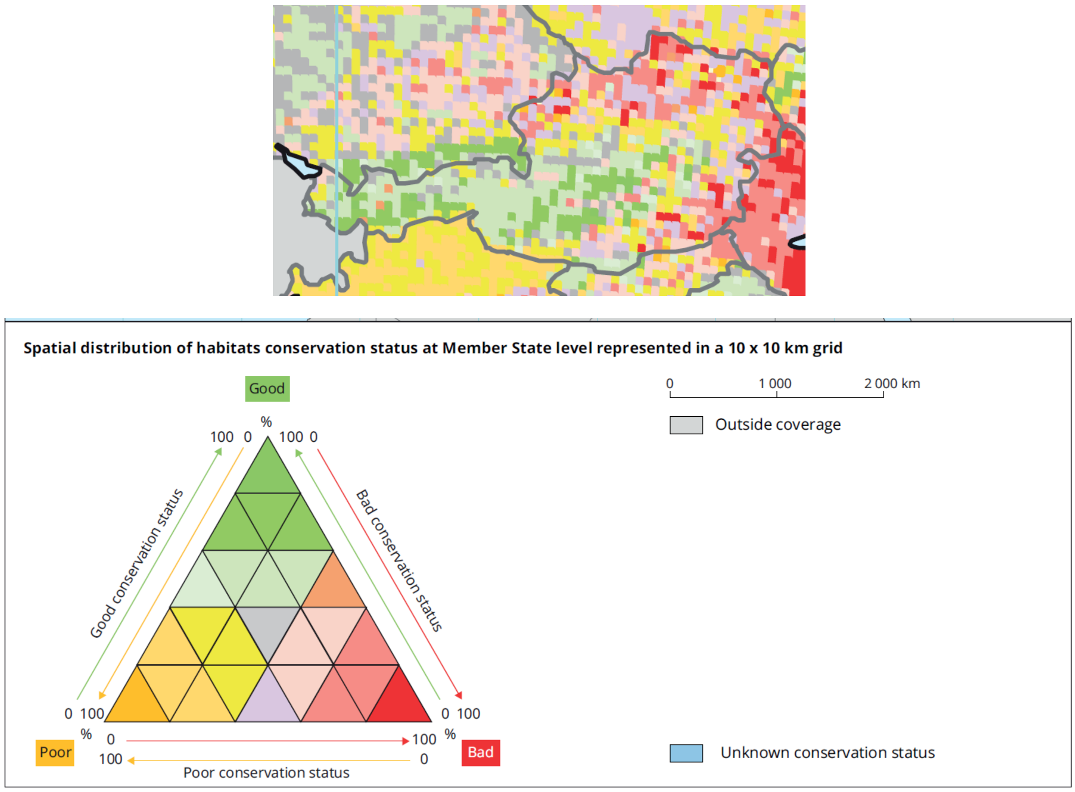
[2] Information on the EU Biodiversity Strategy to 2020 is available at: https://ec.europa.eu/environment/nature/biodiversity/strategy_2020/index_en.htm#:~:text=The%20Strategy%20in%20a%20nutshell,to%20curb%20global%20biodiversity%20loss (accessed 15.7.2022).



Source: EEA 2020: 44

Note: The number of assessments per Member States is indicated in the parantheses

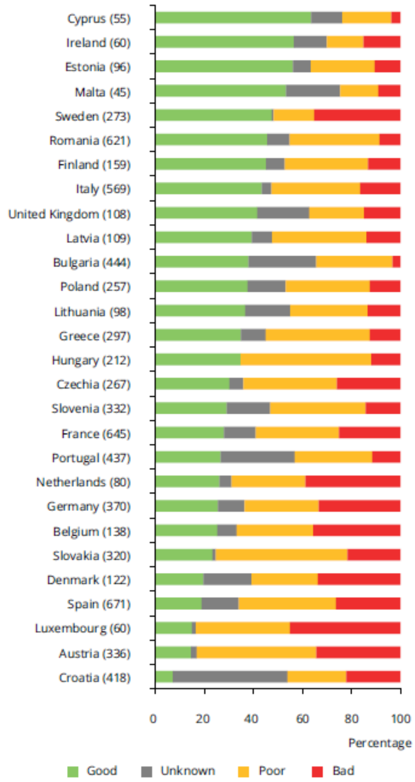
Figure 2: Conservation status of habitats at EU Member State level



Source: EEA 2020: 45

Figure 3: Austria - spatial distribution of habitats' conservation status represented in a 10 km × 10 km grid (excerpt of map 3.4 of the EEA 2020 report)

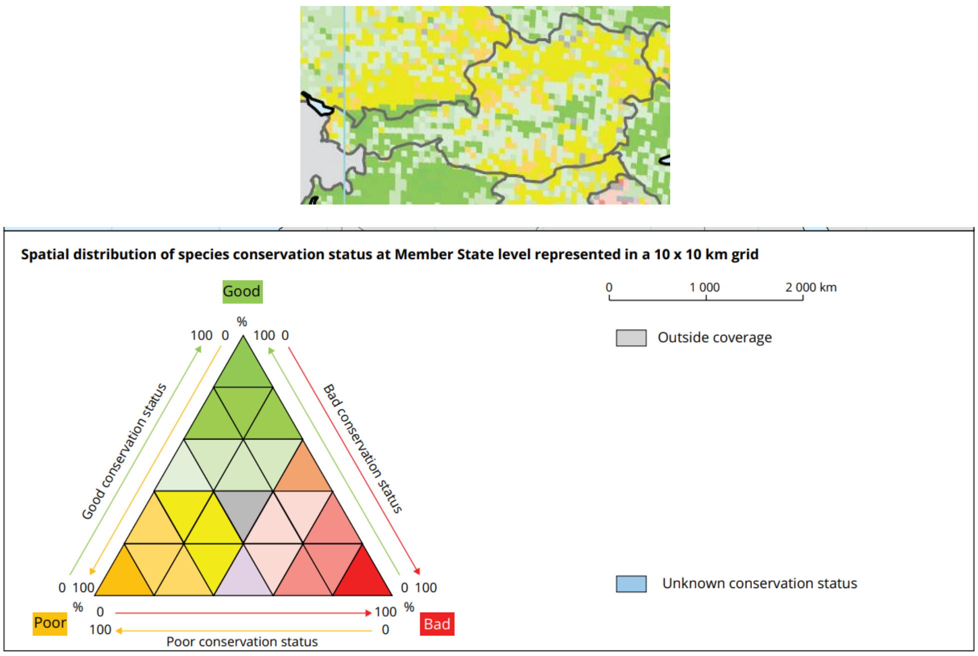
With regard to conservation status of species, the biggest proportion of species assessments showing a good conservation status were reported by Cyprus, Ireland, Estonia and Malta (over 50%). In seven Member States, including Austria, the species assessments showed a bad conservation status exceeding 30%, as can be seen in figure 4, less than 20% of conservation status of species has been classified as good in Austria. (EEA 2020: 50) Figure 5 provides an overview of the picture for Austria.



Source: EEA 2020: 50

Note: The number of assessments per Member States is indicated in the parantheses

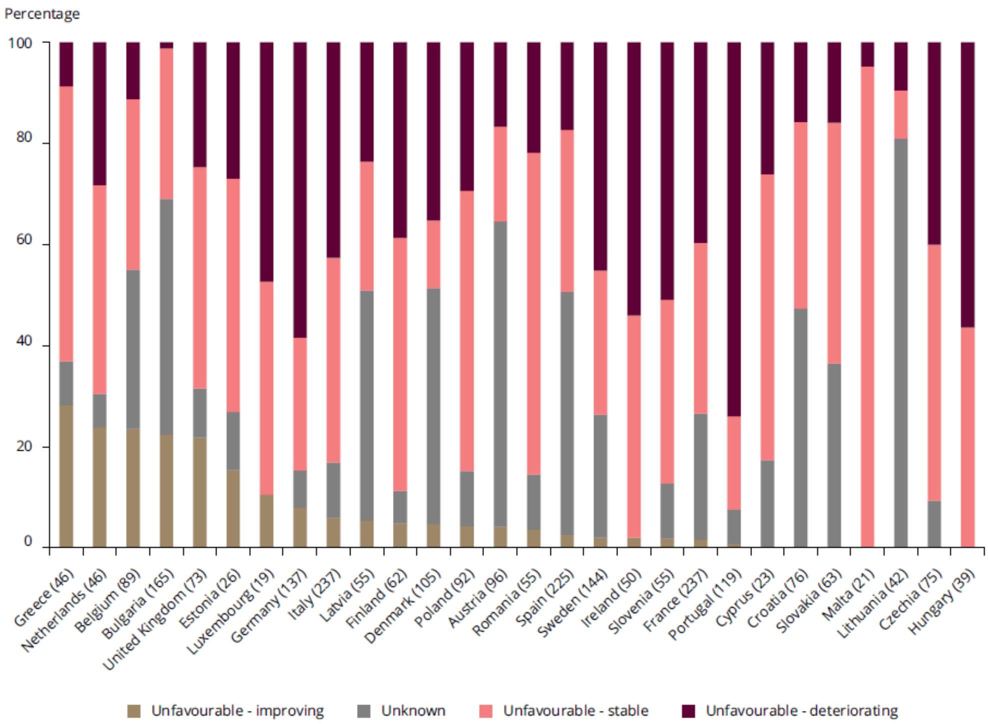
Figure 4: Conservation status of species at Member State level



Source: EEA 2020: 49

Figure 5: Austria - Spatial distribution of species' conservation status presented in a 10 km × 10 km grid (excerpt of map 3.5 of the EEA 2020 report)

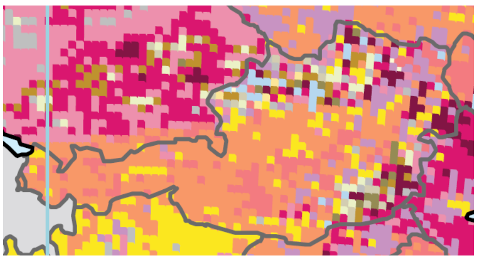
As can be seen from the EEA report, trends in the conservation status of habitats are spatially distinct among EU countries and regions. Most regions showed, including Austria, predominantly stable or deteriorating trends (see figure 6). With regard to the habitat assessments, five countries reported an improving trend in status for over 20 % of their habitats. While seven countries did not report any improvement for habitats with unfavourable status, deteriorating trends were reported by all Member States, including Austria, which indicated almost 20% as deteriorating (see figure 6). Overall, the degree of unknown trends in conservation status varies greatly among Member States, with Austria showing a high percentage (more than 50%, see figure 6). (EEA 2020: 54) Figure 7 provides an overview of the status in Austria.

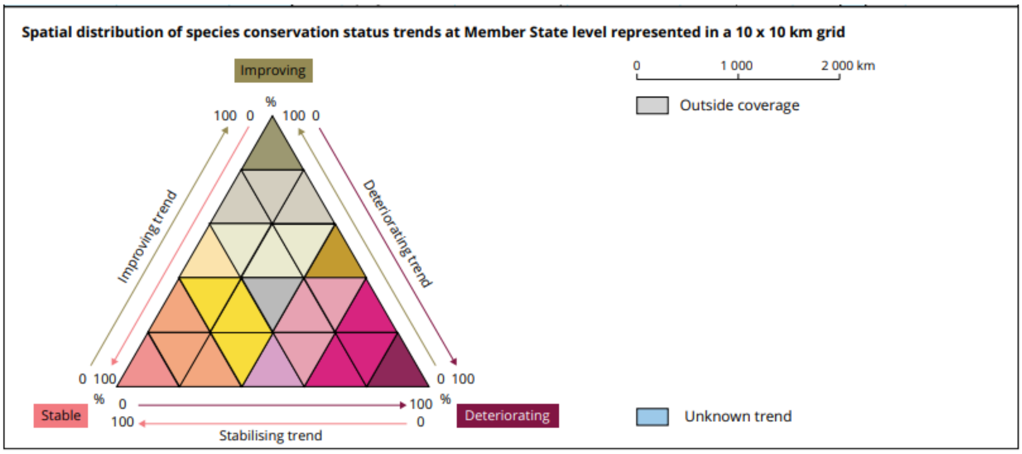


Source: EEA 2020: 56

Note: The number of assessments conducted per Member State is indicated in the parantheses.

Figure 6: Conservation status trends for habitats not in good status at EU Member State level

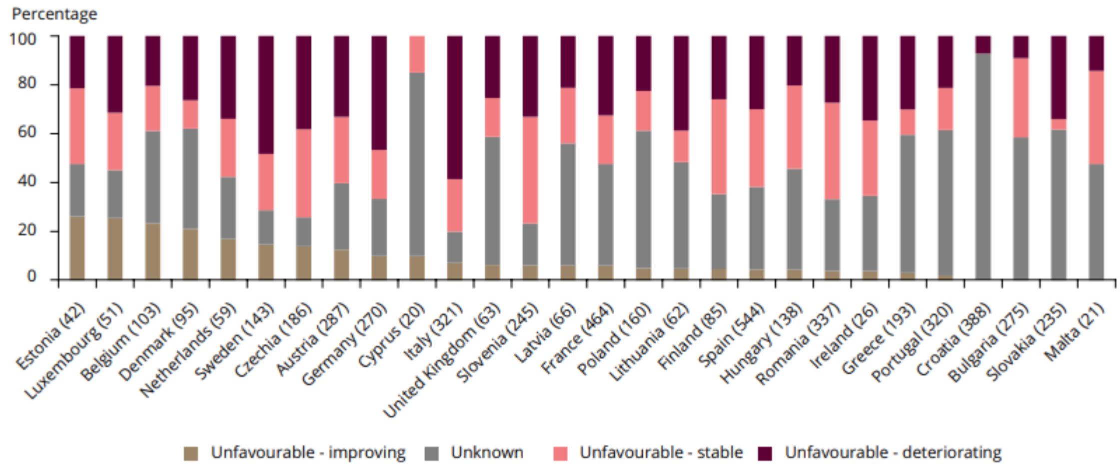




Source: EEA 2020: 55

Figure 7: Austria - Spatial distribution of habitat conservation status trends in a 10 km × 10 km grid (excerpt of map 3.6 of the EEA 2020 report)

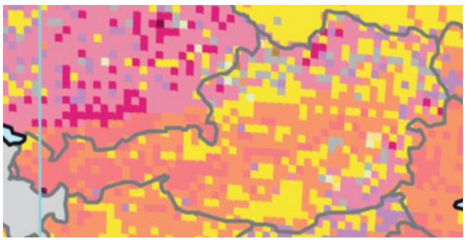
With regard to species conservation status trends, the report shows varying trends across Member States, with deteriorating species trends not scoring as highly as in the habitat assessments. Yet, as per the report, over 80 % of Member States report deteriorating trends for more than one fifth of their species assessments, with Austria having reported around 30% as deteriorating (see figures 8 and 9 below). (EEA 2020: 60)

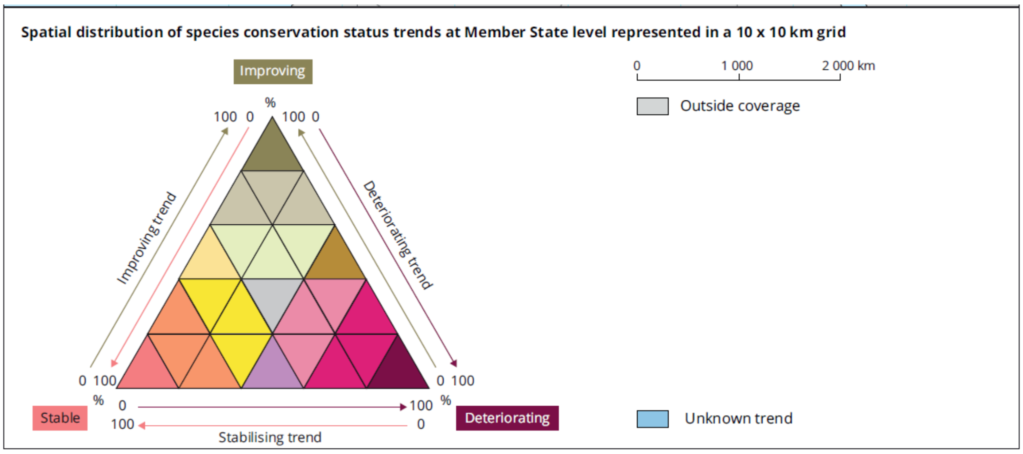


Source EEA: 2020: 60

Note: The number of assessments conducted per Member State is indicated in the parantheses.

Figure 8: Conservation status of trends of species on EU Member State level

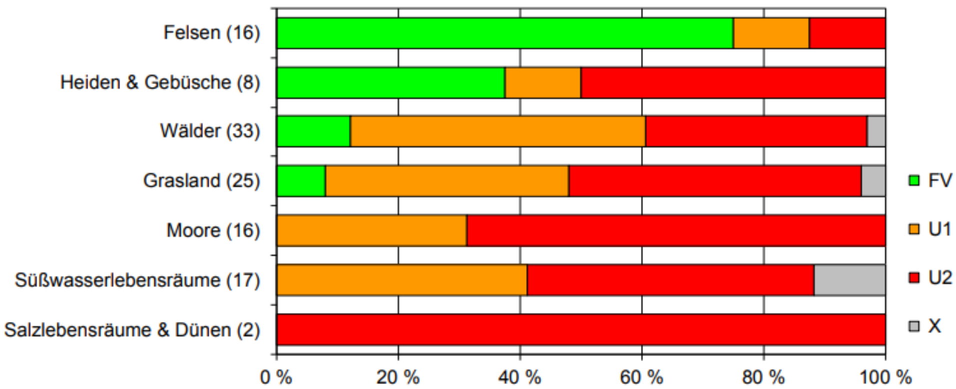




Source: EEA 2020: 61

Figure 9: Austria - Spatial distribution of species conservation status trends at Member State level in a 10 km × 10 km grid (excerpt of map 3.7 of the EEA 2020 report)

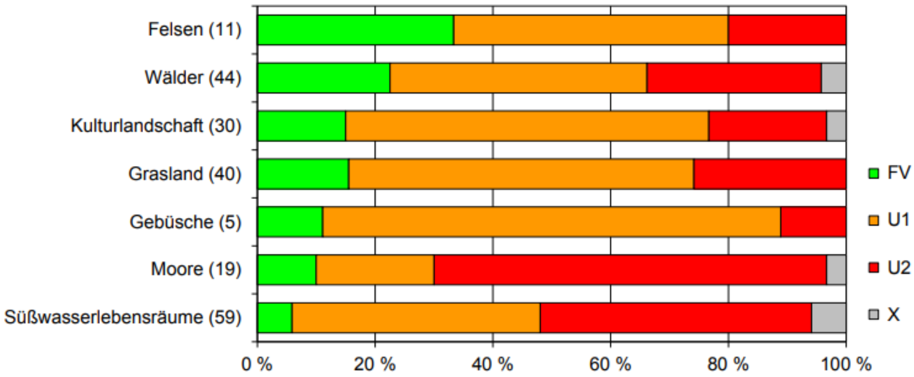
The Austrian 2019 report under Article 17 of the EU Habitats directive, which fed into the EEA report outlined above, indicates that the summary evaluation of the conservation status shows that 18% of the habitat types and 14% of species are in a favourable conservation status, whereas 44% of the habitat types and 34% of the species assessments indicate an unfavourable-poor conservation status, whilst for 3% of the assessments, due to insufficient data, the classification of the conservation status was not possible. The report found that the protected assets in the alpine region have a more favourable conservation status than those in the continental region. (ELLMAUER 2019: 13) With regard to the status of ecosystems as such, the report shows that rocks and forests (next to heaths and scrub for the habitat types) show relatively favourable conditions compared to the other ecosystems, while moors and freshwater habitats (next to the dunes and salt habitats in the habitat types) show worse results. Figures 10 and 11 below show the ecosystem related findings of the report.



Source: ELLMAUER 2019: 16, figure 8

Note*:* Based on Annex I habitat type assessments, structure is based on the system of Appendix I of the Habitats Directive; numbers in brackets reflect the number of ratings in the two biogeographic regions; Felsen = Rocks, Heiden & Gebüsche = Heath & Bushes, Wälder = Forests, Grasland = Grassland, Moore = Moor, Süßwasserlebensräume = Freshwater Habitat, Salzlebensräume & Dünen = Salt Habitat & Dunes; FV = favourable, U1 = unfavourable– inadequate, U 2= unfavourable–bad, X = unknown.

Figure 10: Ecosystem conservation statuses - habitat types in Austria



Source: ELLMAUER 2019: 16, figure 9

Note: Based on the assessments of the species of Appendix II, IV and V of the Habitats Directive; species were assigned to an ecosystem according to their habitat connection; numbers in parentheses represent the number of reviews in the two biogeographic regions; Felsen = Rocks, Heiden & Gebüsche = Heath & Bushes, Wälder = Forests, Grasland = Grassland, Moore = Moor, Süßwasserlebensräume = Freshwater Habitat, Salzlebensräume & Dünen = Salt Habitat & Dunes; FV = favourable, U1 = unfavourable– inadequate, U 2= unfavourable–bad, X = unknown.

Figure 11: Ecosystem conservation statuses – Type in Austria

As will be explained more fully below, moors are highly important ecosystems particularly with regard to climate change, however, as also indicated in the latest Austrian Article 17 report, their status is quite concerning (LORENZ ET Al. 2022: 29), as can be seen in figure 12 below:

FFH-Lebensraumtyp	alpine Region	kontinentale Region
6410 Pfeifengraswiesen	ungünstig–unzureichend	ungünstig–schlecht
7120 Lebende Hochmoore	ungünstig–schlecht	ungünstig–schlecht
7120 Degradierte Hochmoore	ungünstig–schlecht	ungünstig–schlecht
7130 Deckenmoore	ungünstig–schlecht	–
7140 Übergangsmoore	ungünstig–schlecht	ungünstig–schlecht
7150 Torfmoor-Schlenken	ungünstig–schlecht	ungünstig–schlecht
7210 Kalkreiche Sümpfe mit Cladium	ungünstig–unzureichend	ungünstig–unzureichend
7230 Kalk-Niedermoore	ungünstig–schlecht	ungünstig–schlecht
91D0 Moorwälder	ungünstig–unzureichend	ungünstig–unzureichend
	Erhaltungszustand	
Moortyp	**alpine Region**	**kontinentale Region**
Basenarme Niedermoore	ungünstig–schlecht	ungünstig–schlecht

Source: LORENZ ET Al. 2022: 29

Note: State of conservation of the moor types as per the Habitat Directive (= FFH-Lebensraumtypen), as well as of base-poor lowland moors; ungünstig– = unfavourable– inadequate, ungünstig–schlecht = unfavourable–bad; Pfeifengraswiesen = moor grass meadows, lebende Hochmoore = active raised bogs, degradierte Hochmoore = degraded raised bogs, Deckenmoore = blanket bog, transitional bog, Torfmoor-Schlenken = peatlands, Kalkreiche Sümpfe mit Cladium = limy swamps with Cladium, Kalk-Niedermoore = lime lowland moors, Moorwälder = bog woodland.

Figure 12: State of conservation of moors in Austria

The findings of the EEA report with regard to the status of biodiversity and ecosystems in Austria as outlined above were also recently corroborated by a 2020 report of the Austrian Court of Auditors with regard to the Nationalpark Neusiedler See – Seewinkel, which is a national park, a nature and landscape protected area, a Natura 2000 European protected area, as well as a protected wetland in line with the Ramsar Convention and a UNESCO World Heritage Site. However, UNESCO revoked its status as a biosphere reserve in 2016 due to lack of expansion and rezoning. (RECHNUNGSHOF ÖSTERREICH 2019: 7) The report found that the so-called salt lakes of the Seewinkel are at risk due to interventions in the natural balance, such as drainage, agricultural use or development and the resulting lowering of the groundwater level and desertification. It states that, in 1858, 130 salt lakes with a total area of around 3,600 hectares were documented, whereas in 2006, there were only 48 salt lakes left covering only a total area of around 660 hectares, i.e. 18% of the original area, with more or less all salt lakes being severely degraded. It also found that the development is intensified by climate change and the associated decrease in precipitation, whilst a management plan with concrete measures to improve the hydrological balance of the salt lakes was still not implemented at the time of writing of the report. (RECHNUNGSHOF ÖSTERREICH 2020: 8f) In light of the status of the national park as protected area, the findings of the report are even more significant.

The generally concerning status of biodiversity and ecosystems in Austria is also reflected in the so-called red lists pertaining to Austria, which are directories of extinct, lost and endangered species of animals, plants and fungi, plant communities as well as biotope types and biotope complexes. As per the information made available by the Austrian environmental Ministry on its dedicated website,[3] inter alia, around half of the about 500 types of biotopes are threatened by complete destruction, heavily endangered or endangered. With regard to ferns and flowering plants, over 60% of species appear in the red lists, with a similar picture for mosses and lichens. Furthermore, more than half of all amphibians and reptiles, as well as almost half of all fish and a third of all birds and mammals are heavily endangered.

In a recent paper on ecological restoration in Europe, Cortina-Segarra et al. point to the limited success various restoration efforts, such as in the context of the various relevant EU Directives, have had in Europe, outlining the following potential reasons for this lack of success: lack of financial resources, limited political support and uncertainty over requirements of the various Directives, inadequate stakeholder involvement and consultation, unintended impacts of subsidies and incentives in other sectors, inadequate enforcement, lack of definitions and targets, knowledge gaps, limited understanding of socio-economic benefits, etc. (CORTINA-SEGARRA ET AL. 2021: 2)

In addition, it should be noted that significant research gaps remain with regard to the de facto state of biodiversity and ecosystems, including in Austria, therefore the exact status cannot be holistically assessed at this point in time, also aggravating scientific evaluations of possible changes and future impacts. (see e.g. SALCHER-LUGGER ET AL. 2021: 4f, and as also recognized in the various reports outlined above)

Nonetheless, the information that is available at this point in time, as outlined in this section, does not paint a very positive picture with regard to the state of biodiversity and ecosystems in the EU, as well as in Austria. Therefore, the new Biodiversity strategy for 2030 of the EU aims to put Europe's biodiversity on the path to recovery

[3] The most recent red lists of Austria can be found on the website of the Ministry of Environment: https://www.umweltbundesamt.at/umweltthemen/naturschutz/rotelisten (accessed 30.5.2022).

by 2030 and includes specific commitments and actions to be delivered by 2030. (COM 2020)

2.2. Biodiversity loss and environmental degradation as risk drivers

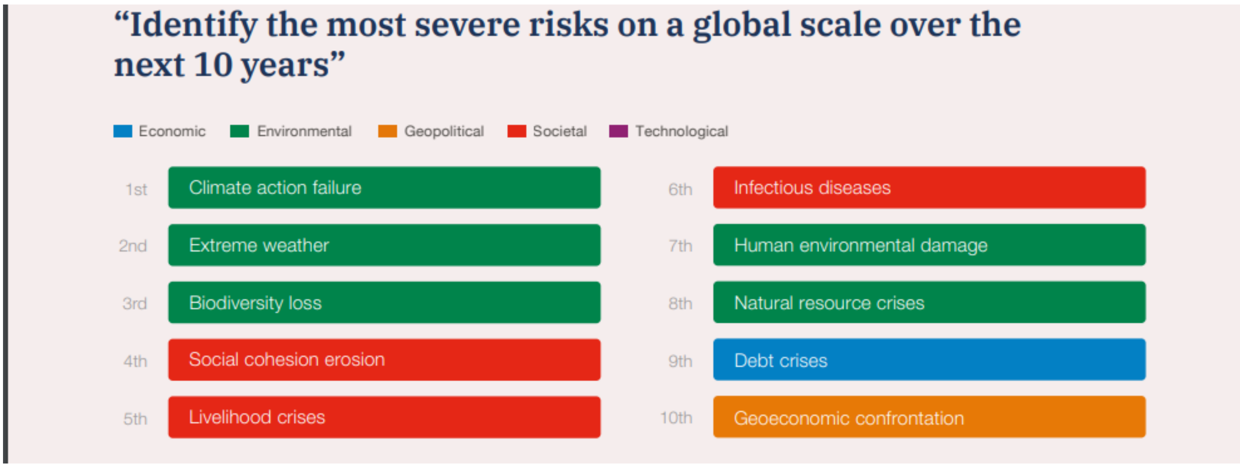
When looking at these trends, and particularly the dimension of these trends, it becomes clear that biodiversity loss and ecosystem deterioration can and should be observed as risk drivers. The following section will provide a snapshot of the various dimensions of risks that this covers.

The following excerpt of the new EU biodiversity strategy shows very clearly the diverse risk dimensions of biodiversity loss and ecosystem degradation: "Biodiversity loss and ecosystem collapse are one of the biggest threats facing humanity in the next decade. They also threaten the foundations of our economy and the costs of inaction are high and are anticipated to increase. The world lost an estimated €3.5-18.5 trillion per year in ecosystem services from 1997 to 2011 owing to land-cover change, and an estimated €5.5-10.5 trillion per year from land degradation. Specifically, biodiversity loss results in reduced crop yields and fish catches, increased economic losses from flooding and other disasters, and the loss of potential new sources of medicine ." (COM 2020: 2)

Similarly, the UNDRR 2019 Global Assessment Report highlights the vulnerability of today's environmental, health and financial systems, supply chains, information and communication systems, being challenged by, and being causal drivers of disruptive influences such as climate change, loss of biodiversity and ecological systems degradation, disease outbreaks, food shortages, etc. (UNDRR 2019: 36) The report goes on to point out that the complexity of the feedbacks and dynamics of ecosystems and biodiversity means that safeguarding species and ecosystems requires more than conservation and protection of natural habitats, also requiring risk-based decision-making, e.g. in agriculture, fisheries and forestry. (UNDRR, 2019, p. 134)

The UNDRR report further states that approximately 20% of the productivity of the Earth's vegetated surface has shown a persistent downward trend in the past two decades, due to climate change, biodiversity loss and poor management practices. The widespread loss of biodiversity and ecosystem health, according to the report, also has a major effect on risk reduction and the mitigation of environmental hazards, as ecosystem services help to regulate climate, filter air and water, and mitigate the impact of natural hazards, and provide benefits such as availability of timber, fish, crops and medicines, as will be further elaborated on in chapter 3 below. In addition, decline of ecosystems leads to the loss of ecosystem services such as pollination and natural resilience builders such as carbon sinks and natural pest control. The report draws the conclusion that loss of ecosystem biodiversity leads to a near-certain prospect of the occurrence of more-frequent hazard events, whilst at the same time a loss of resources to mitigate risks. (UNDRR, 2019, p. 145f)

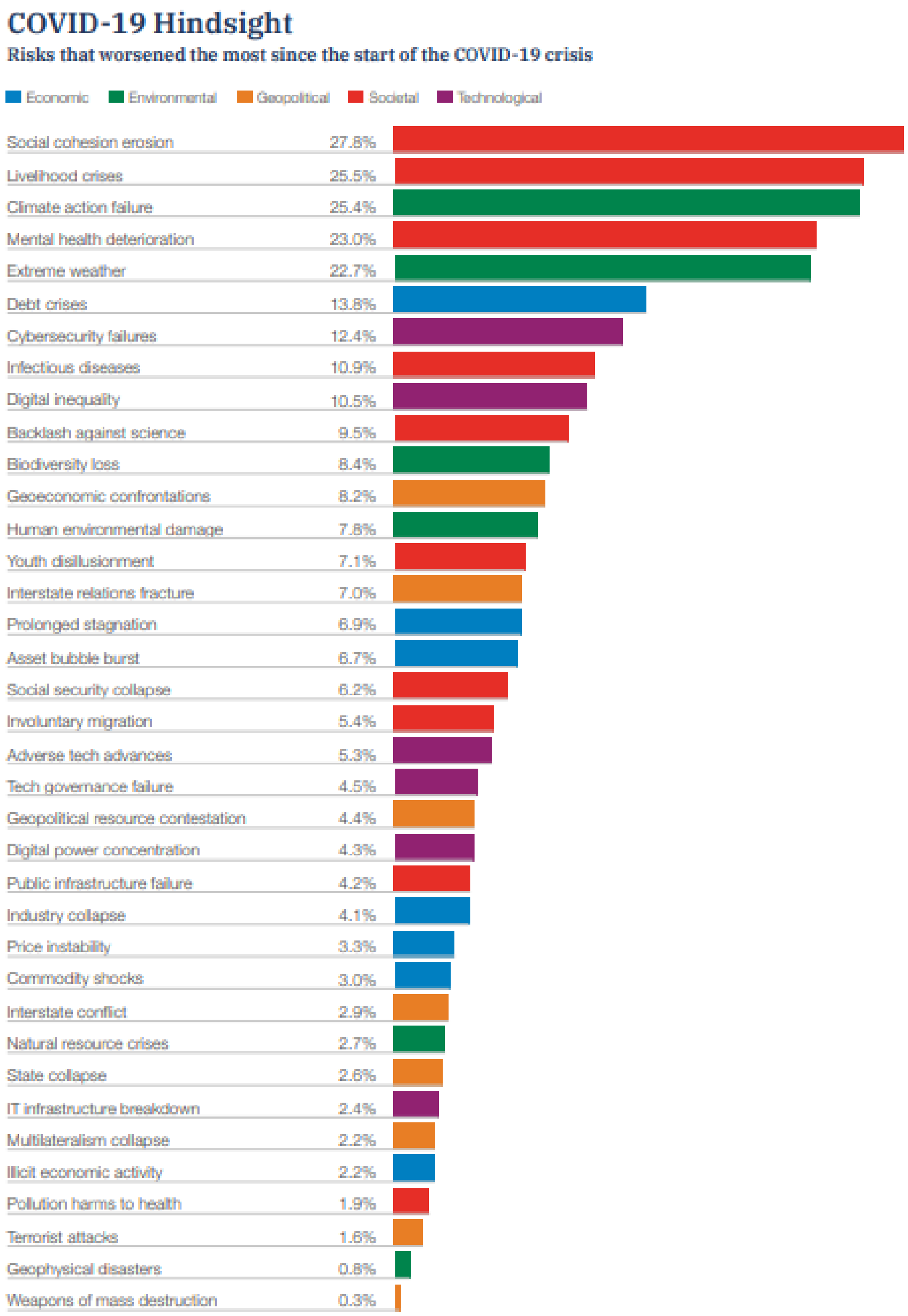
In line with this, the global risks perception survey 2021-2022 of the WEF shows that biodiversity loss has been rated as the third most severe risk on a global scale over the next years, following climate action failure and extreme weather, all of which are classified as environmental risks, as can be seen in figure 13 below.



Source: WEF 2022: 14, figure 1.3

Figure 13: Global Risks Perception Survey 2021-2022 Results

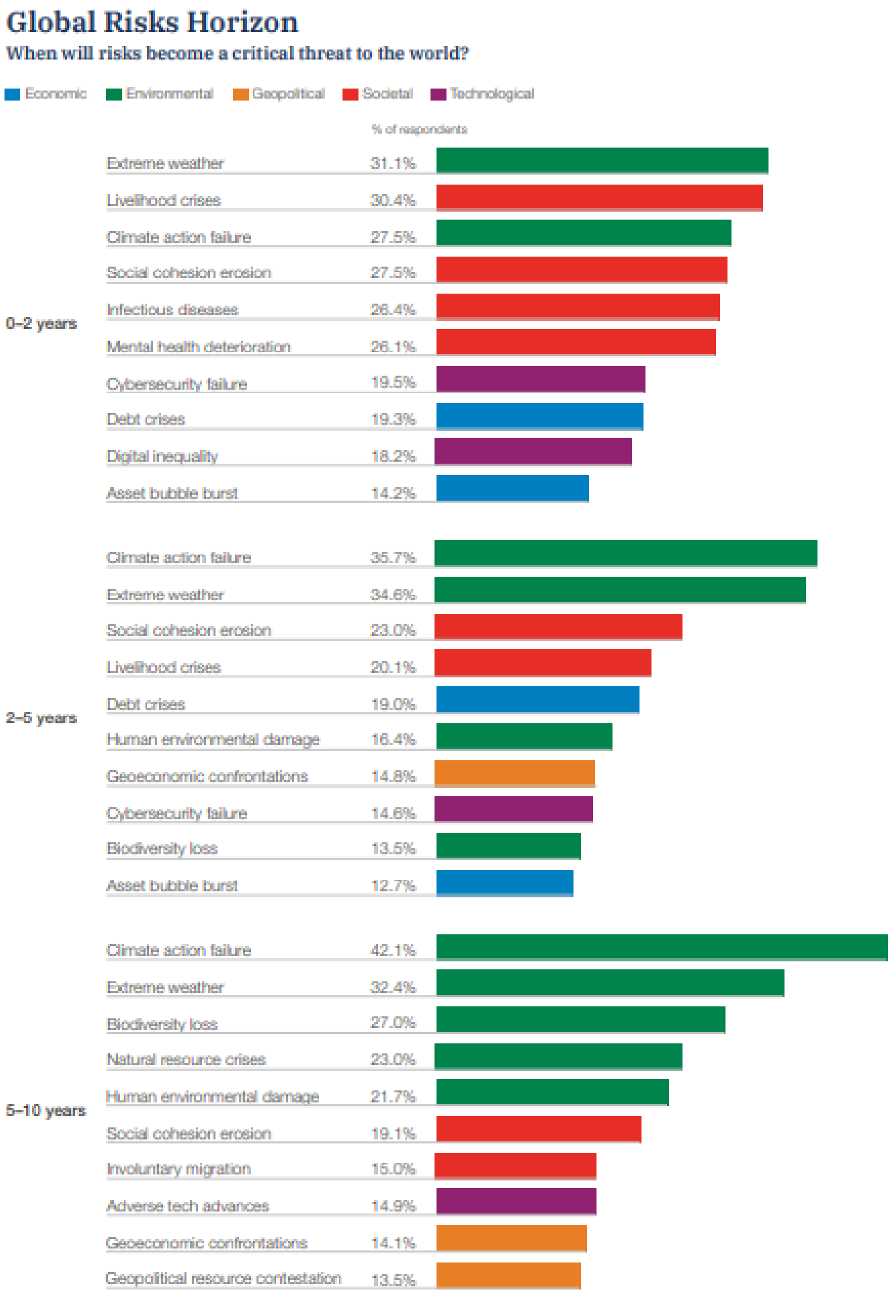
The WEF report notes that concern about environmental degradation predates the pandemic, with increasing concern being noted around climate action failure. (WEF, 2022, p. 23) As outlined in figure 14 below, the WEF report also shows the worsening perception of risks during the COVID-19 pandemic, with an 8,4% increase noticeable with regard to biodiversity loss:



Source: WEF 2022: 24

Figure 14: COVID -19 Hindsight

The WEF report also indicates that there is a perception that biodiversity loss will become a critical threat not immediately, but within the next 2 to 5 years and then increasingly as time goes by, as can be seen from figure 15 below:



Source: WEF 2022: 25, figure III

Figure 15: Global Risks Horizon

Possibly in line with the perception that biodiversity loss will only evolve into becoming a critical threat in the medium- to long-term, for Austria, the WEF survey resulted in biodiversity loss not being contained in the top 5 list of risks, with however climate action failure and extreme weather events having been placed as risk number 1 and risk number 5 respectively, as figure 16 shows.

Economy	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5
Austria	Climate action failure	Erosion of social cohesion	Debt crises in large economies	Digital power concentration	Prolonged economic stagnation Extreme weather events

Source: WEF 2022: 96f

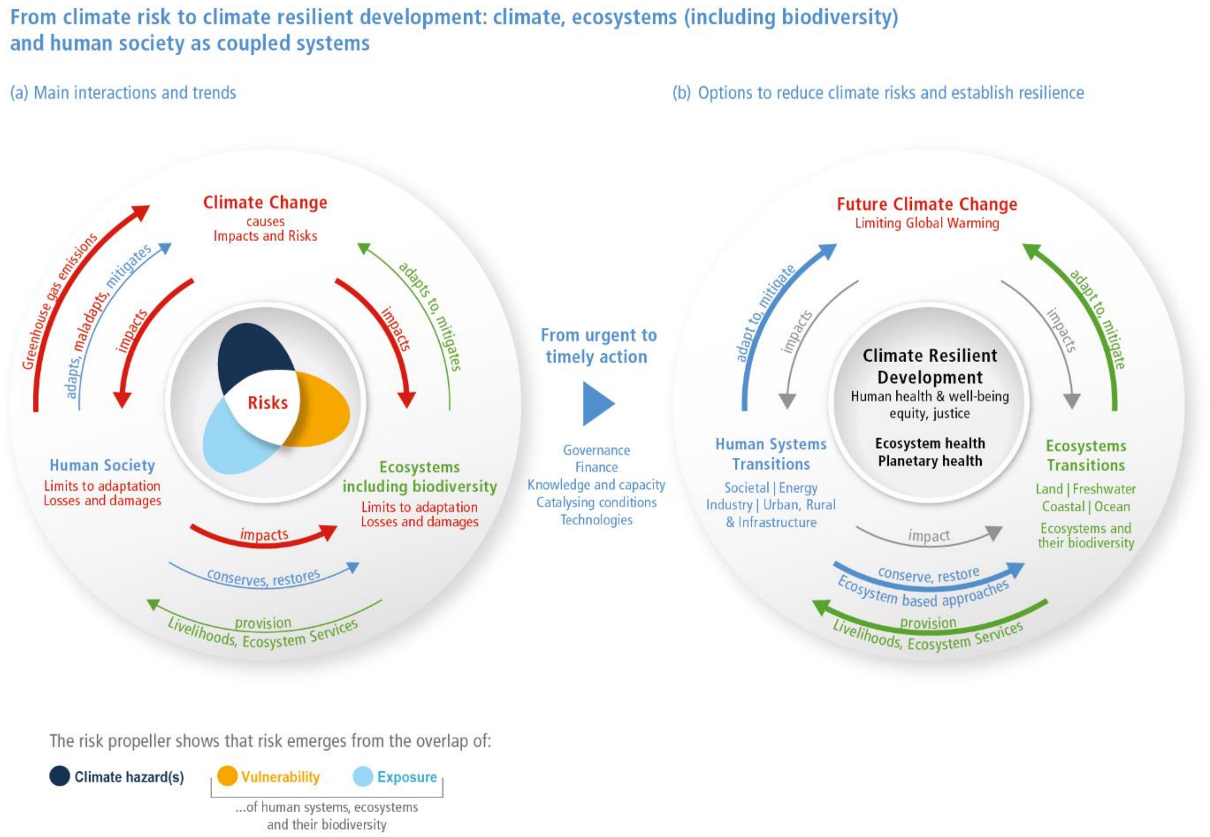
Figure 16: Top Five Risks Identified by the Executive Opinion Survey

Climate action failure being listed as risk number 1 for Austria indicates that the public awareness of risks associated with climate change, and particularly the risks around climate action failure has significantly increased. This also leads to the next thematic area of biodiversity loss and ecosystem degradation signifying risk drivers: there is a growing recognition that the biodiversity crisis and the climate crisis are intrinsically linked. As highlighted by the new EU Biodiversity Strategy for 2030, there is an interrelationship, with climate change accelerating the destruction of the natural world through droughts, flooding and wildfires, and loss and unsustainable use of nature in turn being key drivers of climate change (COM 2020: 2). Also, UNDRR, in its 2019 Global Assessment Report, pointed out that climate change is increasingly recognized as a systemic risk with potentially catastrophic impacts cascading through financial, ecological and social systems. (UNDRR 2019: 55)

The first "Österreichischer Sachstandsbericht Klimawandel 2014", the equivalent to the IPCC for Austria, also highlighted the intrinsic link between climate change and biodiversity loss and environmental degradation, pointing out that climate change is only one of many global challenges, with a sustainable future also dealing with, inter alia, loss of biodiversity. It goes on to highlight that ecosystems that require a long time to develop, as well as alpine habitats located above the treeline are particularly impacted by climate change, and that bogs and mature forests require a long time to adapt to climate change, therefore being particularly vulnerable. Also, it states that in alpine regions, cold-adapted plants can advance to greater heights and increase the biodiversity in these regions, and that cold-adapted species can survive in isolated microniches in spite of the warming. On the other hand, it points to the fact that increasing fragmentation of populations can lead to local extinctions, and that high mountains native species that have adapted to lower peripheral regions of the Alps are particularly affected, as are animals, with changes in the annual cycles already being visible, and the warming of rivers and streams leading to a theoretical shift in the fish habitat by up to 30 km. (APCC 2014: 22f)

Work on the second "Sachstandsbericht zum Klimawandel in Österreich" (APCC Assessment Report on Climate Change in Austria (AAR2), to be completed in 2025) has been initiated in 2022, and it is noteworthy that this iteration of the report will for the first time include a dedicated chapter on ecosystems services, biodiversity, health, forestry, agriculture, and food.[4] This also indicates the growing recognition of the intrinsic link between climate change and biodiversity/ecosystems.

Most recently, the Working Group II contribution to the Sixth Assessment Report of the IPCC has a strong focus on the interactions between the coupled systems climate, ecosystems (including their biodiversity) and human society. The report points out that said interactions are the basis of emerging risks from climate change, ecosystem degradation and biodiversity loss on the one hand, whilst offering opportunities for the future on the other hand. Figure SPM.1 as contained in this report and depicted in figure 17 below showcases the interactions between the coupled systems:



Source: IPCCC 2022a: 8, figure SPM.1

Note: In a) arrow colours represent principle human society interactions (blue), ecosystem (including biodiversity) interactions (green) and the impacts of climate change and human activities, including losses and damages, under continued climate change (red). In b) arrow colours represent human system interactions (blue), ecosystem (including biodiversity) interactions (green) and reduced impacts from climate change and human activities (grey).

Figure 17: From climate risk to climate resilient development: climate, ecosystems (including biodiversity and human society as coupled systems

The findings of the IPCC report also highlight various direct links between climate change and biodiversity/ecosystems, with one of the findings stating that human-induced climate change has caused widespread adverse impacts and related losses and damages to nature, beyond natural climate variability, with the rise in weather and climate extremes having led to some irreversible impacts as natural and human systems are pushed beyond their ability to adapt. (IPCC 2022a, B.1) Inter alia, the report finds that climate change has caused substantial damages and increasingly

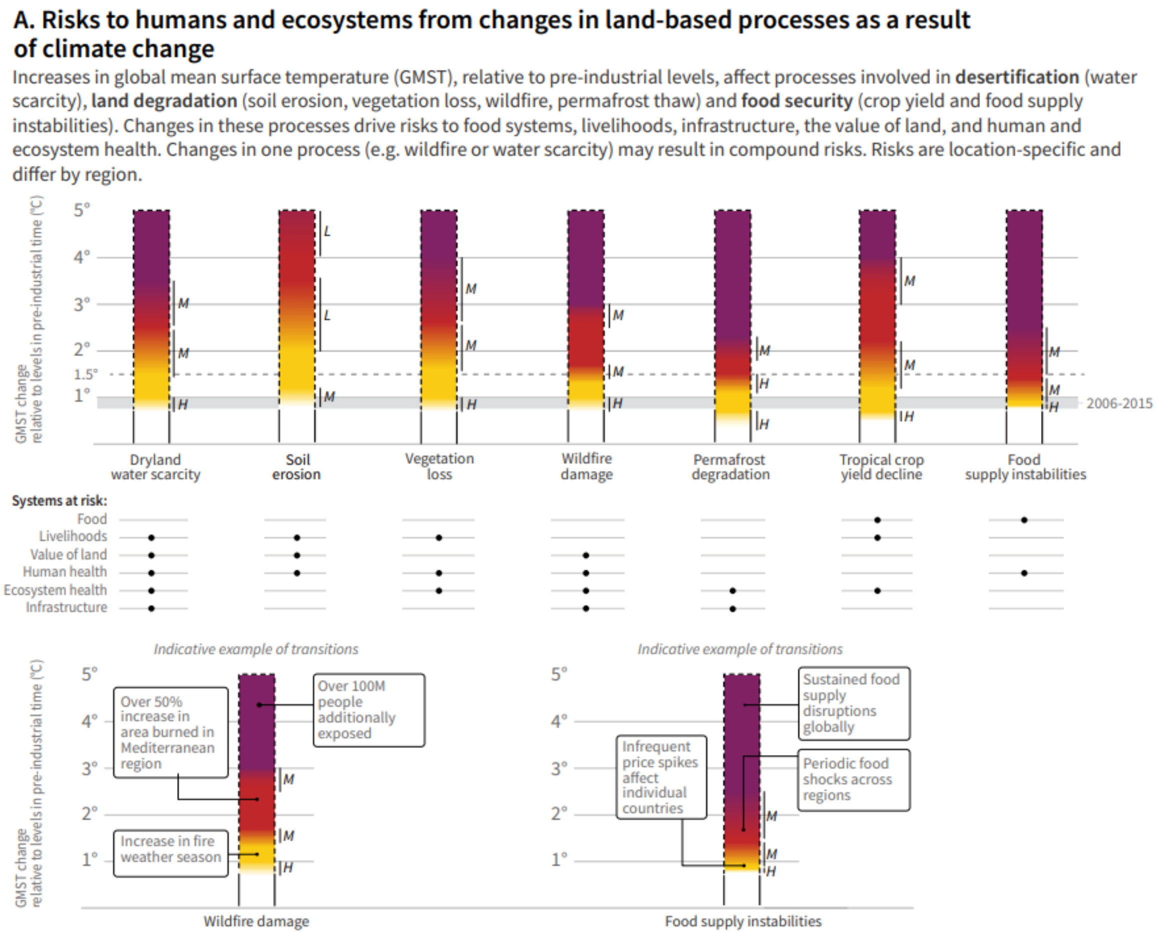
4 For more information on the forthcoming report see: https://ccca.ac.at/wissenstransfer/apcc/aar2 (accessed 30.7.2022).

irreversible losses in terrestrial, freshwater and coastal and open ocean marine ecosystems, with the extent and magnitude of the impacts being larger than estimated in previous assessments: “[w]idespread deterioration of ecosystem structure and function, resilience and natural adaptive capacity, as well as shifts in seasonal timing have occurred due to climate change (*high confidence*). Approximately half of the species assessed globally have shifted polewards or, on land, also to higher elevations (*very high confidence*). Hundreds of local losses of species have been driven by increases in the magnitude of heat extremes (*high confidence*), as well as mass mortality events on land and in the ocean (*very high confidence*) and loss of kelp forests (*high confidence*). Some losses are already irreversible, such as the first species extinctions driven by climate change (*medium confidence*). Other impacts are approaching irreversibility such as the impacts of hydrological changes resulting from the retreat of glaciers, or the changes in some mountain (*medium confidence*) and Arctic ecosystems driven by permafrost thaw (*high confidence*).” (IPCCC 2022a: B.1.2)

The report furthermore points out that human and ecosystem vulnerability are interdependent, with vulnerability of ecosystems and people to climate change differing substantially among and within regions. (IPCC 2022a: B.2) According to the report, there is increasing evidence that degradation and destruction of ecosystems by humans increases the vulnerability of people, with loss of ecosystems and their services having cascading and long-term impacts on people globally. (IPCC 2022a: B2.1)

In terms of risks in the near term (2021–2040), the report indicates that global warming, reaching 1.5°C in the near-term, would cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans. (IPCC 2022a: B.3) In terms of mid to long-term risks (2041–2100), the report indicates that, beyond 2040 and depending on the level of global warming, climate change will lead to numerous risks to natural and human systems. (IPCC 2022a: B.4) With regard to biodiversity loss and degradation, the report indicates that damages to and transformation of ecosystems are already key risks for every region due to past global warming and will continue to escalate with every increment of global warming, particularly: “[i]n terrestrial ecosystems, 3 to 14% of species assessed will likely face very high risk of extinction at global warming levels of 1.5°C, increasing up to 3 to 18% at 2°C, 3 to 29% at 3°C, 3 to 39% at 4°C, and 3 to 48% at 5°C. In ocean and coastal ecosystems, risk of biodiversity loss ranges between moderate and very high by 1.5°C global warming level and is moderate to very high by 2°C but with more ecosystems at high and very high risk (*high confidence*), and increases to high to very high across most ocean and coastal ecosystems by 3°C (*medium to high confidence, depending on ecosystem*). Very high extinction risk for endemic species in biodiversity hotspots is projected to at least double from 2% between 1.5°C and 2°C global warming levels and to increase at least tenfold if warming rises from 1.5°C to 3°C (*medium confidence*).” (IPCC 2022a: B.4.1)

Similarly, the 2020 IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems shows that human use directly affects more than 70% (likely 69–76%) of the global, ice-free land surface. (IPCC 2020: A.1) Inter alia, changes in land conditions, for instance in land cover or land state from either land-use or climate change, affect global and regional climate (IPCC 2020: A.4), with climate change creating additional stresses on land, exacerbating existing risks to livelihoods, biodiversity, human and ecosystem health, infrastructure, and food systems (IPCC 2020: A.5), as can be seen from figure 18.



Source: IPCC 2020: SPM.2

Figure 18: Risks to humans and ecosystems from changes in land-based processes as a result of climate change

Yet, despite the growing recognition of the intrinsic link between climate change and biodiversity loss in scientific and policy-making circles (EEA 2021: 11), a recent IPBES-IPCCC co-sponsored workshop report comes to the conclusion that in practice, they are largely addressed in their respective domains, rather than in a holistic manner. “This functional separation creates a risk of incompletely identifying, understanding and dealing with the connections between the two. In the worst case it may lead to taking actions that inadvertently prevent the solution of one or the other, or both issues. It is the nature of complex systems that they have unexpected outcomes and thresholds, but also that the individual parts cannot be managed in isolation from each other.” (PÖRTNER ET AL. 2021: 4)

As a further area where biodiversity loss and ecosystem degradation pose significant risk drivers, in addition to the intrinsic link between them and climate change and not least in the light of the COVID-19 pandemic, there has been increasing awareness of the link between biodiversity loss and environmental degradation on the one hand, and an increased risk of the emergence of pandemics on the other hand. For example, an IPBES workshop on biodiversity and pandemics in 2020 came to the conclusion that pandemic risk is driven by human ecological disruption and unsustainable consumption, with the risk of pandemics increasing rapidly, being driven by exponentially increasing anthropogenic changes (with more than five new diseases emerging in people every year). The workshop report indicates that biodiversity loss can lead to increased emerging disease risk, particularly when species that adapt well to human-dominated landscapes are also able to harbour pathogens that pose a high risk of zoonotic transmission (with the majority (70%) of emerging diseases and almost all known pandemics being zoonoses, i.e. being caused by microbes of animal origin). The report also highlighted climate change as having been implicated in disease emergence. Reversely, the report indicates that biodiversity can also be threatened by pathogens of wildlife, livestock and people. It comes to the conclusion that reducing anthropogenic global environmental change, and conservation of protected areas and measures that reduce unsustainable exploitation of high biodiversity regions may reduce pandemic risk and the wildlife-livestock-human contact interface and help prevent the spill-over of novel pathogens. (IPBES 2020: 5f)

Similarly, the WEF in 2020 highlighted the link between biodiversity loss and pandemic outbreaks, indicating that the frequency of disease outbreaks has been increasing steadily, with a number of trends having contributed to this rise, with the links to climate change and biodiversity having been the most striking. Inter alia, it points to the role of deforestation, being linked to 31% of outbreaks such as Ebola and the Zika and Nipah viruses, by increasing the likelihood of zoonotic diseases through driving wild animals out of their natural habitats and closer to human populations. On the other hand, according to the WEF, climate change has altered and accelerated the transmission patterns of infectious diseases, whilst at the same time causing human displacement, thereby increasing the vulnerability to biological threats for displaced people. (WEF 2020)

The UNDRR Global Assessment Report 2019 also points to biological hazards affecting people at all levels of society, with new pathogens continuing to emerge by mutating, re-assorting and adapting, and previously well-understood infectious agents changing their behaviour or scale of impact due to climate change and ecosystem changes. (UNDRR, 2019: 104)

In its 2019 report on the state of the world's biodiversity for food and agriculture, the FAO highlights yet another potential for biodiversity loss being a risk driver. It indicates that many key components of biodiversity for food and agriculture at genetic, species and ecosystem levels are declining. This encompasses, inter alia, the proportion of livestock breeds at risk of extinction increasing, whilst diversity of crops and plants in some places in use by farmers decreasing, with e.g. nearly a third of fish stocks being overfished and a third of freshwater fish species assessed being considered threatened, and many species contributing to vital ecosystem services, including pollinators, natural enemies of pests, soil organisms and wild food species, being in decline. At the same time, key ecosystems delivering numerous services essential to food and agriculture, such as supply of freshwater, protection against hazards and provision of habitat for species such as fish and pollinators, are declining rapidly. (FAO 2019: xxxviiif) The FAO points out that biodiversity for food and agriculture is essential, inter alia, to food security, sustainable development and the supply of many vital ecosystem services, including by increasing the resilience of production systems and livelihoods to shocks and stresses, including those associated with climate change, improving livelihoods and supporting food security and nutrition. (FAO 2019: 17)

Furthermore, biodiversity loss and ecosystem degradation, similar to climate change, should be classified as slow-onset events, as for instance recognized by the new EU Strategy on Adaptation to Climate Change. (COMMISSION 2021a: 1) As defined by UNFCCC, slow onset events refer to the risks and impacts associated with increasing temperatures, desertification, loss of biodiversity, land and forest degradation, glacial retreat and related impacts, ocean acidification, sea level rise, and salinization.[5] The fact that biodiversity loss and ecosystem degradation are slow onset events poses additional challenges, e.g. in terms of public awareness, state of research, understanding of future impacts and adverse effects, etc.

To summarize, as outlined by Arce-Mojica et al.: “The mismanagement and the decline of ecosystems is considered to be one of the main drivers of disaster, which not only limits and undermines the coping and adaptive capacities of ecosystems to reduce disaster risk but also exacerbates hazard levels.” (ARCE-MOJICA ET AL. 2019 2) Yet, despite growing evidence of the severity of biodiversity loss and ecosystem degradation, it has been noted that biodiversity loss and climate do not receive equal attention, and the role of biodiversity in mitigating the climate emergency has received only little attention. (MORI 2020: 1729f)

2.3. Reflection of biodiversity loss and ecosystem degradation in national risk assessments

Looking at these recent examples of recognition by the scientific community and policy makers on a global level of ecosystem degradation and biodiversity loss increasingly representing relevant risk drivers, the question remains whether or not this has been reflected in national risk assessments constituting the basis for national disaster risk reduction strategies and approach in general, and particularly with regard to Austria.

As per a 2019 decision by the EU in the context of EU legislation on civil protection, EU Member States are required to provide to the European Commission every three years summaries of the relevant aspects of their risk assessment and the assessment of their risk management capability, focusing on key risks. They are also required to provide information on the priority prevention and preparedness measures needed to address key risks with cross-border impacts, and, where appropriate, low probability

[5] For more information see for instance https://unfccc.int/wim-excom/areas-of-work/slow-onset-events. (accessed 5.8.2022)

risk with a high impact.[6] Member States were requested to submit said information by 31 December 2020 for the first time. It should be noted that, prior to this decision and already since 2013, Member States had been required to report to the Commission on their disaster risk management activities to support formulating an EU risk management policy that would complement and enhance the national ones, with the latest reports under this regime having been submitted in 2018.

In line with the 2019 decision, the European Commission has developed reporting guidelines, which are designed to facilitate reporting and are not mandatory.[7] Reference to biodiversity and ecosystems is made in a few instances, however in terms of risks having an impact on them, rather than them constituting a risk in and of themselves. The guidelines contain a non-exhaustive list of risks relevant under EU legislation and/or policies, which do not contain biodiversity loss or ecosystem degradation as risk category as such, reference is only made to, inter alia, drought and water pollution, animal and plant disease, biological risks, health risks, floods, and risks as per the EU forest strategy (contained in COM(2013)659 final). (COMMISSION 2019: Annex) It should be noted that these areas can be indirectly linked to biodiversity loss or ecosystem degradation, however, the latter have not been included in the list as individual categories.

The guidelines further state that, when identifying the key risks at national or sub-national level (i.e. the key risks that could have significant adverse human, economic, environmental and political/social impacts), Member States should assess the level of impact qualitatively and quantitatively in terms of significant adverse impacts on four categories (i.e. human impacts, economic impacts, environmental impacts, political/social impacts). The guidelines also provide categories and criteria of the different impacts, for environmental impacts, this includes taking into account impact on natural resources, protected areas and habitats (forests, terrestrial biodiversity, aquatic, marine ecosystems, etc.), and natural and urban environments. (COMMISSION 2019: C 428/15f) This again constitutes a substantive link to biodiversity loss and ecosystem degradation.

With regard to risk mapping, Member States should state whether any risk maps have been produced showing the expected spatial distribution of the key risks. Inter alia, the risk maps could show the spatial distribution of all relevant aspects needing protection at national or regional level, such as, inter alia, environmentally protected areas and habitats (Natura 2000 areas, marine protected areas, national parks, forests, maritime and terrestrial biodiversity, river basins). (COMMISSION 2019: C 428/20)

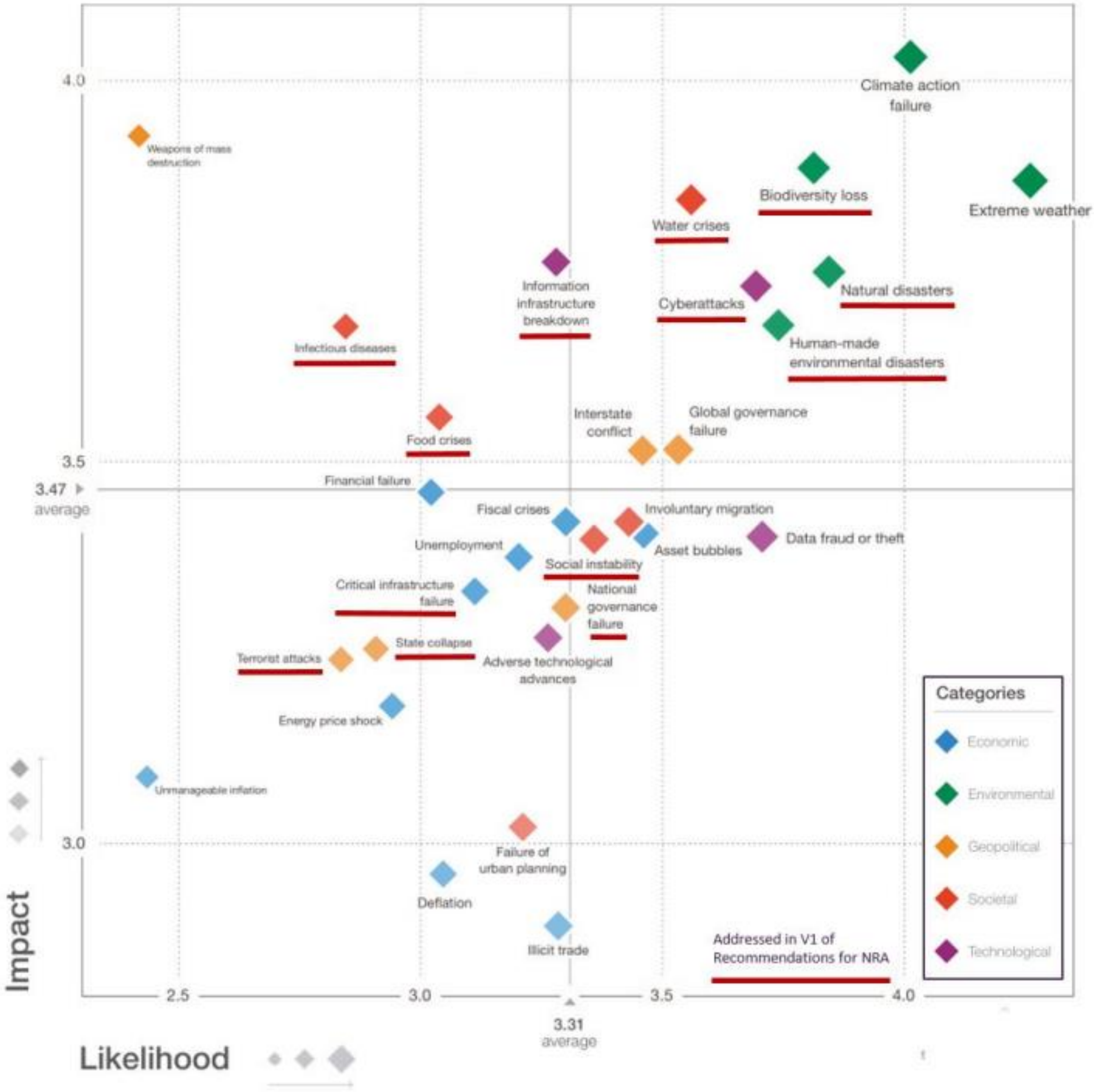
The guidelines also contain a non-exhaustive list of cross-cutting areas of common interest in EU legislation and/or policies, which, inter alia, makes reference to natural areas and habitats, with additional links to ecosystem services accounting, as well as green infrastructure, with additional links to ecosystem services and green

[6] See Decision No 1313/2013/EU as amended by Decision (EU) 2019/420 of the European Parliament and of the Council of 13 March 2019 (OJ L 77, 20.3.2019, p.1).

[7] Contained in Commission Notice, Reporting Guidelines on Disaster Risk Management, Art. 6(1)d of Decision No 1313/2013/EU (2019/C 428/07).

infrastructure, and mapping and assessment of ecosystems and their services. (COMMISSION 2019: Annex)

In 2021, the European Commission Joint Research Centre developed “Recommendations for National Risk Assessment for Disaster Risk Management in EU” with a view to support the use of the new guidelines as outlined above (POLJANŠEK ET AL. 2021) Interestingly, the recommendations cover more risk topics than the guidelines (14 in total, but it is also a non-exhaustive list), and include, inter alia, biodiversity loss. Figure 19 below depicts an overview provided in this report, which shows the overlapping of the risks described in the recommendations with the global perception of risk landscape based on the survey done by the 2020 Global Risk Report as outlined in the previous section. As can be seen, biodiversity loss features very highly in terms of impact and likelihood.



Source: POLJANŠEK ET AL. 2021: 59, figure 8

Figure 19: The global risk landscape 2020

The recommendations specifically highlight that the scientific, political, and economic contexts all converge in identifying biodiversity loss as a major global risk needing urgent consideration, and that biodiversity loss is connected to the following four other global risks: climate change, extreme weather, food crises and water crises. This, in turn, would justify to explicitly address the risk of biodiversity loss also within the Recommendations for National Risk Assessment. (ROBUCHON ET AL. 2021: 107f)

As per the recommendations, the currently available capacities to strengthen biodiversity resilience and decrease the risk of biodiversity loss to EU Member States mainly target direct drivers of biodiversity loss. This includes the following measures Member States could avail themselves of in order to address biodiversity loss and environmental degradation:

- Establishment of protected areas;
- Maintenance or restoration of natural or semi-natural areas outside protected areas;
- The regulation of natural resource extraction;
- The regulation regarding wildlife trade;
- The regulation / restricting the use of specific neonicotinoids;
- The implementation of carbon taxes;
- The use of pollution taxes;
- The reward of biodiversity-friendly agricultural practices through agri-environment schemes and other rural development measures, and the application of penalties for non-compliance to EU standards on good agricultural and environment condition on land and to sustainable management requirements;
- The use of nature-based solutions promoting biodiversity, and sustainable use of land within the urban context; and
- Preventive, eradication and management measures to avoid / limit and mitigate the effects of invasive alien species. (ROBUCHON ET AL. 2021: 112 f)

Despite the importance of considering biodiversity loss as a risk in national risk assessments, the recommendations point out that risk analysis of biodiversity loss is aggravated by a lack of methodologies, particularly qualitative methodologies, with the best methodologies currently available being quantitative in nature and addressing only a limited number of risk drivers. (ROBUCHON ET AL. 2021: 113)

In addition, they point out that biodiversity loss is strongly related to other major risks, such as climate change, and that geospatial interlinkages, e.g. through cross-border trade, need to be considered when assessing the drivers of biodiversity loss. (ROBUCHON ET AL. 2021: 115) Furthermore, and similar to the status of knowledge regarding the state of biodiversity and ecosystems in Austria as outlined above, the recommendations highlight the significant knowledge gaps that remain which would need to be filled to improve quantitative risk analysis of biodiversity loss, including gaps in biodiversity inventories, in biodiversity status, in biodiversity variables, in integrated scenarios, and in the understanding and assessment of diverse biodiversity values. (ROBUCHON ET AL. 2021: 117f)

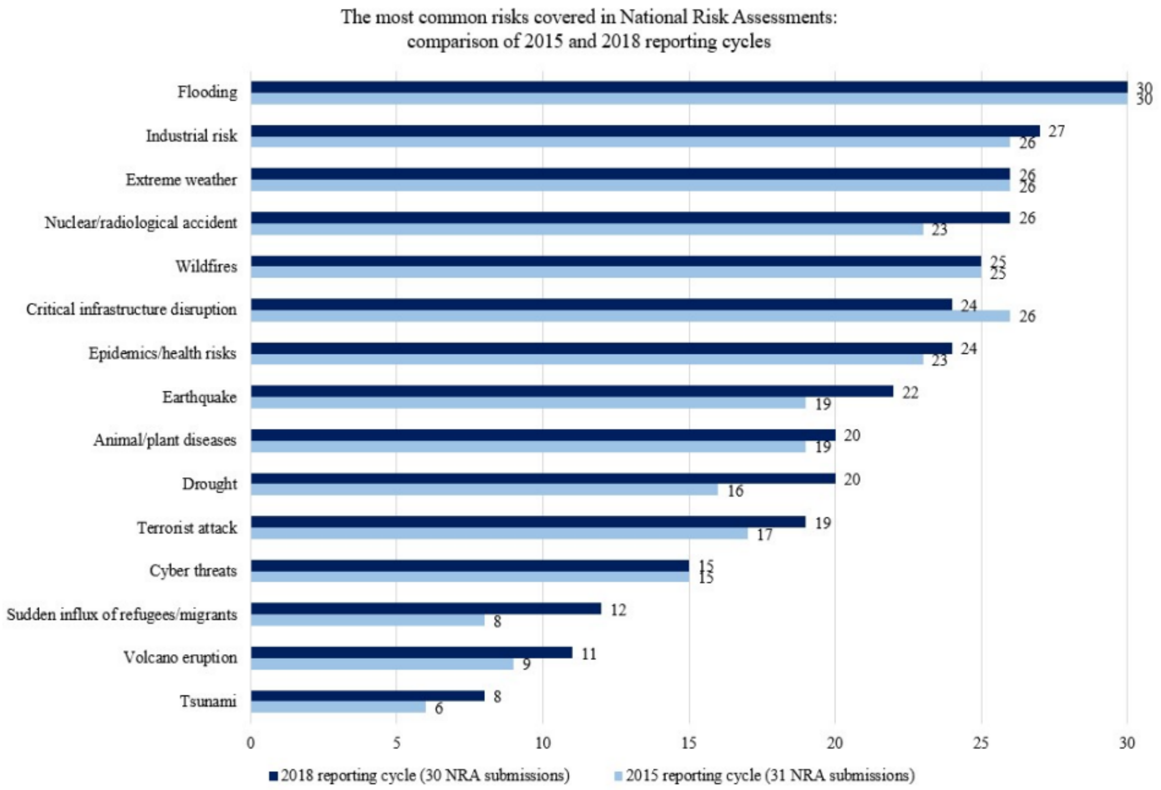
The recommendations come to the conclusion that mainstreaming biodiversity concerns and including them in sectoral policies would be crucial, including trade, agriculture, forestry, fisheries, spatial planning, energy, transport, health, tourism and the financial sector, and insurance. (ROBUCHON ET AL. 2021: 116f)

Considering the extent of the threat posed by ecosystem degradation and biodiversity loss and the growing recognition thereof by the scientific community and policy makers as outlined above, the question remains whether or not the disaster risk reduction discourse and related policy-making processes have incorporated this growing recognition into their thinking as well.

The national risk assessments by EU Member States as referred to above are unfortunately not made available to the public. However, the European Commission regularly issues Commission Staff Working Documents, providing an overview of natural and man-made disaster risks the European Union may face, which includes mainly the information made available by Member States in line with the reporting guidelines. The latest was issued in March 2021, its starting point was the information provided by EU Member States in the 2018 reporting cycle, which was complemented with the most recent available evidence. (COMMISSION 2021b: 9)

In this document, various risk drivers are outlined, one of which being environmental degradation heightening the risk of disaster. “Ecosystems provide multiple services and benefits, including those highly relevant to disaster risk reduction and mitigation, such as regulation of climate pests and diseases, water retention and flood control, landslide prevention and coastal protection. The ability of ecosystems to provide ecosystem services depends on their condition. Regrettably, biodiversity and ecosystems face immense pressure at a global and European scale.” (COMMISSION 2021b: 40) Inter alia, the document points out a decline in the potential of ecosystems to deliver protection against riverine floods, as well as the potential of environmental degradation leading to new risks such as new infectious diseases. Furthermore, the document highlights the reciprocal interconnectedness between environmental degradation and natural disasters, each aggravating the other and vice versa. (COMMISSION 2021b: 40f) This assessment is very much in line with the issues enumerated in the previous section.

The document then goes on to provide an overview of the information provided in the national risk assessments on an aggregated level. As can be seen in figure 20 below, there is no specific reference to environmental degradation as such, even though natural hazards such as flooding, extreme weather, wildfires, animal/plant diseases and drought feature prominently, which can indirectly also be seen as being linked to biodiversity loss and ecosystem degradation.



Source: COMMISSION 2021b: 53, figure 21

Figure 20: The most common risks in National Risk Assessments (NRAs) in 2015 and 2018 reporting cycles

The commission staff working document also provides an overview of most of the disaster risks identified in figure 20 above. As the information is provided on an aggregate level, it is not possible to retrieve information on a national level. Nonetheless, based on the information provided, it seems that Austria included the following risks in its national risk assessments in the 2018 reporting cycle, which, as outlined above, could be seen as being indirectly linked with biodiversity loss and ecosystem degradation: extreme weather (COMMISSION 2021b: 74), flooding (COMMISSION 2021b: 83), wildfires as risk were reported in 2015, however no longer in 2018 (COMMISSION 2021b: 101), and epidemics/pandemics (COMMISSION 2021b: 123). It should again be noted that, unfortunately, this information is not conclusive due to confidentiality restrictions around accessibility of national risk assessments.[8]

It remains to be seen in how far the new reporting requirements as outlined above will have an impact on biodiversity loss and ecosystem degradation also being included in national risk assessment as standalone category, as, going forward, the information is supposed to cover key disaster risks with cross-border implications, low-probability risks with a high impact, and related priority prevention and preparedness measures

[8] As Kern et al. have pointed out, due to the distribution of responsibilities between different ministries and the competences within the federal states, disaster risk assessment and management are not the responsibility of a single institution or authority in Austria. The risk assessments that are being conducted are based on the relevant guidelines of the European Commission and ISO and national standards, and are mainly scenario-based and focusing on single risks. (KERN ET Al. 2021: 7 and 44)

to address these risks. (COMMISSION 2021b: 55) This particularly in light of the fact that the EU has stepped up its action on fighting climate change and environmental degradation, e.g. via the European Green Deal and the new EU strategies on biodiversity, forests, adaptation, and farm-to-fork, as well as the fact that environmental degradation represents a global phenomenon and slow-onset event, which cannot be effectively addressed within national or regional borders. (COMMISSION 2021b: 59) It also remains to be seen whether Austria will include biodiversity loss and ecosystem degradation in its national risk assessment going forward, bearing in mind the restricted access to said information.

2.4. Link between climate change adaptation and disaster risk reduction

In addition to highlighting biodiversity loss as an important risk to be addressed in the context of national risk assessment and related capability assessments, the recommendations on national risk assessment reporting also highlight yet another important aspect, namely the link between adaptation on the one hand, and disaster risk reduction on the other hand: “[t]he policy cycle for the implementation of integrated disaster risk management should have capacity to integrate climate change adaptation strategies and efficiently consider adaptation measures during [disaster risk management] planning.” (ROBUCHON ET AL. 2021: 14 and 64) Specifically, the recommendations highlight the need for better synergies between disaster risk reduction and climate change adaptation strategies. (ROBUCHON ET AL. 2021: 20) As indicated in the previous section, this is even more important when considering the intrinsic link between climate change and biodiversity loss.

The recommendations point out that the European Commission advocates for a horizontal coordinated, cross sectoral approach among competent authorities related to different policy areas that may address or affect disaster prevention, and that, as per the reporting guidelines on disaster risk management, Member States are asked to take into consideration national and subnational climate change adaptation strategies and/or action plans, and to describe if and how these are integrated with the planning of national disaster risk prevention and preparedness measures or vice-versa. (ROBUCHON ET AL. 2021: 54)

It is also highlighted that climate change adaptation strategies and disaster risk strategies are fundamentally very similar processes, both trying to manage and reduce the risk of future disasters, following the same risk concepts and risk assessment processes. Therefore, according to the recommendations, national adaptation strategies should be part of the national risk assessment context. (ROBUCHON ET AL. 2021: 54f) Furthermore, the recommendations highlight that the synergies between disaster risk reduction and climate change should go beyond weather and climate events and related risks, with climate change having much more far-reaching consequences in the field of disaster risk reduction, including the creation of new risks being on the one side related to the exposure and vulnerability of interlinked human-natural systems and their behaviour in the light of socio-economic processes, and on the other side new risks being related to a systemic and compound nature of risk since they are emerging in a particular sector or are the result of cascading effects. The recommendations point out that both of these aspects are still under-presented in risk assessment models. (ROBUCHON ET AL. 2021: 56)

This is also highlighted for instance in the 2021 commission staff working document on national risk assessments in the EU, which highlights that the links between disaster risk-relevant policies and climate change adaptation work should be emphasized, indicating that climate and environmental authorities should work closely together. (COMMISSION 2021b: 60) Also, in the new EU Adaptation Strategy, the need for enhanced synergies between work on adaptation and disaster risk reduction is highlighted. The strategy further indicates that the European Commission will draw up an EU wide climate risk assessment, which will, inter alia, pay special attention to ecosystem vulnerabilities. (COMMISSION 2021a: 14f)

Despite the substantive overlaps that can be identified between climate change adaptation and disaster risk reduction, particularly with regard to weather-related hazards, it has been noted that they are still very much being addressed in silos, also due to a difference in conceptual frameworks, terminology and semantics - a divide which ecosystem-based approaches, namely EbA and Eco-DRR (see chapter 3 below for more information), would have the potential to bridge. (DOWALD and ESTRELLA 2015: 4, MCVITTIE ET AL. 2018: 42, and SUDMEIER-RIEUX ET AL. 2019: 43) “(…) both EbA and Eco-DRR enable people and ecosystems to adapt to the impacts of climate change and/or disasters through the sustainable management, conservation and restoration of ecosystems to provide ecosystem goods and services.” (MCVITTIE ET AL. 2018: 43). However, the assessment methodology for disaster risk reduction and for climate change adaptation are sometimes different in nature, as climate change adaptation is based on the notion of vulnerability, which includes the factors of exposure, sensitivity and adaptability. (SUDMEIER-RIEUX ET AL. 2019: 33) Also, EbA addresses mostly climate-related natural hazards, the scope of Eco-DRR also includes other types of disaster, such as e.g. earthquakes. (MCVITTIE ET AL. 2018: 43) Furthermore, climate change adaptation refers more often to long-term impacts / slow-onset events, which require adaptation in the long-term, whereas in disaster risk reduction, impacts are more acute resulting from e.g. extreme events or smaller, cumulative events, and even though disaster impacts might take years to recover from, they are often considered short-term and locally-specific. Yet, on the ground, there are only few differences between addressing climate change adaptation versus disaster risk reduction. (SUDMEIER-RIEUX ET AL. 2019: 36) “Convergence between [disaster risk reduction] and [climate change adaptation] is occurring although it is not embraced by all, especially among those [disaster risk reduction] academics who consider the adaptation and resilience discourse to be something like a band-aid, rather than addressing main underlying causes of risk…” (SUDMEIER-RIEUX ET AL. 2019: 43). This is also pointed out by Rosenzweig and Solecki with regard to cities, outlining that disaster risk reduction, which relates to short-term climate extremes, and climate change adaptation that relates more to longer-term persistent risks are addressed very often in silos. Therefore, a new systems-oriented approach to risk assessment and planning would be needed, which also accounts for increasing risks within more vulnerable communities and sectors. (ROSENZWEIG AND SOLECKI 2018: 757)

As outlined by UNDRR, climate change adaptation and disaster risk reduction are inexorably linked in terms of implementation, even if separate at the policy level. (UNDRR 2021: 172) This is also reflected by the EEA, which outlines that climate change adaptation and disaster risk reduction fall under different policy, institutional and legal frameworks, being addressed by different communities. In light of the intrinsic link, closer policy coordination and collaboration would be beneficial. (EEA 2021: 19) In this context, specific guidance is increasingly being developed to bridge the gap between climate change adaptation and disaster risk reduction (see e.g. ADAMS ET AL. 2020). For example, the so-called PLAtform for Climate Adaptation and Risk reDuction (PLACARD) has been working with various European stakeholders on the understanding and promoting the benefits of connecting the two communities, including to develop tools and approaches to facilitate further collaboration.[9]

This highlights that, in light of the substantive link between climate change adaptation and disaster risk reduction, there is need to also enhance and reflect this link in the overall understanding, policy-making, and on-the ground implementation. As already outlined above, EbA and Eco-DRR offer great potential and opportunities in this regard, the next section will therefore provide an overview of the opportunities that biodiversity and ecosystems offer for disaster risk reduction in general, before turning to the specific topic of EbA and Eco-DRR.

2.5. Opportunities of biodiversity and ecosystems for disaster risk reduction

"Ecosystems are crucial for [disaster risk reduction] and [climate change adaptation] on two levels: for prevention and post-disaster recovery, in fact for every step of disaster management." (SUDMEIER-RIEUX 2013: 23) In addition, in its recent thematic assessment of the sustainable use of wild species, IPBES pointed out that "[b]illions of people in all regions of the world rely on and benefit from the use of wild species for food, medicine, energy, income and many other purposes" (IPBES 2022: A.1).

It has been increasingly acknowledged that ecosystems can reduce vulnerability to hazards, whilst at the same time they act as physical buffers to reduce the impact of natural hazards such as landslides, flooding, avalanches, storm surges, wildfires and drought (SUDMEIER-RIEUX 2013: 25 and 29) On the other hand, they provide multiple benefits and services, which contribute to disaster risk reduction, including by providing regulating services in the form of natural infrastructure (i.e. by absorbing energy from physical hazard events), provisioning services in the form of supporting livelihoods for the reduction of vulnerability, supporting services (i.e. support to soil formation, photosynthesis, nutrient cycling, and as basis for agriculture and livelihoods), and cultural services. (see e.g. UNDRR 2020: 9, WALZ ET AL. 2021: 1f,

[9] More information available at: https://climate-adapt.eea.europa.eu/knowledge/adaptation-information/research-projects/placard (accessed 26.8.2022).

and SUDMEIER-RIEUX 2013: 29) Therefore, it should be acknowledged that, beyond regulating services of ecosystems, a wide range of other services they provide all contribute to disaster risk reduction. (SUDMEIER-RIEUX K., ARCE-MOJICA T., BOEHMER H.J. ET AL. 2021: 807) As outlined by Sudmeier-Rieux et al., the overall aim of disaster risk reduction is to work on reducing risk factors by reducing exposure, vulnerability and hazards, with a number of things, in many cases linked to poor environmental management, contributing to increasing risk in each of the three risk factors. Therefore, there has been an increased recognition in the international policy discourse that resilience needs to be enhanced by an improvement, maintenance and managing of ecosystem functions. (SUDMEIER-RIEUX ET AL. 2019: 4) As outlined by UNDRR: "[h]ealthy and well-managed ecosystems provide important services that can address a range of risk factors. First (...) they can reduce some **hazards**. Second, they act as natural or green infrastructure that reduces **physical exposure** to a range of hazards and reduces their impacts on critical infrastructure and basic services (...). And third, they can reduce **vulnerability** by providing food, water and other services." (UNDRR 2020: 11f) In addition, through carbon storage and sequestration, ecosystems play also an important role in climate change mitigation. (UNDRR 2020: 17)

In a recent paper, Walz et al. provided an overview of the role of different ecosystems and related services with regard to the three dimensions of risk. Regarding the two dimensions of disaster risk hazard and exposure, they point out that ecosystem services can provide local climate and air quality regulation, sequestration and storage of carbon (as also outlined by UNDRR, see above), moderation of extreme events, prevention of soil erosion, and treatment of waste-water. Regarding reduction of vulnerability, they point to the provisioning services such as access to food, fresh water, raw materials and medicinal resources that are offered by ecosystems, support of mental and physical health, spiritual experience and sense of place services, as well as aesthetic appreciation and inspiration for culture, art and design. Furthermore, they point to the maintenance of soil fertility, pollination services, biological control (i.e. pest and vector-borne diseases), richness in genetic diversity, etc. (WALZ ET AL. 2021: 7ff) On the other hand, they point out that there is evidence of ecosystems and their services also being subject to impacts of disasters and natural hazards, entailing degradation, decrease, damage, disruption, impacts, or destruction of ecosystems and their services, with, in turn, impacts on their role regarding the different dimensions of disaster risk. (WALZ ET AL. 2021: 2) This is particularly true for climate-related hazards impacting crops, livestock, and forests. However, their paper showed that especially impacts on ecosystem services were very much underreported in relevant reporting of disaster-related losses, even though there is scientific evidence for the direct relation to manifested disaster-related losses of ecosystem services. (WALZ ET AL. 2021: 10) They point out that there is "(...) clear evidence that ecosystems are exposed to and impacted by droughts, floods and storms and that resulting losses of ecosystems have a strong feedback on overall disaster risk. Thus, we argue that ecosystems should be included in the definition of exposure as essential element and considered as such in any future risk assessment." (WALZ ET AL. 2021: 10). This links to the issue of inclusion of ecosystem consideration also in national risk assessments, which was outlined previously. Furthermore, this highlights the implications that (disaster-related) losses of ecosystems have on the overall disaster risk, thereby showcasing the need to monitor ecosystem loss and loss of related services, including how this modifies disaster risk in turn, for a holistic understanding of disaster risk. (WALZ ET AL. 2021: 10)

As the above highlights, there is a general recognition that biodiversity loss and ecosystem degradation are on the one hand increasingly relevant risk drivers, including due to their intrinsic link to climate change, and on the other hand that there is urgent need to address these two issues in the light of the growingly dire picture that becomes more and more apparent. For example, in 2020, political leaders participating in the United Nations Summit on Biodiversity agreed on a leaders' pledge, containing a commitment to reverse biodiversity loss by 2030 (it was endorsed by 93 countries and the President of the European Commission for the European Union).[10]

Furthermore, the 2021 World Conservation Congress of the IUCN culminated in the Marseille Manifesto, which came, inter alia, to the following conclusion: "(…) The climate and biodiversity emergencies are not distinct, but two aspects of one crisis. (…) Our response to these emergencies must be mutually reinforcing. For example, measures designed to address climate change must not lead to further biodiversity loss. Humanity has reached a tipping point. Our window of opportunity to respond to these interlinked emergencies and share planetary resources equitably is narrowing quickly." (IUCN 2021: 2)

Similarly, in the run up to the finalization of the Post-2020 Global Biodiversity Framework under the CBD, the Kunming Declaration "Ecological civilization: building a shared future for all life on Earth" was adopted by Ministers. The declaration highlights that the unprecedented and interrelated crises of biodiversity loss, climate change, land degradation and desertification, ocean degradation, and pollution, and increasing risks to human health and food security, pose an existential threat to society, culture, prosperity and the planet. It recognizes that these crises share many underlying drivers of change, and that the main direct drivers of biodiversity loss are land/sea use change, overexploitation, climate change, pollution and invasive alien species. Furthermore, it contains a commitment to, inter alia, continue to promote the mainstreaming of the conservation and sustainable use of biodiversity into decision-making and strengthen cross-sectoral coordinating mechanisms on biodiversity, as well as to increase the application of ecosystem-based approaches to address biodiversity loss, restore degraded ecosystems, boost resilience, mitigate and adapt to climate change, etc. (CBD 2021: preamble, paragraphs 3 and 10)

This highlights that there is also a recognition of the potential and opportunities that biodiversity and ecosystems in general, and actions taken to prevent biodiversity loss and/or to restore ecosystems in particular also have in order to tackle the challenges at hand and thereby contribute to disaster risk reduction.

[10] More information on the pledge is available at: https://www.leaderspledgefornature.org/ (accessed 13.6.2022)

In recent years, and as will be further outlined in chapter 3 below, the integrative approaches of so-called nature-based solutions / ecosystem-based approaches have gained prominence in the academic and policy discourse around disaster risk reduction and adaptation to climate change, but also for instance sustainable development: "[n]ature-based solutions (NbS), including ecosystem-based disaster risk reduction (Eco-DRR) and ecosystem-based adaptation (EbA) play an important role in reducing disaster and climate risk, in particular in addressing systemic risk arising from an increasingly complex and evolving risk landscape." (UNDRR 2020: 6) Also in the 2019 IPBES report, there is an acknowledgement that nature-based solutions, such as green infrastructure and other ecosystem-based approaches, can be cost-effective for meeting the Sustainable Development Goals in cities. (IPBES 2019: D9) Also, the EU 2021 Adaptation Strategy acknowledges that the implementation of nature-based solutions on a larger scale would increase climate resilience and contribute to multiple Green Deal[11] objectives. It recognizes that so-called blue-green (as opposed to grey) infrastructures are multipurpose, "no regret" solutions, that provide environmental, social and economic benefits and help build climate resilience, and that they are essential for sustaining healthy water, oceans and soils. It also highlights the role nature-based solutions should play in land-use management and infrastructure planning, providing benefits such as carbon sequestration, tourism opportunities, and biodiversity conservation and restoration. (COMMISSION 2021a: 11f)

This is also reflected in the first draft of the Post-2020 Global Biodiversity Framework, which is currently being negotiated under the Umbrella of the CBD, which was released in July 2021 with the aim to conclude negotiations later in 2022. Most notably, target 8 of the first draft of the CBD open-ended working group on the post-2020 global biodiversity framework aims to minimize the impact of climate change on biodiversity, contribute to mitigation and adaptation through ecosystem-based approaches, and ensure that all mitigation and adaptation efforts avoid negative impacts on biodiversity (CBD OPEN ENDED WORKING GROUP ON THE POST-2020 GLOBAL BIODIVERSITY FRAMEWORK 2021: Target 8) This again highlights the clear link between climate change and biodiversity loss and related actions, as well as the importance and potential of ecosystem-based approaches.

Furthermore, the IPCC Sixth Assessment Report, the latest in the series of IPCC reports, also highlights the linkage between climate change and strategies to tackle climate change on the one hand, and biodiversity/ecosystems and nature-based / ecosystem-based approaches on the other side. "For cities, three broad mitigation strategies have been found to be effective when implemented concurrently: i) reducing or changing energy and material use towards more sustainable production and consumption; ii) electrification in combination with switching to low-emission energy sources; and iii) enhancing carbon uptake and storage in the urban environment, for example through bio-based building materials, permeable surfaces, green roofs, trees, green spaces, rivers, ponds and lakes [Footnote 58: These examples are considered to be a subset of nature-based solutions or ecosystembased approaches]. (*very high confidence*)." (IPCC 2022b, C.6.2.)

[11] More information on the EU Green Deal available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en. (accessed 6.8.2022)

The IPCC report also highlights reforestation, improved forest management, soil carbon sequestration, peatland restoration and blue carbon management as examples of methods of carbon dioxide removal, that can enhance biodiversity and ecosystem functions, etc. (IPCC 2022b: C.11.2) As will be outlined in the next chapter, all of these fall under the umbrella of nature-based solutions.

On the other hand, the IPCC report calls for coordinated cross-sectoral policies and planning, in order to maximise synergies and avoid or to reduce trade-offs between mitigation and adaptation, as e.g. land and aquatic ecosystems can be adversely affected by some mitigation actions. (IPCC 2022b: D.2)

In its recent proposal for a Nature Restoration Law by the European Commission (COMMISSION 2022), which was issued in June 2022, the link between the restoration of ecosystems and the prevention and build-up of resilience to possible future communicable diseases with zoonotic potential is highlighted. Furthermore, it highlights that recent geo-political developments have underlined the need for safeguarding food security and the resilience of food systems, with evidence showing the positive impacts of restoring agro-ecosystems and nature in general in terms of the EU's long-term sustainability and resilience. (COMMISSION 2022: 1 and recitals 19 and 21) The proposal also points to the fact that soils are an integral part of terrestrial ecosystems, highlighting the need to restore degraded soils and enhance soil biodiversity, and to Natura 2000 as the key instrument to promote the protection of valuable and threatened species and habitats and ecosystems. (COMMISSION 2022: recitals 22 and 23)

In order to address the call for an urgent reversal of biodiversity loss, the Commission committed to propose legally binding targets to restore degraded EU ecosystems, in particular those with the most potential to remove and store carbon and to prevent and reduce the impact of natural disasters. (COMMISSION 2022: 2) The proposal therefore sets multiple binding restoration targets and obligations across a broad range of ecosystems, covering at least 20% of the EU's land and sea areas by 2030 and all ecosystems in need of restoration by 2050. This is supported by an implementation framework in the form of preparing and carrying out national restoration plans, which shall cover the period up to 2050, with intermediate deadlines corresponding to the overall targets and obligations set out in the regulation. (COMMISSION 2022: 3f)

Articles 11 and 12 of said draft regulation contain various provisions with regard to the preparation and content of the national restoration plans, which contain a number of references to climate change and disaster risk reduction: Inter alia, Member States shall identify synergies with climate change mitigation, climate change adaptation and disaster prevention, and prioritise restoration measures accordingly. (COMMISSION 2022: Article 11.5). Furthermore, with regard to the content of the plans, Member States shall include, inter alia:

- the estimated co-benefits for climate change mitigation associated with the restoration measures over time, as well as wider socio-economic benefits of those measures,

- a dedicated section setting out how the national restoration plan considers the relevance of climate change scenarios for the planning of the type and location of restoration measures,
- the potential of restoration measures to minimise climate change impacts on nature, to prevent natural disasters and to support adaptation, synergies with national adaptation strategies or plans and national disaster risk assessment reports, and
- an overview of the interplay between the measures included in the national restoration plan and the national energy and climate plan. (COMMISSION 2022: Article 12.2.j) and k))

In the proposal, the European Commission, referring to the intrinsic link between securing biodiverse ecosystems and tackling climate change, highlights nature and nature-based solutions as fundamental for fighting the climate crisis. (COMMISSION 2022: recital 15) Furthermore, it highlights the contribution of restoration of ecosystems to the maintenance, management and enhancement of natural sinks with a view to increase biodiversity and fight climate change. (COMMISSION 2022: recital 16)

All of the above highlights that there is growing recognition of the opportunities and potential that biodiversity and ecosystems offer in terms of disaster risk reduction, whilst at the same time there is a recognition of the complex interplay and interlinkage particularly with climate mitigation and adaptation, but also more broadly sustainable development actions. However, as Mori points out, "(…) biodiversity has not been fully considered as part of the equation. That is, although biodiversity is predominantly seen as a target for conservation, it is rarely appreciated for the contribution it can make to solving issues such as climate change." (Mori 2020: 1729)

Nonetheless, in the Sendai Framework for Disaster Risk Reduction 2015-2030, referred to as the Sendai Framework in the following, which is the global agreement in the area of disaster risk reduction, there are various references to the need to protect and preserve, as well as make use of ecosystems in order to, as well as whilst addressing the broader issue of disaster risk reduction. For example, it is stated that "[i]t is urgent and critical to anticipate, plan for and reduce disaster risk in order to more effectively protect (…) ecosystems, and thus strengthen their resilience". (UNDRR 2015: para. 5)

It contains a recognition of declining ecosystems and climate change representing underlying disaster risk drivers, which need to be addressed through more dedicated action. (UNDRR 2015: para 6)

Indirectly, one could also see ecosystems and the services they provide to societies as being addressed in the context of two of the seven global targets that were agreed to support the assessment of global progress in achieving the outcome and goal of the Sendai Framework, namely the goal to reduce direct disaster economic loss in relation to global gross domestic product, and to substantially reduce disaster damage to critical infrastructure and disruption of basic services, including through developing their resilience by 2030. (UNDRR 2015: para 8 c) and d))

Furthermore, under priority area 1 „Understanding disaster risk“, countries are encouraged to make use of and strengthen baselines at national and local level,, and to periodically assess disaster risks, vulnerability, capacity, exposure, hazard characteristics and their possible sequential effects at the relevant social and spatial scale on ecosystems. (UNDRR 2015: para 24 b))

Under priority area 2 "Strengthening disaster risk governance to manage disaster risk". Parties, at global and regional levels, are to foster collaboration across global and regional mechanisms and institutions for the implementation and coherence of instruments and tools relevant to disaster risk reduction, such as for climate change, and biodiversity. (UNDRR 2015: para 28 b)) Furthermore, they are to promote transboundary cooperation to enable policy and planning for the implementation of ecosystem-based approaches with regard to shared resources to build resilience and reduce disaster risk. (UNDRR 2015: para 28 d))

Under priority area 3 "Investing in disaster risk reduction for resilience", Parties, at national and local levels, are to promote the mainstreaming of disaster risk assessment, mapping and management into rural development planning and management of, inter alia, mountains, rivers, coastal flood plain areas, drylands, wetlands and all other areas prone to droughts and flooding, and at the same time preserve ecosystem functions that help to reduce risks. (UNDRR 2015: para 30 g) Furthermore, they are to strengthen the sustainable use and management of ecosystems and implement integrated environmental and natural resource management approaches that incorporate disaster risk reduction. (UNDRR 2015: para 30 n)

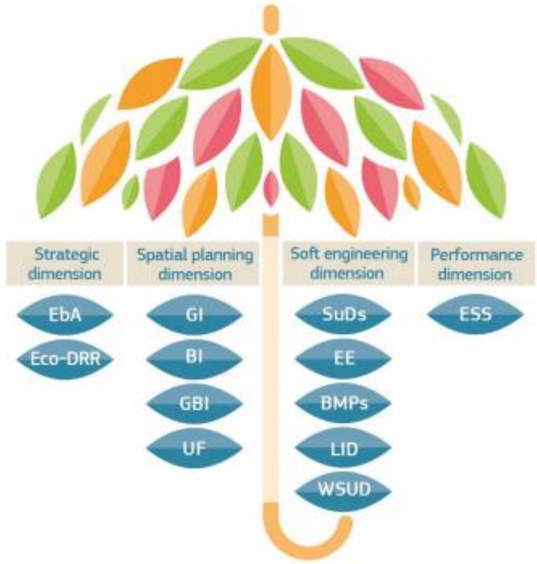
The above shows that there are direct or indirect substantive linkages to ecosystems / biodiversity and the related ecosystem-based approaches and a recognition of their relevance also in the context of disaster risk reduction, in terms of risk drivers, as well as the need for their protection, but also their potential to contribute to disaster risk reduction efforts in the various priorities of the Sendai Framework. Particularly the concept of ecosystem-based disaster risk reduction, as enshrined in the Sendai Framework, has gained traction in the academic and policy discourse in the past few years. The following section will therefore look into this in more detail.

3. Ecosystem-based disaster risk reduction and ecosystem-based adaptation

As outlined above, and in line with the realization that ecosystems and biodiversity play a significant role in disaster risk reduction, climate change adaptation and mitigation, and so on, in recent years, the integrative approaches of Eco-DRR and EbA, under the wider umbrella of nature-based solutions, have been developed and have gained more and more traction particularly with regard to the development of on-the ground guidance for practitioners.

By the definition of the European Commission,[12] nature-based solutions are "(…) solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource efficient and systemic interventions. Nature-based solutions must therefore benefit biodiversity and support the delivery of a range of ecosystem services" (COMMISSION 2021c: 4). The concept therefore is based on the understanding of the dependence of human wellbeing on the various ecosystem services, i.e. supporting, provisioning, regulating and cultural services, as outlined in the previous section. (OECD 2020: 5) According to the understanding of the European Commission, nature-based solutions range from minimal or no intervention, to the creation of new ecosystems, and represent an evolution of terms used to express similar ideas, such as urban forestry, green and blue infrastructure, or the delivery of ecosystem services. Additional concepts and practices under their umbrella also include, inter alia, EbA and Eco-DRR. (COMMISSION 2021c: 4) Yet, it should be highlighted that nature-based solutions do not only include new solutions, in addition to new opportunities to incorporate ecosystem considerations into policy options, they also incorporate existing ideas and knowledge. (OECD 2020: 7) Figure 21 below provides an overview of the range of concepts and approaches that the umbrella concept of nature-based solutions encompasses, and showcases the various dimensions said solutions cover.

[12] The definition of the European Commission is also available at: https://ec.europa.eu/info/research-and-innovation/research-area/environment/nature-based-solutions_en (accessed 14.6.2022)



Source: COMMISSION 2021c: 4, figure 1

Note: EbA – ecosystem-based adaptation; Eco-DRR = ecosystem-based disaster risk reduction; GI = green infrastructure; BI = blue infrastructure; GBI = green-blue infrastructure; UF = urban forestry; SuDS = sustainable urban drainage systems; EE = ecological engineering; BMPs = best management practices; LID = low-impact design; WSUD = water-sensitive urban design; ESS -= ecosystem services.

Figure 21: Nature-based solutions

The following will therefore introduce the concepts of EbA and Eco-DRR and provide an overview of the current literature and policy/practical guidance that has been made available over the past few years.

3.1. Introduction to ecosystem-based disaster risk reduction and ecosystem based adaptation

In 2019, Parties under the CBD agreed on the so-called "Voluntary guidelines for the design and effective implementation of ecosystem-based approaches to climate change adaptation and disaster risk reduction and supplementary information". As part of these guidelines, the then fairly new and conceptually similar concepts and practice of EbA and Eco-DRR were shaped as integrative approaches to reduce the risk of climate-related and other types of hazards and emphasize the importance of biodiversity and ecosystems in reducing risk. (CBD 2019: 24) In general, they are perceived as holistic approaches that use biodiversity, and ecosystem functions and services to manage the risks of climate-related impacts and disasters. (CBD 2019: 41)

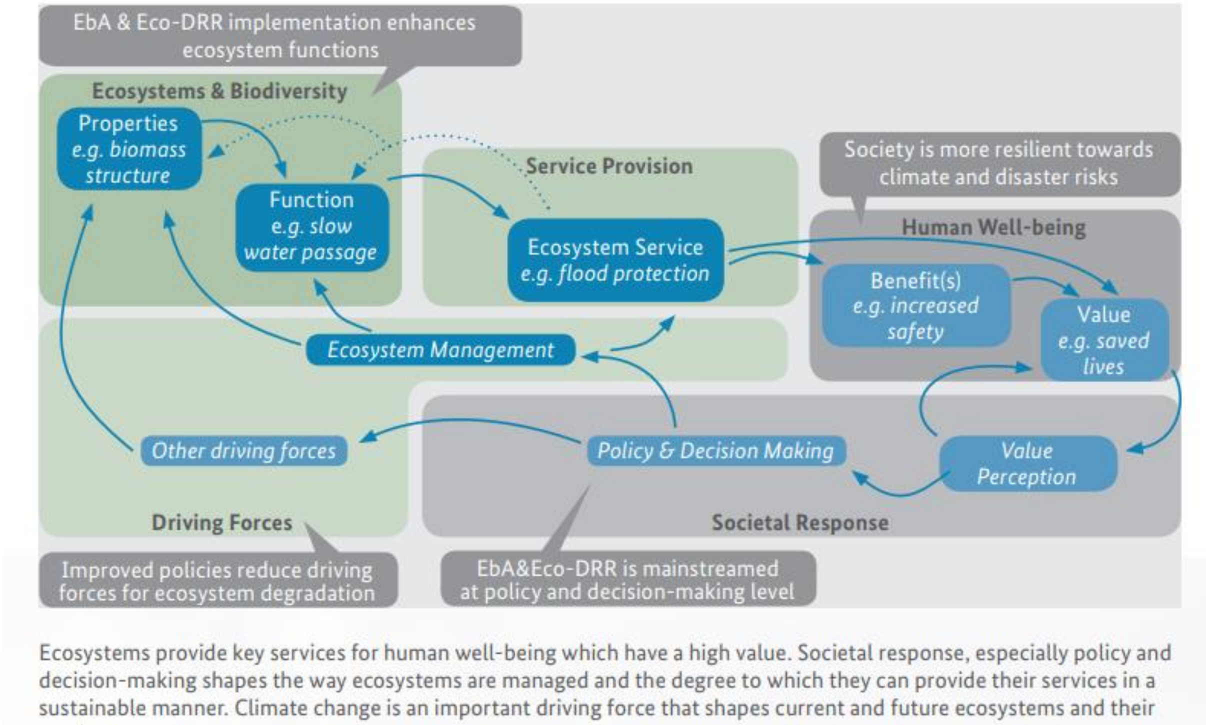
As per the guidelines, the two concepts are defined as follows:

"Ecosystem-based adaptation (EbA) is the use of biodiversity and ecosystem functions and services, as part of an overall adaptation strategy, contributing to the well-being of societies, including indigenous peoples and local communities, and helping people adapt to the adverse effects of climate change. EbA aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change.

Ecosystem-based disaster risk reduction (Eco-DRR) is the holistic, sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim of achieving sustainable and resilient development." (CBD 2019: 41)

The guidelines point out that the loss of biodiversity alters ecosystem functioning across temporal and spatial scales, thereby reducing ecological integrity and the corresponding capacity to provide ecosystem services. In response, EbA and Eco-DRR emphasize the importance of biodiversity and ecosystems in effective overall measures to address climate change adaptation and disaster risk reduction. (CBD 2019: 14)

As outlined by the guidelines, EbA and Eco-DRR build on other practices such as ecosystem conservation and restoration, providing multiple benefits for people, ecosystems and biodiversity, and thereby enable planning for climate change adaptation and disaster risk reduction on longer time scales. In addition, they can be cost-effective compared to standard engineered infrastructure, and emphasize community participation, as well as the use of traditional and local knowledge systems. Through their participatory nature and cross-sectoral approach, they can achieve multiple policy objectives, including local, regional and national strategies and related multilateral agreements in the area of climate change, disaster risk reduction, and sustainable development. (CBD 2019: 14) In addition, the guidelines point out that ecosystems can also prolong the sustainability and lifetime of built infrastructure. At the same time, biodiversity underpins the ecosystem processes and functions that provide critical services. (CBD 2019: 21) Figure 22 below showcases the linkages between policies, management, ecosystems and human-wellbeing within a social-ecological system in the context of EbA and Eco-DRR as contained in the guidelines.



Source: CBD 2019: 23, figure 2

Figure 22: Linkages between policies, management, ecosystems and human-wellbeing within a social-ecological system in the context of EbA and Eco-DRR

Therefore, the guidelines point out that countries are increasingly integrating ecosystem-based approaches into national risk reduction plans and strategies. Examples of mainstreaming EbA and Eco-DRR have been synthesized in a CBD Technical Series document (see LO 2016). However, the guidelines point out that a gap remains between policy development and implementation, in turn the objective of the guidelines is to support and enable the design and implementation of EbA and Eco-DRR strategies as part of an overall climate change adaptation or disaster risk reduction strategy, on multiple scales (i.e. short, medium and long-term, as well as on local, sub-national and national level). (CBD 2019: 14)

As, in practice, and also in the light of the conceptual linkages between adaptation to climate change and disaster risk reduction as outlined previously, EbA and Eco-DRR are difficult to distinguish, the guidelines address both concepts simultaneously. (CBD 2019: 24)

According to the guidelines, the following features are characteristic for EbA and Eco-DRR activities, they:

> a) enhance resilience and reduce social and environmental vulnerabilities to current and future climate change impacts and disaster risk, thereby contributing to incremental and transformative adaptation and disaster risk reduction,
>
> b) generate societal benefits, contributing to sustainable and resilient development using equitable, transparent and participatory approaches,
>
> c) make active use of biodiversity and ecosystem services through sustainably managing, conserving and restoring ecosystems, and
>
> d) are part of overall strategies for climate change adaptation and risk reduction that are supported by policies at multiple levels, and encourage equitable governance while enhancing capacity. (CBD 2019: 24)

Some concrete examples of EbA and Eco-DRR activities provided in the guidelines include restoration of floodplains, greening of cities, crop diversification with indigenous varieties that are resistant to climate variability, the creation of protected areas, sustainable management of grasslands and rangelands, and training activities to enhance knowledge on the use of ecosystems for climate change adaptation. (CBD 2019: 25)

Other examples provided include community-based adaptation, climate-smart agriculture, natural water retention measures, and building with nature solutions. The guidelines also set out that, in practice, EbA and Eco-DRR have included many approaches that are considered nature-based solutions, including ecological restoration, integrated coastal zone management, integrated water resources management, green infrastructure, and protected areas management. The guidelines further state that such approaches often place emphasis on participatory processes and community engagement. (CBD 2019: 26) Figure 23 below provides an overview of the examples of EbA and Eco-DRR as provided by the CBD guidelines.

Hazard/climate change impact	Ecosystem type	EbA or Eco-DRR intervention options	Outcome
Drought Soil erosion Erratic rainfall	Mountains and forests	Sustainable mountain wetland management Forest and pasture restoration Restoration of pastures with deep-rooting native species	Improved water regulation Erosion prevention Improved water storage capacity
Erratic rainfall Flood Drought	Inland waters	Conservation of wetlands and peatlands River basin restoration Transboundary water governance and ecosystem restoration	Improved water storage capacity Flood risk reduction Improved water provisioning
Erratic rainfall Temperature increase Shift of seasons Drought	Agriculture and drylands	Ecosystem restoration and agroforestry Intercropping of adapted species Using trees to adapt to changing dry seasons Sustainable livestock management and pasture restoration Drought resilience by sustainable dryland management	Improved water storage capacity Adaptation to higher temperatures Adaptation to shifting seasons Improved water provisioning
Extreme heat Temperature increase Floods Erratic rainfall	Urban	Green aeration corridors for cities Storm water management by green spaces River restoration in urban areas Green facades for buildings	Heat wave buffering Adaptation to higher temperatures Flood risk reduction Improved water regulation
Storm surges Cyclones Sea level rise Salinization Temperature increase Ocean acidification	Marine and coastal	Mangrove restoration and coastal protection Coastal realignment Sustainable fishing and mangrove rehabilitation Coral reef restoration	Storm and cyclone risk reduction Flood risk reduction Improved water quality Adaptation to higher temperatures

Source: CBD 2019: 42

Figure 23: Examples of EbA and Eco-DRR interventions and outcomes

As can be seen from the above, EbA and Eco-DRR approaches can be used in a broad range of areas and to address many of the natural hazards that countries are faced with.

In addition, the guidelines outline multiple benefits going beyond climate change adaptation and disaster risk reduction, ranging from environmental, to economic and social benefits that can emanate from the implementation of EbA and Eco-DRR approaches, outlining that they are often referred to as no- or low-regret options. (CBD 2021: 28) Inter alia, they outline that EbA and Eco-DRR also enhance biodiversity conservation, and that, with the post-disaster reconstruction period offering an opportunity to build back better, this provides new opportunities to conserve and restore biodiversity. “As biodiversity underpins the services provided by ecosystems, investing in approaches that enhance biodiversity is like broadening a risk reduction investment portfolio to provide long-term returns for the future. Assessing multiple benefits of nature-based solutions can be challenging due to the considerations of benefits/costs across socio-cultural, socio-economic, environment, biodiversity, ecosystem, and climate elements, but is an area of active research." (CBD 2021: 28)

Furthermore, the guidelines point to direct economic benefits, as well as broader benefits of effective EbA and Eco-DRR, including, inter alia, avoided costs of using artificial systems, improved social cohesiveness, contributing to employment and income security, improving the quality of life and mental and physical health of people, knowledge enhancement, and the engagement of people and communities, helping to build trust and responsibility while maintaining livelihoods and providing potential business opportunities. Furthermore, they can address underlying key risk drivers, thereby generating more robust solutions. The guidelines, however, acknowledge that these benefits are difficult to quantify in monetary terms. (CBD 2019: 34f)

The guidelines go on to say that governments urgently need to implement resilient adaptation and risk reduction measures, as mounting evidence shows that sustainable management, conservation and restoration of ecosystems are effective solutions for the current global challenges. "By addressing risk across scales and through a social-ecological lens, EbA and Eco-DRR provide flexible and effective options as part of an overall strategy for adaptation and disaster risk reduction, while promoting multiple benefits for people, nature and the economy." (CBD 2019: 35)

The guidelines therefore provide a framework for planning and implementing EbA and Eco-DRR (see figure 24 below), as well as key principles and safeguards. The safeguards encompass social and environmental measures with the aim to avoid unintended consequences, as well as to enhance transparency, and to promote the realization of benefits. In turn, the principles serve as high-level standards to guide planning and implementation. (CBD 2019: 43)

Table 1 Framework for planning and implementing EbA and Eco-DRR

Overarching considerations: Integrating knowledge of IPLCs, mainstreaming, raising awareness and building capacity

Step	Purpose
A. Understanding the Social-Ecological System (SES)	Identify key features of the target SES, including biodiversity and ecosystem services, and their inter-linkages with people
B. Assessing vulnerabilities & risks	Identify the main climate change and disaster risks and impacts on the SES
C. Identifying EbA and Eco-DRR options	Identify potential options within an overall adaptation/risk reduction strategy
D. Prioritising, appraising and selecting options	Develop criteria for prioritizing and appraising options, including consideration of scale and monetary- and non-monetary benefits
E. Project design & implementation	Design and implement selected options, ensuring ongoing stakeholder engagement, capacity-building, mainstreaming and monitoring
F. Monitoring & evaluation	Improve implementation by providing information for adaptive management and encourage continual learning to help inform future policy and practice

Source: CBD 2019: 35, table 1

Figure 24: Framework for planning and implementing EbA and Eco-DRR

The guidelines also specifically set out governance opportunities for EbA and Eco-DRR, also a central element of the Sendai Framework. Inter alia, governance aspects are highlighted as key considerations when planning EbA and Eco-DRR measures, the argument being that multi-level and multi-sectoral approaches are required to address holistic ecosystem management for risk reduction objectives. Specifically, the guidelines identify the following three areas as key governance challenges:

1. Multi-level governance, like climate change, disaster risk reduction and ecosystem governance occur within a complex web of stakeholders operating at different levels, highlighting the role of local and regional settings for the formulation of adaptation and risk reduction strategies;
2. Multi-sectoral governance, i.e. the integration of adaptation and risk reduction issues in different sectors and corresponding policies as central mechanism of governance; and
3. Governing under uncertainty, i.e. challenges in formulating and implementing adaptation strategies due to considerable uncertainties around the sensitivity of the climate system, regional climate impacts and the consequences for social-ecological systems. (CBD 2019: 36)

The guidelines therefore state that governance arrangements should be able to: a) undertake process-oriented approaches, b) react flexibly to new scientific findings and c) develop strategic stakeholder relationships according to the needs and opportunities arising, whilst considering the long-term perspective of all climate-related planning. (CBD 2019: 36)

In terms of institutional arrangements, the guidelines point out that policy responses need to consider diverse contexts and socio-economic considerations beyond the relatively restricted means of national governments, highlighting that linking ecological dynamics with policies in complex, multi-jurisdictional settings with adaptive management and governance frameworks can move social-ecological systems toward greater sustainability. (CBD 2019: 36)

The guidelines stress that policy integration is relevant at all levels of governance, with e.g. subnational actors playing a key role in effective governance and the need to address trade-offs between environmental and economic objectives through policy development, land use planning and permitting and licensing of infrastructure or economic activities. More specifically, in terms of relevant stakeholders, according to the guidelines, the integration of ecological concepts into governance frameworks requires a dialogue between actors from multiple areas, including ecologists, hydrologists, climate experts, social scientists, resilience experts and legal scholars. Therefore, a broad suite of stake- and rights holders should be considered in the planning phase of a project, and opportunities for joint action with government institutions on different levels should be identified and built into coherent climate change adaptation or risk reduction strategies. In addition, duplication of efforts or gaps should be avoided by clearly defining roles, responsibilities and mandates while respecting equity and human rights aspects. (CBD 2019: 36)

The guidelines also stress the following specific governance principles relevant for the mainstreaming of EbA and Eco-DRR: inclusive decision-making, transparency, responsiveness and accountability. The guidelines state that "[i]n times of uncertainty, polycentric governance systems, with multiple centers of semiautonomous decision-making, can have numerous advantages such as enhanced adaptive capacity, provision of good institutional frameworks for natural resource systems, and mitigation of risks due to redundant governance actors and institutions". (CBD 2019: 37)

As outlined above, the guidelines also contain a set of principles and safeguards in the form of social and environmental measures to avoid unintended consequences of EbA and Eco-DRR to people, ecosystems and biodiversity, which are clustered around the themes of: building resilience and enhancing adaptive capacity, inclusivity and equity, consideration of multiple scales, and effectiveness and efficiency. (CBD 2019: 43)

Furthermore, the guidelines include the following three overarching considerations for EbA and Eco-DRR design and implementation when undertaking the gradual process for planning and implementing EbA and Eco-DRR: integrating knowledge, technologies, practices and efforts of indigenous peoples and local communities; mainstreaming of EbA and Eco-DRR; and raising awareness and building capacity. It is stated that taking these actions into account can enhance uptake of EbA and Eco-DRR approaches, and improve effectiveness and efficiencies, enabling more and better outcomes from the interventions. (CBD 2019: 45)

The guidelines follow a stepwise approach to the design and implementation of effective EbA and Eco-DRR, which is linked to a toolbox providing a non-exhaustive selection of further guidance and tools for each of the five steps, whilst it is made clear that stakeholder engagement, mainstreaming, capacity-building, and monitoring should be conducted throughout the process. (CBD 2019: 45)

One of the main overarching considerations, as outlined above, is the mainstreaming of EbA and Eco-DRR, i.e. the integration of ecosystem-based approaches into the planning and decision-making processes at all levels in the area of climate and disaster-risk, i.e. into national and regional developments policies, processes and budgets at all levels. According to the guidelines, this may start with the integration of ecosystem considerations into adaptation and disaster risk reduction objectives, strategies, policies, measures, and operations. (CBD 2019: 47) The importance of alignment with national and subnational development frameworks is highlighted, as well as of mainstreaming into relevant plans, policies and practices at multiple scales. Furthermore, it is highlighted that a disaster and climate risk reduction lens should be incorporated also in the implementation of environmental impact assessments and strategic environmental assessment. (CBD 2019: 47f) The guidelines include the following key actions for the mainstreaming of EbA and Eco-DRR, which, for the sake of the analysis to be conducted in the next chapters of this thesis, are replicated in full:

"a. Underscore the value of healthy ecosystems in adaptation and disaster risk reduction policies and frameworks, supporting the maintenance of functioning and provisioning of essential services under current and future climate change scenarios.

b. Assess existing national adaptation and disaster risk reduction policies, plans and investments, in addition to broader (non-adaptation- and DRR-related) environmental, land use and development policies and plans to identify entry points for promoting Eco-DRR/CCA implementation. These include, but are not limited to:

> i. National Biodiversity Strategies and Action Plans (NBSAPs)
>
> ii. National Adaptation Plans (NAPs) and linkages to Nationally Determined Contributions (NDCs) and national legislation (...)

iii. National Plans for Land Degradation Neutrality

iv. Disaster risk management plans, including national drought strategies

v. Land-use planning, including urban planning

vi. Agricultural, fisheries, water, infrastructure, and other sectors (…)

vii. Development policies

viii. Budget plans

c. Align EbA and Eco-DRR with national and sub-national development frameworks and mainstream into relevant plans, policies and practice at multiple scales to enhance long-term sustainability and possibilities for funding (…).

d. Align with international frameworks and conventions, such as the [Sustainable Development Goals], CBD Strategic Plan for Biodiversity, and others, and incorporate EbA and Eco-DRR measures into reporting schemes.

e. Improve convergence in the design and implementation of EbA and Eco-DRR into existing programmes of work (including adaptation, environment, development, humanitarian), including climate-proofing existing interventions.

f. Incorporate a disaster and climate risk reduction lens when implementing Environmental Impact Assessments (EIAs) and Strategic Environmental Assessments (SEAs) to prevent unintended environmental impacts that may exacerbate risk and to promote EbA and Eco-DRR measures.

g. Invest in risk-informed development by protecting existing healthy natural/green infrastructure from new development (e.g. water-infrastructure or coastal) and by creating boundary conditions for the design of such large-scale developments.

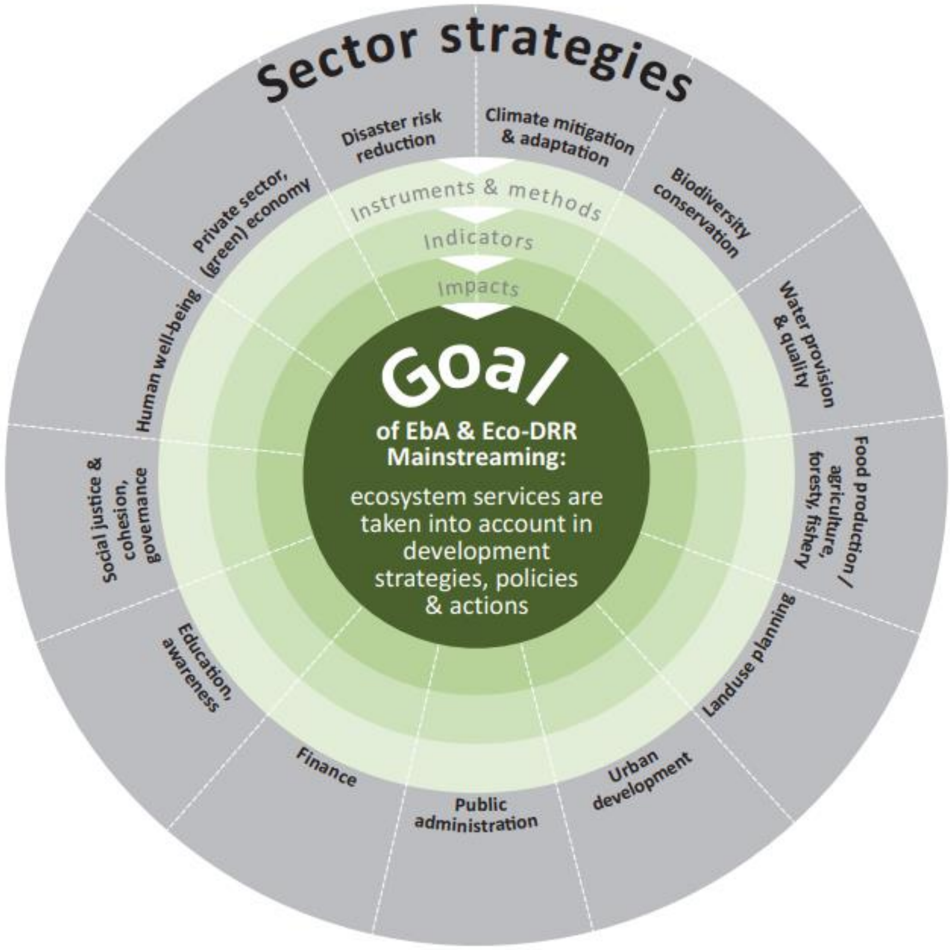
h. Create entry points for ecosystem-based solutions in ministerial guidelines for tenders by developing boundary conditions, including considering green or hybrid solutions before grey when more effective.

i. Create incentive structures for the promotion of eco-friendly infrastructure development and incentives for private sector to include EbA and Eco-DRR (e.g. tax reduction); and

j. Screen national tax systems and public funding to avoid/eliminate perverse incentives, ecosystem degradation, or maladaptation.

k. Review technical standards, e.g. procurement documents, guidance and [monitoring and evaluation] project cycle needs to allow flexibility of ecosystem solutions." (CBD 2019: 48f).

As can be seen from the above, the mainstreaming of EbA and Eco-DRR covers a wide range of different sectors and areas, policy and planning frameworks and decision-making processes. As this is a very complex task, the guidelines also outline various entry points for the integration of EbA and Eco-DRR (see CBD 2019: 50f). Figure 25 below showcases the simple framework for mainstreaming EbA and Eco-DRR within key development and sectoral strategies as contained in the guidelines:



Entry points for mainstreaming EbA and Eco-DRR within key development and sectoral strategies by embedding ecosystem-based approaches into existing instruments and methods, selecting appropriate indicators for monitoring and evaluation, ensuring successful impact by developing a theory of change.

Source: CBD 2019: 52, figure 7

Figure 25: Entry points for mainstreaming EbA and Eco-DRR within key development and sectoral strategies

The guidelines also contain information on awareness raising and capacity building measures (CBD 2019: 53f), as well as a stepwise approach to the design and implementation of effective EbA and Eco-DRR. (CBD 2019: 55ff)

As has been shown, the guidelines provide comprehensive information on EbA and Eco-DRR in general, as well as practical guidance for their implementation.

3.2. Opportunities and challenges of ecosystem-based disaster risk reduction and ecosystem based adaptation

The following section will provide a snapshot of opportunities offered by EbA and Eco-DRR on the one side, but also the challenges that decision-makers and practitioners face with regard to their implementation and wider uptake.

With regard to opportunities, the CBD guidelines provide a comprehensive overview of opportunities per the various sectors. (CBD 2019: 95 to 151)

Whilst there are still knowledge gaps (see further below), and as was outlined already in the previous chapter, existing research has shown that ecosystems indeed play a role in the reduction of disaster risk, particularly in terms of the reduction of the physical exposure to hazard events by serving as natural infrastructure buffers and protective barriers, e.g. with regard to forests and the management of wildfires, management of stormwater, flood mitigation in urban areas, and the reduction of mountain hazards e.g. through use of vegetation on steep slopes. (SUDMEIER-RIEUX K., ARCE-MOJICA T., BOEHMER H.J. ET AL. 2021: 808, UNDRR 2021: 64)) Also, there are close links to hazard mitigation through ecosystem services related to water and soil protection, erosion control, soil fertility maintenance and water purification, stabilization of regional climates, and storing and sequestering of carbon. (SUDMEIER-RIEUX ET AL. 2019: 73f) Also notable are the various services and functions ecosystems provide in addition to hazard reduction, such as in terms of strengthening of livelihoods and the reduction of vulnerability as another relevant aspect of disaster risk reduction. (SUDMEIER-RIEUX K., ARCE-MOJICA T., BOEHMER H.J. ET AL. 2021: 808) As Faivre et al. have pointed out, this is now also recognized in a range of EU policies, pointing to the central role ecosystems play in terms of natural hazard reduction, including e.g. the Floods Directive, the Biodiversity Strategy, the EU Green Infrastructure Strategy, and the EU Action plan for nature, people and the economy. (FAIVRE ET AL. 2018: 5)

In general, it can be summarized that ecosystems have the potential to mitigate the risk of negative external impacts and/or to provide buffers against natural hazards, reduce the frequency of hazard occurrence, and provide natural habitats, thereby reducing the risk of animal-human conflict and of the spread of diseases. At the same time, ecosystem-based approaches have the potential to maintain or even improve ecosystem functions and biodiversity, and improve living conditions and human well-being. (UNDRR 2021: 42f)

Furthermore, nature-based solutions as umbrella concept for EbA and Eco-DRR are tools to strengthen the resilience of ecosystems and help address various societal challenges, also with a view to comply with the Sustainable Development Goals (EEA 2021: 20f), as outlined in figure 26 below:

Core societal challenges (CSCs) for CCA and DRR where NbS can provide direct benefits			
CSC no	**Challenges**	**Relevant SDG**	**Relevance of NbS and related concepts for CCA and DRR**
CSC 1	Improving society's resilience to extreme weather- and climate-related events	SDG 13	Increases resilience to abrupt natural hazards and slow-onset events including heat waves, heavy precipitation, droughts, flooding, sea level rise, wildfires, landslides and avalanches, windstorms and storm surges
CSC 2	Food security, sustainable agriculture and forestry	SDG 2, SDG 15	Protects, restores and promotes sustainable use of terrestrial ecosystems including sustainable management of forests, combats desertification, halts and reverses land degradation and loss of biodiversity
CSC 3	Preserving habitat, reducing biodiversity loss and increasing green and blue spaces	SDG 14, SDG 15	Reduces or prevents loss of natural capital/biodiversity and the ecosystem services it provides (clean air, water and soil); enhances coastal resilience and marine protection; increases natural insurance value, thus improving ecological resilience
CSC 4	Water management	SDG 6	Improves water quality and quantity and reduces water stress
CSC 5	Social justice, cohesion and equity, and reducing risk for groups of society highly vulnerable to climate change	SDG 10	Improves liveability, health and well-being for an ageing population and deprived communities to counteract growing inequalities and enhance social cohesion
CSC 6	Public health and well-being (related to climate change impacts)	SDG 3	Reduces mortality and morbidity directly or indirectly due to adverse heat and flood events; reduces stress and anxiety
CSC 7	Make cities and human settlements inclusive, safe, resilient and sustainable	SDG 11	Regenerates urban and rural areas; promotes sustainable land use and liveable urban development, including urban green and blue spaces and urban agriculture
Other societal challenges (OSCs) where NbS can provide multiple benefits			
OSC no	**Challenges**	**Relevant SDG**	**Sub-topics**
OSC 1	Environmental quality, including air quality and waste management	SDG 12	Regulate chemicals and micro-pollutants in water bodies, reduce eutrophication of water bodies, abate urban air pollution problems (e.g. traffic emission, industry) and restore polluted soils (e.g. heavy metal in former brownfield sites)
OSC 2	Public health and well-being (in addition to public health and well-being related to climate change)	SDG 3	Improve mental well-being (thinking, attentiveness, concentration and sociability, stress, depression, etc.); develop and maintain immune defences (against asthma, allergies, diabetes, intestinal disease, cancer, etc.); enhance physical health (exercise and sport)
OSC 3	Sustainable economic development and decent employment (including green jobs)	SDG 8	Promote inclusive and sustainable economic growth (potential for new economic opportunities) through full and productive employment and decent work for all (potential for green jobs)
OSC 4	Climate change mitigation	SDG 13	Sequestering carbon and reducing greenhouse gas emissions

Source: EEA 2021: 21, table 1.1

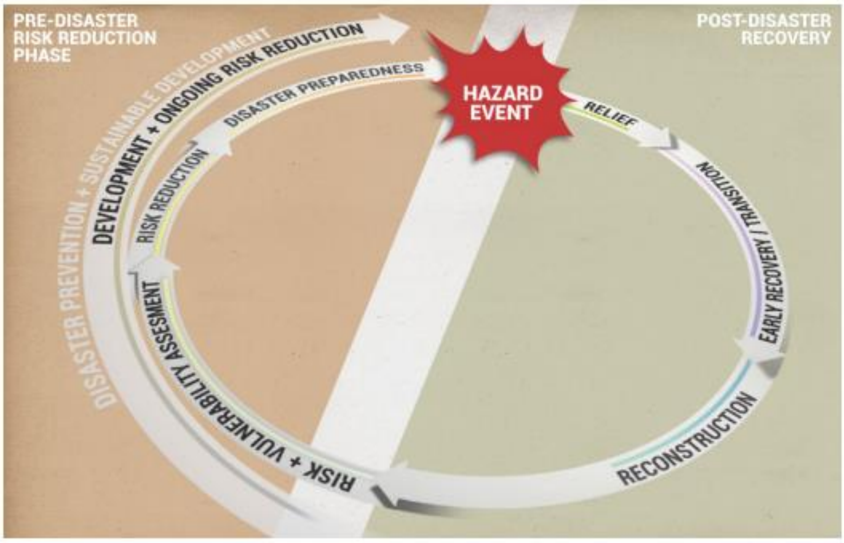
Note: CCA = climate change adaptation, DRR = disaster risk reduction, SDG = sustainable development goals

Figure 26: Societal challenges and nature-based solutions for climate change adaptation and disaster risk reduction

Furthermore, and as already pointed out before, Eco-DRR/EbA measures are considered as cost-efficient ways to address disaster risks with mitigation effects for multiple hazard types, albeit more often in the long-term, therefore requiring long-term planning. In addition, biodiversity and ecosystems can support adaptation to potential hazard modifications caused by climate change. (PORATELLI 2020: 2, SUDMEIER-RIEUX ET AL. 2019: 81, UNDRR 2020: 39, OECD 2020: 9, and MCVITTIE ET AL. 2018: 43) Therefore, they are often described as no-regrets options, as they support biodiversity conservation on the one hand, and improve livelihood security and reduce risk on the other hand. (ARCE-MOJICA ET AL. 2019: 2, OECD 2020: 9) Furthermore, it has been pointed out that their benefits can outweigh the costs of implementation and maintenance, and increase the effectiveness and operable life of grey infrastructure. (OECD 2020: 10) As Chabba et al. point out, techno-centric measures, which disaster risk reduction strategies traditionally rely on, represent a hazard-by-hazard risk management approach, which in turn does not consider the interlinkages and systemic nature of disaster risks, with the often highly resource- and capital-intensive measures more often than not disrupting ecological processes and further increasing vulnerability. (CHABBA ET AL. 2022: 1f)

Furthermore, as ecosystem degradation can directly and indirectly contribute to natural hazards becoming disasters, ecosystem conservation, management and restoration should also be seen as suitable measures for disaster risk reduction. (SUDMEIER-RIEUX ET AL. 2019: 49) In addition, they can be seen as crucial tools to manage increasingly complex and systemic risks caused by unsustainable development practices and environmental changes, which in turn create and perpetuate patterns of vulnerability, exposure and risk. (UNDRR 2020: 39) Also with regard to the uncertainties related to climate change, they can assist in managing uncertainty by allowing for flexibility to adapt, contrary to e.g. grey infrastructure options. (OECD 2020: 9)

In addition, as Sudmeier-Rieux et al. point out, in the disaster risk reduction discourse, there have been calls for a paradigm shift towards disaster risk reduction through long-term planning and investments in the reduction of underlying risk factors with the aim to reduce hazard impacts (see figure 27 below for an amended version of the classic disaster management cycle, see also e.g. UNDRR 2021: 128f). As they highlight, Eco-DRR and EbA can play a vital role in this, with a need to take into account ecosystem considerations in all phases of the disaster risk reduction spiral. (SUDMEIER-RIEUX ET AL. 2019: 101 and 111) For example, they indicate that, adding a layer of ecosystem related information in risk assessment processes can improve vulnerability, hazard and risk assessments, as this provides additional information with regard to the interface between the risk components and ecosystem properties. (SUDMEIER-RIEUX ET AL. 2019: 118) As also outlined by UNDRR, it would be important to include ecosystem-related information in risk assessments in terms of ecosystem susceptibility and risk robustness in a transdisciplinary manner, however sourcing data as basis for the assessment is often challenging, establishment of a national database of environmental assessments, studies and monitoring systems might therefore be needed. (UNDRR 2021: 78ff) Specific tools and approaches to address this issue could include the so-called strategic environmental assessment, post-crisis integrated strategic environmental assessments, the inclusion of environmental considerations in post-disaster needs-assessments, and e.g. the use of integrated valuation of environmental services and trade-offs. (UNDRR 2021: 88f) This also follows a similar line as the recommendations regarding the reporting guidelines for EU Member States with regard to national risk assessments as outlined in the previous section. As Faivre et al. indicated, the integration of EbA and Eco-DRR into governance and development plans can also improve risk understanding in general, whilst providing opportunities for faster implementation. (FAIVRE ET Al. 2018: 6)



Source: SUDMEIER-RIEUX ET AL. 2019: 101, figure 9.2

Figure 27: Disaster risk reduction spiral

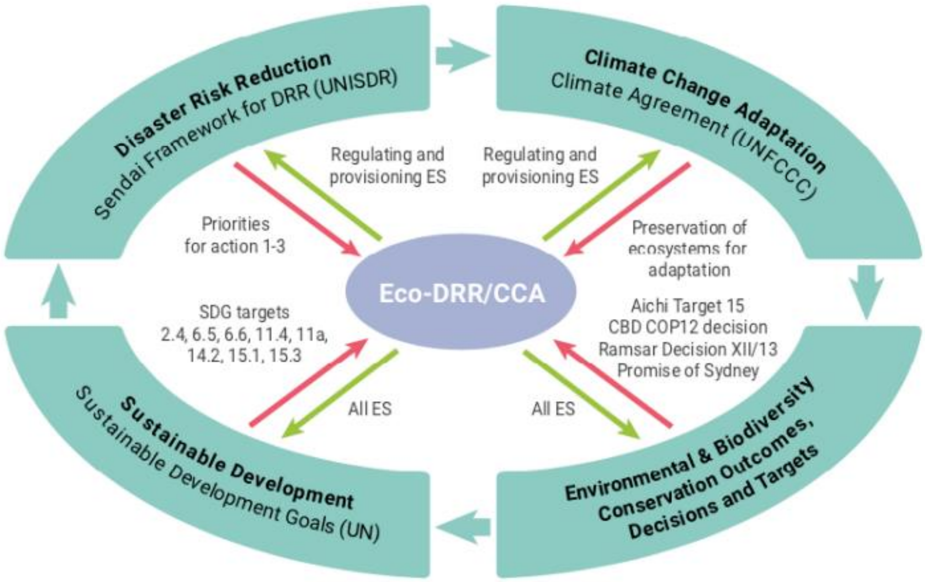
UNDRR provided a non-exhaustive list of nature-based solutions for the different phases of disaster risk reduction, as showcased in figure 28 below, which impressively shows the various entry points throughout the entire cycle of disaster risk reduction for ecosystems, their services, and in turn ecosystem-based approaches:

Phase		Time frame after hazard event	Objectives	Main actions	Ecosystem services privileged	Ecosystem-management component
Response		Hours to days after	Save lives	Search & rescue, emergency skills	Provisioning services	Avoiding dumping of hazardous materials in environmentally sensitive areas or habitats; possible use of provisioning services from ecosystems (food, wood, shelter, etc.)
Rehabilitation / Recovery		Days to months after	Secure livelihoods	Temporary shelters, provision of basic services, e.g. water, food	Provisioning, regulatory services	Rapid environmental assessments, sourcing of sustainable materials for recovery, waste management
Reconstruction		Months to years after	Reconstruct livelihoods	Reconstruction/ provision of housing and infrastructure, job creation	Provisioning, regulatory, supporting and cultural services	Environmentally sensitive reconstruction, sustainable materials sourcing, improved waste management, ecosystem restoration, green infrastructure and improved ecosystem management for DRR
Prevention	**a) Risk and vulnerability assessments**	Continuously updated	Analyses and assess risk	Hazard and exposure mapping, vulnerability assessments, risk	Regulatory and provisioning services	Integrating ecosystems in risk assessments (see Priority for action 1)
	b) Development planning and risk reduction	Continuous process, on regular intervals	Hazard, vulnerability and exposure reduction	Risk-sensitive land use planning, based on assessments	Provisioning, regulatory, supporting and cultural services	Ecosystem and land management plans, ecosystem protection and restoration included in planning and zoning (see Priority for action 3)
	c) Preparedness	Continuously updated	Increase readiness for future hazard events	Creation and maintenance of early warning systems, evacuation plans	Regulatory and provisioning services	Including ecosystems in environmental emergency preparedness programmes

Source: UNDRR 2021: 129, table 3.9

Figure 28: Nature-based solutions for the different phases of disaster risk reduction

As can be seen in figure 29 below, Eco-DRR and EbA can also contribute to the implementation of and are embedded in many of the various global frameworks and agreements relating to sustainable development. It shows the various ecosystem services and priorities and how they are linked to goals and targets of the various relevant global frameworks. (UNDRR 2020: 24) As pointed out by UNDRR, there is therefore a possibility of cross-fertilization between the work undertaken following and in line with the various agreements on the one hand, and disaster risk reduction strategies on the other hand, including the possibility of sharing data and indicators and thereby reducing reporting burdens for countries. (UNDRR 2021: 12)



Source: UNDRR 2020: 24, figure 5

Note: Green arrows: illustrate various levels of ecosystem services; red arrows: highlight the main provisions of each agreement related to Eco-DRR / EbA; SDG = Sustainable Development Goals; ES = ecosystem services;

Figure 29: Eco-DRR/EbA major priorities and decisions with regard to major international framework agreements

Additionally, as a recent OECD Environment Policy Paper pointed out, there is also increasing recognition of the synergies between ecosystem health and human well-being on the one hand, and economic benefits on the other hand, as investments in ecosystems also provide economic dividends. (OECD 2020:3) This being an important argument in political decision-making, it is worth mentioning this as a clear opportunity of ecosystem-based approaches, also from an economic point of view.

Furthermore, grey infrastructure may imply trade-offs due to risk transfer and in addition structural measures need to be maintained on a regular basis, with only a limited life cycle and a limited capacity to adapt to changing conditions. (UNDRR 2021: 47) However, blue or green infrastructure can complement substitute, or safeguard grey infrastructure, therefore a hybrid approach offers various benefits. (UNDRR 2021: 50) This in addition to the fact that ecosystem-based approaches offer greater potential to adapt to change caused by climate change, etc. A combination or a change to blue or green infrastructure has therefore become more and more common in developed countries, including the EU, where e.g. the 2000 EU Water Framework Directive has played an important role in this respect, albeit it being noteworthy that implementation thereof on Member State level is still lagging behind. (UNDRR 2021: 61)

As was already outlined above, a manifold range of risks can be addressed via ecosystem-based approaches. For example, this includes the risk of gravity-driven natural hazards such as in the Alpine region. As outlined by Poratelli, at this point in time, the main instruments for addressing these hazards are structural measures for the prevention of said hazards, risk mapping with a view to implementing land use limitations, and non-structural measures including monitoring and early warning systems. (PORATELLI 2020: 2) As their study shows, as an alternative and to complement these measures, protection forests as Eco-DRR solution can have a general protective effect through, inter alia, reduction of soil erosion and the transport of sediments into catchments, as well as offering direct protection of specific assets. Protection forests can protect against the occurrence of hazards, e.g. in relation to avalanches, but also mitigate the impact of hazards, e.g. in relation to rock fall. (PORATELLI 2020: 2) Therefore, protective forests can be highly effective in the prevention and mitigation of mass movements in the Alps, also with regard to addressing changing hazards due to climate change with resilient solutions. (PORATELLI 2020: 6) Similarly, as Arce-Mojica et al. point out, due to their hydrological and geo-mechanical properties, forests can contribute to the stabilization of hillslopes and reduce the risk of shallow landslides. However, the protective function of forests and vegetation depends on various factors, including soil moisture and type/thickness, water infiltration, climatic conditions, geological and topographic characteristics, etc., but also the health of the forest, species composition, root system, and so on. (ARCE-MOJICA ET AL. 2019: 1) Similarly, as Dorren and Moos summarize, forests that cover steep slopes can protect against snow avalanches (by reducing the probability thereof), shallow landslide release (through reinforcement effects of tree roots), the impact of falling rocks (through the barrier effect of individual trees and the reduction of energy of falling blocks), bank and surface erosion, and indirectly against debris flows and floods (through reduction of onset probability and intensity, water infiltration, increased water storage capacity and reduced concentration time of catchments, higher porosity of the soil and interception of precipitation by leaves). Furthermore, vegetation leads to improved soil structure and aggregate stability and fixation of the soil, protection of the surface from rain splash, and binding and stiffening the upper soil mantle. (DORREN AND MOOS 2022: 2) As Moos et al. have pointed out the practice of protection forests has a long tradition in many countries, with communities endeavouring to use forests for the protection of their livelihoods. (MOOS ET AL. 2018: 498) Klein et al. also pointed to the potential of the diversity of ecosystem services in mountains in relation to improved social and ecological resilience. They also pointed out that biodiversity and natural resources are of value particularly for local people and that ecosystem-based approaches promote cross-scale and cross-governance approaches, which is particularly important in mountains due to the risk of secondary and cascading hazards, and requiring simultaneous mobilization of relief efforts for multiple on-going hazards. (KLEIN ET AL. 2019: 149f)

Also with regard to soil loss, e.g. in the form of natural hazards such as landslides and erosions, which is a global threat e.g. in terms of implications for provision of food and resources, can be addressed via a combination of engineering principles with ecosystem functioning, i.e. in the form of vegetation, and land management approaches. As Gonzalez-Ollauri points out, the discipline of soil and water bioengineering already utilizes various ecosystem-based approaches, including techniques such as landscape architecture, soil mechanics, hydrogeology, plant ecology and ecosystem service management, all of which should be explored more closely also from a disaster risk reduction perspective. (GONZALEZ-OLLAURI 2022: 1)

This is also reflected by Whelchel et al., who pointed to the potential of watershed management applications that use ecosystems such as floodplain forests and wetland, agricultural lands, but also public amenities to reduce downstream flooding risks. (WHELCHEL ET AL. 2018: 30)

As Trémolet and Karres (2020) have pointed out, there is also potential in protecting water resources of European cities via nature-based solutions, noting a dependence of existing water supply systems depending heavily on grey infrastructure in the form of engineered solutions for drinking water supplies. (TRÈMOLET AND KARRES 2020: 12f) Their analysis showed the feasibility and cost-effectiveness of nature-based solutions for supporting drinking water protection for many European cities, with e.g. improved cultural practices representing a low cost approach, as well as planting of cover crops showing strong potential to address sediment and nutrient pollution at low cost. (TRÈMOLET AND KARRES 2020: 15, 17) Their analysis also shows the potential of forest protection in terms of reduction/avoidance of spoil loss and protection of water quality, and riparian buffers in terms of protection of source catchments by reducing sediment and nutrient pollution at local scales. (TRÈMOLET AND KARRES 2020: 17f) They also point to co-benefits (in addition to financial benefits), such as freshwater biodiversity, carbon sequestration / avoided carbon emissions, amenity value and positive health/well-being impacts. (TRÈMOLET AND KARRES 2020: 18)

Chabba et al. point out that Eco-DRR measures in marginalized urban communities offer opportunities for a cost-effective increase in urban resilience and sustainability, thereby addressing pre-existing socio-economic vulnerabilities, which are being aggravated by climate change and disaster risk exposure. (CHABBA ET AL. 2022: 2) Similarly, Brink et al. have highlighted the potential of urban EbA, including in light of its focus on societal welfare. (BRINK ET AL. 2016: 112) This is particularly important, as a recent EEA briefing pointed out that current climate change adaptation measures are not necessarily equitable, with e.g. lower access of most vulnerable groups to green space and early warning systems, affordability of flood insurance or flood-proofing measures, etc. (EEA 2022) Also, Carter et al. point out that e.g. green infrastructure at the landscape scale plays an important role in urban climate change adaptation in general and flood risk management in particular in light also of the interacting pressures due to urbanisation and climate change that cities and urban areas are increasingly faced with, yet planning and governance challenges remain, inter alia, in light of the multiple sectors and stakeholders involved in ownership and management. (CARTER ET AL. 2018: 1536 and 1548)

Yet another area where ecosystem-based approaches can address risks are peatlands, which have been described as playing an important role in tackling climate change and biodiversity loss as significant risk drivers, also from a disaster risk reduction perspective. Peatland drainage contributes to various environmental problems and related hazards, including greenhouse gas emissions, nitrogen pollution and biodiversity loss. Therefore, ecosystem-based solutions, such as improved management of drained peatlands, have gained attention, as they can result in the avoidance of greenhouse gas emissions, reinstalling carbon sequestration, reduction of nitrogen mineralization, and enhanced nitrogen removal, as well as restoration of biodiversity. (TANNEBERGER ET AL. 2021: 2)

Holden et al. showcased the potential of nature-based solutions as climate change adaptation approach, supporting the reduction of drought impacts due to climate change through the management of vegetation cover in mountain headwater catchments, highlighting that, whilst afforestation as a tool can in some cases be detrimental to water supply, the overall socio-economic benefits (as dividends from headwater catchments are likely increased) versus dis-benefits need to be factored in. However, they indicate that further research is needed to enhance the understanding of the contribution of nature-based solutions to climate change offsetting, and the point in time and conditions when the potential of nature-based solutions to reduce hydrological drought impacts caused by anthropogenic climate change would be exceeded. (HOLDEN ET AL. 2022: 7)

Sebesvari et al. have showcased the contribution of Eco-DRR to shoreline stabilization, erosion control and wave energy attenuation, as well as the protection of existing grey infrastructure. (SEBESVARI ET AL. 2019: 2)

As outlined by the OECD, climate change will particularly intensify risks of water-related hazards, with a deteriorating natural environment increasing the vulnerability thereto and resulting in negative impacts on human well-being. (OECD 2020: 8) Ecosystems and related approaches can play a vital role in countering the related risks. Inter alia, urban flooding can be managed by the implementation of green drainage systems or the installation of green roofs, the risk of drought can be reduced through the maximization of water storage capacity and/or the slowing of water release. (OECD 2020: 12)

In terms of ecosystem-based agriculture, a study by Björklund et al. indicates that biodiversity and ecosystem services can be promoted whilst increasing food production in the long-term and enhance the resilience of livelihoods and agriculture. (BJÖRKLUN ET AL. 2012: 828 and 851) As they show, dropping water levels, soil erosion, loss of soil fertility, and extinction of crop varieties and wild species as a result of industrialized agriculture leading to an alteration of ecosystems and their services can be addressed through ecosystem-based agriculture practices. (BJÖRKLUN ET AL. 2012: 825) However, they highlight the importance of increased diversity of managed and wild flora and fauna, as well as of increased multifunctionality as part of agroecological management methods. Also, they show the need for more research on ways to scale-up eco-based farming systems. (BJÖRKLUN ET AL. 2012: 851)

Marchal et al. also point towards an increased link between disaster insurance and nature-based solutions / Eco-DRR through the emerging concepts of “insurance value of ecosystems” / “nature insurance value”, as the sector is moving from an ex-post perspective, to a more ex-ante preventative role. (MARCHAL ET AL. 2019: 1 and 16)

Yet another approach was taken by Al Kautsar and Mulyono, who used the ecosystem-based DRR concept to explain roles, relationships and the entire network of disaster-management actors, concluding that it can be used as a framework to examining real-life cases of disaster management. (AL KAUTSAR AND MULYONO 2020: 310)

Last but not least, ecosystem-based approaches of course also have an impact in terms of countering biodiversity loss and ecosystem degradation as such. For example, Straatsma et al. point out that river restoration has a positive influence on fish, macroinvertebrates, as well as aquatic plants, as proven by meta-analyses of restoration success. (STRAATSMA ET AL. 2017: 1) Their analysis showed a reversed decline of biodiversity via the combination of large-scale physical reconstruction of floodplains with ecological rehabilitation in densely populated river deltas. However, they point out that habitat restoration as such is not sufficient for full biodiversity recovery, as flora and fauna species face multiple stressors within and outside the floodplain areas. Despite various challenges remaining, they still come to the conclusion that regional river restoration has a very high potential for the enhancement of habitats for species and biodiversity in general, and countering the decline of species on the whole delta region. (STRAATSMA ET AL. 2017: 6)

To summarize, the list of measures available to Eco-DRR and EbA to minimize the various risks, including those increasingly aggravated by climate change, covers a wide range of options, including landscape restoration, wetland restoration, climate smart agriculture/agroforestry, urban greening, blue-green infrastructure, pre- and post-disaster management, and hybrid infrastructure. (UNDRR 2021: 31ff) The above is only a snapshot of the steadily growing research on the various ways ecosystem-based approaches can contribute to disaster risk reduction.

On the other hand, it must be acknowledged that there are also quite a number of challenges that remain with regard to the implementation and broader uptake of ecosystem-based approaches. Some of these challenges will be outlined in the following paragraphs.

Despite the increasing attention ecosystem related approaches have received on the international policy level, the potential of ecosystems and related approaches, including their performance in terms of hazard mitigation, is not yet very well understood or documented, further gathering of scientific evidence will be necessary to support policymakers in order to enhance the use of Eco-DRR measures and to increase the general uptake by practitioners. (see e.g. SUDMEIER-RIEUX K., ARCE-MOJICA T., BOEHMER H.J. ET AL. 2021: 803, GONZALEZ-OLLAURI 2022: 1, OECD 2020: 15) A dominance of technical and structural solutions can still be observed with regard to disaster risk reduction and climate change, which might be linked to the persisting lack of evidence and robust performance data of the effectiveness of ecosystem-based approaches. (SUDMEIER-RIEUX 2019: 8 and OECD 2020: 15) Yet another problem in this regard and as outlined by Sudmeier-Rieux, Arce-Mojica, Boehmer, et al., is that the term Eco-DRR, contrary to nature-based solutions, is rarely referenced in scientific publications, whilst they acknowledge that this might be due to the fact that the term as such is relatively new and will therefore probably gain traction over time, similar to the term nature-based solutions (SUDMEIER-RIEUX K., ARCE-MOJICA T., BOEHMER H.J. ET AL. 2021: 807f) “[S]cience appears to be lagging behind compared to the promotion of [nature based solutions] in international and policy areas. However, we have to consider that this is a complex field, which involves multiple disciplines and perspectives, confusing practitioners and policy makers due to the slight differences and overlaps among the [nature-based solution] concepts." (ARCE-MOJICA ET AL. 2019: 10)

This showcases yet another challenge, namely that the delineation between the various concepts of nature-based solutions, ecosystem-based approaches, i.e. Eco-DRR and EbA, etc. is still very difficult, largely also because of the substantive overlaps and intrinsic interlinkages between the various concepts and approaches, potentially leading to confusion and hindering their uptake by practitioners. (see also SUDMEIER-RIEUX ET AL. 2019: 8 and 63) This is also outlined by Calliari et al., who indicate that there is no widely-agreed upon definition of nature-based solutions, and that the distinction between them and other ecosystem-based approaches is still disputed, leading to those terms seeming conceptually arbitrary and impractical. (CALLIARI ET AL. 209: 692) They therefore propose a dynamic assessment framework for climate proofing nature-based solutions, which takes into account the impact of climate change on the frequency and intensity of hazards on the one hand, but also the effectiveness of the proposed solution on the other, indicating that previous assessment frameworks were too static to also consider changing future conditions, even if they took into consideration socio-economic and climate change scenarios. (CALLIARI ET AL. 209: 692)

Knowledge gaps also exist with regard to the tipping points of ecosystems, the effect of ecosystems on slow-onset disasters such as drought, the effect of disasters on ecosystem health and services, and the timespan needed for ecosystem protection. (SUDMEIER-RIEUX ET AL. 2019: 207) As also Ha has pointed out, ecosystems are highly complex and dynamic, combining biotic and abiotic components, as they consist of animals, plants, living communities and non-living environments, as well as complex interactions among them, thereby making assessments and analysis more difficult. Furthermore, ecosystems and natural disasters follow a two-way pattern, i.e. there being a systemic interaction between them, also adding to the difficulty of assessments and analysis. (Ha 2020: 1897)

As outlined by Holden et al., there is also a lack of quantitative evidence of the effect of nature-based solutions on modulating the biophysical impacts resulting from anthropogenic influence on extreme weather and climate events, i.e. anthropogenic climate change, with most quantitative assessments focusing on climate change mitigation potential. They highlight the difficulties of quantifying the potential due to lack of sampling distribution, problems with attributing individual extreme events to anthropogenic climate change, with extreme events resulting from a combination of human-induced and natural drivers of climate change and internal climate variability. According to them, there is need for methods to, from a meteorological perspective, quantify the role of anthropogenic climate change in the changing characteristics of extreme events, which in turn would then also be used for quantifying the role of nature-based solutions in moderating the impacts of said events. (HOLDEN ET AL. 2022: 2)

Similarly, Moos et al. highlighted the lack of quantification of risk reduction provided by protection forests, which in turn would be necessary for an objective comparison with technical/structural measures. Also, knowledge regarding effects of forests in terms of risk reduction is still lacking, with Moos et al. pointing to the need for detailed forest data and on natural hazard processes at larger scales, as well as a better accounting for uncertainties around forest effects and natural dynamics. (MOOS ET AL. 2018a: 509) Therefore, Moos et al. developed a general framework for the integration of protection forests into quantitative rockfall (intensity and frequency) analysis. (MOOS ET AL. 2018b: 56f) As they point out, real-case comparison of slopes with and without forests are very rare, therefore rockfall simulation models are used to consider the effect of trees, which however also show limitations (such as e.g. lack of distinction between individual tree species, interaction between block and slope surfaces, etc.). (MOOS ET Al. 2018b: 65)

As outlined by UNDRR, there is need to enhance the understanding of how to scale up nature-based solutions for large scale solutions, as so far mainly small-scale solutions have been used in practice. In addition, solutions need to be tailored to the specific context, limits to nature-based solutions are not well researched yet, and locally specific knowledge of ecosystem parameters is needed, whereas grey infrastructure is more or less context-independent, thereby potentially aggravating the case for nature-based solutions. Therefore, UNDRR calls for the development of ecological engineering performance standards. (UNDRR 2021: 68)

Furthermore, lack of evidence might also negatively impact public perception of ecosystem-based approaches, thereby aggravating decisions by decision-makers to choose them over traditional, more well-known and generally accepted approaches. (GONZALEZ-OLLAURI 2022: 2)

In addition, it has been noted that e.g. evidence with regard to the role of drylands and agro-economic systems from a disaster risk reduction perspective is still lagging behind, as is research with regard to negative ecosystem services (such as e.g. trees becoming fuel for forest fires or wetlands offering habitat for mosquitoes as vectors for malaria) (SUDMEIER-RIEUX K., ARCE-MOJICA T., BOEHMER H.J. ET AL. 2021: 808), as well as quantitative evidence for the impact of prevention of biodiversity loss on climate change (MORI 2020: 1731). Also, further research is needed with regard to protective forests and vegetation, it has e.g. been noted that there is a lack of comparative studies with regard to different types of vegetation, the role of heterogeneous mountains and of biogeographical regions under various physical and social-ecological settings, as well as the negative effects of vegetation as trigger factors. (ARCE-MOJICA 2019: 2 and 10)

Overall, it has been noted that there are methodological issues with regard to measuring the benefits of ecosystems and related approaches, particularly in terms of quantitative comparison with e.g. structural engineering measures, therefore aggravating classic cost-benefit analysis and the existence of evidence of economic viability as basis for political decision-making. (see e.g. SUDMEIER-RIEUX ET AL. 2019: 80 and CHABBA 2022: 2)

Similarly, the OECD points out that comparative studies regarding the value of nature-based solutions versus alternative solutions are still lagging behind, as are economic appraisals that accurately capture their co-benefits, e.g. the stimulatory economic effect of job creation. (OECD 2020:9) Inter alia, this is due to the fact that the long-term nature of benefits aggravate an estimation of the economic benefits, particularly in the early implementation stage, and the non-monetary nature of many benefits make a quantification more difficult. (UNDRR 2020: 19) As outlined by UNDRR, in cost-effectiveness analysis, contrary to cost-benefit analysis, which only addresses costs and benefits in monetary terms, only costs are assessed in monetary terms, whereas benefits are evaluated from a outcome/effect perspective, which can lead to very different assessment results when comparing grey with green/blue infrastructure. (UNDRR 2021: 52) However, as outlined by UNDRRR, more work is necessary with regard to standardization and ecosystem service assessment. (UNDRR 2021: 56) As Onuma and Tsuge pointed out, grey infrastructure usually generates environmental costs due to landscape and ecosystem deterioration, whilst green infrastructure on the hand create environmental benefits in the form of enhanced biodiversity and improved landscapes. (ONUMA AND TSUGE 2018: 22f) They highlight that cost-benefit analysis can indeed be used to compare the efficiency of grey and green infrastructure on the basis of net benefit or the benefit-cost ratio. Also, they aim for including the aspect of uncertainty into cost-benefit analysis, as e.g. the function of green infrastructure is not always certain in light of lack of experience/scientific knowledge, size of population, etc. (ONUMA AND TSUGE 2018: 23)

In addition, as Faivre et al. pointed out, there is need for an identification of the types of financial, social, economic and political incentives that would be needed to increase the uptake of ecosystem-based approaches. (FAIVRE ET AL. 2018: 9)

Also, as Sudmeier-Rieux et al. have pointed out, the incorporation of data on ecosystem degradation and ecosystem services as part of risk assessments, also as basis for decision making, is still lagging behind. (SUDMEIER-RIEUX ET AL. 2019: 122) Similarly, Hinzpeter and Sandholz advocate for an inclusion of ecosystem-based approaches into Post Disaster Needs Assessments, indicating that post-disaster situations are potential windows of opportunities for an enhancement of ecosystem-based approaches. (HINZPETER AND SANDHOLZ 2018: 114)

Furthermore, with regard to on-the ground implementation and scaling up the uptake of ecosystem-based approaches, as Dorren and Moos pointed out, implementation standards for Eco-DRR are still generally lacking, and problems might arise due to conflicting interests, e.g. with regard to land ownership and property rights. (DORREN AND MOOS 2022: 1) In addition, they argue that, without sound quantified evidence of the net benefit of specific protective functions, including return on investment and the financial and organisational resources needed to ensure the durability, the scaling up of Eco-DRR will remain problematic. (DORREN AND MOOS 2022: 2) Similarly, as the OECD points out, there is an issue with scaling up the uptake of nature-based solutions, with the majority so far having been implemented on a one-off pilot project basis and in an ad hoc manner. (OECD 2020: 13) Also Chabba et al. point out that, as most disaster risk reduction investments rely on cost-benefit analysis as conceived relatable communication tool towards political decision makers and the general public, the notion that structural disaster risk reduction is the more viable option is being perpetuated, as it cannot account for the benefits provided by diverse ecosystems and does not consider issues related to equity. Furthermore, conventional cost-benefit analysis does not account for risk variability and uncertainty in e.g. the mitigation effects of ecosystems, as ecosystems respond non-conformingly and non-linearly to changing conditions, thereby further weakening the reliability of the analysis of Eco-DRR. Therefore, they developed a nuanced risk-based approach to cost-benefit analysis, with the aim to providing actionable information. (CHABBA ET AL. 2022: 2) Furthermore, the OECD paper points out that existing methods for the assessment, valuation and monitoring of co-benefits of nature-based solutions are in many cases underdeveloped or their application is challenging. In addition, the hydrological and other services that different ecosystems types deliver differ quite significantly, and the costs and benefits of the various related solutions are location specific. (OECD 2020: 14)

As already highlighted, there are also various issues related to the overall awareness of the multiple benefits and opportunities offered by ecosystem-based approaches within the disaster risk reduction community. As e.g. outlined by Sudmeier-Rieux et al., tools and approaches for long-term risk reduction include integrated water resource management, sustainable land management, integrated coastal zone management, integrated fire management, and protected area management, however their link to disaster risk reduction is not always taken in to consideration by disaster managers. (SUDMEIER-RIEUX ET AL. 2019: 151, UNDRR 2020: 37) This is also mirrored by the OECD paper, which points out that there is still limited awareness around the importance of ecosystems to overall resilience on the one hand, and the potential of nature-based solutions in terms of meeting risk management objectives on the other hand, with in many cases still a prevailing perception that traditional grey solutions are the most practical and reliable option for the management of water-related risks. Furthermore, nature-based solutions are still being perceived as difficult to implement, and access to finance is still a major barrier for the scaling-up of nature-based solutions. (OECD 2020: 20) Therefore, the OECD proposes a policy evaluation framework for the assessment of national enabling environments with regard to the deployment of nature-based solutions. (OECD 2020: 20ff)

In the context of disaster-related impacts and the advancement of disaster-risk reduction efforts, there is a general lack of understanding and consideration of ecosystems and related services and related losses, as outlined by Walz et al. Therefore they advocate an inclusion of disaster-related losses of ecosystems and their services in the Sendai Framework Monitor, identifying various specific indicators under the relevant targets of the Sendai Framework, such as e.g. under green infrastructure, economic loss, agricultural losses, etc. (WALZ ET AL. 2021: 10) “Given the direct link between ecosystems and [disaster risk reduction], the comprehensive monitoring of disaster-related losses of ecosystems and their services is essential for planning sustainable [disaster risk reduction] strategies and measures.” (WALZ ET AL. 2021: 11). At the same time, they point out the difficulty of assessing the value of ecosystems and their services, particularly when going beyond the provisioning services they provide. (WALZ ET AL. 2021: 11) This is also echoed by Sebesvari et al., who argue that, even though ecosystems are not directly included in any of the targets of the Sendai Framework, thereby aggravating the monitoring of ecosystem losses and damages, as well as the progress in the implementation of ecosystem-based measures, there are entry points to include monitoring of related losses, most notably under green infrastructure such as wetlands as entry point and making use of custom targets and indicators. (SEBESVARI ET AL. 2019: 2)

With regard to approaches entailing land-use change, Fedele et al. also call for ecosystem services assessments to consider feedback loops and multiple impacts on ecosystem services, in order to enable a locally appropriate design and implementation of sustainable land-use solutions. This particularly as they point out that radical change might be needed in light of uncertainties and complexities of the impacts of drivers of change due to climate change, biodiversity loss, etc. (FEDELE ET AL. 2018: 17)

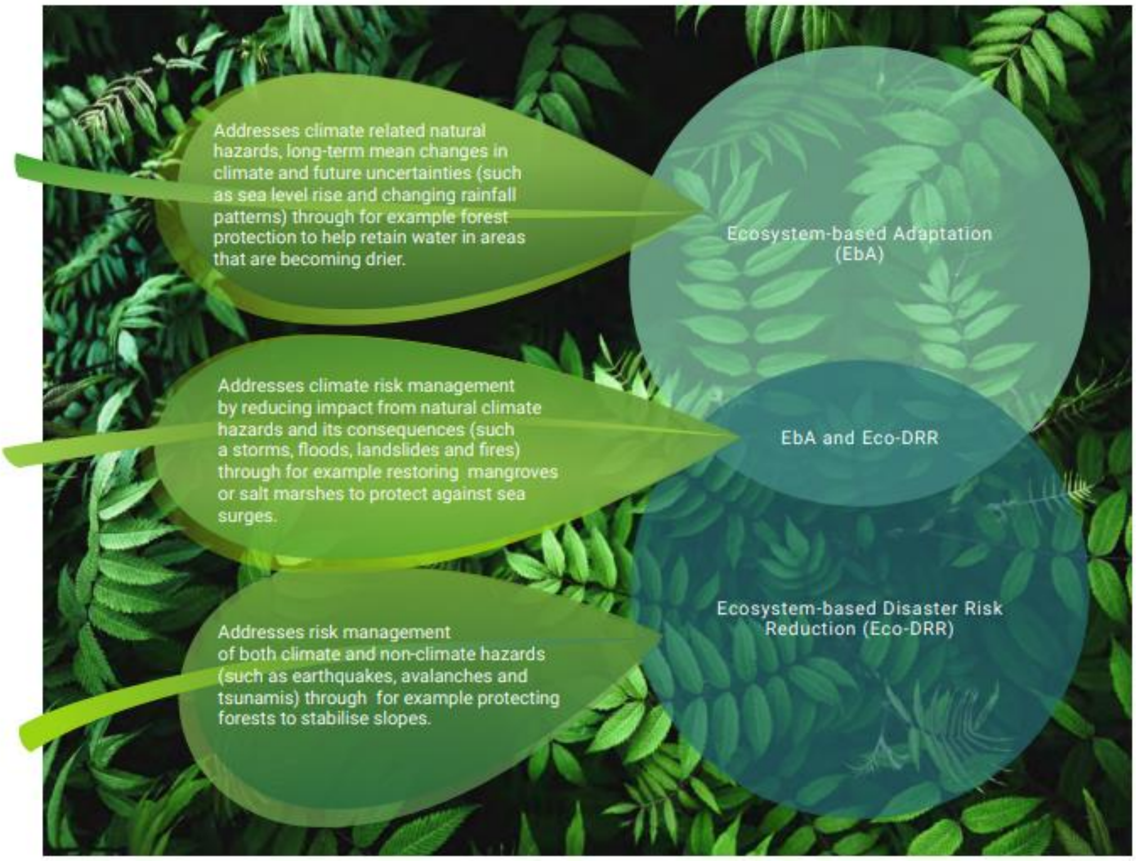
With regard to the specific example of protection forests, various management guidelines have been made available in various countries; however, as Poratelli et al. point out, the use of protection forests in risk management is still uncommon. (PORATELLI 2020: 6) Also, with regard to peatland restoration, Tanneberger et al. point out that, despite strong scientific evidence underpinning ecosystem services from peatland rewetting and technical guidance available, there is still need to create social acceptance and support for the implementation of such approaches. (TANNEBERGER ET AL. 2021: 3) On the other hand, due to local specificities of ecosystems, the establishment of standard ecological engineering guidelines for various ecosystem types and hazards has been aggravated. (SUDMEIER-RIEUX ET AL. 2019: 206)

In general, as pointed out by the EEA, there is need for the development of technical standards, capacity-building and sufficient funding to further promote the update of nature-based solutions. (EEA 2021: 11)

As e.g. also Whelchel et al. have highlighted with regard to eco-engineering, there is also further need for definitions, design, calibration and monitoring at various scales, geographies, and coastal, watershed and urban circumstances, as well as the creation of equivalences and assurances, indicating that the immideiate goal should be the incorporation of ecosystem dynamics and characteritics also into regulatory guidance and standards. (WHELCHEL ET AL. 2018: 30) "(…) a shift from traditional single objective engineering to multiple objective solutions is paramount (…) Even if process steps are meticulously followed, eco-engineering projects remain challenging as they currently often require innovative techniyues that lack proper design standards and performance metrics in response to locally specific constraints and opportunities." (WHELCHEL ET AL. 2018: 39)

With regard to green infrastructure at landscape level, Carter et al. have pointed out that complementary research is needed to look into different locations, as well as additional adaptation functions, e.g. food production, and cooling effects in terms of air transfer and reduction of heat stress. Yet, they also highlight the demanding nature of progressing climate change adaptation at landscape scale, inter alia due to cross administrative boundaries (CARTER ET AL. 2018: 1549), which also leads to the challenge outlined in the next paragraph.

Similar to the silo approach taken to climate change adaptation and disaster risk reduction, it can be noted that this is also true for EbA and Eco-DRR due to the different policy, legal and institutional contexts, with national coordination and planning mechanisms for disaster risk reduction and climate change offering valuable entry points for promoting and mainstreaming integrated Eco-DRR and EbA approaches. (SUDMEIER-RIEUX 2019: 66 and 69, and DOSWALD AND ESTRELLA 2015: 6) And, whilst there is an evolution of hybrid Eco-DRR/EbA projects, they are still being recognized either as Eco-DRR or EbA. As Sudmeier-Rieux et al. point out, there is a need to maximize synergies between disaster risk reduction and climate change communities with the aim to avoid mal-adaptation and/or to increase risk, as well as to avoid a duplication of respective efforts. Therefore, the EbA discipline could benefit from Eco-DRR knowledge, and the sustainability of Eco-DRR could profit from EbA adaptive management sensitive to climatic and environmental changes. Enhanced synergies would in turn promote integrated multi-level governance tools, integrated multi-hazard and climate change assessments, and community-based approaches for disaster risk reduction and climate change adaptation. (SUDMEIER-RIEUX ET AL. 2019: 70) “[Disaster risk reduction] processes have multiple connections with climate change adaptation and mitigation, yet few [disaster risk reduction] plans take these connections into account. (...) Failure to identify and harness mutual benefits of [disaster risk reduction] and [climate change adaptation] is a missed development opportunity. Healthy ecosystems and their management play a key role in supporting post-disaster recovery, but importantly also reducing future risks and supporting adaptation.” (UNDRR 2020: 35f) As outlined by UNDRR, there are many commonalities between the two concepts of Eco-DRR and EbA, particularly due to their focus on ecosystem management, restoration and conservation aiming to increase resilience, making it difficult to distinguish between them in practice, figure 30 showcases the overlaps between the two concepts. (UNDRR 2021: 29f) Yet, despite the potential offered by increased synergies between climate change adaptation and disaster risk reduction in general, and EbA and Eco-DRR in particular, this has not yet been fully acknowledged by on-the ground practitioners, as was outlined in this section.



Source: UNDRR 2021: 29, figure 2.2.

Figure 30: Overlap between EbA and Eco-DRR

In addition, Eco-DRR projects aim to work and influence both, disaster risk reduction and environmental policies, yet environmental ministries usually play only a marginal role in disaster risk reduction. (SUDMEIER-RIEUX ET AL. 2019: 65) This is similarly also reflected by UNDRR, which pointed out that the integration of disaster risk reduction and climate change adaptation into legal frameworks still remains the exception, as climate change adaptation responsibilities usually lie with environmental ministries without an explicit requirement for coordination with institutions responsible for disaster risk management, which again links back to the silo issue outlined above. (UNDRR 2021: 176)

Yet another challenge is that ecosystems and biodiversity are highly complex processes, requiring a holistic understanding and analysis of a specific situation and location in order to avoid unintended consequences of measures (e.g. reforestation with monocultures). (SUDMEIER-RIEUX ET AL. 2019: 88)

It should also be noted that ecosystem restoration is harder and more cost intensive compared with conservation, which e.g. in case of urban landscapes requires novel ways of reshaping. (UNDRR 2021: 63)

Furthermore, not all hazards can be effectively mitigated via ecosystems, which is particularly true for non-climatic hazards such as earthquakes or volcanic eruptions, even though they can mitigate the impacts thereof, that the magnitude of the hazards surpasses the protective capacity of the ecosystem, and that ecosystem-based solutions often require a lot of land. (SUDMEIER-RIEUX ET AL. 2019: 53, 55, 69) Particularly the latter can become a problem, as land-use / spatial planning typically takes place within a political context, which can make long-term planning more difficult and favour short-term gains. At the same time, integrating disaster risk reduction into environmental impact assessments as a tool for land-use / spatial planning would offer great potential in order to institutionalize Eco-DRR and EbA. (SUDMEIER-RIEUX ET AL. 2019: 126 and 136) Similarly, as the OECD points out, due to the long-time scales needed for the development of intended benefits, the large spatial scales, dynamic uncertainty and diffused benefits, in many cases nature-based solutions seem to be ill suited for decision making within institutional, regulatory and financial frameworks that were designed for grey infrastructure. (OECD 2020: 13) For example, the adaptation and other co-benefits of solutions that aim at the restoration of badly degraded ecosystems can take a long time to develop, e.g. due to the growth rate of living components, therefore not delivering risk reduction effects within the time frame desirable to policy makers. (OECD 2020: 13f). In addition, ecosystems are highly dependent on larger enabling environmental processes, cannot be managed in isolation, and, as already pointed out, related approaches might be very land-intensive, with potential trade-offs with other productive use of the land. (OECD 2020: 14) Another challenge is the dynamic nature of ecosystem-based solutions, caused by the involvement of living components, which on the one hand can increase adaptability, yet on the other hand also be a potential source of uncertainty, thereby aggravating the development of projections of the level of future services being provided. Therefore, it is vital that Eco-DRR and EbA anticipate climate impacts and the related tolerance of ecosystems thereto, as the OECD pointed out. (OECD 2020: 14)

Also, ecological infrastructure, i.e. a combination of engineered infrastructure used by disaster risk reduction, such as dikes, embankments or seawalls, with protective functions of ecosystems, i.e. green infrastructure, whilst potentially being less costly and more locally feasible, can be time-consuming, in addition to being land-intensive. Furthermore, it can fail if long-term maintenance is not guaranteed, and might be not be feasible due to biological limitations, space constraints, or prohibitive costs. (SUDMEIER-RIEUX ET AL. 2019: 161 and 163ff)

In addition, it should be noted that there might be a need for a combination of investment in ecosystems with other risk mitigation measures, e.g. through a hybrid approach combining Eco-DRR and EbA measures with human-built infrastructure, as well as early warning systems and disaster preparedness measures. (SUDMEIER-RIEUS ET AL. 2019: 80) This is also echoed by the EEA, which points to a need for more information on trade-offs and synergies emanating from a combination of ecosystem-based approaches and grey infrastructure (EEA 2021: 11)

Furthermore, Sudmeier-Rieux et al. point out that a preference can still be observed for immediate structural engineering approaches, rather than for investments in long-term prevention measures, such as Eco-DRR and EbA measures. (SUDMEIER-RIEUX ET AL. 2019: 81) This is also reflected in the recent OECD paper, which outlines that use of nature-based solutions remains limited, as, contrary to grey infrastructure, their use has not been mainstreamed in the various relevant policy areas, inter alia due to the existence of various barriers in enabling environments, which are still oriented more towards grey infrastructure. (OECD 2020: 3) This is an interesting finding, as it directly relates to research question 3 of this thesis.

Also, it should be noted that EbA and Eco-DRR measures can also have unintended negative consequences, such as e.g. increase in insect pests, reduction of public access to beaches or shorelines, loss or damage of natural habitats, opportunity costs of land-use change, etc. (MCVITTIE ET AL. 2018: 50f)

Another challenge remains with regard to the issue of governance. As outlined above, the CBD guidelines emphasize integrating risk governance in Eco-DRR and EbA approaches and projects. However, in practice, it seems that many challenges remain with regard to the actual on the ground implementation of risk governance in the context of Eco-DRR and EbA, not least due to the fact that those two are fairly new concepts and the knowledge gaps and lack of conceptual clarity as outlined above. For example, in a recent paper, Triyanti and Chu indicate that governance is being perceived as increasingly the main challenge facing disaster risk reduction and climate change adaptation (TRIYANTI and CHU 2018: 18) In a similar vein, UNDRR contested that many of the obstacles to disaster risk governance relate to a poor understanding of the motivation of people and organisations to act for the common good, and that there is a need to overcome the bias of decision-making toward the short-term, or toward the pursuit of private interests to the detriment of public interest. (UNDRR 2014: 27) In a recent paper, Wamsler et al. state that "... the widespread understanding that citizen involvement in [nature-based solutions] and [Climate Change Adaptation] per se leads to more positive, sustainable outcomes does not hold true" (WAMSLER et al. 2020: 246). Yet, the paper found that, albeit current citizen involvement often hampers sustainable outcomes, that should not question its relevance, but rather its structural conditions, such as limited processes for mainstreaming nature and climate considerations into sectoral planning and the perception that citizen involvement is a secondary consideration. (WAMSLER et al. 2020: 247) In addition, the paper points to a lack of consideration of personal sphere with regard to citizens, civil servants, and decision-makers. The paper argues that nature-based solutions and climate change adaptation often cannot be considered under the rational choice theory, which in turn has an impact on risk perceptions, individual motivations and behaviour. (WAMSLER et al. 2020: 247f) The paper attributes the same level of importance to subjectivities as an integral part of an individual's understanding of his/her relationship to others, as power structures, and therefore points to the need to also address the cognitive/emotional and relational qualities of decision-makers and civil servants in order for them to obtain new capacities to address also the personal sphere. (WAMSLER et al. 2020: 248)

Anderson and Renaud, in a recent paper, summarized the findings of Wamsler et al. as follows: barriers to citizen involvement include lack of institutional capacity and resources, conflicting public interest, resistance to change, and place attachment, with current organizational structures, due to lack of flexibility, not being conducive to successful citizen engagement. (ANDERSON and RENAUD 2020: 2) They also point to another study, which identified the following core topics in the context of perceptions of nature-based solutions: co-benefits, risk reduction efficacy, socio-economic and location-specific factors, participation, environmental attitudes, and uncertainty. Pointing to research gaps, Anderson and Renaud highlight the "… overly generic policy guidelines for societal interactions in the context of [nature-based solutions]" (ANDERSON and RENAUD 2020: 2). Based on their analysis, Anderson and Renaud come to the following insights: distinct social interactions across project phases need to be involved, and long-term issues of nature-based solutions are dependent on a broader range of public acceptance of the outcomes of the respective project. Therefore, they highlight a number of interconnected factors that are crucial for the success of such projects. Based on this, they suggest strategies leveraging said factors and increasing public acceptance. Therefore, they provide a "Public Acceptance of Nature-based Solutions framework" that is supposed to support practitioners in increasing public acceptance of nature-based solution projects. (ANDERSON and RENAUD 2020: 14) The paper also includes an overview of recommendations for increasing public acceptance of nature-based solutions. (ANDERSON and RENAUD 2020: 16ff.) The paper concludes that more research on the factors leveraging public acceptance of nature-based solutions, as well as the interactions among individuals, societies, and nature-based solutions is needed: "[p]ublic perceptions determine acceptance, which is crucial for the success and continued uptake of [nature-based solution]" (ANDERSON and RENAUD 2020: 19). Furuta and Shimatani even go so far to state that, in some cases, participatory planning processes with cross-sector, cross-professional and interactive design approaches are even more important than technical guidelines, particularly as many do not go beyond their respective sectoral silos. (FURUTA AND SHIMATANI 2018: 93)

Last but not least, and of particular interest for this thesis are challenges relating to the integration/mainstreaming of ecosystem-based approaches into national disaster risk reduction strategies and related implementation and action plans. In this regard, as UNDRR points out, more guidance is needed, as well as with regard to the promotion of the uptake of ecosystem-based approaches. Furthermore, awareness-raising and knowledge sharing, and sharing of experiences and lessons learned also still need to be enhanced. (UNDRR 2020: 33f) However, it should be noted that various documents and pieces of guidance have been developed and made available in recent years in order to support decision makers and practitioners in mainstreaming ecosystem-based approaches, similar to the CBD Voluntary Guidelines which were outlined above (see e.g. PARTNERS FOR RESILIENCE 2019, UNDRR 2021: 158-215, SUDMEIER-RIEUX ET AL. 2019: 184-190, UNDRR 2020: 30-36, UNEP 2015: 38-39, LO 2016: 61-70, MATTHEWS & OCAMPO DELA CRUZ 2022: 22-32, FAIVRE ET Al. 2018: 8f). Nonetheless, as outlined above, mainstreaming of EbA and Eco-DRR on a broader scale still remains limited. This is also reflected in a recent EEA report, which points out that, even though nature-based solutions are increasingly integrated into the various policy frameworks, the concept as such is not sufficiently embedded yet. (EEA 2021: 119) As also Young et al. pointed out, one of the reasons for the lack of a systematic implementation of nature-based solutions / ecosystem-based approaches, particularly on the local level, might be the challenge of translating abstract concepts into practical solutions, highlighting the need for an operational definition of ways for the incorporation of nature-based solutions into local planning. (YOUNG ET AL. 2019: 2)

This section has shown that, despite the many opportunities of EbA and Eco-DRR and the growing recognition thereof, quite a number of challenges remain, with many referring to the need for broadening the knowledge base and filling the remaining knowledge gaps, but also issues related to awareness, perception, enabling environments, access to funding, and so on.

4. Methodological approach

As the previous section has outlined, the mainstreaming of ecosystem-based approaches in policies, strategies, etc. relevant to particularly disaster risk reduction, but also for many other sectors would be vital for laying the foundation for the further uptake of said approaches, providing the necessary enabling environment, such as the legal and regulatory framework, as well as increasing overall awareness of decision-makers, practitioners and the general public of a) ecosystem degradation and biodiversity loss posing significant risk drivers, and b) the manifold added value of ecosystem-based approaches in the context of disaster risk reduction and adaptation. One of the aims of this thesis is therefore to analyse whether or not mainstreaming of ecosystem-based approaches can be observed in the relevant Austrian policies and/or strategies. The following section will therefore provide an overview of the methodological approach taken in this regard. At the outset it should be noted that, as was already outlined above, in light of the difficulty of clearly delineating the concept of nature-based solutions from ecosystem-based approaches, notably the former being conceived as an umbrella concept under which ecosystem-based approaches can be subsumed, the methodological approach taken in this thesis encompasses both concepts.

In a recent EEA report on nature-based solutions in Europe (EEA: 2021), the EEA conducted a review whether, and if so, in how far nature-based solutions options are addressed in the various global and EU policy frameworks. The approach of this report will be used as matrix for the methodological approach of this thesis.

For the review, the EEA defined "policy" as follows: "(…) understood as a set of ideas or plans that is used as a basis for making decisions in politics and also usually includes instruments for its implementation; these can be a regulation, strategy, action plan, agenda or global agreement, decision, resolution or framework" (EEA 2021: 25). Which policies to review in terms of enhancing the implementation and degree of support for nature-based solutions were identified through a desk-based review, in-house expertise and research project findings. (EEA 2021: 25) Figure 31 provides an overview of the policies reviewed in the EEA report.

Policy area	Global policy	EU policy
Cross-cutting	• 2030 Agenda for sustainable development, Sustainable Development Goals (2015) • United Nations (UN) Convention to Combat Desertification (1996) ([a])	• European Green Deal (2019) • Bioeconomy strategy (2012) and its update (2018)
Biodiversity (including forestry)	• UN Convention on Biological Diversity (1993) ([a]) • Ramsar Convention (1975) ([a])	• Biodiversity strategy for 2030 (2020) • Green infrastructure strategy (2013) • Habitats Directive (1992) • Birds Directive (1979/2009) • EU forest strategy (2013) • LULUCF Regulation (2018)
Climate	• Sendai Framework for Disaster Risk Reduction 2015-2030 (2015) • UN Framework Convention on Climate Change (1994) ([a]), Paris Agreement (2015)	• Action plan on the Sendai Framework for Disaster Risk Reduction (2016) • Strategy on adaptation to climate change (2013, 2021)
Water and agriculture		• Farm-to-fork strategy (2020) • Floods Directive (2007) • Water Framework Directive (2000) • Common agricultural policy (2013) • Nitrates Directive (1991)
Urban	• New urban agenda – Habitat III (2016)	• Urban agenda for the EU (i.e. Pact of Amsterdam, 2016)

Note: ([a]) The original agreements/treaties, as well as relevant subsequent conclusions, resolutions and decisions, were reviewed. LULUCF, Land use, land use change and forestry.

Source: EEA 2021: 26, table 2.1

Note: LULUCF = Land Use, Land-Use Change and Forestry

Figure 31: Global and EU policies included in the EEA review

The approach comprises three steps in total, whereby, in a first step, the policies outlined above were first reviewed in terms of explicit inclusion of nature-based solutions, ecosystem-based approaches or related terminology, as well as for implicit references to the use of nature, ecosystems and biodiversity. (EEA 2021: 26f)

For the review of explicit inclusion, the following search terms were used: nature-based solutions; ecosystem approach and ecosystem-based approaches; sustainable management, ecosystem-based management, sustainable forest management; green and/or blue infrastructure; ecosystem-based adaptation; natural water retention measures; and ecosystem-based disaster risk reduction. (EEA 2021: 26)

The second step comprised an assessment of references to climate change adaptation and/or disaster risk reduction, based on an initial key term search, i.e. risk, adaptation, and a review of the documents to identify linkages with these concepts, particularly to identify cases where other terms were used. (EEA 2021: 26)

The assessment of the extent of a specific policy supporting the deployment of nature-based solutions was made on the basis of expert judgement and on the basis of the review. In doing so, four levels of support were identified, as outlined in figure 29 below. The following key considerations were used to determine the level of support:

"(1) Are [nature-based solutions] terms used 'explicitly' or 'implicitly' in the policy text (and related documents, for global policies)?

(2) Are these concepts linked in the policy to climate change adaptation and/or disaster risk reduction?; and

(3) How strongly are [nature-based solutions] terms and related concepts for climate change adaptation and disaster risk reduction embedded in the policies and their objectives, actions instruments?" (EEA 2021: 27)

Level of support	Description
Strong explicit support	Explicit mention of NbS in connection with CCA and/or DRR; strong embedding throughout the policy, including in objectives, actions and instruments
Strong implicit support	Strong framing of nature, biodiversity and ecosystems as a means to address CCA and/or DRR challenges but no explicit mention of NbS; strong embedding throughout the policy, including in objectives, actions and instruments
Medium support	NbS are mentioned explicitly or implicitly, but they are not a prominent feature in the policy and/or linkages to CCA and DRR are weak or missing
Low support	NbS are neither a prominent feature of nor relevant for or mirrored in policy measure design and supported actions, particularly with regard to CCA and DRR

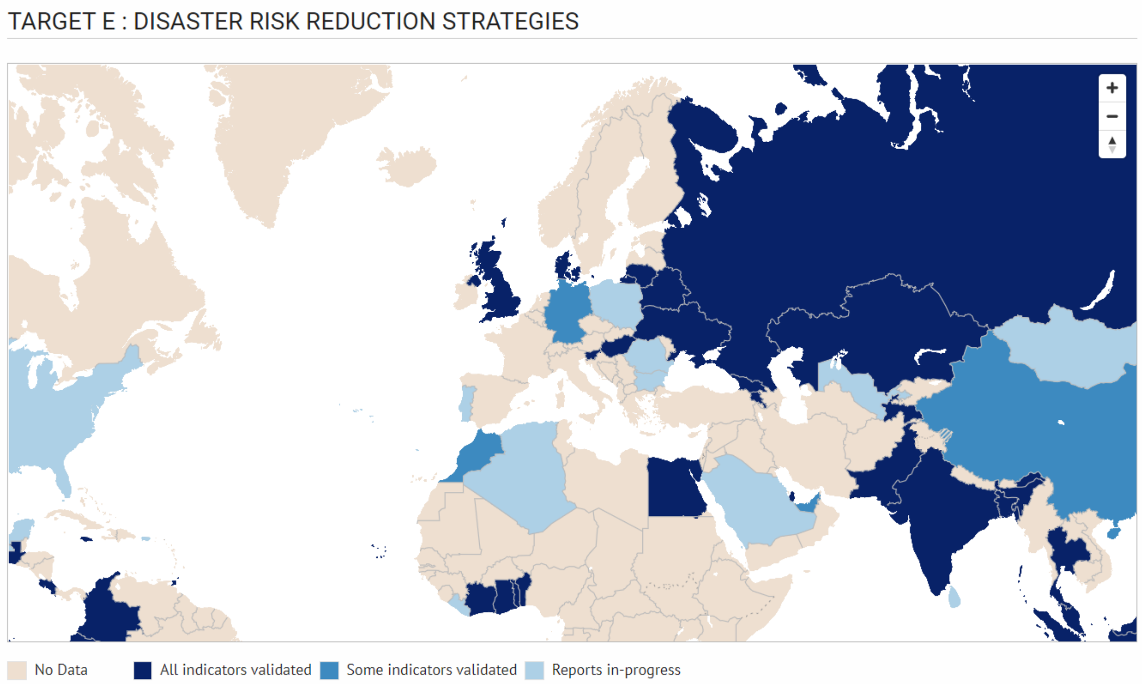
Source: EEA 2021: 26, table 2.2

Figure 32: Levels of support of nature-based solutions for climate change adaptation and disaster risk reduction in policies (EEA report)

This thesis will follow the same methodological approach as outline above, following the three steps in assessing the various policies/strategies. It should be noted that, in order to achieve a holistic perspective of the current approach taken to disaster risk reduction, it would of course be necessary to broaden the scope of analysis significantly by also including the current regulatory and legal framework in Austria, budget/funding approaches and activities in the various sectors, as well as de facto on the ground practice. However, as this would exceed the scope of this thesis, the analysis will be limited to policies/strategies.

In terms of relevant Austrian policies/strategies to be reviewed in order to assess the status of support of Eco-DRR and EbA therein, the selection was based on the CBD guidelines, which were outlined in the previous chapter, in combination with the results of the desk-based review of the existing literature as outlined in the previous section, with special consideration of the various pieces of existing guidance in terms of mainstreaming of Eco-DRR and EbA in existing policies, etc., as also outlined in the previous chapter, and following the example of the EEA report.

Based on this, various policies/strategies were identified. It should however be noted that, even though Target E of the Sendai Framework provides for a substantial increase of the number of countries with national and local disaster risk reduction strategies by 2020, and Target E "... [providing] a unique opportunity to ensure integration of [nature-based solutions] in the national and local disaster risk reduction strategies" (UNDRR 2020: 6), at this point in time, there is no national disaster risk reduction strategy in place in Austria (as e.g. can be seen from the data included in the Sendai Framework online Monitoring tool for the year 2020 (and subsequent years) as outlined in figure 33 below, Austria has not provided data regarding the fulfillment of Target E). However, it should be noted that there is a national strategy in place for crisis and disaster control management, the so-called "Staatliches Krisen- und Katastrophenschutzmanagement (SKKM)-Strategie 2020", which aims at ensuring the swift coordination among the federal authorities and the coordination and cooperation with the federal states.[13]



Source: https://sendaimonitor.undrr.org/analytics/global-target/13/6 (accessed 28.6.2022)

Figure 33: Sendai Framework online Monitoring tool – Target E

Furthermore, a new biodiversity strategy is currently being developed in Austria. As it is still at a preparatory stage (a first round of public consultation was conducted last year), and seeing that the previous version of the biodiversity strategy will therefore soon become obsolete, the analysis will not include this sector.

Table 1 below outlines the various strategies, action plans, and policies that were selected for the review, covering various relevant sectors, including biodiversity, adaptation and mitigation, land degradation, land-use planning, water, infrastructure, agriculture, etc., very much in line with, inter alia, the CBD guidelines.

Table 1: Policy / strategy documents relevant for the mainstreaming of Eco-DRR and EbA in Austria

Policy / strategy document	*Available at*
Current Government Programme	"Österreichisches Regierungsprogramm 2020–2024", available at: https://www.bundeskanzleramt.gv.at/bundeskanzleramt/die-bundesregierung/regierungsdokumente.html (accessed 1.8.2022)

[13] Information available at: https://www.bmi.gv.at/204/skkm/start.aspx. (accessed 10.7.2022) In 2021, the Austrian government took a decision to establish a new Crisis Security Act, which would provide a legal framework including clear responsibilities for state crisis and disaster control management (preparatory work is currently still under way). https://www.bmi.gv.at/news.aspx?id=4F6B56354A4665503371383D (accessed 22.8.2022)

Policy / strategy document	*Available at*
Nationally determined contribution	“The update of the nationally determined contribution of the European Union and its Member States”, available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Austria%20First/EU_NDC_Submission_December%202020.pdf (accessed 1.8.2022)
Austrian Strategy for Adaptation to Climate Change	„Die österreichische Strategie zur Anpassung an den Klimawandel“, available at: https://www.bmk.gv.at/en/topics/climate-environment/climate-protection/austrian-strategy-adaptaion.html; Part 1: https://www.bmk.gv.at/dam/jcr:a275450e-8589-4576-9d85-1a740e9391cd/NAS_Kontext_2017_kleiner.pdf Part 2: https://www.bmk.gv.at/dam/jcr:c7120fee-1e70-49e0-bbab-252c75d0993a/NAS_Aktionsplan2017.pdf (accessed 1.8.2022)
Biodiversity Strategy	“Biodiversitäts-Strategie Österreich 2030” (forthcoming, public consultation material available at: http://xn--biodiversittsdialog2030-57b.at/assets/documents/konsultation/Unterlage_OeffentlKonsultation_BiodivStrategie.pdf) „Biodiversitäts-Strategie Österreich 2020+“, available at: https://www.bmk.gv.at/dam/jcr:f634d5ea-ec43-4724-bded-42ba936d6c56/Biodiversitaetsstrategie2020.pdf (accessed 1.8.2022)
National disaster risk reduction strategy	Not available in Austria
Flood risk management plan	“Hochwasserrisikomanagementplan 2021”, available at: https://info.bml.gv.at/dam/jcr:c923f099-47b5-4724-b82a-36537169ce57/RMP2021.pdf (accessed 1.8.2022)
Infrastructure expansion plan	„Eisenbahninfrastuktur: Leitstrategie des Bundesministeriums über die Ausgestaltung“, available at: https://www.bmk.gv.at/themen/verkehrsplanung/ausbauplan/leitstrategie.html (accessed 1.8.2022) „Mobilitätsmasterplan 2030 für Österreich: Der neue Klimaschutz-Rahmen für den Verkehrssektor, Nachhaltig – resilient – digital“, available at: https://www.bmk.gv.at/themen/mobilitaet/mobilitaetsmasterplan/mmp2030.html (accessed 1.8.2022)
National Energy and Climate Plan	"Integrierter nationaler Energie- und Klimaplan für Österreich Periode 2021 bis 2030“, available at: https://www.bmk.gv.at/themen/klima_umwelt/klimaschutz/nat_klimapolitik/energie_klimaplan.html (accessed 1.8.2022)
Forest Strategy	„Wald schützt uns! Aktionsprogramm Schutzwald: Neue Herausforderungen – starke Antworten“, available at: https://info.bml.gv.at/dam/jcr:7059b12e-d48c-445f-b8df-f0b61da963e0/UnserWald_BMNT2020_BF.pdf (accessed 1.8.2022)
Rural Development Programme	„Österreichische Programm für ländliche Entwicklung 2014–2021“, available at: https://info.bml.gv.at/dam/jcr:75392463-65c3-44dd-bb3b-5bcad12df0fa/Programme_2014AT06RDNP001_9_0_de.pdf “Österreichischen Programm zur Förderung einer umweltgerechten, extensiven und den natürlichen Lebensraum schützenden Landwirtschaft (ÖPUL)“, available at: https://info.bml.gv.at/themen/landwirtschaft/eu-agrarpolitik-foerderungen/laendl_entwicklung/ausgewaehlte_programminhalte/oepul/oepul2015.html (accessed 1.8.2022)

Policy / strategy document	*Available at*
National common agricultural policy strategy	Forthcoming, the "GAP-Strategieplan Österreich für die Jahre 2023 bis 2027“ was submitted to the European Commission for approval on 30th December 2021 (https://info.bmlrt.gv.at/themen/landwirtschaft/eu-agrarpolitik-foerderungen/nationaler-strategieplan.html)
Spatial Development Plan	“Österreichische Raumentwicklungskonzept (ÖREK) 2030”, available at: https://www.oerek2030.at/fileadmin/user_upload/Dokumente_Cover/OEREK-2030.pdf (accessed 1.8.2022)
Masterplan Tourism	„Plan T - Masterplan für Tourismus“, available at: https://info.bmlrt.gv.at/themen/tourismus/masterplan-tourismus-plan-t.html (accessed 1.8.2022)
Moor strategy	„Moorstrategie Österreich 2030+“, available at: https://info.bmlrt.gv.at/service/publikationen/wasser/moorstrategie-oesterreich-2030.html (accessed 1.8.2022)
National Park Strategy	„Nationalpark-Strategie Österreich 2020+“, available at: https://www.nationalparksaustria.at/files/NPA_Download/BMNT_Nationalparkstrategie_Oesterreich_2020plus.pdf
Flood Plain Strategy	„Auenstrategie für Österreich 2020+ „, available at: https://info.bml.gv.at/service/publikationen/wasser/Auenstrategie-fuer-Oesterreich.html (accessed 1.8.2022)
Water Resources Management Plan	„3. Nationale Gewässerbewirtschaftungsplan (NGP 2021)“, available at: https://info.bml.gv.at/themen/wasser/wisa/ngp/ngp-2021.html (accessed 1.8.2022)

In line with the approach taken in the EEA report, the policies / strategies outlined above were searched for explicit mentioning of the following terms:

- „Ökosystem“ (Ecosystem);
- „Biodiversität“ / „Artenvielfalt“ / „Artenschutz“ (Biodiversity);
- „Naturbasiert“ (Nature-based) / „Ökosystem-basiert“ (Ecosystem-based);
- „Natürliche Infrastruktur“ (Natural Infrastructure);
- „Blaue / Grüne Infrastruktur“ (Blue / Green Infrastructure);
- „Integriertes / Nachhaltiges Management” (Integrated /Sustainable Management);
- „Öko-Engineering“ (Eco-engineering)

In a second step, the above-mentioned policies/strategies were searched for the following key terms with a view to reviewing the documents to identify linkages with these concepts, particularly to identify cases where terms other than the ones highlighted above were used: “Anpassung” (Adaptation) and “Katastrophenrisiko” (Disaster Risk).

For the assessment of the extent of a specific policy supporting the deployment of nature-based solutions, the four levels of support, as outlined in figure 32 above, were used, based on the following considerations:

- Were any of the identified terms used 'explicitly' or 'implicitly' in the policy / strategy text?
- Are these concepts linked in the policy / strategy to climate change adaptation and/or disaster risk reduction?
- How strongly are the terms and related concepts for climate change adaptation and disaster risk reduction embedded?

5. State of mainstreaming of ecosystem-based approaches in the Austrian disaster risk reduction policy approach

This chapter will provide a substantive overview for each of the relevant high-level policies/strategies identified for Austria, based on the findings of the analytical steps outlined in the previous chapter. In doing so, information will be provided whether or not ecosystem-based approaches/nature-based solutions were explicitly or implicitly referenced, and, if so, whether in the context of climate change adaptation and/or disaster risk reduction or not. Should this not be the case, information will be provided on possible substantive entry points for ecosystem-based approaches in the respective policy/strategy. The strategies are mainly available in German, but have been translated for the sake of analysis as outlined below.

Current Government Programme – strong explicit support

In the government programme of the current Austrian government, there are various references to biodiversity and ecosystems, however not in the explicit context of ecosystem-based / nature-based approaches for disaster risk reduction or climate change adaptation, but prominence is given to sustainable forest management and there is reference to integrative water management planning, as well as integrative ecological flood protection, also with reference to a role in the context of disaster risk reduction. Therefore, it would be categorized as showing strong explicit support with regard to ecosystem-based approaches, also as there are various references to tackling biodiversity loss and ecosystem degradation. In addition, there are various substantive entry points, which could be used for integrating ecosystem-based approaches as outlined below.

Inter alia, there is a commitment to climate protection through bio economy, including an acknowledgement of the challenges posed by surface sealing, species extinction, soil erosion and air pollution. (BUNDESREGIERUNG 2020: 99)

There is a specific acknowledgment of the protective function of intact ecosystems against natural hazards and in terms of contributing to climate regulation, therefore the Austrian federal government assumes responsibility for the protection of biodiversity by setting initiatives in all sectors to preserve biodiversity, connect habitats and promote structural diversity. Inter alia, there is recognition that clean and ecologically intact waters offer protection against flooding, and that water ecological measures contribute to the long-term securing of water resources. In addition, an Austria-wide soil protection strategy is to be developed, wherein guidelines for reducing land use and improving soil quality are defined. (BUNDESREGIERUNG 2020: 99)

The programme also contains various measures to preserve biodiversity, including the development of a revised national biodiversity strategy (“Biodiversity Strategy 2030+”), including a biodiversity fund for its implementation, as well as support to the federal states in designating new and maintaining existing wilderness areas, Natura

2000 areas, biosphere reserves and protected areas. (BUNDESREGIERUNG 2020: 101) In addition, it contains a commitment to further develop the recording and evaluation of ecosystem services, a nationwide coordination of state-specific insect and species protection monitoring, standardization of bio-indicators and biotope mapping, promotion of the habitat network and structural diversity in the landscape, the development of biotope network systems that enable biodiversity, the creation of incentives for biodiversity measures, measures to restore degraded ecosystems, and establishment of EU-wide wildlife ecological spatial planning and development of wildlife management solutions in accordance with EU law. (BUNDESREGIERUNG 2020: 101)

With regard to the protection against natural hazards, inter alia, the need for an expansion of flood protection and pooling of responsibility for flood protection, unifying funding criteria, giving priority to non-structural measures over technical flood protection, with an emphasis on decentralized and ecological flood protection, is highlighted. Furthermore, there is a commitment to strengthening sustainable protective forest management (natural regeneration of the forest, and climate-friendly forest). (BUNDESREGIERUNG 2020: 102) There is also a commitment to a further development of integrative water management planning, as well as integrative ecological flood protection with regular and uniform progress controls (BUNDESREGIERUNG 2020: 103) These can be seen as explicit references to nature-based / ecosystem-based approaches in the context of disaster risk reduction, even if they are not explicitly labelled as such.

With regard to soils and regional planning, there is a commitment to developing a nation-wide soil protection strategy for economical use of land, a target path for reducing land use to a net 2.5 ha/day by 2030 and, in the medium term, compensating for additional soil sealing by unsealing corresponding areas, and the designation of agricultural production areas and ecological priority areas (BUNDESREGIERUNG 2020: 104)

With regard to agriculture and animal welfare, there is a commitment to increased funding for the relevant federal agency with the goal to further the development and research for alternative crop protection and soil protection additives for agroecological applications, as well as risk research on the negative effects of pesticides and their metabolites and the impact on biodiversity (BUNDESREGIERUNG 2020: 110)

With regard to ensuring competitive, multifunctional and nationwide Austrian agriculture and forestry, there is a commitment to, inter alia, avoiding soil erosion, humus build-up, sustainable forest management, preserving non-productive landscape elements or landscape areas to improve biodiversity , and preservation of soil fertility (BUNDESREGIERUNG 2020: 110) There is also a strategic positioning of organic and sustainable farming in terms of achieving environmental and climate policy goals in agriculture. (BUNDESREGIERUNG 2020: 112)

With regard to forestry, there is a clear commitment to strengthening sustainable forest management as already outlined, acknowledging, inter alia, the protective function of forests, the implementation of the so-called “protective forest action program" by 2024, support for site-appropriate and climate-friendly reforestation and care after weather and climate-related calamities, an expansion of a biotope network system, retention areas, rapid site-specific reforestation of damaged protective forests and targeted afforestation of high altitudes to increase water retention capacity, avalanche protection and reduce soil erosion, expanding the natural forest reserve network and secure it through nature conservation contracts, and funding measures for the implementation of Natura 2000 (BUNDESREGIERUNG 2020: 114).

Furthermore, there is a commitment to increasing funding for basic research on, inter alia ecological functions of soil, biodiversity, etc. (BUNDESREGIERUNG 2020: 83)

With regard to the military, there is a commitment to further develop the armed forces with a focus on specific priorities, including assistance services, in particular disaster protection and assistance, and the development of a comprehensive legal framework for state crisis and disaster protection management. (BUNDESREGIERUNG 2020: 163ff)

As can be seen from the above, even though ecosystem-based / nature based approaches, under special consideration of EbA and Eco-DRR are not specifically mentioned in the government programme, there is specific reference to sustainable forest and integrated water management, furthermore there are various substantive entry points for the integration of ecosystem-based approaches throughout the document, which could be used in the subsequent implementation of said programme.

Nationally determined contribution – strong explicit support

In the context of climate change mitigation, in its 2020 updated nationally determined contribution of the EU (which submits on behalf of all Member States) under the UNFCCC, the important role of nature-based solutions is highlighted in order to address challenges such as biodiversity loss and ecosystems degradation, poverty, hunger, health, water scarcity and drought, gender inequality, disaster risk reduction and climate change. (EU 2020: para. 10)

Adaptation Strategy – strong explicit support

There are no explicit references to ecosystem-based approaches, nor to nature-based solutions, yet there is a clear recognition of the important role of ecosystems and biodiversity throughout the strategy. In addition, there is a specific reference to blue/green infrastructure, and sustainable forestry and water management also in light of disaster risk reduction, etc. As outlined below, there are a number of substantive entry points that can be identified for the integration of ecosystem-based approaches.

In the Adaptation Strategy, 14 areas of activity have been defined, including goals and recommended actions per field. In the following, the fields of activity with potential for the integration of ecosystem-based approaches are outlined (it should be noted that the strategy encompasses much more detailed information than this, but in light of the limited scope of this thesis only the relevant high-level information is provided).

The first refers to agriculture, with the goal of securing sustainable, resource-saving and climate-friendly production, as well as maintaining and improving the ecological services of agriculture under changed climatic conditions. As per the strategy, this needs, inter alia, a sustainable construction of the soil and securing soil fertility, structure and stability, increased establishment and promotion of water-saving irrigation systems and improvements in irrigation planning, breeding and targeted use of water-saving, heat-tolerant plants in terms of regionally adapted management, risk minimization as well as development and expansion of instruments for risk diversification, integrated landscaping to secure soil and improve agroecology, and preservation of existing alpine pastures and revitalization of abandoned alpine pastures. (BMNT 2017: 5f)

With regard to forestry, the objective refers to the preservation of the multifunctional effects of the forest through sustainable management adapted to climatic changes, inter alia through adaptation of the choice of tree species and origin, including targeted promotion of diversity through appropriate silvicultural management and rejuvenation of overaged stands, and soil-friendly management. (BMNT 2017: 6)

Another activity area relates to water balance and water management, with the objective being sustainable protection of water resources as a basis of life and living space as well as securing the supply of high-quality drinking water, environmentally friendly cleaning of wastewater and strengthening the protection of the population against natural hazards under changed climatic conditions. This entails, inter alia, forward-looking water management planning of groundwater resources, and adaptive flood risk management. (BMNT 2017: 7)

With regard to the area of building and living, the goal as per the strategy is to ensure the quality of living by taking planning, structural and usage-related adjustment measures on buildings and in the surrounding area. This should be achieved through, inter alia, the forced application of passive and active cooling with alternative, energy-efficient and resource-saving technologies, the climatological improvement of urban areas, in particular consideration of micro/meso-climatic conditions in urban and open space planning, the implementation of structural measures on buildings to protect against extreme weather events, an increase in water retention, and adaptation of building standards and norms to climate change. (BMNT 2017: 8)

In terms of protection against natural hazards, the objective relates to strengthening the precautionary principle through area precautions, personal precautions and behavioural precautions in order to reduce the negative consequences of climate change-related natural hazards. Inter alia, this entails the promotion of sustainable spatial development strategies with increased involvement of hazard zone planning and risk presentation, the promotion of water retention in the area as well as the reactivation of natural floodplains (and areas) in particular as a contribution to area precaution. (BMNT 2017: 9)

With regard to disaster management, the strategy sets the objective of a rapid and professional management of disasters through better networking and preparation of all stakeholders, especially with regard to changing climatic conditions. Inter alia, it calls for a continuation of the national risk analysis and development of a uniform methodology for carrying out risk analyses and a continuation and networking of research activities and development of innovations related to disaster management. (BMNT 2017: 9)

One of the fields of activities relates to ecosystems and biodiversity, with the goal referring to their conservation and promotion by protecting species vulnerable to climate change, connecting habitats, sustainable land use and adapting nature conservation concepts to climate change-related changes. There is quite a long list of relevant recommended actions, including, inter alia, improving the knowledge base through research on climate change impacts on ecosystems/biodiversity, increased consideration of climate change in existing monitoring systems and expansion of monitoring and early warning systems, integrating climate change into nature conservation instruments, and strengthening of knowledge transfer on the importance of biodiversity and ecosystems for climate change adaptation. In addition, the retention of extensive land use in montane to alpine mountain ranges and in select locations, adaptation of the design of public and private open spaces in settlements to nature conservation goals and climate change effects, maintaining and improving the embedding and connectivity of protected areas and habitats, protection of wet habitats, accelerating water body rehabilitation and strengthening integrated catchment area management for bodies of water and avoiding severe warming of bodies of water, and the preservation of ecosystem services in sustainable land use and nature conservation are recommended. (BMNT 2017: 10)

In terms of spatial planning, the objective is to cope with the challenges of climate change to ensure sustainable spatial development through the consistent application and further development of existing planning goals and instruments and through the preservation of ecosystem functions. Recommended actions include, inter alia, the creation and safeguarding of flood retention and flood drainage areas and clear regulation of bans and restrictions on zoning, securing of fresh and cold air production areas, ventilation paths as well as green and blue infrastructure within the settlement area, increased protection of ecologically significant open spaces and minimization of further habitat fragmentation, climate proofing of spatial plans, development concepts, processes, and promotion of quantitative soil protection and consideration of soil quality in land use. (BMNT 2017: 11)

Last but not least, with regard to urban open spaces and green spaces, the aim, according to the strategy, is to secure the urban quality of life under changing climatic conditions by maintaining and improving the diverse functions of urban open spaces and green spaces. This entails, inter alia, the adaptation of the water management strategy for green and open spaces and of soil management in urban green and open spaces, the preservation and promotion of biological diversity in urban green and open spaces. (BMNT 2017: 12)

As has been highlighted, there are a large number of entry points for ecosystem-based approaches throughout the strategy.

Flood Risk Management Plan – strong explicit support

The latest flood risk management plan also offers various entry points for ecosystem-based / nature-based approaches, with specific references to e.g. natural water retention measures, non-structural flood prevention measures, and protective forests, however there is no explicit mentioning of Eco-DRR or EbA as such. Nonetheless, it would be categorized as displaying strong explicit support.

As per the flood risk management plan, the flood risk management objectives should be achieved through non-structural flood prevention measures and/or a reduction in the likelihood of flooding. If necessary, this overriding objective should be supplemented by risk area-specific, topographical, hydrological or catchment area-related concrete objectives, which are presented in programmes of measures at risk area level. The plan outlines four goals, with the first referring to avoidance of new risks, achieved through planning measures or non-structural measures (e.g. hazard zone planning, zoning, local development, building regulations, maintenance, etc.). With regard to the second goal, i.e. reduction of existing risks, the plan points out that risks can be reduced either by adapting the stock, building hydraulic engineering systems or removing potential damage (e.g. settlement) from the endangered area. The plan points to the necessity of defining the right package of measures, highlighting that, within the framework of structural measures, retention measures (technical retention or optimization of existing retention areas) should be given priority over linear structures (flood protection dam or protective wall), and as part of the non-structural measures, flood-adapted use and development playing an important role alongside careful planning. Goal 3 of the plan refers to improved preparedness and coping skills, goal 4 to the strengthening of risk and hazard awareness. (BMLRT 2021a: 80f)

In developing the plan, a detailed overview of relevant measures was created, covering all aspects of flood risk management. In addition to the structural flood protection measures, this selection of measures therefore includes above all non-structural measures that serve the goals of flood risk management and take into account aspects of flood forecasting and early warning, improvement of water retention, land securing and sustainable land use methods, protective measures against sources of pollution in the event of a flood, etc. (BMLRT 2021a: 86ff)

The plan contains a commitment to flood-aware regional and spatial planning and measures within the framework of settlement development. It highlights that soil consumption and soil sealing are still at a high level (with the daily land consumption in Austria having been 11.5 ha/day on average for the three-year period 2018-2020). It therefore points out that new, sustainable approaches to residential and commercial development are required, as the increasing use of land has negative ecological and economic consequences, including loss of biological functions, loss of productivity, threat to biological diversity, increased flood risk, as high sealing densities in flood-prone settlements increase the risk of flooding, loss of dust binding capacity, and heat effects, pointing to the importance of parks and green islands. As outlined in the plan, the preservation and expansion of retention space is an essential goal of passive flood protection, in particular, areas for dynamic water body development and renaturation, floodplains, sedimentation and deposition areas and hydro-morphologically dynamic areas are of importance. (BMLRT 2021a: 107-112)

Furthermore, it is recognized that agricultural areas can play a crucial role in many areas in the context of flood risk management, particularly in terms of keeping the water in a retention-effective manner, therefore the contribution of agricultural management forms and the development of areas for the purpose of retention can make a significant contribution to reducing the risk of flooding. The plan highlights the importance of site-adapted approaches, with flood-compatible management of agricultural land including all measures that reduce surface runoff, such as increased soil cover, greater surface roughness, avoidance of soil compaction, stable soil structure and soil aggregates, increase in infiltration rate, avoidance of splash effects and siltation. As an important measure, the maintenance of a long-lasting ground cover by main crops with a long growing season and high stocking density is mentioned, the maintenance of an infiltration-capable soil structure by avoiding deep soil inversion, mulch sowing methods, the sufficient supply of organic matter and the processing of sloping areas across slopes is highlighted, as is the need to loosen existing soil compaction. Furthermore, the plan outlines that the multiple use as agricultural land in a retention basin or developed retention area is common practice in the context of flood risk management, with compensating for yield losses in the event of an incident. Therefore, it is highlighted that dealing with existing flood protection measures for agricultural areas and, if necessary, removing them instead of expensive maintenance, would be helpful with regard to the creation of additional retention space. (BMLRT 2021a: 136)

There is also an explicit reference to natural water retention measures, highlighting the importance of the protection of the remaining retention areas. Furthermore, it is emphazised that preventing erosion and increasing the organic content in the soil leads to an increase in the storage capacity of soil water, and that adaptation measures in the areas of flooding, such as land use changes in the catchment area, can contribute to greenhouse gas reduction through carbon sequestration. (BMLRT 2021a: 345)

With regard to hydrological/hydraulic measures, it is highlighted that in the Austrian body of water, abiotic conditions create a mosaic of habitats with a large number of species, and that different demands on the substrate conditions, the flow rates, the oxygen balance, bank structures and bank vegetation determine the species composition and biodiversity as well as the productivity and the self-cleaning power of the water bodies. Therefore, the plan indicates that the water body type-specific habitat equipment, structurally diverse banks and the connection to tributaries and natural floodplains are necessary for the survival of many running water organisms, and that all necessary habitats must be available in sufficient numbers and sizes and be accessible. In this regard, it is highlighted that the restoration of type-specific habitat conditions is not only a basic requirement for functioning ecosystems and achieving good ecological status in water bodies, it is also indispensable in view of future additional pressures from climate change to increase the resilience of water bodies. In this regard, it is also recognized that floodplains, bogs and wetlands in the catchment area can provide a significant contribution to water retention in the context of flood risk management. (BMLRT 2021a: 218)

The plan explicitly stresses that protective forests are essential for the protection against diverse natural hazards, with almost a quarter of the population benefiting directly from the protective forest as a green, cost-effective and sustainable protective infrastructure against natural hazards. (BMLRT 2021a: 148f)

With regard to the planning and implementation of near-natural water management measures, it is recognized that the planning and implementation of space-intensive measures often requires long planning periods, negotiations on the procurement of land, integral analyzes and construction methods that are specially adapted to the flora and fauna. It is highlighted that the overriding principle is to minimize interventions in the body of water and the surrounding area, and that the current ecological status of the body of water must be preserved or improved as part of the implementation of protective measures in the direction of good ecological status or good ecological potential. The measures are to be selected according to the following order of priority:

- Passive flood protection through non-structural measures prior to structural flood protection measures,
- Retention measures before linear protection measures,
- Use of natural retention before technical restraint measures,
- Retention basins in the shunt before those in the main line,
- Measures in the area surrounding the water body before measures directly on the water body.
- Near-natural and water-specific types of measures and construction methods before non-natural types of measures and construction methods or those that do not correspond to the type of water body
- Measures that increase discharge should generally be avoided.
- Undeveloped areas are to be preserved as drainage and retention areas. (BMLRT 2021a: 150ff)

There is also a reference to the floodplain strategy 2020+ for Austria, highlighting that the targeted designation and maintenance of floodplains for flood retention and the reconnection of floodplains as part of hydraulic engineering measures should be promoted. (BMLRT 2021a: 154)

With regard to the improvement of patency, there is, inter alia, a recognition that an intact continuum enables recolonization after catastrophic events, an evasion in unfavourable habitat conditions, and promotes unhindered gene exchange to preserve genetic diversity. In addition, there is a recognition that, through the networking of the habitats, the aquatic life benefits from habitats of longer stretches of water and that, in this way, existing as well as newly created habitats can multiply their ecological effect. Therefore, it is indicated that, as part of flood risk management, the reconnection of tributaries and the opening of floodplains make a significant contribution to reducing flood peaks, and that the elimination of transverse structures can help to reduce possible overloads caused by blockages. (BMLRT 2021a: 216)

Last but not least, there is a reference to hydrological/hydraulic measures, there is a recognition that all necessary habitats must be available in sufficient numbers and sizes and be accessible, with the restoration of type-specific habitat conditions not only being a basic requirement for functioning ecosystems and achieving good ecological status in water bodies, but also being indispensable in view of future additional pressures from climate change in order to make water bodies more resilient. In this regard, it is recognized that floodplains, bogs and wetlands in the catchment area can provide a significant contribution to water retention in the context of flood risk management. (BMLRT 2021a: 218)

As can be seen there is clear acceptance of the underlying assumptions and ideas of Eco-DRR und EbA, i.e. importance of biodiversity and intact ecosystems also in the context of disaster risk management and climate change adaptation, and there is reference to specific Eco-DRR and EbA solutions, however there is no explicit reference to or recognition of ecosystem-based approaches / nature-based approaches as such. As indicated, there are various substantive entry points to enhance the use of ecosystem-based approaches / nature-based approaches on the basis of the plan.

Infrastructure Development Plan – Low support

In the two relevant plans, there is no reference to ecosystem-based approaches / nature-based solutions, and only quite general references to sustainability and biodiversity, thereby offering a number of entry points for the mainstreaming of ecosystem-based approaches / nature-based solutions.

The guiding strategy for railway infrastructure does not contain any reference to biodiversity, ecosystems, nor to related approaches. It only contains a very vague reference that a modern railway network should create the conditions for sustainable, environmentally friendly and safe mobility (BMVIT 2017: 12)

In the Mobility Masterplan 2030, there is reference to biodiversity, pointing out that high land use is one of the main reasons for the loss of biodiversity, with natural habitats often being disrupted by transport infrastructure and thus irreversibly destroyed. It is indicated that entire ecosystems react sensitively to anthropogenic interference, and that this development can be countered by avoiding fragmentation effects and landscape-adapted alignments in infrastructure buildings, as well as by promoting particularly space-efficient means of transport and modes of locomotion. (BMKUEMIT 2021: 56)

With regard to soil sealing and land consumption, it is highlighted that the land consumption of the transport system is an important environmental indicator. The plan aims to connect the modes of transport according to their environmentally relevant strengths through targeted mobility management and to reduce land consumption by shifting to active mobility and public transport. (BMKUEMIT 2021: 56)

As per the plan, the guiding principles of climate-neutral and sustainable mobility are sufficiency (necessary behavioural changes), consistency (use of regenerative energy in the transport system), and efficiency (the same goal can be achieved with less use of energy, space, transport capacities and other resources, as well as through regional production and trade links with short transport routes). (BMKUEMIT 2021: 19)

The plan uses the levers of avoiding, shifting and improving with the aim of achieving a sustainable CO2-free transport system, identifying the following two essential limiting factors in the system: with regard to rail infrastructure and shift potential, there are limits due to infrastructure projects having long lead times and available annual construction capacities, as well as ecological limits such as land use, e.g. due to goals such as limiting soil sealing to 2.5 hectares per day. (BMKUEMIT 2021: 9)

As per the plan, the national climate goal for transport is the mandatory guideline on which the strategic planning of all modes of transport must be based, whereby CO2 emissions from transport must be reduced from around 24 million tCO2 eq (as of 2019) to almost zero tCO2 eq by 2040. (BMKUEMIT 2021: 16)

As was highlighted above, there would be various substantive entry points, particularly in the Mobility Masterplan, for mainstreaming ecosystem-based approaches, yet in general the two plans have to be categorized as low level of support as there is not recognition of the relevant approaches, let alone in the context of disaster risk reduction or climate change adaptation.

National Energy and Climate Plan – Low support

There is no explicit reference to ecosystem-based approaches/nature-based solutions, nor to biodiversity or ecosystems, let alone in the context of disaster risk reduction or climate change adaptation in the national Energy and Climate Plan. Therefore, it is categorized as low level of support. However, there are a number of substantive entry points for their mainstreaming throughout the plan. For example, the plan states that economic, ecological and social dimensions are given equal priority in the national energy and climate plan. (BMNT 2019a: 8) As part of the most important goals and fields of action of the plan, the following issues are outlined, inter alia: with regard to farming, manure management, including the introduction of a significant part of manure into the biogas utilization track, humus maintenance and build-up, conservation of permanent grassland, adaptations in animal husbandry; with regard to forestry, the aim is a continuous increase in timber growth and timber harvest while adhering to the basic principles of sustainable forest management; with regard to spatial planning, the aim is to improve spatial planning and energy planning; with regard to transport, the aim is to increase the share of renewable energy in transport; and with regard to agriculture and forestry, the aim is an expansion of agricultural and forestry bioenergy production. (BMNT 2019a: 10f) Specifically, in the area of hydropower, as per the plan, preference should be given to revitalization, especially for ecological reasons. (BMNT 2019a: 156) There is also reference to tax-ecological measures. (BMNT 2019a: 173) In addition, the plan makes various references to other sectoral plans and strategies, inter alia with regard to climate change, forestry, agriculture, etc.

Forest strategy – strong explicit support

The fact that there is a dedicated action programme for protective forests in place in Austria, which contains a clear recognition of the valuable ecosystem services it provides, under special consideration of its role in the context of disaster risk reduction. Therefore, it is categorized as strong explicit support. The content of the programme is briefly outlined below.

There is an acknowledgement of Austria being a mountainous country, half of which would not be inhabitable without a protective forest, and of the various ecosystem services and benefits it offers. Yet, there is also an acknowledgement of new challenges for the protective forest, including climate change, low wood prices, high management costs, pressure from leisure activities and modern sports equipment. There is also a recognition of climate change impacts, including increased fungal diseases and tree pests such as the bark beetle, as well as impact of warmer conditions on the spread of non-native pests. The strategy therefore points out that sustainable, active, site-specific management and measures are required to adapt the plant communities. On the other side, warming at higher altitudes is also seen as an opportunity for the protective forest. (BMLRT 2020: 5)

The strategy points out that 48% of Austria's area is covered b< forest, fulfilling several functions: in terms of carbon capture and storage, as a producer of the renewable raw material wood, as a space for relaxation and leisure, and as protection against natural hazards, with forests being able to store water, bind snow, reduce wind speeds and protect the soil from erosion. (BMLRT 2020: 8)

There is a strong acknowledgement that, as a green, cost-effective and sustainable protective infrastructure, protective forests play an important role in the prevention of natural hazards in Austria, with the following effects: property protection, retention areas, site protection against soil removal, debris formation and erosion, keeping water bodies clean, and as a water reservoir and air filter. The strategy outlines that the Austrian Forest Act distinguishes between site protection forests and property protection forests (the former are forests protecting sites that are endangered by the erosive forces of wind and water or gravity, the latter protecting people and their settlements, infrastructure or cultivated soil from natural hazards such as avalanches, rockfall, landslides, floods and wind erosion as well as from damaging environmental influences). (BMLRT 2020: 9)

Yet, the strategy highlights the urgent need to improve the protective forest situation in Austria, e.g. with the stability and resilience of the protective forest ecosystems urgently needing to be increased, old trees needing support by young ones, and the need for a general rejuvenation of the protective forest. (BMLRT 2020: 10)

The strategy therefore contains guidelines, emphasizing that the protective purpose in protective forests is paramount, awareness of the protective forest must be strengthened, the management of protective forests should be attractive for forest owners in the future, protection forests are a valuable habitat for plants and animals, that there is need for research, monitoring and training, that sustainable protective forest management requires a joint approach by all stakeholders and cross-sectoral political coordination, and that protective forest management is efficient and impact-oriented. (BMLRT 2020: 10)

The overall four aims of the action programme are to make protective forest fit for the future, by observing and exploring, planning and developing, and preserving and restoring the protective forest. (BMLRT 2020: 15) Further, to achieve more for the protective forest together, by experience, use and conserving protective forests, and shaping protective forests regionally and networking them nationwide. (BMLRT 2020: 23) Thirdly to strengthen awareness of the protective forest, including by recognizing and communicating, and learning and understanding. (BMLRT 2020: 29) And lastly by making protective forests attractive, i.e. to easily manage and design, invest and operate, and value protective forests. (BMLRT 2020: 35)

The strategy also contains various lighthouse projects, as well as related fields of action.

<u>Rural Development Plan – strong explicit support</u>

There is no reference to ecosystem-based approaches nor to nature-based solutions. Yet, there are various acknowledgements of the importance of biodiversity and ecosystems and their services, as well as a specific reference to the important role of protective forests in terms of risk prevention. Therefore, the plan is categorized as showcasing strong explicit support. As the plan is quite voluminous, only the high-level principles, as contained in the strategy section, are depicted below, outlining the various entry points for an integration of ecosystem-based approaches.

The underlying strategy of the plan outlines that Austria continues to pursue the goal of a multifunctional, sustainable agricultural and forest policy strategy that follows the paradigm of growth and securing competition-oriented agriculture and forestry (BMLRT 2021b: 201) It states that a characteristic of Austrian agriculture is the moderate intensity of production and that the slowdown in agricultural structural change and the associated protection of valuable agricultural habitats and species was an important success of the agro-environmental programme (österreichische Agrar-Umweltprogramm (ÖPUL)) as the central element of the plan. In general, the plan highlights that a comprehensive approach to environmental measures is required, and that specific measures are needed in areas with regional deficits. (BMLRT 2021b: 201)

In this regard, it outlines various measures as foreseen in the ÖPUL. This includes special measures with plant protection and fertilizer requirements to minimize material inputs into water bodies in polluted or endangered areas. Moreover, it states that nature conservation measures were further developed through an integration of a result-oriented nature conservation plan and by improving the impact orientation of individual requirements in coordination with nature conservation experts, which will play an important role in the preservation and development of ecologically valuable agricultural areas inside and outside of protected areas, with special consideration of species-rich grassland areas. In addition, there is a requirement for the creation of biodiversity areas, which are composed of four different insect-flowering mixes. There is also a requirement of a minimum percentage for planting biodiversity areas on arable land (5%), as well as increased training and awareness-raising measures such as biodiversity monitoring on agricultural land, and educational and advisory services in the area of tension between nature conservation and agriculture. (BMLRT 2021b: 201f)

Moreover, the plan states that, since agricultural production should also be climate-friendly, cohesion with emission reduction and carbon storage measures is of particular relevance, as is the promotion of organic farming and other humus-building and greenhouse gas-reducing measures. (BMLRT 2021b: 204)

The plan outlines further that the strategy aims to ensure the sustainable management of natural resources, climate protection, a balanced development of the rural economy and the creation and preservation of jobs. The plan also states that around 3.5% of the ÖPUL programme volume is earmarked for measures in the area of protection against natural hazards, mobilization of wood in accordance with the principles of sustainability and strengthening the ecological value of forest ecosystems, as well as for relevant educational, information and advisory measures. It further highlights that securing the protective function of forests and their reconstruction after natural disasters represent an important contribution to risk prevention, this being a special need in Austria as a mountainous region. It also states that the improvement of forest biodiversity is to be achieved through protected areas and action areas. (BMLRT 2021b: 205)

The above highlights that there is an explicit recognition of biodiversity and ecosystems and their relevant contribution to rural development, as well as the need for ecosystem-based approaches e.g. with regard to hazard prevention, even if not specifically referenced.

National common agricultural programme – strong explicit support

The national common agricultural programme strategy plan will replace the previous rural development programs (ÖPUL, as outlined in the previous section) as of 2023 as a funding instrument for rural areas. There is no recognition of ecosystem-based approaches or nature-based solutions, but a strong acknowledgement of the importance of biodiversity and ecosystems, as well as of specific solutions with particular focus on the protective function of forests. Therefore, the plan is categorized as offering strong explicit support. In addition, there is a large number of entry points for ecosystem-based approaches, as outlined below (it should be note that, due to the large volume of the plan, only the strategy highlights are reflected below).

The strategy plan is the central instrument for the further development of Austrian agriculture and is of enormous importance for rural areas. It is aimed at the sustainable competitiveness and resilience of agricultural operations and at securing food for the population, while at the same time significantly increasing ambition with regard to resource and climate protection. The plan states that, through investments, knowledge transfer and innovation, it makes a substantial contribution to improving the vitality and quality of life in rural areas and that, together with other instruments, it will make significant contributions to achieving the Green Deal goals. (BMLFRW 2021: 35)

The plan states that the raising of cattle, sheep and goats on alpine pastures is supported, which guarantees, in combination with targeted interventions, area-wide grazing of these sensitive alpine ecosystems. Furthermore, it states that ensuring the management of disadvantaged areas is a key objective, and that there is a further expansion of the environmental and climate benefits. Inter alia, the planting of catch crops on arable land makes a significant contribution to the build-up and maintenance of humus. With the so-called evergreen system, it is highlighted that a year-round soil cover is implemented on at least 85% of the arable land of a farm, and that the greening of all tramlines of the wine, fruit and hop areas significantly reduces soil erosion and consequently the nutrient input into surface water. In addition, the plan states that grassland management that promotes animal welfare and conserves resources is promoted through grazing. (BMLFRW 2021: 35)

In the plan, there is an obligation to maintain permanent grassland for the protection of carbon-rich wetlands and peatlands, soil and erosion protection, as well as for crop diversification, crop rotation and fallow land, reinforced by ÖPUL with specific interventions for soil and water protection as well as air pollution control. Furthermore, the plan states that, as a response to the climate challenges, it is planned that emissions affecting the climate will be reduced or CO2 stored in around 50% of the area and in over 25% of the large livestock units kept. At the same time, around 6,000 investment projects are planned to provide environmental and climate services in rural areas. Additionally, the expansion of the bio-economy is being pushed, in particular the increase in the provision and use of renewable energy. (BMLFRW 2021: 36)

The plan also specifically supports the goals and measures of the National Action Plan for the Sustainable Use of Pesticides 2022 - 2026, which is currently being developed. Furthermore, organic production is to increase to at least 30%. Furthermore, the plan supports sustainable forest management by promoting biodiversity and the adaptation of forests to changing climatic conditions and supporting forest protection measures and protection against natural hazards. (BMLFRW 2021: 36)

The plan also acknowledges, the need to strengthen biodiversity-promoting agriculture, therefore, agro-biodiversity should be supported even more in the future, e.g. species-rich agricultural areas are specifically promoted through interventions such as nature conservation, mowing of mountain meadows or result-oriented management. In addition, the creation, maintenance and care of landscape elements such as (fruit) trees, bushes, flowering areas and bee pastures are supported. Furthermore, the proportion of obligatory biodiversity areas in grassland and arable land will be increased significantly. Also, specific measures to support species and habitats in Natura 2000 areas will be significantly expanded. Last but not least, the plan proposes a comprehensive offer for knowledge transfer and advice, especially regarding site-adapted use of resources, biodiversity, climate protection and digitization. (BMLFRW 2021: 36f)

As this shows, there is strong support for measures to protect and promote biodiversity and ecosystems, as well as an acknowledgement of the particularly important role protective forests can play.

Spatial development plan – strong explicit support

The Spatial Development plan is categorized as showing strong explicit support, as there is a clear recognition of the value of biodiversity and ecosystems in tackling climate change and biodiversity loss/ecosystem degradation. There is also one specific reference to the importance of green infrastructure. Yet, there is no specific mentioning of ecosystem-based approaches or nature-based solutions, although there are a large number of substantive entry points for their use.

In the plan, there is a commitment to ecological sustainability in spatial development, recognizing that the climate crisis, the loss of biodiversity, environmental pollution as well as the reduction of agricultural land due to land use for settlements and infrastructure jeopardize future prospects and room for manoeuvre for future generations. Therefore, the plan highlights that the spatial dimension of environmental sustainability means a climate-friendly, economical and careful use of spatial resources, with minimizing soil sealing and compensation for unsealing, securing open space functions and ecosystem services, expansion of green spaces in urban areas, including with regard to their microclimatic function, and national parks, nature reserves and landscape protection areas, and Natura 2000 constituting central elements. (ÖROK 2021: 14f)

It is emphasized that rural regions should aim to distinguish themselves as specialized bio-economy and industrial sites, while ensuring climate and biodiversity protection. (ÖROK 2021: 15f)

There is also, as already outlined, a recognition of the need for protecting open spaces with their diverse functions, with undeveloped and unsealed open spaces covering approx. 90% of the area in Austria, performing important functions in urban and rural areas, and forming part of risk and protection-management with regard to natural hazards and safeguarding biodiversity. There is also a recognition that it is the task of spatial development and spatial planning to secure the diversity and quality of open and green spaces to protect natural resources and biodiversity in coordination with economic use of spaces, which includes the management of competition for space. (ÖROK 2021: 21)

There is also a recognition of the importance of preservation of agricultural and forest areas and quality of soil functions for maintaining food production, highlighting the need of setting quantitative and qualitative goals to ensure high quality agricultural and forest land. (ÖROK 2021: 69f)

There is also a recognition of the need for planning climate-resilient water supply and disposal and supporting circulatory systems, in light of the effects of climate change such as periods of drought, dryness and heavy precipitation. There is also a recognition of the importance of the preservation and expansion of biodiversity as important factors for clean drinking water resources and retention capacity of soils during heavy precipitation events. Based on this, there is a need for coordination between spatial planning and water management. (ÖROK 2021: 70f)

The plan sets out that securing, networking, development and functional management of open and green spaces gains priority in the light of the effects of climate change and progressing biodiversity losses. It outlines that measures are needed to preserve natural areas, maintain quality and recreational value of the landscape and biodiversity and to stop the loss of species and habitats. It highlights further that these measures require an integrated and equivalent consideration of the planning objects of settlement area versus open and green space, particularly in relation to natural and cultural landscapes. There is explicit reference to green infrastructure, which is defined as a strategically planned network of ecologically valuable natural and semi-natural areas with environmental elements. (ÖROK 2021: 74f)

The plan points out that, since in Austria there is no framework legislation of the federal government or coordinated federal spatial planning, intensive coordination between spatial and sectoral planning are important, and particularly with regard to coordination between sector goals, spatial goals and goals for climate and biodiversity protection and climate change adaptation. (ÖROK 2021: 123) It highlights that in case of conflicts of use, attention should be paid to the aspects of climate protection and climate change adaptation. (ÖROK 2021: 130)

As has been outlined, there are quite a large number of references to the need for addressing biodiversity loss and ecosystem degradation, also in the context of disaster risk reduction and climate change adaptation.

Masterplan Tourism – Low support

No reference can be found to ecosystem-based / nature-based solutions in the Masterplan Tourism, therefore it is categorized as showing low level of support. However, there are a few entry points for mainstreaming said approaches also in the sector of tourism, which is of particular relevance in light of the economic role it plays in the Austrian economy, as well as the risks it is faced with due to climate change, but also biodiversity loss and ecosystem degradation. Most prominently, there is a commitment to sustainability contained in the plan (BMNT 2019b: 7), outlining the importance of intact Austrian nature, as well as the diverse landscapes for Austria's tourism sector. However, there is also a recognition of the significant impact of tourism on these resources, therefore it is demanded that a reasonable balance of interests should be found. (BMNT 2019b: 9f) The plan outlines the aim to position Austria as a "green" destination, highlighting the importance of sustainability and an active promotion of climate and environmentally compatible tourism. (BMNT 2019b: 26)

Moor / Peatland Strategy – strong explicit support

There is no specific reference to ecosystem-based approaches/nature-based solutions in the Moor Strategy. Yet the fact that, in and of itself there is a dedicated strategy on moors and peatlands recognizing the important role they play in terms of climate change and ecosystem degradation, is the reason for the categorization as showcasing strong explicit level of support.

In the strategy, there is a clear recognition of moors in terms of the valuable ecosystem services they provide in terms of water retention both in relation to flood protection and providing water also during drought periods, and in terms of carbon sequestration and therefore their role in tackling climate change. On the other side, there is also a recognition of their endangered status both in quality and in quantity. Therefore, the strategy aims to protect existing moors and their ecosystem services, restore damaged moors and their ecosystem services, promote sustainable use of peatlands, raise awareness around the importance of moors and peatlands, and motivate joint action by all relevant stakeholders until 2030. (LORENZ ET AL. 2022: 9)

The below image shows the revitalisation of the Tanner Moor, an example of the projects being conducted as part of the moor strategy (see LORENZ ET AL. 2022: 61f for more information on this specific project).

Source: Image by Johanna Lütterfelds (2022)

Figure 34: Revitalisation of the Tanner Moor

National Park Strategy – strong implicit support

There is no reference with regard to ecosystem-based approaches or nature-based solutions. The existence of a specific strategy for national parks is an acknowledgement of the importance of protected areas, which as such are tools in the context of ecosystem-based approaches. However, there is no reference to the importance of national parks also in terms of disaster risk reduction, only in terms of addressing climate change and biodiversity loss. Therefore, the strategy is categorized as showcasing strong implicit support. The various substantive entry points that could be used for the future integration of ecosystem-based approaches are outlined below.

In the strategy, it is outlined that the six Austrian national parks are places of outstanding biological diversity. The strategy contains a vision which refers to Austria's natural heritage in 2035 on the one side, referring to the natural and cultural landscapes typical of Austria being preserved through a wide range of protection and support measures as well as differentiated, sustainable management. (BMNT 2017: 6)

On the other side, the vision refers to Austria's national parks in 2035, outlining that national parks stand for the preservation of the national natural heritage and are part of the Austrian identity, and that all natural ecosystem types are protected by national parks. It additionally states that there is a coherent network of protected areas in which each national park functions as the center of an ecological network and plays an active role, with the national parks helping to increase the chances of survival of species, communities and ecosystems in the long term and to achieve the national biodiversity goals according to the Biodiversity Strategy Austria 2020+. Furthermore, it sets out that the cooperation of the national parks under the brand "National Parks Austria" is successful, and synergies are also used from an economic point of view. Also, the vision sets out that the national parks successfully contribute to the development of solutions for current challenges such as climate change, loss of species, invasive species, and fragmentation. In addition, it states that national parks are innovation spaces. (BMNT 2017: 6)

The strategy also sets out various goals, including in terms of improving scientific knowledge of the status and trends of biodiversity, e.g. via completing the basic data and implementing long-term monitoring in order to check the status and trends of selected species and habitats as indicators for biodiversity. (BMNT 2017: 18) Yet another goal aims at the availability and implementation of management plans for all national parks with common standards and harmonization in terms of function, content, structure, target group, deadlines, binding nature and preparation. (BMNT 2017: 26)

As this shows, there are a number of entry points which could be used for the further integration of ecosystem-based approaches, also in the context of disaster risk reduction.

Flood Plain Strategy – strong explicit support

There is clear recognition of flood plains as important green infrastructure and their role in flood related disaster risk reduction, as well as their role in terms of biodiversity and provision of ecosystem services in the strategy. Therefore, it is categorized as showcasing a strong explicit level of support. Below, information is provided on specific aims, including recommended actions, with specific reference to and therefore signifying relevant entry points for ecosystem-based approaches.

There is explicit acknowledgement of the high level of biodiversity present in well-functioning flood plains, and that they provide extremely important ecosystem services, including flood retention, groundwater formation, sustainable wood production, etc. At the same time, there is recognition that the status of existing flood plains in Austria is very much under pressure, among other factors due to the lasting trend of increased soil sealing. Inter alia, the strategy therefore aims to contribute to the protection and reestablishment of ecosystems and their services and the enhancement of green infrastructure, a coordinated approach to the various water and biodiversity related directives at EU level, the development of a “wise use” approach for flood plains, development of an Austrian-wide joint understanding regarding the treatment of flood plains, etc. (BMLFUW 2015: 5)

Aim 1 of the strategy is therefore to protect and secure existing flood plains, to enhance the connectivity between running water and flood plains, and the clearing and recreation of retention areas. This should achieve, inter alia, flood protection and flood management implementation making use of flood plains. (BMLFUW 2015: 6f)

Aim 2 refers to enhancing and expanding flood plains, with the objective to restore peatlands, ensuring sufficient space in the agricultural practice for the outflow and retention of rivers, enhancing the ecological network of flood plains and adjoining habitats, acquiring and provision of areas for passive flood protection as potential for the enlargement of flood plains, and recognition of flood plains as green infrastructure, as well as their role in natural water retention measures. Inter alia, measures like reintegration of flood plains in flood protection projects, ensuring a sustainable load and sediment management, consideration of flood plains in the national water management plan and in the national biodiversity strategy, securing of areas for flood protection and ecological regeneration of flood plain locations, etc. are listed. (BMLFUW 2015: 8f)

Aim 3 is related to sustainable use of and reduction of threats to flood plains, including achieving sustainable river basin management and better coordination between environmental protection, spatial planning, and water management. (BMLFUW 2015: 10f)

Aim 4 relates to the need for increasing knowledge and awareness of the flood plains and their ecosystem services, including relevant data, inventories, etc. (BMLFUW 2015: 12)

The fact in and of itself that there is a dedicated strategy available in Austria with regard to flood plains shows that there is recognition of the importance of their ecosystems, including with regard to disaster risk reduction and protecting biodiversity. As has been shown, there are various entry points and specific references to ecosystem-based approaches throughout the strategy.

Water Resources Management Plan – strong explicit support

There is no specific reference to ecosystem-based approaches or nature-based solutions, however, there is strong recognition of the need for protection of ecosystems and the role water management plays with regard to climate change adaptation in particular, e.g. in the context of sustainable management approaches. Therefore, the Water Resources Management Plan is categorized as showcasing strong explicit support for ecosystem-based approaches. The various entry points which can be found throughout the plan are outlined below.

In order to achieve the goals and principles of the Water Framework Directive, the National Water Management Plan was developed as a river basin-related planning, (BMLRT 2022: 8) The specifications of the NGP are based on the goals and principles of the relevant legal framework, according to which water management, taking into account the polluter pays principle in the sense of sustainable management for the protection of and keeping the resource clean, including, inter alia, the following principles: impairments to the landscape and other perceptible damage can be avoided; deterioration is avoided and that the status of aquatic ecosystems and the terrestrial ecosystems and wetlands directly dependent on them are protected and improved with regard to their water balance; that sustainable water use based on long-term protection of existing resources is promoted; that improvement of the aquatic environment is ensured; keeping groundwater and spring water so clean that it can be used as drinking water; protect groundwater in such a way as to ensure a gradual reduction in groundwater pollution and the prevention of further pollution; and keeping surface waters so clean that surface waters can be used for common and commercial purposes and fish waters can be preserved. (BMLRT 2022: 10)

According to the environmental goals of the plan, waters are to be protected, improved and rehabilitated so that there is no further deterioration of the actual status and the "good status" is achieved in all water bodies. (BMLRT 2022: 139)

There is also an entire chapter on the issue of effects of climate change on Austrian water management. With regard to impacts of climate change on water management, there is acknowledgement that the changes in the climatic framework have a variety of effects on water bodies. (BMLRT 2022: 280) Furthermore, there is acknowledgement that, as a result of the general rise in temperature, glaciers are melting and the permafrost line is shifting to higher altitudes and, as a result, rubble and rocky slopes in the mountains are becoming increasingly unstable and the sediment balance in water bodies is affected. Also, it acknowledges that the mean discharges are expected to change only slightly, although a shift from summer to winter is foreseeable and that, due to climate change, an increase in flood events is to be expected, although the extent is currently difficult to estimate. The plan also states that local heavy rain events will occur more frequently. On the other side, it acknowledges that longer dry periods and associated pronounced low water discharges will occur more frequently in the future, especially in summer and that, as a result, on the one hand less water is available for uses and on the other hand there is less dilution, e.g. from sewage treatment plant effluents. Additionally, the strategy states that it is to be expected that groundwater recharge will decrease in some regions, especially in southern and eastern Austria and that, as a result, the groundwater resources available for various uses will decrease. There is a reference that the effects of climate change on flood discharges and corresponding adaptation measures are presented in more detail in the draft Flood Risk Management Plan. (BMLRT 2022: 282)

There is also a dedicated section regarding adaptation strategies to climate change and related measures in the field of water management, with reference to the recommendations for action for the activity field “water balance and water management” of the Adaptation Strategy, which include an analysis of existing data and promotion of further data collection on the resource of water, improved coordination/information regarding water consumption and water needs, future guarantee of water supply, conscious use of water as a resource, increased consideration of low water in the management of water resources, achieving and securing the good ecological and chemical status of bodies of water, including groundwater, intensification of water management planning of groundwater resources, adaptive flood management with robust measures, increased consideration of water temperatures in water management measures, and installation of industrial water management instruments. It concludes with stating that, in the future, the increasing pressure of use will require intensified forward-looking water management planning for the quantitative management of groundwater. (BMLRT 2022: 283)

In addition, there is recognition that measures to improve the ecological status of water bodies increase the resilience of water bodies to the effects of climate change, indicating that near-natural bodies of water can withstand high temperatures better than regulated sections, they also have a positive effect on the local climate and have an important recreational function for people. It recognizes also that a successful adaptation of water management to climate change can best be ensured through an integrative, interdisciplinary approach and that e.g. natural water retention measures can contribute just as much to ecological improvement as to the reduction of flood discharges from small-scale heavy precipitation and to the creation of recreation areas for people and to the improvement of groundwater recharge. (BMLRT 2022: 283)

With regard to water scarcity and drought, it is pointed out that further changes in the amount of precipitation, generally rising air temperatures and increased periods of drought and heat and the associated effects on the water cycle and water availability for the various water uses are to be expected. Therefore, it states that, in addition to higher-level climate protection measures, special adaptation measures are required with regard to drought and water shortages, therefore emphasizing the need for sustainable use and management of groundwater resources. (BMLRT 2022: 285)

With regard to drought, the plan states that, compared to other European countries, the problems due to drought in Austria can be considered to be rather minor, therefore the creation of nationwide drought risk management plans across Austria is not considered necessary, but would be advisable in low-rainfall regions with already high levels of utilization of the sustainably available water resources. With regard to water shortage, the plan states that, in general, Austria has no problem with water stress, but locally and regionally the degree of utilization of the available resource is high. (BMLRT 2022: 286)

As can be seen, there is clear recognition of the role water management plays particularly in the light of climate change adaptation, even though there is no reference to ecosystem-based approaches.

6. Findings and assessment of the current state of mainstreaming of ecosystem-based approaches in the Austrian disaster risk reduction policy approach

An overview of the findings and substantive assessment of the previous chapter are simplified in table 2 below, which provides an overview of the findings per policy/strategy, including the assessment of the level of support for nature-based solutions/ecosystem-based approaches in the context of climate change adaptation and disaster risk reduction.

Table 2: Level of support of relevant Austrian policies / strategies in terms of nature-based solutions / ecosystem-based approaches

Policy / strategy	*Nature-/ecosystem-based related terms*								*Reference to disaster risk reduction*	*Reference to climate change adaptation*	*Level of support*
	Ecosystem	Biodiversity	Nature-based	Ecosystem,-based	Natural Infrastructure	Blue / Green Infrastructure	Integrated / sustainable Management	Eco-engineering			
Current Government Programme	X	X	-	-	-	-	X	-	X	-	Strong explicit support
Nationally determined contribution	X	X	X	-	-	-	-	-	X	X	Strong explicit support
Climate Change Adaptation Strategy	X	X	-	-	-	X	-	-	-	X	Strong explicit support
Biodiversity Strategy	-	-	-	-	-	-	-	-	-	-	n/a
National disaster risk reduction strategy	-	-	-	-	-	-	-	-	-	-	n/a
Flood risk management plan	X	X	-	-	-	-	-	X	X	X	Strong explicit support
Infrastructure expansion plan	X	X	-	-	-	-	-	-	-	-	Low support
National Energy and Climate Plan	-	-	-	-	-	-	-	-	-	-	Low support
Forest Strategy	X	X					X		X	-	Strong explicit support
Rural Development Programme	X	X					X		X	-	Strong explicit support
National common agricultural policy strategy	X	X	-	-	-	-	X	-	X	-	Strong explicit support

Policy / strategy	*Nature-/ecosystem-based related terms*								*Reference to disaster risk reduction*	*Reference to climate change adaptation*	*Level of support*
	Ecosystem	Biodiversity	Nature-based	Ecosystem,-based	Natural Infrastructure	Blue / Green Infrastructure	Integrated / sustainable Management	Eco-engineering			
Spatial Development Perspective	X	X	-	-	-	X	X	-	X	X	Strong implicit support
Masterplan Tourism	X	X	-	-	-	-	-	-	-	-	Low support
Moor / peatland strategy	X	X	-	-	-	-	X	-	X	-	Strong explicit support
National Park Strategy	X	X	-	-	-	-	-	-	-	-	Strong implicit support
Flood Plain Strategy	X	X	-	-	-	X	X		X	-	Strong explicit support
Water Resources Management Plan	X	X	-	-	-	-	X	-	-	X	Strong explicit support

This shows that there is an expression of support in one form or another of ecosystem-based approaches/nature-based solutions observable in a large majority of the policies/strategies that were analysed, either explicitly or implicitly, with either showing a link to either disaster risk reduction or climate change adaptation, or both. With the exception of one, all documents also made reference to biodiversity and ecosystems in one form or another. However, the above also shows that, with the exception of one document, none of the policies/strategies actually refers to the term "ecosystem-based approach" and/or "nature-based solution", nor to "EbA" and/or "Eco-DRR".

7. Discussion of findings and identification of possible entry points for mainstreaming ecosystem-based approaches in Austria

The findings show that there seems to be broad cross-sectoral recognition of the important role that biodiversity and ecosystems play in general, whilst there is also general recognition observable that efforts need to be stepped up to tackle biodiversity loss and ecosystem degradation throughout many of the policies/strategies that were assessed.

Furthermore, the findings suggest that there is broad support for solutions and approaches that can be seen as falling under the general category of ecosystem-based approaches. This is particularly true for protective forests and in the area of flood protection and management. However, there is almost no mentioning and therefore recognition of other EbA and/or Eco-DRR solutions, albeit the vast number of different approaches and solutions available under their umbrella.

However, it also has become clear that the encompassing labels of EbA / Eco-DRR / nature-based solutions are not being used in the documents, even if in principle the respective policy/strategy is supportive of the underlying ideas and concepts of those approaches.

As was elaborated in chapter 5, for each of the documents that was analysed, substantive entry points can be identified for an enhanced integration/mainstreaming of ecosystem-based approaches to a varying degree (it should of course be highlighted that this cannot be seen as an exhaustive list of all the entry points to be found in the respective policy/strategy). Entry points were identified whenever there was e.g. a reference to sustainability and/or environmental considerations, disaster risk management tools, such as the developments of plans, risk assessments, etc.. The outcome of this mapping, as contained in chapter 5 for each of the documents analysed, shows that there would be room to further increase the uptake of specific ecosystem-based approaches as targeted, sector specific solutions based on the foundations laid by the various policies/strategies. Therefore, already based on the existing body of policies/strategies in the various sectors, there would be a sound basis for using and further promoting ecosystem-based approaches to tackle issues of disaster risk reduction and climate change adaptation.

As was also outlined, there are quite a number of cross-references between a number of policies/strategies, which can also be used to improve synergies in the implementation thereof, as well as to increase the potential contribution of the individual policies/strategies.

However, and as will be elaborated in more detail in the next chapter, the analysis conducted as part of this thesis can only be seen as providing a snapshot, not allowing for generalized conclusions with regard to the overall approach to disaster risk reduction in Austria. Furthermore, it should be noted that the fact that biodiversity and ecosystem related considerations are included in a specific policy/strategy does not automatically imply that they are de facto considered in the on-the ground practice in the respective sectoral approach. For this, as will be outlined in the next two chapters, further work would be needed in terms of analysing e.g. the legal and regulatory framework, including on the level of the provinces (Bundesländer), funding frameworks, local approaches, the general on-the ground practice, etc.

As the assessment of the high-level policy documents cannot address all three underlying hypotheses and research questions of this thesis in full, the assessment of the hypotheses and research questions against the findings of the theoretical part contained in chapters 2 and 3 and the analytical findings contained in chapters 5 to 7 of this thesis will be discussed in the next chapter.

8. Conclusions

To conclude, the findings of this thesis will be assessed against the underlying hypotheses and research questions that built the basis for this thesis.

To recollect hypothesis 1, which stated: Biodiversity loss and environmental degradation increasingly constitute significant risk drivers, whilst at the same time biodiversity and ecosystems offer great potential in preventing and mitigating natural hazards, therefore protection of biodiversity and ecosystems should be at the forefront of disaster risk reduction efforts. However, current disaster risk reduction approaches in Austria so far do not yet consider the threat posed by biodiversity loss and environmental degradation, nor the opportunities that biodiversity and ecosystems offer to the extent possible and necessary.

The following was research question 1: *Is there recognition of biodiversity loss and ecosystem degradation as risk drivers on the one side, as well as the opportunities that particularly ecosystems offer in terms of disaster risk reduction on the other side in current high-level policies relevant to disaster risk reduction in Austria?*

As has been shown in chapter 2 as part of the theoretical part of this thesis, biodiversity loss and ecosystem degradation, also in combination with climate change, indeed pose significant risk drivers, with the disaster risk reduction community more and more acknowledging this, as well as the need to protect biodiversity and ecosystems, as well as the diverse range of services they provide. At the same time, as also shown in chapter 2, biodiversity and ecosystems have a lot to offer in terms of addressing the three risk factors and throughout all phases of the disaster risk cycle. Unfortunately, despite the commitment under the Sendai Framework, Austria does not have a national disaster risk reduction policy. Furthermore, unfortunately the national risk assessments prepared in compliance with the relevant EU reporting requirements are not publicly available. Therefore, seeing that these two documents would be the best starting point to address this research question are not available at this point in time, this question cannot be answered conclusively. However, from the limited information available, as outlined in chapter 2, it seems that there is still a lack of acknowledgement of the importance of biodiversity loss and economic degradation as risk drivers in national risk assessments.

As outlined in chapters 5 to 7, as the analytical findings have shown, there is general recognition in almost all the policies/strategies relevant for disaster risk reduction in Austria of the important role of biodiversity and ecosystems, as well as in some of the documents also a recognition of the deteriorating trend that can be observed also in Austria. However, whilst there is acknowledgement in some of the documents that biodiversity and ecosystems can support in terms of disaster risk reduction and, in a few instances also climate change adaptation, there is no broad recognition of biodiversity loss and ecosystem degradation posing risk drivers as such.

To turn to hypothesis 2, which read: In light of the increasing risks caused by climate change, there is a need for enhanced linkages between adaptation and disaster risk reduction. Eco-DRR and EbA play an increasingly important role in discussions and efforts on an international level and in the context of international cooperation and sustainable development efforts. The two approaches offer enormous potential for addressing numerous threats and challenges disaster risk reduction and adaptation practitioners and policy makers are faced with.

Based on this, research question 2 read as follows: *What are the advantages/potential and disadvantages/challenges of Eco-DRR and EbA and in how far can they be used for addressing disaster risk reduction and adaptation?*

Throughout this thesis, it has become apparent that ecosystem-based approaches have much to offer, particularly from a disaster risk reduction perspective. There are a large number of benefits, which have been outlined in chapter 3 as part of the theoretical part of this thesis. As has been shown, they can be useful tools for disaster risk reduction and climate change adaptation, allowing for cost-effective, longer-term planning, moving from a hazard specific disaster risk reduction approach to a more holistic, integrated, forward looking approach, also in terms of building back better, increasing the overall resilience to tackle the twin crises of climate change and biodiversity loss, including with regard to the many uncertainties linked to them, and offering more flexibility compared to more traditional approaches to disaster risk reduction, also with a view to addressing future changes due to climate change. Furthermore, they can be powerful tools to address various societal challenges in the context of sustainable development and support countries in complying with various international commitments in the environmental and disaster risk reduction sector.

Also, as has been pointed out in chapter 2 based on the theoretical findings, approaches to climate change adaptation and disaster risk reduction are still in many cases following a silo approach, which, not least in light of the intrinsic link between climate change and biodiversity loss and ecosystem degradation, should be overcome in order to increase synergies and enhance the effectiveness of approaches also in the long-term. As has been shown, EbA and Eco-DRR do offer an opportunity to overcome this silo approach.

Yet, it should be acknowledged that there are a large number of challenges remaining with regard to EbA and Eco-DRR in general, and their implementation in particular. The next chapter will outline a number of issues, which should be addressed by relevant stakeholders going forward in order to enable the enhanced uptake of ecosystem-based approaches.

Hypothesis 3 read: Eco-DRR and EbA are still underused concepts in the overall disaster risk reduction approach in Austria.

And, based on that, research question 3 referred to: *What is the status of mainstreaming of Eco-DRR and EbA, i.e. the integration of ecosystem considerations in current disaster risk reduction related policies/strategies in Austria?*

As was outlined previously, there is no national disaster risk reduction strategy in place in Austria. Furthermore, the new biodiversity strategy is currently being developed and therefore not yet available for the analysis. Seeing that these two documents would be relevant cornerstones for a holistic assessment, this question cannot be conclusively answered. Furthermore, the fact that federalism in Austria contributes to fragmentation, particularly in the area of environmental protection and disaster management, further aggravates a conclusive answer to this question. Additionally, as was pointed out in chapter 4, the scope of analysis of this thesis was limited to policies and strategies, and did not include the current regulatory and legal framework, including on the level of provinces (Bundesländer), budget/funding approaches and activities in the various sectors, as well as local strategies, plans, etc. It must also be borne in mind that, on the basis of the status of mainstreaming of ecosystem-based approaches in the various policies/strategies only, no assumptions can be made with regard to the on-the ground practice of disaster risk reduction, as there might very well be a gap between the high-level documents and the actual practical implementation.

With this caveat, based on the analysis conducted in this thesis, it seems that there is general recognition of particularly some ecosystem-based approaches in the context of disaster risk reduction, under special consideration of protective forests and flood management related approaches, visible in Austria. However, the labels of EbA and Eco-DRR / nature-based solutions are not being used. In this regard, it should be borne in mind that some of the specific approaches encompassed by the concepts of EbA and Eco-DRR, such as e.g. protective forests, are not new per se, but were in use long before being labelled as such, which might be the reason for the underuse of the labels in the various high-level documents. Yet, this might also be an indication for a lack of awareness around the added value and benefits of ecosystem-based approaches to natural hazard management. Furthermore, e.g. the areas of infrastructure expansion, climate and energy, and tourism, in which case the strategies/policies showed only limited to no support for ecosystem-based approaches and/or their underlying concepts and ideas, show that there is room for improving the general awareness around biodiversity and ecosystems and enhancing the integrating of ecosystem-based approaches.

However, the fact that there are specific policies/strategies in place addressing protective forests, moors/peatlands, and flood plains with clear reference to their contribution in terms of disaster risk reduction, with also other sectoral policies/strategies currently being prepared, including a revised version of the biodiversity strategy, are clear indications of the recognition in Austria of the relevance of ecosystem-based approaches.

As has been shown in chapter 3 in the theoretical part of this thesis, EbA and Eco-DRR offer a large number of benefits and opportunities. This, together with the growing recognition that there is an urgent need to halt and reverse biodiversity loss and ecosystem degradation, are strong indications for the need for scaling-up the overall use of ecosystem-based approaches. As was outlined in chapter 5, based on the analytical findings, a large number of substantive entry points can be observed in all of the existing policies/strategies for a further integration of sector specific approaches both, to support disaster risk reduction and climate change adaptation efforts on the one side, whilst at the same time tackling biodiversity loss and ecosystem degradation on the other side. In addition, based on these entry points, there would be opportunities to further increase the synergies between climate change adaptation and disaster risk reduction through ecosystem-based approaches. As was outlined, e.g. the

CBD guidelines contain a simple framework for mainstreaming EbA and Eco-DRR within key development and sectoral strategies (see figure 25 above).

Looking at the large number of different approaches under the umbrella of EbA and Eco-DRR, there is untapped potential for disaster risk reduction approaches also in Austria, as e.g. the recent cross-border research project "GreenRisk4ALPS" with Austrian participation (facilitating risk-based protective forest management as part of an integrated and ecosystem-based natural hazard management in the Alpine Space) has shown.[14] Its project aims and objectives related to overcoming conflicts and resistances with new risk mitigation alternatives and science-based communication support, implementing innovative ecosystem-based risk management for natural hazards by generating recommendations adapted to local practical, socioeconomic, scientific and political needs, and creating protective forest books (see e.g. below an image showcasing an example of a mountainous terrain, where a mixture of grey infrastructure and protective forests have been used to protect a ski slope located at a subjacent level).

Source: Image by Johanna Lütterfelds (2021)

Figure 35: Example of the Kasberg, Grünau im Almtal

Overall, the large potential of EbA and Eco-DRR has been highlighted by this thesis. Decision makers and practitioners should look even more closely into their uptake, not only to tap into their potential in terms of disaster risk reduction and climate change adaptation, but also as powerful tools to tackle biodiversity loss and ecosystem degradation as increasing risk drivers facing our society together with climate change.

[14] More information available at: https://www.alpine-space.org/projects/greenrisk4alps/en/home (accessed 6.8.2022).

9. Outlook

Biodiversity loss and ecosystem degradation will, if no urgent action is taken to counter these two issues, hand in hand with climate change, increasingly constitute significant risk drivers. This should be at the forefront of deliberations and actions taken by disaster risk reduction managers, policy makers, and the public at large. There is therefore need to further increase awareness of the interdependence between disaster risk and biodiversity loss and ecosystem degradation. In addition, there is need to overcome the persisting silo approach in terms of disaster risk reduction and climate change adaptation in order to benefit from the synergies a holistic approach to those two issues would offer.[15] This would also entail close cooperation and coordination among the relevant stakeholders, may that be Ministries, political decision-makers, or practitioners. Depending on the outcome regarding the finalization of the EU restoration law as outlined in chapter 2, this might be a good example of enhanced coordination necessary between environment-related climate change adaptation, and disaster risk reduction efforts.

As was highlighted in various parts of this thesis, there are a number of challenges that need to be addressed in order to increase awareness around ecosystem degradation and biodiversity loss posing significant risk drivers on the one hand, and their potential in terms of disaster risk reduction and climate change adaptation on the other hand. The same goes for the increase of the overall uptake of ecosystem-based approaches as a meaningful opportunity to tackle biodiversity loss and ecosystem degradation on the one hand, and significantly contribute to disaster risk reduction and climate change adaptation on the other hand.

Inter alia, as was pointed out, there is a need to increase the knowledge and evidence base and close remaining knowledge gaps with regard to EbA and Eco-DRR. This relates to, inter alia, assessing and monitoring/evaluating the benefits and effectiveness of ecosystem-based approaches, including economic evaluations as basis for decision-making, and quantification of benefits and co-benefits, including with regard to ecosystem services. More information is also needed with regard to unintended consequences of Eco-DRR and EbA. Furthermore, there is need for greater conceptual clarity around the terms of nature-based solutions and Eco-DRR and EbA.

There is also need to increase the general understanding of biodiversity loss and ecosystem degradation as slow onset events, both in terms of scientific understanding of future developments and impacts, but also raising public awareness in general and increasing understanding that those issues cannot comprehensively be addressed solely on a local level. In addition, the knowledge base on biodiversity loss and ecosystem degradation needs to be significantly enhanced, e.g. with regard to biodiversity inventories, status, variables, and scenarios. At the same time, the

[15] See e.g. a recent project, "PLACARD" (PLAtform for Climate Adaptation and Risk reDuction), which aimed at bonding climate change adaptation and disaster risk reduction by sharing knowledge and enhanced collaboration between the multiple research, policy and practice communities, and resulted in 20 recommendations in five substantive areas. More information available at: https://www.placard-network.eu/strengthening-institutional-coordination-capacities/ (accessed 23.8.2022).

knowledge base around ecosystem loss and damage will need to be enhanced, and, as pointed out repeatedly, there is need for incorporating biodiversity loss and ecosystem degradation in national risk assessments as standalone category.

Overall, there is also need to further develop sector specific guidance, standards, guidelines, etc. in order to support practitioners, even though, as was pointed out, the body of guidance available for practitioners is steadily growing.

With regard to the specific case for Austria, the development of a national disaster risk reduction strategy would seem advisable, and not only to comply with target E of the Sendai Framework, even though the fragmented responsibilities due to federalism in Austria in the area of disaster risk reduction should be borne in mind. This would be a useful tool to acknowledge and increase awareness around the importance of biodiversity and ecosystems also in the context of disaster risk reduction, as well as of the benefits ecosystem-based approaches can offer. In addition, if not already done so (which, due to the confidentiality regime around national risk assessment, this thesis could not conclusively evaluate), biodiversity loss and ecosystem degradation should be included in the next iteration of the Austrian national risk assessment, thereby acknowledging their role as risk drivers also for the risk landscape in Austria.

As was pointed out in the previous chapter, the scope of analysis of this thesis was limited to policies and strategies, therefore, in order to achieve a holistic, meaningful picture of the de facto status of mainstreaming of EbA and Eco-DRR in Austria, the analysis would need to be extended to also cover the current regulatory and legal framework, budget/funding approaches and activities in the various sectors, as well as local strategies, plans, etc. Furthermore, based on the findings of this thesis, no assertions can be made with regard to the on-the ground disaster risk reduction practice, further research would be necessary in this regard as there is a real possibility that ecosystem-based approaches are being used independent of the status of their mainstreaming. This might particularly be the case as various of the specific approaches encompassed by the concepts of EbA and Eco-DRR are not new per se, but were in use long before being labelled as such, as was outlined in the previous chapter. In general, an enhanced use of the specific labels of EbA and Eco-DRR in relevant policies, strategies, legal framework etc. might lead to an increase in awareness by policy-makers, practitioners, and the public at large of the important role they can and continue to play with regard to climate change adaptation and disaster risk reduction.

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KURZZUSAMMENFASSUNG

Der Verlust der biologischen Vielfalt und die Zerstörung von Ökosysteme stellen zunehmend bedeutende Risikotreiber dar, insbesondere, wenn sie nicht Hand in Hand mit dem Klimawandel adressiert werden. Daher sind diese beiden Themen auch in den Bereichen Anpassung an den Klimawandel und Katastrophenvorsorge zunehmend in den Fokus der Wissenschaft und der politischen Entscheidungsträger gerückt. Gleichzeitig wächst die Erkenntnis, dass Biodiversität und Ökosysteme auch ein enormes Potenzial für die Verringerung des Katastrophenrisikos und Bemühungen rund um Klimawandelanpassung bieten. Darüber hinaus werden die Synergien zwischen Klimawandelanpassung und Katastrophenvorsorge zunehmend anerkannt, wie auch die Notwendigkeit, bestehende Silos in dieser Hinsicht aufzubrechen.

Angesichts dieser Erkenntnis wurde das Konzept der ökosystembasierten Ansätze zur Klimawandelanpassung, die sogenannte ökosystembasierte Anpassung (EbA), und zur Katastrophenvorsorge, die sogenannte ökosystembasierte Katastrophenvorsorge (Eco-DRR), entwickelt und zunehmend im wissenschaftlichen und politischen Diskurs in den diversen internationalen multilateralen Foren gefördert. Wie diese Arbeit aufzeigen soll, bieten sie großes Potenzial, auch im Hinblick auf die Bewältigung des Biodiversitätsverlusts und der Schädigung von Ökosystemen, obschon verschiedene Herausforderungen hinsichtlich der praktischen Umsetzung bestehen. Trotz des allgemein anerkannten Potenzials von EbA und Eco-DRR bleibt deren Akzeptanz in der Praxis jedoch begrenzt.

Das Mainstreaming von EbA und Eco-DRR in relevante Policies, Strategien, Gesetzgebung, Förderprogramme, usw. zielt darauf ab, die allgemeine Akzeptanz dieser Ansätze in der Praxis zu erhöhen. Daher wurde im Rahmen dieser Arbeit der Status des Mainstreamings von EbA und Eco-DRR im aktuellen österreichischen Policy-Ansatz zur Katastrophenvorsorge analysiert, unter anderem durch eine Analyse relevanter Policies und Strategien. Unter Berücksichtigung verschiedener Vorbehalte in Bezug auf die Analyse zeigte diese, dass die meisten Policies und Strategien die Bedeutung von Biodiversität und Ökosystemen anerkennen, sowie ein gewisses Maß an Unterstützung in Bezug auf ökosystembasierte Ansätze (insbesondere in Bezug auf Schutzwälder und wasserbezogene Bewirtschaftungsansätze) aufweisen, ohne dass diesbezüglich ausdrücklich auf EbA und/oder Eco-DRR verwiesen wird. Die Forschungsfrage, ob Biodiversitätsverlust und Ökosystemdegradation explizit als Risikotreiber im österreichischen Ansatz der Katastrophenvorsorge anerkannt werden, konnte jedoch nicht abschließend beantwortet werden.

Basierend auf dem theoretischen und analytischen Teil dieser Arbeit werden weiterer Forschungsbedarf und Maßnahmen identifiziert, die notwendig sind, um das allgemeine Bewusstsein für und die Akzeptanz von EbA und Eco-DRR zu erhöhen. Insbesondere im Hinblick auf den österreichischen Politikansatz zur Katastrophenvorsorge werden für jede der analysierten sektoralen Policies und Strategien spezifische Mainstreaming-Ansatzpunkte identifiziert, die das große Potenzial zur weiteren Förderung von EbA und Eco-DRR Ansätzen aufzeigen.

ABSTRACT

Biodiversity loss and ecosystem degradation will, if no urgent action is taken to tackle these two issues, hand in hand with climate change, increasingly constitute significant risk drivers. Therefore, these two issues have increasingly risen to the attention of the scientific community and political decision makers also in the spheres of climate change adaptation and disaster risk reduction. At the same time, there is growing recognition that biodiversity and ecosystems also offer enormous potential for disaster risk reduction and climate change adaptation efforts. Furthermore, there is increasing acknowledgement of the synergies between climate change adaptation and disaster risk reduction and the need to break down persisting silos in this regard.

In light of this recognition, the concept of so-called ecosystem-based approaches to climate change adaptation and disaster risk reduction, i.e. ecosystem-based adaptation (EbA) and ecosystem-based disaster risk reduction (Eco-DRR), have been developed and increasingly promoted in the academic community and the policy discourse in various international multilateral fora. As this thesis aims to point out, they offer great potential and benefits, including in terms of addressing biodiversity loss and ecosystem degradation, even though various challenges with regard to the on-the ground implementation remain. However, despite the broadly acknowledged potential of EbA and Eco-DRR, the on-the ground uptake still remains limited.

Mainstreaming of EbA and Eco-DRR in relevant policies, strategies, legal, regulatory and budgeting frameworks, etc. aims for increasing the general uptake of these approaches on the ground. Therefore, in the context of this thesis, the status of mainstreaming of EbA and Eco-DRR in the current Austrian policy approach to disaster risk reduction was analysed via, inter alia, an analysis of relevant high-level policies and strategies. Bearing in mind various caveats with regard to the analysis, it showed that most of the policies and strategies contained a recognition of the importance of biodiversity and ecosystems, as well as some level of support with regard to ecosystem-based approaches (particularly with regard to protective forests and water related management approaches), albeit not explicitly referencing EbA and/or Eco-DRR in this regard. The research question, whether or not biodiversity loss and ecosystem degradation are explicitly recognized as risk drivers in the Austrian disaster risk reduction approach, could however not be conclusively answered.

Based on the theoretical and analytical part of this thesis, various areas of further research and other actions necessary to increase the overall awareness around and uptake of EbA and Eco-DRR are identified. With regard to the Austrian policy approach to disaster risk reduction in particular, specific entry points are identified for each of the existing sectoral policies and strategies that were analysed, displaying the large potential to further enhance the uptake of EbA and Eco-DRR.