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RECONECT

Catalogue defining regions with comparable demands and characteristic features of NbS

Deliverable D5.1

Authors: Ramboll

Contributors: IHE, AMPHI

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Authors (Partner)	RAMBOLL			
Responsible Author	Name	Maria Facchin Asmussen	Partner	RAMBOLL
Contributors (Partner)	IHE Delft, AMPHI			

Abstract (for dissemination, 100 words)	This report examines the demand for large-scale Nature-based Solutions (NbS) in the EU, identifying regions with comparable demands through a systematic three-step approach. Spatial analyses reveal a widespread demand for NbS, reinforcing the need for targeted interventions and informed policy decisions. The findings emphasise the importance of integrating large-scale solutions with smaller-scale solutions and governance policies to meet diverse demands effectively.
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Executive Summary

This report focuses on the demand for large-scale Nature-based Solutions (NbS) and identifies regions with comparable demands for NbS. A three-step, systematic approach is applied to identify regions with comparable demands within the EU. First, the most pressing demands for implementing large-scale solutions are identified via a literature review of past RECONECT deliverables. The literature review identifies which goals demonstrators have highlighted as the main targets of their NbS within RECONECT's three areas of action: Water, Nature, and People. The three most frequently highlighted goals within each category progress into the second step where spatial data are identified and sourced to map regions with comparable demands. Results are compared to the potential locations of up to four selected NbS which have characteristic features to meet the mapped demands.

Results from the first step show that most frequently implementation of NbS is driven by nature-related goals such as enhancing and/or maintaining biodiversity and habitat area. This may reflect the growing focus on biodiversity conservation and protection which we have seen worldwide in particular in the last couple of years. At the same time, demands for water- or people-related NbS may be underrepresented due to limited understanding of the correlation to climate adaptation and mitigation and the potential benefits of NbS.

The top 3 demands identified in nature are to maintain and enhance biodiversity, habitat provision and distribution, and to increase habitat area. Within water the top 3 demands are flood risk reduction, improve water quality, and groundwater management, whilst top 3 people-related demands for implementation of NbS are to stimulate economic benefits, increase recreational opportunities, and maintain/enhance cultural values.

Via spatial analyses the overall results show that as much as 99 % of areas within Europe present a demand for the implementation of NbS. This is a compelling testament to the urgency and relevance of these approaches. The results reinforce the viability and significance of NbS, catalysing further support, investment, and informed policy decisions to harness the potential of these solutions in building a resilient future for Europe. Nature-related demands encompass 96 % of the EU, which underscores the continent's need to conserve and restore ecosystems, which are fundamental to sustaining life on Earth. The need for NbS providing benefits in the water challenge area is apparent in about 60 % of the EU, emphasising the vital importance of sustainable water management and the preservation of aquatic ecosystems. Finally, about 26 % of the EU displays a demand for NbS supplying benefits for people, which underscores the intrinsic link between human well-being and nature.

The produced maps make it possible to study, match, and consider areas in demand of NbS and build a foundation for twinning collaboration between policy makers in the respective regions. By comparing the results for demand for NbS against the potential for NbS, the analysis shows between 60 % and 90 % of the demand must be met by smaller-scale solutions, governance policies, and/or other solutions. It must be stressed though, that the implementation of large-scale NbS is not necessary across the entire area of demand, as solutions that span smaller areas can effectively mitigate the demand for larger areas.

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1 Introduction

1.1 Purpose

This report focuses on the demand for large-scale Nature-based Solutions (NbS) and identifies regions of comparable demands for NbS. The deliverable supports the aggregation of the evidence base portfolio for NbS and assists policy makers in building the case for NbS.

Whilst RECONECT deliverable D5.5 “Report describing the potential for implementation of large-scale NbS in Europe” analysed the *potential* for large-scale NbS, this deliverable analyses the *demands* for large-scale NbS. By drawing on previous RECONECT deliverables that identified goals for NbS, data are selected to map regions with demands that meet the goals, e.g., if there is a goal to increase recreational opportunities in an area, it can be assumed that demand arises in or in proximity to existing built-up areas where many people reside but have limited access to green spaces. Hence, data such as population density, built-up areas, land use, and/or green areas are analysed to map this demand for NbS.

The outcome of this deliverable is a discussion of demands to assist policy makers in building the case for NbS and an overview of regions with comparable demands for NbS. Outputs include large-scale maps of Europe showing regions defined by similar demands for NbS based on the discussion. The maps make it possible to study, match, and consider areas in demand of NbS and build a foundation for twinning collaboration between policy makers in the respective regions. The results are evaluated against the potential locations for large-scale NbS (based on D5.5 “Report describing the potential for implementation of large-scale NbS in Europe”).

1.2 Target audience

The outcomes of this report target regional and national policymakers and agencies in the EU. The outcomes can be used as a dialogue starter for potential interregional and -national twinning collaboration. Within a region, outcomes may also serve more technical experts as a foundation for initiating more detailed spatial analyses of demands for NbS as well as kickstarting policy dialogues around funding mechanisms for the estimated demand.

1.3 Background

D5.1 draws on previous deliverables in RECONECT, and specifically information from D2.3 “Scope of works for Demonstrators A and B”, D2.6 “Co-monitoring and co-evaluation plans for Demonstrators A and B”, D3.4 “Preliminary report describing co-monitoring activities”, and D5.5 “Report describing the potential for implementation of large-scale NbS in Europe”.

2 Defining goals and demands for NbS

2.1 A growing demand for NbS

There is a growing demand for NbS due to several interconnected factors that have become increasingly prominent in recent years. These factors include environmental degradation, climate change, urbanisation, and a growing recognition of the benefits that nature provides to human well-being and biodiversity. Some of the key reasons for the growing demands are:

- Environmental Sustainability: NbS offer a sustainable approach to addressing environmental challenges. By utilising and restoring natural processes, such solutions aim to minimise negative impacts on the environment while promoting long-term sustainability.
- Climate Change Mitigation and Adaptation: NbS play a crucial role in mitigating climate change and adapting to its impacts. Forest conservation, reforestation, and afforestation efforts, for example, can help sequester carbon dioxide from the atmosphere, reducing greenhouse gas emissions and combating global warming. Similarly, nature-based approaches like coastal wetland restoration can provide natural buffers against storm surges and protect vulnerable communities from the impacts of rising sea levels.
- Biodiversity Conservation: NbS prioritise the conservation and restoration of biodiversity. Preserving and restoring biodiversity not only protects species and habitats but also ensures the sustainability of ecosystem services that support human societies.
- Human Health and Well-being: NbS offer numerous benefits to human health and well-being. Access to green spaces and recreational opportunities, such as parks and gardens, can enhance community cohesion, reduce health inequalities, and contribute to overall quality of life.
- Economic Opportunities: NbS present economic opportunities through sectors such as ecotourism, sustainable agriculture, and green infrastructure development. NbS also have the potential to provide cost-effective alternatives to conventional infrastructure, such as green roofs and urban forests, which can contribute to energy savings and stormwater management.
- Resilience and Risk Reduction: NbS enhance the resilience of communities and ecosystems to natural hazards. By conserving and restoring natural ecosystems, such as mangroves, forests, and wetlands, these solutions can act as natural barriers against floods, landslides, and other disasters.
- Cultural and Spiritual Values: NbS acknowledge the cultural and spiritual values associated with nature. They recognise the intrinsic connection between people and the natural world, respecting traditional knowledge, indigenous practices, and local wisdom.

As stated, these reasons are interconnected and a potential NbS may meet several demands.

2.2 Summarising themes and sub-goals of NbS from previous deliverables

In the process of RECONECT, demands have been identified by demonstrators in a list of goals and sub-goals for NbS. These goals have been divided into three overall areas of action or challenges: Water, Nature, and People. E.g., in relation to Water there is a goal to manage water quantities and a sub-goal to reduce risk of flooding. Whether an NbS meet this demand can be identified by monitoring indicators such as inundation depths, flood water extent, and surface run-off reduction. Figure 1 shows examples of goals, sub-goals, and indicators that are used to analyse the demand for NbS in RECONECT.

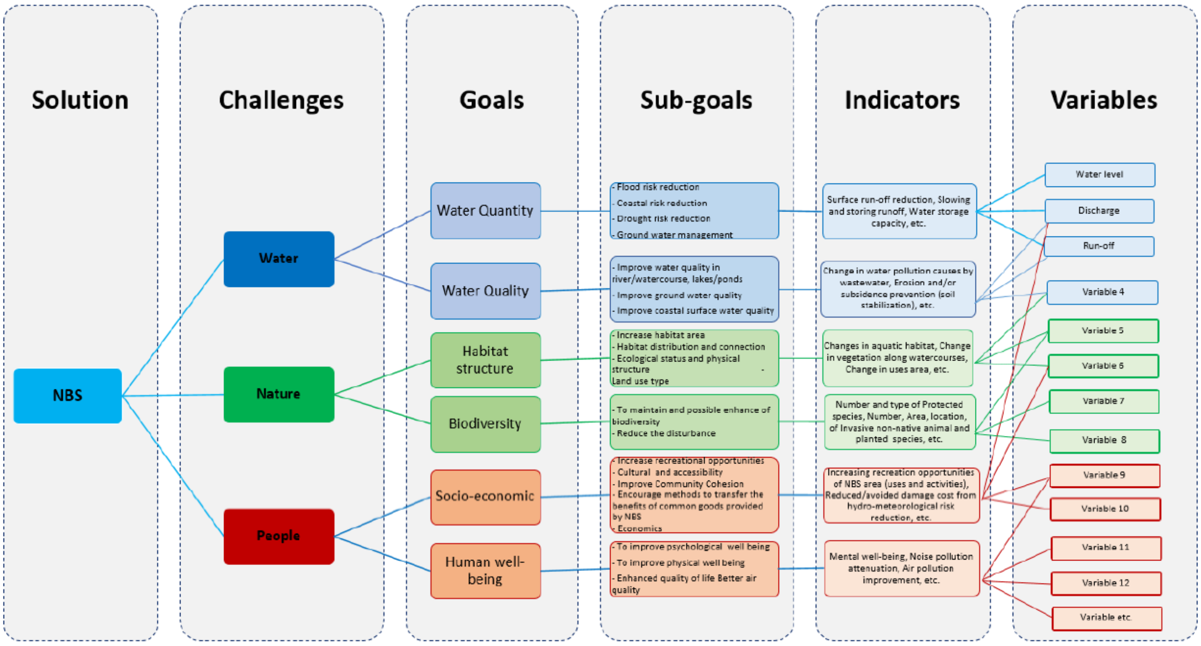

Figure 1. Inspiration to factors that might be important for NbS selection (from RECONECT D2.6 “Co-monitoring and co-evaluation plans for Demonstrators A and B”).

These challenges and correlated parameters have been the foundation for much of the monitoring and evaluation in the RECONECT project. To identify regions in the EU with comparable demands for large-scale NbS, a systematic approach is identified which also leverages this past work. The following section describes the methodology for identifying regions with comparable demands.

2.3 Methodology

To identify regions with comparable demands for large-scale NbS a three-step, systematic approach has been developed. The systematic approach provides structure and consistency to this complex task. It promotes transparency, and replicability, allowing for thorough assessments, and traceable outcomes. The three-step approach is shown in Figure 2.

Figure 2. Three-step approach to identifying regions with comparable demands for large-scale NbS.

In the first step (A) the most pressing demands for implementing large-scale solutions are identified. This is done via a literature review of past deliverables to identify which sub-goals demonstrators have highlighted as the most relevant benefits for their (planned) NbS.
In the second step (B) the most frequent sub-goals stated by demonstrators are selected, and the indicators related to them and other relevant data are evaluated as proxies for demand, e.g., if there is a demand to reduce flood risk, flood extent maps can be used as proxies for flood risk to identify locations where that particular demand exists. These data should reflect the multifaceted aspects of NbS, encompassing ecological, hydrological, and socio-economic dimensions.

This step also includes data sourcing. Spatial data related to the identified sub-goals and indicators are compiled to allow for locating regions with comparable demands. The analysis

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is a large-scale GIS analysis on EU level (similar to D5.5 “Report describing the potential for implementation of large-scale NbS in Europe”.). All data are sought out from public, regional platforms and databases such as Copernicus, Natura 2000, Eurostat, etc., to ensure and maintain the systematic approach and allow for replicability and consistency. When data sources and parameters have been identified, thresholds for demands are identified.

Finally, in step C, overlay spatial analyses are performed on the identified datasets to map regions with comparable demands. By identifying regions with similar demands, policymakers can facilitate knowledge sharing and collaboration among these areas, encouraging the exchange of best practices and lessons learned. These regions of demand are evaluated against the potential locations for NbS with characteristic features that can meet the specific demands. The included NbS are the ones researched in D5.5 which are afforestation, forest buffers, retention basins, and floodplain restoration. D5.5 researched the geographic potential for these four large-scale NbS based on the following criteria: Slope, distance from streams, distance from roads, land use type, and soil class and hydrogeology, also see (Mubeen, Ruangpan, Vojinovic, Torrez, & Plavšić, 2021).

Performing a spatial overlay analysis between the demand for NbS and the potential for NbS yields valuable insights into where NbS interventions are most needed and feasible. Understanding the spatial relationship between demand and potential allows for the optimisation of project planning and design, and by targeting research and investments in these areas, decision-makers can efficiently allocate resources and maximise the benefits of NbS initiatives.

Note that the analysis is limited to the 27 EU Member States as of the time of this report, i.e., physiographically European countries such as the United Kingdom, Norway, Switzerland, Liechtenstein, Serbia, Albania, North Macedonia, etc., are not included in the analysis.

3 Step A: Identifying sub-goals NbS fulfil

To identify the most pressing reasons for implementing large-scale NbS, this first step (A) looks into previous deliverables and demands and challenges identified by demonstrators. This literature review exploits the issues highlighted mainly in D2.3 “Scope of works for Demonstrators A and B”, supplemented by information found in D2.6 “Co-monitoring and co-evaluation plans for Demonstrators A and B” and the preliminary report for D3.4 “Preliminary report describing co-monitoring activities”. The methodology consists of compiling the results from the mentioned documents in an Excel file to determine the most frequently targeted sub-goals.

For a start, each sub-goal (here as a proxy for demand) as highlighted by demonstrators in previous deliverables is listed with its adhering indicators and grouped into the three overall challenges (Water, Nature, and People). The frequency with which each sub-goal appeared is counted, and all sub-goals are subsequently ranked, reflecting the most pressing demands as experienced by demonstrators. The results are presented in Table 1.

Table 1. Results from the literature review highlight demonstrators’ reasons for and demand to implement NbS.

Sub-goals selected by demonstrators	Frequency	Challenge
Stimulate/increase economic benefits	10	People
Flood risk reduction in urban areas and around rivers, lakes, water-courses, etc.	9	Water
Maintain and enhance biodiversity	8	Nature
Habitat provision and distribution (quality)	8	Nature
Increase habitat area (quantity)	7	Nature
Improve water quality in rivers/watercourses, lakes/ponds	6	Water
To reflects ecological status and physical structure of habitats	6	Nature
Increase recreational opportunities	6	People
Land use type	5	Nature
Maintain and, if possible, enhance cultural values	5	People
Groundwater management	4	Water
Reduce disturbance to ecosystems	4	Nature
Education and awareness about NbS	4	People
Landslide risk reduction	3	Water
Improve community cohesion	3	People
Encourage new business models and other community benefits provided by NbS	3	People
Accessibility	3	People
Improve groundwater quality	2	Water
Drought risk reduction	2	Water
Improve coastal water quality	2	Water
Coastal flood risk reduction	2	Water
To improve psychological well-being	1	People
To improve physical well-being	1	People
Better air quality	1	People

Ranking the sub-goals and highlighting the frequency with which they appear yield an overview of the general tendencies that drive demonstrators in their choice of implementing large-scale NbS. The results show that the ranking is well-balanced between the three challenges. Indeed, the top 3 of the ranking is compounded by “Stimulate/Increase economic benefits” (People), “Flood risk reduction” (Water) and a shared third place between “Maintain and enhance biodiversity” and “Habitat provision and distribution” (both Nature).

However, by looking at the general trend in ranking, it can be observed that the bottom part of the ranking is exclusively shared by Water and People, while all the sub-goals from the Nature theme are found in the higher half of the ranking. This may reflect the growing focus on biodiversity conservation and protection which we have seen worldwide in particular in the last couple of years. Many regions face significant challenges related to habitat loss, species decline, and degraded ecosystems. As a result, demands for NbS may have a bias towards restoring and protecting natural habitats and ecological processes, rather than for instance land use management, which has been a constant since the beginning of urban planning.

At the same time, demands for water- or people-related benefits of NbS may be underrepresented due to limited understanding of the correlation to climate adaptation and mitigation and the potential benefits of NbS. People-focused nature-based solutions, such as urban green spaces and nature-based education programs, may be less recognised as viable options for addressing certain challenges.

It's important to note that the results do not imply that NbS with a greater focus on water or people benefits are less important or effective. In reality, all three categories are interconnected, and addressing one aspect often has positive ripple effects on the others. Effective planning and implementation of NbS should always consider a holistic approach that integrates the needs of nature, water, and people for comprehensive and sustainable outcomes.

As a final note to the presented methodology, it is also necessary to highlight a couple of limitations:

1) In the context of RECONECT, the focus for NbS is mainly on large-scale NbS. Especially in the early phases of RECONECT, some demonstrators may have struggled to see the possibilities for placing NbS in urbanised areas for people to benefit, whereas it is/was easier to picture the implementation of NbS in an existing natural environment.

2) Our ranking of demands stems from a quite limited poll of large-scale NbS cases. For example the low prioritisation of the indicator “improvement of coastal water quality” might be due to the lower number of coastal NbS compared to inland NbS within RECONECT.

3) The choice of sub-goals was not only driven by demand of specific NbS benefits, but also by the demonstrators’ possibility of monitoring and quantifying said sub-goals. For example, a people indicator such as “improvement of psychological well-being" might have been relevant for more than one case study but given the time and resource intensity of its quantification (e.g., through population surveys), it wasn’t listed by many demonstrators.

Nevertheless, we believe that these limitations do not forfeit the overall aim of mapping and comparing the demand for NbS, as the RECONECT case studies offer a representative sample of the large-scale NbS projects that are being currently developed in the EU. Moreover, in the interest of producing replicable and consistent analyses, the prioritisation of more easily quantifiable indicators was not regarded as a drawback. Thus, the sub-goals identified will carry into the next step to select parameters as proxies for demand.

4 Step B: Identifying and collecting data and defining thresholds for demand

4.1 Water-related parameters for demand

After identification of the most frequent demands for implementing NbS, the top 3 sub-goals (or demands) of each area of challenge are selected to prioritise and focus the analysis going forward. For Water, the top three demands as shown in Table 1 are:

- Flood risk reduction in urban areas and around rivers, lakes, watercourses, etc.,
- improve water quality in rivers/watercourses, lakes/ponds, and
- groundwater management.

We note that the top three water related demands are oriented on inland water management, focusing on quantity and quality of rivers, watercourses, and lakes. As stated earlier all the demands are interconnected, and this is even more true for demands within the same area of challenge. Floods can cause damage to ecosystems, infrastructure, and human settlements, affecting both water quality and groundwater levels. Poor water quality can harm aquatic life, reduce biodiversity, and limit water availability for various uses, including groundwater recharge. Mismanaged groundwater can lead to depletion of aquifers and ecological disruptions.

Rapid urbanisation often exacerbates the issues in all three areas. Increased impervious surfaces in cities can lead to higher flood risk, as water cannot be absorbed by the ground. Urban development can also contribute to water pollution through runoff carrying pollutants into rivers and groundwater. Additionally, growing urban populations can strain groundwater resources, leading to over-extraction and declining water tables.

To map out regions with demands, inspiration for possible parameters as proxies for demand are sought out in the previous RECONECT deliverables (mainly D2.6 "Co-monitoring and co-evaluation plans for Demonstrators A and B"). Moving forward, a general goal for this exercise is to keep the spatial analyses as simple and uncomplicated as possible to allow for transparency and easy replicability.

4.1.1 Proxies and thresholds for mapping demands for flood risk reduction

NbS may play a crucial role in reducing flood risk by harnessing the natural capacity of ecosystems to mitigate and manage excessive water flows. Wetlands, floodplains, and natural vegetation act as natural sponges, absorbing and storing water during heavy rainfall events. By restoring and preserving these natural features, NbS enhance the capacity of landscapes to retain floodwaters, reducing peak flows and minimising downstream flooding (Lallemant, et al., 2021).

Mapping areas in the EU where there is a demand to reduce flood risk requires relevant GIS datasets that directly or indirectly capture various aspects of the hazard such as hydrology and topography, as well as aspects of the exposed system covering social and/or physical impacts and adaptive capacities. Possible data may include flood extents, precipitation patterns, elevation models, evapotranspiration patterns, infiltration capacities, land use, population densities, and infrastructure locations.

For this analysis population density and flood extents are highly appropriate data to use due to their direct relevance in assessing vulnerability and potential impacts. Population density data provides insights into the concentration of people and infrastructure in specific areas, helping identify regions with higher human exposure to potential flooding. Areas with dense populations are likely to experience more significant social and economic consequences during flood events, underscoring the urgency to implement flood risk reduction measures. On the other hand, flood extents data offer critical information on the spatial extent of flooding, indicating areas most prone to inundation. By overlaying flood extents with population density data, it is possible to pinpoint high-risk zones where large populations may face great impacts in flood events.

Table 2 displays the spatial analysis conducted to map the demand for NbS to reduce flood risk.

Table 2. Data for mapping regions with demands to decrease the risk of flooding.

	Dataset	**Threshold**	**Source**
Flood risk reduction	Population density	>2,000 persons/km^2	Eurostat (Eurostat, 2022)
	Potential flood-prone area	All probable extents	European Environment Agency (European Environment Agency, 2020)

The population density dataset originates from the European Commission Joint Research Centre. It consists of 1 x 1 km cells that provide data on the population count for the year 2018 across Europe.

To assess potential flood exposure, the analysis utilities the European Environment Agency's (EEA) dataset "Potential flood-prone area extent" from January 2020. This dataset is particularly valuable as it delineates regions that experience flooding once every 100 years (a 1% likelihood of flooding) under conditions of unrestricted water flow (European Environment Agency, 2023). This flood-prone area extent dataset provides a comprehensive representation of various flood-related aspects. It encompasses both active floodplains (where flooding is still recurrent) and former floodplains, which are areas where flooding has been limited due to flood protection measures. These former floodplains could potentially experience flooding again if certain conditions are met, such as surpassing flood protection capacities or the removal of factors that regulate water presence. The dataset has a spatial resolution of 100 metres.

4.1.2 Proxies and thresholds for mapping demands for improving water quality in rivers/watercourses, and lakes/ponds

NbS offer significant benefits in improving water quality in inland surface waters like rivers and lakes through their ability to mimic and enhance natural processes. Wetlands, constructed or restored, act as natural filters, removing excess nutrients, sediment, and pollutants from water as it flows through their vegetation and soil. Riparian buffers and vegetated shorelines prevent soil erosion and nutrient runoff from adjacent lands, thus reducing the influx of pollutants into water bodies. Moreover, reforestation efforts and preservation of natural vegetation contribute to reducing runoff and enhancing water quality through natural processes (UN Environment-DHI, 2018).

When assessing areas with a demand for NbS to improve water quality in rivers/watercourses, and lakes/ponds, relevant GIS datasets may include land use, historic water pollution sites, nutrient load modelling, population densities and infrastructure, industrial facilities and other pollution sources, and hydrography and river networks.

Considering landslide susceptibility and the extent of river networks may also be vital aspects of assessing water quality in rivers. They help identify potential sources of sediment, nutrients, and pollutants, allowing for more effective water quality management, protection of aquatic ecosystems, and safeguarding the overall health of rivers and the communities relying on them (UN Environment-DHI, 2018).

For this analysis the Corine Land Cover (CLC) 2018 dataset is a vital resource for understanding land cover and land use across Europe. Coordinated by the European Environment Agency (EEA) as part of the Copernicus Land Monitoring Service, the dataset represents 44 thematic land cover classes for the 2018 reference year in a 100 m spatial resolution. By overlaying the Corine Land Cover data, particularly in relation to agriculture, with flood-prone areas we identify areas where heavy rainfall or storm events can lead to increased surface runoff. In particular in agricultural areas, runoff can carry sediment, fertilisers, pesticides, and other contaminants from fields into rivers. Identifying flood-prone regions helps pinpoint areas where runoff and erosion are more likely to occur, potentially degrading water quality.

For this analysis it is assumed there is a demand for NbS to improve water quality when areas with expected use of pesticides overlap flood-prone areas *or* if rivers are in a 500 m proximity of areas with a susceptibility to landslide.

The European Landslide Susceptibility Map Version 2 (ELSUS v2) is a comprehensive continental-scale map that evaluates the susceptibility of areas to landslides. This assessment is based on a heuristic-statistical model created through collaboration between prominent geological and environmental research institutions. The development of ELSUS v2 considered elevation, climatic conditions, and various other landslide conditioning factors such as slope angle, shallow sub-surface lithology, and land cover. To further enhance the accuracy of the map, data from over 149,000 landslides across Europe were used for model calibration and validation. The dataset encompasses all European Union Member States, except Malta and has a resolution of 200 metres.

The spatial analysis to map the demand for NbS to improve water quality is displayed in Table 3.

Table 3. Data for mapping regions with demands to improve water quality in rivers/watercourses, and lakes/ponds.

	Dataset	Threshold	Source
Water quality threatened by certain land uses	Corine Land Cover	Areas with expected use of pesticides	Copernicus (European Union's Copernicus Land Monitoring Service information, 2020)
	Potential flood-prone area	All probable extents	European Environment Agency (European Environment Agency, 2020)
Water quality threatened by landslide	River Networks	All probable extents with 500m buffer	European Environment Agency (European Environment Agency, 2012)
	Landslide susceptibility	Medium, high, very high	European Commission Joint Research Centre (European Commission, Joint Research Centre (JRC), 2018)

4.1.3 Proxies and thresholds for mapping demands for groundwater management

Groundwater management faces several threats that jeopardise the sustainability and quality of this vital resource. Over-extraction, driven by increasing water demand for agricultural, industrial, and domestic purposes, poses a significant threat. Unsustainable pumping rates can lead to groundwater depletion, declining water tables, and land subsidence (Graaf, 2016). Pollution from various sources, including agricultural runoff, industrial discharges, and improper waste disposal, poses another major challenge to groundwater quality. Climate change exacerbates groundwater management challenges by altering precipitation patterns, reducing recharge rates, and exacerbating drought conditions (UN Environment-DHI, 2018). To safeguard groundwater resources, effective management strategies, including nature-based solutions, must be implemented to address these threats and ensure the long-term viability and resilience of this invaluable water source (European Environment Agency, 2022).

By preserving and restoring wetlands, floodplains, and natural vegetation, large-scale NbS can increase groundwater recharge rates by allowing rainwater to infiltrate and percolate into the aquifers. These natural areas act as sponge-like features that store and slowly release water, providing a buffer against drought and ensuring a more consistent groundwater supply (UN Environment-DHI, 2018). Moreover, protecting natural areas from excessive development helps maintain the integrity of aquifer recharge zones and ensures the sustainable replenishment of groundwater resources.

Relevant datasets for mapping areas with demand for groundwater management may include aquifer maps, and soil data to understand soil properties and infiltration rates. Climate data informs the assessment of potential changes in precipitation patterns and their impact on groundwater recharge.

The research process for suitable datasets revealed a global dataset for locations of groundwater vulnerability to floods and droughts (Richts & Vrba, 2016). The dataset presents the intrinsic vulnerability of groundwater systems and its sensitivity to flooding and droughts. The assessment is global and based on globally available parameters: Type of aquifers (e.g., aquifers in carbonated rocks or aquifers in fluvial deposits) and annual groundwater recharge. In order to obtain a numerical dimension of vulnerability, individual weighting and a rating scale have been assigned to both parameters. The result is divided into three categories of groundwater vulnerability: Low, moderate and high. This analysis utilises these results of high groundwater vulnerability to floods and/or landslides as an indicator for regions with a demand for groundwater management.

Table 4. Data for mapping regions with demands for groundwater management. For this analysis results from a previous UNESCO-study are utilised without any further processing.

	Dataset	**Threshold**	**Source**
Groundwater management	Groundwater vulnerability	Areas with high vulnerability to floods and/or droughts	Bundesanstalt für Geowissenschaften und Rohstoffe & UNESCO based on (Richts & Vrba, 2016)

4.2 Nature-related parameters for demand

For nature the top three demands are:

- Maintain and enhance biodiversity,
- habitat provision and distribution (quality), and
- increase habitat area (quantity).

The top three nature related demands share a strong focus on ecological conservation and restoration. As stated, this may reflect the recent, growing focus on biodiversity rather than e.g., land use management. Biodiversity conservation ensures the maintenance of key species and ecological processes that underpin ecosystem stability and resilience. Improving habitat quality and distribution enhances ecosystem functions, such as pollination, water purification, and climate regulation, which benefit both wildlife and human communities.

4.2.1 Proxies and thresholds for mapping demands to maintain and enhance biodiversity

NbS can play a pivotal role in maintaining and enhancing biodiversity by embracing the inherent interconnectedness between ecosystems and species. In general biodiversity is a broad term covering all different kinds of life including animals, plants, and fungi (Hancock, 2023). NbS such as wetlands, forests, and grasslands, provide essential niches for diverse flora and fauna. In aquatic ecosystems, nature-based solutions like riparian restoration contribute to thriving fish populations and aquatic biodiversity.

Biodiverse areas face a myriad of potential threats that augments the demand to maintain and/or enhance biodiversity. Deforestation, urban expansion, and agriculture, disrupt the interconnected web of life, diminishing the available space for species to thrive. Pollution from diverse sources, including industrial emissions and agricultural runoff, poses contamination risks to air, water, and soil, endangering the health of both flora and fauna. Climate change exacerbates these challenges, altering habitats, disrupting migration patterns, and intensifying weather events that reshape ecosystems. (European Environment Agency, 2023)

Datasets appropriate for mapping locations with a demand for maintaining and enhancing biodiversity with NbS may include ecosystem distribution data, such as habitat areas and vegetation cover. Furthermore, potential exposure to various climate hazards such as landslide and flooding locate areas in danger of disruption and even destruction.

For this EU scale analysis GIS data from the World Database on Protected Areas (WDPA) is utilised. WDPA is a global database of protected areas. It is a joint effort between the International Union for Conservation of Nature (IUCN) and the United Nations Environment Programme (UNEP), managed by UNEP-World Conservation Monitoring Centre, to compile protected area information for all countries in the world from governments and other authoritative organisations (UNEP-WCMC, 2016). The database holds spatial data for international themes such as Ramsar and UNESCO-MAB Biosphere Reserves, as well as nationally designated protected areas such as national parks, wildlife and plant sanctuaries, ecological corridors, and habitat protection areas (UNEP-WCMC and IUCN, 2023).

Specifically for this analysis the WDPA data set is filtered to include protected areas that indicate biodiversity is significantly present. Note however, that identifying typologies with “significant biodiversity” is a somewhat subjective matter; especially in the nationally designated typologies where the definition is not always clearly defined or comprehensive. Examples of typologies include for instance “areas of special aesthetic value” and “rest area”, and it’s not clear what such areas encompass. As such results will have a large degree of epistemic (or systematic) uncertainty, yet they provide one indicator of the demand for NbS to maintain and enhance biodiversity on EU level.

The included typologies include data tags such as Special Protection Area (Birds Directive), Ramsar site, UNESCO Global Geopark, Nature Reserve, Nature Park, and National Park. Data filtered out includes buffer zones on protected areas, Nature Monument, Scientific Reserve, Indigenous and Community Conserved Area, and Landscape Park. A demand to maintain and enhance biodiversity is expected to incur in all typologies that match the tags that indicate biodiversity is present, see Table 5.

Table 5. Data for mapping regions with demands to maintain and enhance biodiversity.

	Dataset	**Threshold (typologies included)**	**Source**
Maintain and enhance biodiversity	World Database for Protected Areas	Ramsar, areas under the Habitats Directive and Bird Directive, UNESCO-MAB Biosphere Reserve, World Heritage Site (natural or mixed), areas under the Barcelona Convention, as well as many national typologies such as Biosphere Park, Flora Protection Area, Animal Refuge, Ecological Development Area, Biotopes, and similar typologies.	Protected planet (UNEP-WCMC and IUCN, 2023)

This analysis does intentionally not include any potential threats to biodiversity such as areas exposed to climate hazards. Areas that are exposed to climate hazards will certainly have a higher demand for maintenance, but it’s assumed that in any area where biodiversity is present there is a demand to maintain and/or enhance it.

4.2.2 Proxies and thresholds for mapping demands for habitat provision and distribution (quality)

By reviving degraded habitats and strategically planting native vegetation, nature-based approaches not only provide sanctuaries for existing species but also attract new ones, enriching biodiversity. NbS also facilitate the creation of corridors, linking fragmented habitats and enabling species to adapt and migrate in response to changing environmental conditions. By mimicking natural processes, these solutions nurture a mosaic of habitats, ensuring a resilient and interconnected landscape that can accommodate various species' needs and support healthy ecosystems in the face of ongoing environmental challenges (The World Bank, 2022).

Mapping locations with a demand for improving quality of habitat provision and distribution relies on datasets that capture ecological and spatial factors as well as potential threats to the quality of habitats. As part of the EU Biodiversity Strategy for 2030, EU Member States are required to report the conditions of current habitats, and as such an analysis of habitat provision in terms of quality is readily available at EU level in the “State of Nature report” (European Environment Agency, 2023). The analysis is based on the Member States' reporting on the conservation status of and trends in targeted habitats and species (Article 17 of the Habitats Directive) within their European territories. The result categorises the conditions/quality of a habitat as one of four possible statuses: Favourable, unfavourable-inadequate, unfavourable-bad or unknown.

This analysis utilises this dataset from Article 17, Habitats Directive and considers all areas where a habitat is classified “unfavourable-inadequate”, “unfavourable-bad” or “unknown” as in demand for NbS to improve habitat provision. The resolution of the dataset is 10 km grid cells and covers all of the EU. Besides filtering out habitats in “favourable status”, it is decided to also exclude urban areas that are assumed to only be part of the data set due to the relatively low resolution. Hence, areas where population density is higher than 2,000 persons/km^2 are excluded.

Table 6. Data for mapping regions with demands for habitat provision and distribution (quality).

	Dataset	**Threshold**	**Source**
Habitat provision and distribution (quality)	Article 17, Habitats Directive	Unfavourable-inadequate, unfavourable-bad or unknown.	European Environment Agency (European Environment Agency, 2023)
	Population density	<2,000 persons/km^2	Eurostat (Eurostat, 2022)

4.2.3 Proxies and thresholds for mapping demands to increase habitat area (quantity)

As stated previously NbS hold the promise of significantly increasing habitat areas through their capacity to restore, expand, and connect natural landscapes. Nature-based approaches such as reforestation, wetland creation, and green infrastructure contribute to expanding habitat areas, providing shelter and resources for plants and animals (The World Bank, 2022). Moreover, repurposing urban spaces through sustainable design can introduce new habitats within developed areas. Through these multifaceted strategies, NbS have the potential to reverse habitat loss trends, fostering healthier ecosystems, and supporting biodiversity amidst the challenges of urbanisation and environmental change.

Mapping locations with a demand for NbS to increase habitat area involves datasets that capture ecological and geographical dimensions. Existing habitat areas, land cover and land use may provide insights into existing habitats, as well as the inverse; locations where habitat distribution is sparse and limited.

This analysis utilises the Copernicus Corine Land Cover data (described in 4.1.2) to locate regions where there is a lack of green and blue areas suitable for habitats. The Corine Land Cover is grouped into two overall land cover types: Areas suitable for habitats (e.g., forests, water bodies, moors and heathland) and areas unsuitable for habitats (e.g., urban fabric, industrial areas, arable land, and pastures). The EU Biodiversity Strategy for 2030 aims to protect a minimum of 30 % of the EU's land and sea areas by 2030 (European Commission, Directorate-General for Environment, 2020). Hence, for this analysis it is assumed, that there is a demand to increase habitat areas, when in a 40,000-ha area (20x20 km) there are less than 30 % green and blue spaces suitable for habitats.

Table 7. Data for mapping regions with demands for NbS to increase habitat area. A demand incurs when there is less than 30 % green or blue areas suitable for habitats.

	Dataset	Threshold	Source
Increase habitat area	Corine Land Cover	Areas with <30 % green or blue areas suitable for habitat in a cell grid size of 20 km	Copernicus (European Union's Copernicus Land Monitoring Service information, 2020)

4.3 People-related parameters for demand

For people the top three demands are:

- Stimulate/increase economic benefits,
- increase recreational opportunities, and
- maintain and, if possible, enhance cultural values.

The top three people related demands focus on socioeconomics indicators and society as a whole, with less attention given to the individual's well-being in aspects such as accessibility, psychological and physical well-being. The focus on increasing economic benefits highlights the potential for NbS to create sustainable livelihoods and economic opportunities. Investing in nature can lead to industries such as ecotourism, sustainable agriculture, and green infrastructure development, which generate jobs and income while promoting environmental sustainability. It can be postulated that the currently defined demands for NbS favour societies rather than individuals.

4.3.1 Proxies and thresholds for mapping demands to stimulate/increase economic benefits

NbS can stimulate and increase economic benefits for communities and people by forging symbiotic relationships between nature and humans. Green infrastructure projects, such as urban parks and green spaces, not only enhance aesthetic appeal but also attract tourism, boosting local economies. Implementation of NbS contributes to increased productivity, generating revenue and employment opportunities. Furthermore, NbS that improve water quality and reduce flood risks, like constructed wetlands and floodplain restoration, yield long-term cost savings by minimising damages and losses. Additionally, ecotourism and recreational activities generate income for local businesses and create livelihoods (Pino, et al., 2020).

Climate risk datasets contribute to identifying areas where natural flood adaptation measures can yield economic savings by minimising damages and losses to infrastructure and other systems and limiting the need for stormwater treatment. Data related to tourism may also offer insights into regions where NbS enhance economic opportunities. Smaller green spaces may encourage people to spend more time in an area and enjoy nearby attractions, shopping, and dining, whilst larger green spaces also offer new activities for visitors such as hiking, playing ball, and birdwatching. Demographic data, including population density and income levels, assist in understanding where NbS could have the greatest impact on communities.

This analysis focuses on the significant, economic benefits related to potential, avoided damages and losses from flood and/or landslide exposure as well as the increased revenue streams from more tourism. Areas with a demand for increasing economic benefits due to avoided flood or landslide risks are identified similarly to areas with a demand to reduce flood risk where high population densities are overlapped with probable flood extents (see section 4.1.1) as well as landslide exposure (see section 4.1.2).

Areas with a potential for increased tourism are identified by locating *existing* tourism attractions. These existing attractions act as focal points drawing in visitors, and by pinpointing their locations, prime areas where enhancing the natural environment could amplify tourism activities can be discerned. The synergy between culture and outdoor experiences is a potent draw for tourists, resulting in longer stays, increased spending, and a boost to local economies. Existing tourism data are downloaded via OpenStreetMap, and points that are tagged as disused or closed are filtered out. Included tourism tags include galleries, theatres, parks, hotels, landmarks, etc. If there are more than 50 tourist attractions in a 10 km x 10 km area the area is included as having potential for increased tourism.

Table 8. Data for mapping regions with demands to stimulate/increase economic benefits.

Stimulate economic benefits	Dataset	Threshold	Source
Avoided flood damages and losses	Population density	>2000 persons/km^2	Eurostat (Eurostat, 2022)
	Potential flood-prone area	All probable extents	European Environment Agency (European Environment Agency, 2020)
Avoided landslide damages and losses	Population density	>2000 persons/km^2	Eurostat (Eurostat, 2022)
	Landslide susceptibility	Medium, high, very high	European Commission Joint Research Centre (European Commission, Joint Research Centre (JRC), 2018)
Increased tourism revenue	Existing tourist attractions	>50 attractions/100 km^2	Geofabrik (OpenStreetMap contributors, 2023)

OpenStreetMap (OSM) is a collaborative, open-source mapping platform that allows users from around the world, to contribute, edit, and access geospatial data. Note that, it therefore comes with uncertainties and/or inconsistencies in data quality, as it relies on contributions from a global community of volunteers. Some data may be outdated, inaccurate, or incomplete. For an EU level GIS analysis OSM data is, however, still the most exhaustive data source for tourism, and therefore considered the best available option for this analysis.

4.3.2 Proxies and thresholds for mapping demands to increase recreational opportunities

As mentioned above NbS also hold potential to fulfil demands for increased recreational opportunities. Urban green spaces and restored ecosystems create inviting settings for leisure activities such as hiking, biking, and birdwatching. Multi-functional wetlands and restored riverbanks offer spaces for fishing, kayaking, and picnicking. By integrating accessible green infrastructure, NbS transform urban environments into havens for relaxation and exploration.

In regards to relevant datasets, it is prudent to locate regions where green and blue spaces are sparse or few and far between. If an area already has green areas or is in close proximity to the ocean or any river networks which typically also offer natural environments, although these areas may not be specifically designed to the many benefits that NbS offer, the demand for NbS to increase recreational opportunities will be very low if recreational spaces are already accessible and available. As such land use and land cover data are crucial for identifying existing green spaces, or in other words, the lack thereof. Certain age distributions may also have a higher demand for NbS, as for example families with children or retirees with more leisure time than working adults may prioritise to live in areas where green spaces are readily available.

For this particular analysis the Copernicus Corine Land Cover data (described in section 4.1.2) is utilised to locate regions where there is a lack of green and blue spaces suitable for recreational areas. To identify the areas lacking recreational spaces, the Corine Land Cover is grouped into two overall land cover types: Areas suitable for recreational activities such as green urban areas, sport and leisure facilities, forests, and water courses, and areas unsuitable for recreational activities such as urban fabric, industrial areas, arable land, and vineyards. As stated earlier, the EU 2030 Biodiversity Strategy aims to protect a minimum of 30 % of the EU's land areas by 2030. The percentages are an EU average, and areas with high population densities will likely have lower percentages of natural environments than 30 %. For this analysis it is defined, that there is a demand for (more) natural environments suitable for recreational opportunities in an area, when in a 2,500-ha area (5x5 km) there is less than 10 % green and blue spaces. The relatively small cell size is chosen, based on a study conducted in England that shows that people's willingness to pay for a potential park with recreational opportunities increases with distance until approximately 3,000 metres at which point it starts to decrease with distance (Andrews, Ferrini, & Bateman, 2017). From this it is assumed that Europeans generally are willing to travel up to 5 km for recreational activities.

Furthermore, population density is utilised again as areas with high population densities are required for the NbS to meet the benefit of increasing recreational opportunities for people. It is decided not to use any further data on demographics such as age, as it is believed there will always be a demand for NbS where there are people, no matter the age distribution. The demand as stated may be higher in some regions where the percentage of children and elderly is high, but this analysis does not aim to differentiate on the levels of demand; to map regions with any size of demand is therefore deemed sufficient.

Table 9. Data for mapping regions with demands to increase recreational opportunities.

	Dataset	Threshold	Source
Increase recreational opportunities	Corine Land Cover	Areas with <10% green or blue areas in a 5 km by 5 km area	Copernicus (European Union's Copernicus Land Monitoring Service information, 2020)
	Population density	>2,000 persons/km^2	Eurostat (Eurostat, 2022)

4.3.3 Proxies and thresholds for mapping demands to maintain and enhance cultural values

By revitalising traditional land use practices and preserving culturally significant landscapes, NbS can ensure the continuation of cultural traditions rooted in nature. Restoration efforts in culturally emblematic areas, such as sacred sites and ancestral territories, may not only conserve biodiversity but also honour and strengthen indigenous and local identities (Bush, Frantzeskaki, Ossola, & Pineda-Pinto, 2023). Interpretive signage, cultural programs, and eco-tourism initiatives within conserved spaces promote a deeper understanding of cultural heritage, inviting communities and visitors to engage.

Mapping locations with a demand for NbS to maintain and enhance cultural values requires datasets that encapsulate ecological and cultural dimensions. Cultural heritage sites and indigenous territories datasets provide insights into areas of profound cultural significance, guiding the identification of places where NbS can coalesce with local traditions. Socio-economic data, including demographic trends and community preferences, may illuminate regions where cultural engagement with nature is particularly vibrant.

Note, that “cultural values” is a very broad term, and it may differ from country to country and even community to community what is considered “cultural values”. Thus, while a broad GIS analysis can provide valuable insights, it must be complemented with localised, context-specific assessments to capture the true essence of enhancing cultural values within the diverse tapestry of Europe.

For this EU scale GIS analysis, focus is on generic, broad term cultural values related to nature and people. The analysis utilises data from the World Database on Protected Areas (WDPA) and supplement with data from OpenStreetMap (OSM). As mentioned earlier WDPA is a global database of protected areas. The database holds spatial data for international themes such as Ramsar and World Heritage sites, regional designations such as Marine Protected Areas and Sites of Community Importance on the EU Habitats Directive, as well as nationally designated protected areas such as monuments, forests, and Indigenous and Community Conserved Areas.

Specifically for this analysis the WDPA data set is filtered to include protected areas that have a significant cultural value for people. Again, this is a subjective matter, and results of this particular analysis will have an underlying epistemic uncertainty and are up for discussion, yet they provide one indicator of the demand for NbS to enhance cultural values on EU level. The analysis includes data tags such as World Heritage Sites, Natural Heritage Areas, Botanical Reserves, Ecocultural corridors, and Historical trees and forests. Data filtered out includes Natura 2000, Wildlife reserves, Protected Landscapes, and Ramsar sites.

OSM amenity data supplement the analysis with more social, cultural values and include solely data with the tags “places of mourning” and “places of worship”. All other amenity data are filtered out, including hospitals, cafes, and schools. Cultural venues such as theatres, cinemas, community centres are also filtered out, as these are often located in built up areas where large-scale NbS are not feasible and/or will be placed too far away to have any considerable effect on city amenities. Once more, this is a subjective *and* local matter, and analyses on more national, and regional levels are certainly recommended.

Table 10. Data for mapping regions with demands to enhance cultural values.

Enhance cultural values	Dataset	Threshold (overall typologies in-cluded)	Source
Culturally significant nature sites	World Database for Protected Areas	Areas of Aesthetic Value, (Nature) Monument, Ecocultural corridor, Indigenous and Community Conserved Areas, Historical Trees Having Antiquarian Importance, Natural Area of Special Interest, Heritage Area, Old Growth Forest, UNESCO Global Geopark, UNESCO-MAB Biosphere Reserve, World Heritage Site	Protected planet (UNEP-WCMC and IUCN, 2023)
Culturally significant people sites	Amenities	Places of mourning Places of worship	Geofabrik (OpenStreetMap contributors, 2023)

5 Step C: Areas with a demand for NbS

By utilising and extracting relevant data (identified in step B), GIS overlay analyses are performed to map locations in the EU where the demands (identified in step A), are present. Results are presented in the following chapter. The first section (5.1) provides an overview of the overall results, whilst sections 5.2, 5.3, and 5.4 go through results for the three different demands within each area of action (Water, Nature, and People).

Note that (as stated in section 2.3), the analysis is limited to the 27 EU Member States as of the time of this report. Physiographically European countries such as the United Kingdom, Norway, Switzerland, Liechtenstein, Serbia, Albania, North Macedonia, etc., are not included in the analysis.

5.1 Aggregated results

Table 11 shows the overall results from the GIS analysis for demands for NbS. Results are divided into their areas of action and an aggregated result for each area of action is also presented. Any overlapping areas within an area of action have been merged, so that areas are not counted twice in the aggregated results. The column "Evaluation" presents an assessment of the accuracy of the results. A more detailed discussion of the results and their accuracy follows in the discussion of the individual demands in sections 5.2, 5.3, and 5.4

Table 11. Results for the GIS analyses of demands for NbS. Note that any overlapping results within each area of action have been dissolved to calculate the aggregated results in the final column so that areas only contribute once. Hence, the aggregated results are different from the sum of the three individual demands within an area of action.

Area of action	Demand	Result	Evaluation	Aggregated result
Water	Flood risk reduction	6,000 km^2	Underestimated	2,513,000 km^2
	Improving water quality in rivers/watercourses and lakes/ponds	639,000 km^2	Underestimated	
	Groundwater management	2,199,000 km^2	Overestimated	
Nature	Maintain and enhance biodiversity	915,000 km^2	Uncertain	4,055,000 km^2
	Habitat provision and distribution (quality)	3,892,000 km^2	Overestimated	
	Increase habitat area (quantity)	1,381,000 km^2	Reasonable	
People	Stimulate/increase economic benefits	1,023,000 km^2	Underestimated	1,098,000 km^2
	Increase recreational opportunities	89,000 km^2	Reasonable	
	Maintain/enhance cultural values	33,000 km^2	Uncertain	

Results show that the spatial demand for NbS is greatest for demands related to nature. Combined the total demand for NbS to improve conditions for "nature" is 4,055,000 km^2, see Table 11. For these analyses focus have been on biodiversity and habitats and as such the results (and focus of the RECONECT projects) align well with the increased focus the EU has had on habitat protection and in particular biodiversity in recent years. For instance, the EU has already launched projects like the Biodiversity Strategy for 2030. The fact that these GIS analyses emphasise a significant demand to protect nature underscores the EU's recognition that preserving natural ecosystems and their components is pivotal in addressing global challenges like climate change and the loss of ecosystem services.

Results also show a great demand to improve groundwater management (Table 11). This particular analysis is bound with some uncertainties due to constraints in the underlying dataset (see more in section 4.1.3), and whilst results here are assumed to be overestimated due to these constraints, the fact that there is a great demand for groundwater management also aligns well with the EU's focus on groundwater protection under the laws of the Water Framework Directive and the Groundwater Directive (European Commission, 2023).

The demand to reduce flood risk based on this analysis is only present in about 5,500 km^2 (less than 1 % of the total EU area). These results are assumed to underestimate the full extent of the flood challenge as the analysis only considers fluvial flood events and does not account for pluvial (rainfall-induced) or coastal flooding, both of which are significant contributors to flood risk in many regions. Climate changes increase the frequency and intensity of extreme rainfall events, making pluvial flooding an escalating concern. Coastal areas, especially in low-lying regions, face growing threats due to rising sea levels and more frequent storm surges. Therefore, an analysis that solely focuses on fluvial flooding provides only a partial picture of the overall flood risk (see more in section 5.2.1).

The biggest demand under "People" is the stimulation of economic benefits, whilst demands to increase recreational opportunities and maintain/enhance cultural values are quite small. While NbS focusing on benefits for people are undoubtedly important for human well-being, the primacy of nature in supporting life and maintaining ecological balance propels the greater demand for its preservation.

Figure 3 maps the spatial extent of overlapping demands in the EU. Combined the nine demands cover 4,187,000 km^2 of the European Union (99 % of the total area). Areas with most overlapping demands are in Ireland, France, Belgium, Netherlands, Italy, Slovakia, and Croatia.

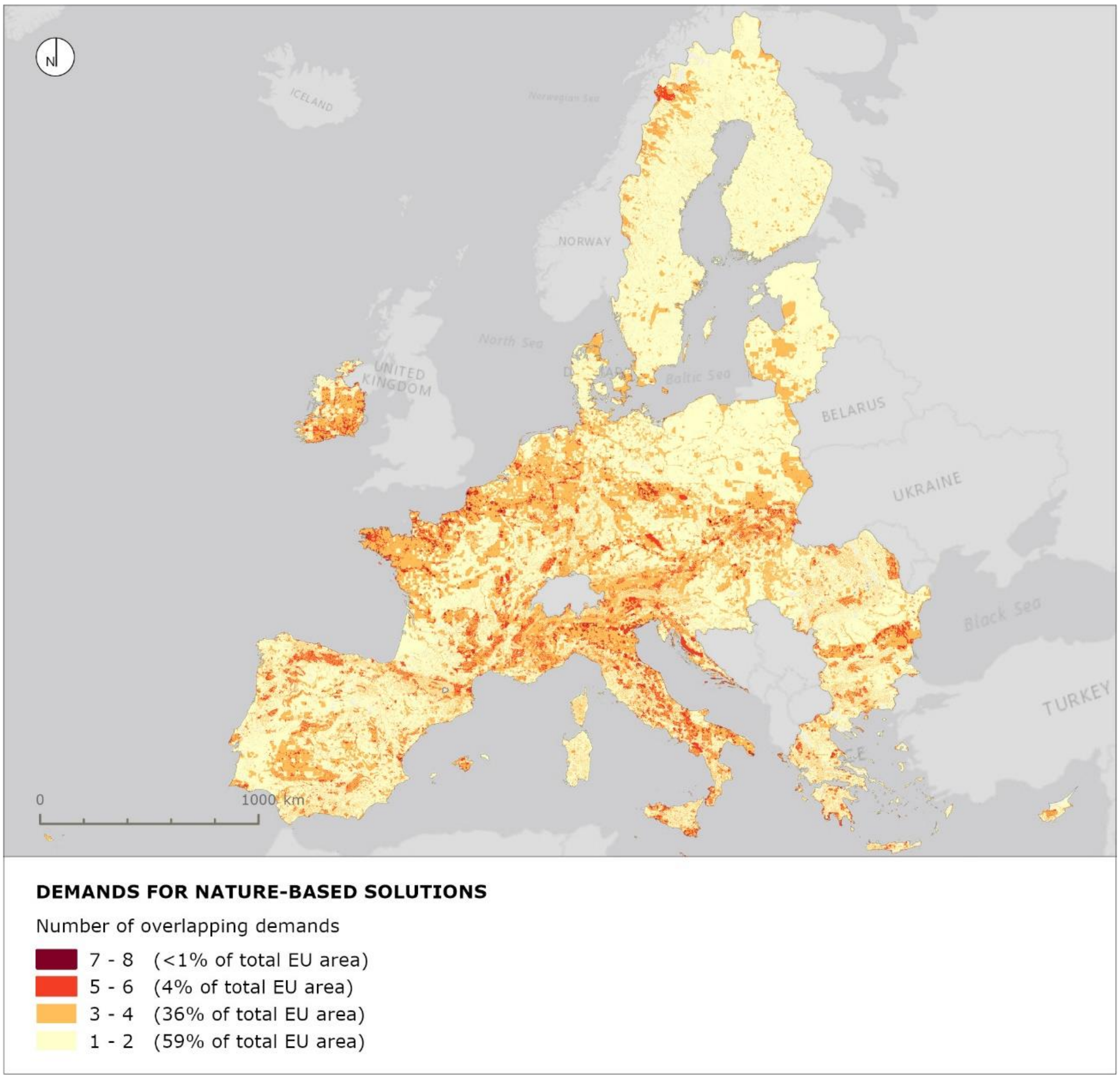

Figure 3. Areas with overlapping demands. In total there are nine individual demands, but there are no places in the EU where all nine demands overlap. Areas with most overlapping demands are in Ireland, France, Belgium, Netherlands, Italy, Slovakia, and Croatia.

5.2 Results for Water-related parameters for demand

5.2.1 Areas with a demand for flood risk reduction

The total area with a demand for NbS to reduce flood risk is shown in Figure 4. The demand area is around 5,500 km^2 (<1 % of the total area of the EU). As stated in 4.1.1 the area is found by overlapping areas with a population density higher than 2,000 persons/km^2 with flood prone areas.

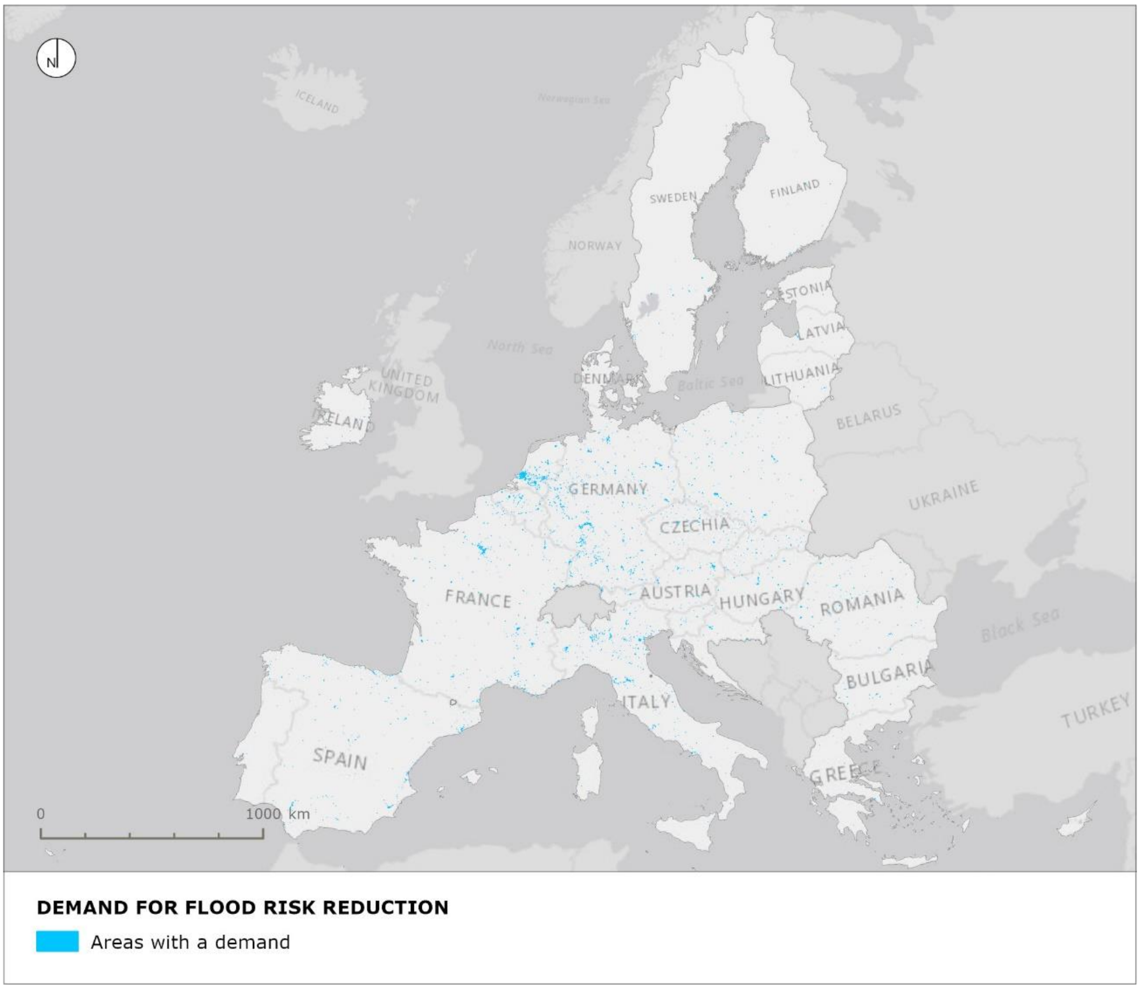

Figure 4. Spatial result for the analysis for areas with a demand for reducing flood risk. The total area with a demand is 5,500 km^2.

Flood plains along the Rhine River in Germany and the Netherlands, plains along the Seine in France, areas along the Danube River in Austria and Hungary, and rivers running through northern Italy cause great flooding in densely populated areas leading to a demand for NbS to reduce flood risk. Whilst there are also flood prone areas along the many rivers in e.g., Sweden and lakes in Finland, the population density in these areas is low and therefore due to the defined threshold for population density there is no defined vulnerability in these areas, and hence no risk.

It is worth noting that the background data only considers fluvial flooding, and not pluvial or coastal flooding. There are currently no readily available datasets on an EU scale representing pluvial or coastal flood events, and as NbS also mitigate those types of flooding, the demand for NbS to reduce flooding from all flood hazards is very likely much bigger than shown in Figure 4. As such these results of 5,500 km^2 are expected to be underestimated.

After having identified areas with a demand for flood risk reduction, results are evaluated against the potential locations for NbS with characteristic features that effectively meet this demand. In D5.5 “Report describing the potential for implementation of large-scale NbS in Europe” the geographic potential for the following four-large scale NbS were mapped: Forest buffers, afforestation, floodplain restoration, and retention basins. As the demand for flood risk reduction can be met by all four types of NbS, the geographic, potential span for all four NbS are dissolved and overlayed with the demand to show the regions where the demand for flood risk reduction is met by the potential for *any* of the four selected large-scale NbS, see Figure 5.

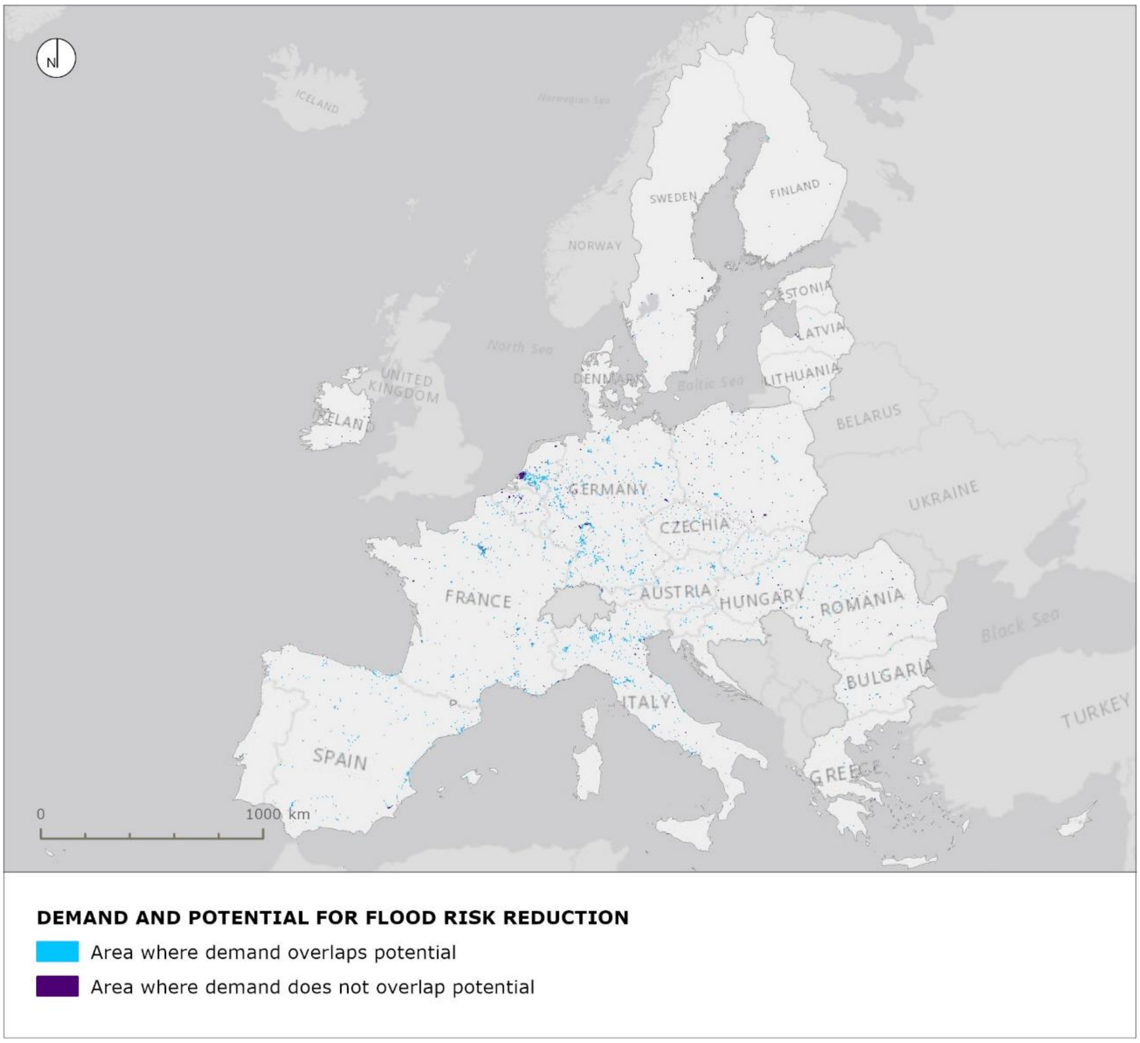

Figure 5. Areas where the demand for flood risk reductions overlaps with the potential for four selected large-scale NbS with characteristic features to meet the demand (forest buffers, afforestation, floodplain restoration, and retention basins).

The area where potential meets demand is about 800 km^2, which means that 4,700 km^2 of the total demand (5,500 km^2) must be met by other types of solutions based on these overall assessments.

This result that the bulk of the areal demand (85 %), needs to be addressed through alternative solutions is not unexpected given the conditions defined here for flood risk demand and the limitations inherent in large-scale NbS implementation. Large-scale NbS require significant land area and may not be suitable for densely populated regions where land is scarce and/or already allocated for other purposes.

It must be stressed though that this analysis for demand does not suggest that 5,500 km^2 have to be an NbS or another type of solution for flood risk reduction. A potential solution may span 2 km^2 but mitigate the demand from a much larger area. Also, in particular for flood risk reduction it is worth noting that depending on factors such as topography, landscape characteristics, and the size of water catchments, certain large-scale NbS may still be feasible upstream, outside of areas with immediate demand, to mitigate downstream risks. E.g., floodplain restoration on the outskirts of a city could help minimise damages downstream in densely built-up areas.

5.2.2 Areas with a demand for improving water quality in rivers/watercourses, and lakes/ponds

The areas with a demand for improving water quality are shown in Figure 6. The total area is around 639,000 km^2 (about 15 % of the area of the EU). The total demand is partly made up of flood prone areas that overlap agricultural areas where the use of pesticides is expected to cause poor water quality, and partly made up of areas in proximity to rivers with a medium, high or very high susceptibility to landslides which may threaten the water quality in the rivers. These two areas have then been dissolved so potentially overlapping areas in the two categories are not counted twice.

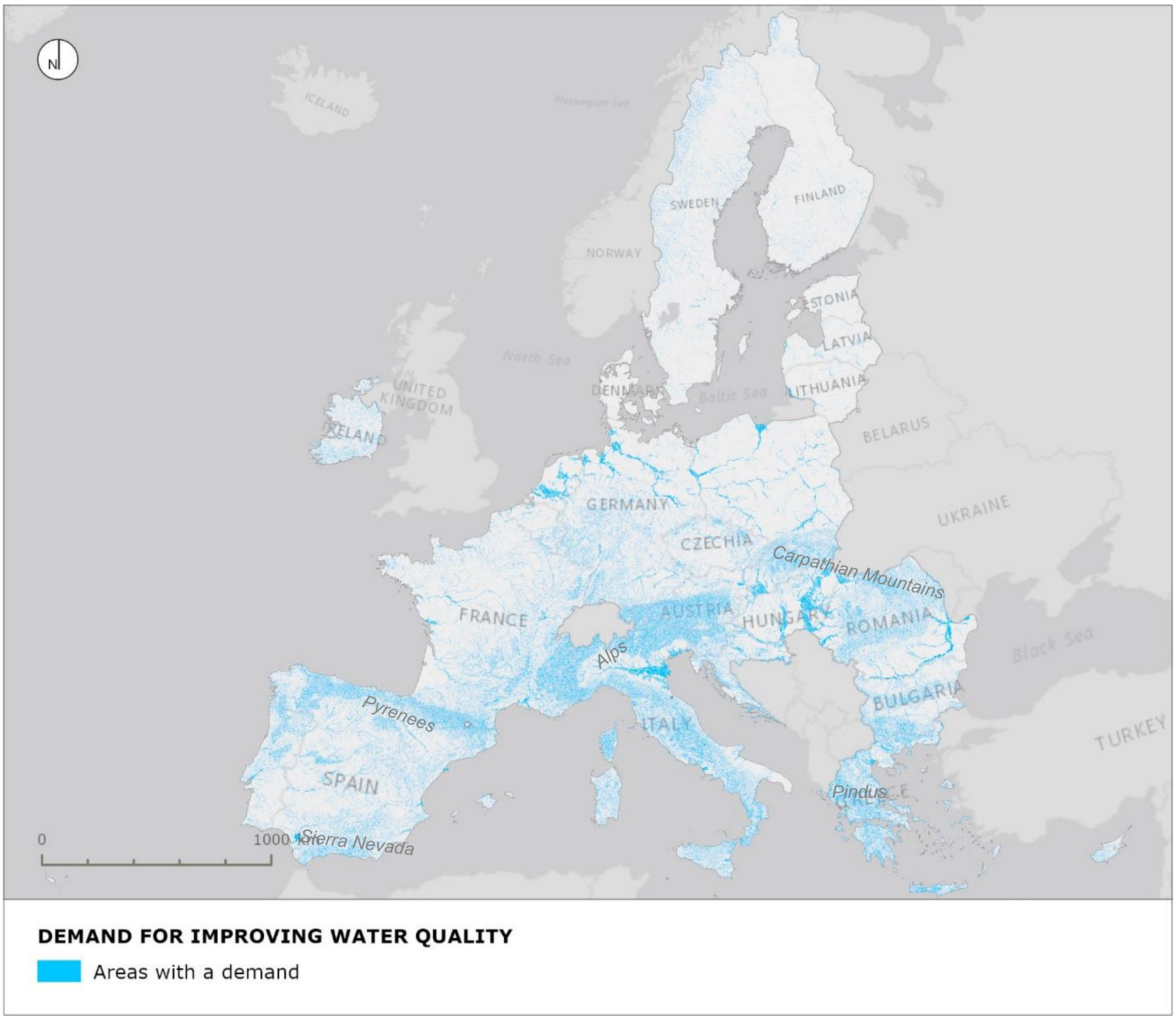

Figure 6. Spatial result for the analysis for areas with a demand for improving water quality. The total area with a demand is 639,000 km^2.

The high demand in central and northern Europe (France, Netherlands, Germany, Poland, Hungary) is mainly due to the complex river network in Europe coupled with the fact that 1.6 million km^2 are used for agriculture (Eurostat, 2022). River flooding can lead to the inundation of agricultural areas, industrial sites, and urban centres, resulting in the dispersion of pollutants into waterways.

Within the expansive, the significance of NbS in improving water quality becomes even more apparent when considering the risk of landslides. Many regions within the EU are susceptible to landslides, and damages are often exacerbated by unsustainable land use practices. As stated in section 4.1.2, landslides can dislodge large amounts of soil, sediments, and pollutants into waterbodies, contaminating them and posing a risk to aquatic ecosystems and human health. The demand for improving water quality in the south-eastern regions of the EU are mainly driven by the threats of landslide in mountainous areas such as the Pyrenees and Sierra Nevada in Spain, the Alps (Italy, Liechtenstein, and Austria), the Carpathian Mountains (Slovakia and Romania), and the Pindus (Greece).

These results are reported with uncertainty and are most likely underestimated. This analysis only considers some overall physical threats to water quality based on readily available GIS data. Assessing water quality on an EU scale presents considerable challenges due to the vast geographic diversity and complexity of such a large area. The diversity of water bodies, including rivers, lakes, coastal areas, and groundwater sources, further compounds the complexity of evaluation, as different water types require distinct monitoring techniques.

The 2018 “State of Water” from European Environment Agency stated that as much as 60 % of surface waters (rivers and lakes) were “failing to achieve good chemical status” (European Environment Agency, 2018), so in comparison to these numbers, this analysis vastly underestimates the demand for improving water quality. Analyses on more local scale are recommended to improve level of knowledge and certainty.

After having identified areas with a demand for improving water quality, results are evaluated against the potential for NbS that can effectively address these demands. Of the four previously mentioned large-scale NbS, retention basins and floodplain restoration are highly effective in improving water quality via functions such as sediment filtration, nutrient removal, and pollutant filtration. Forest buffers and afforestation may also play important roles in erosion control but may have limitations in directly (and effectively) addressing water quality issues, and therefore they are not included in this next step. I.e., the geographic potential for all retention basins and floodplain restoration areas are dissolved and overlayed with the demand. Figure 7 shows the regions where the demand for water quality improvements is met by the potential for the two defined NbS.

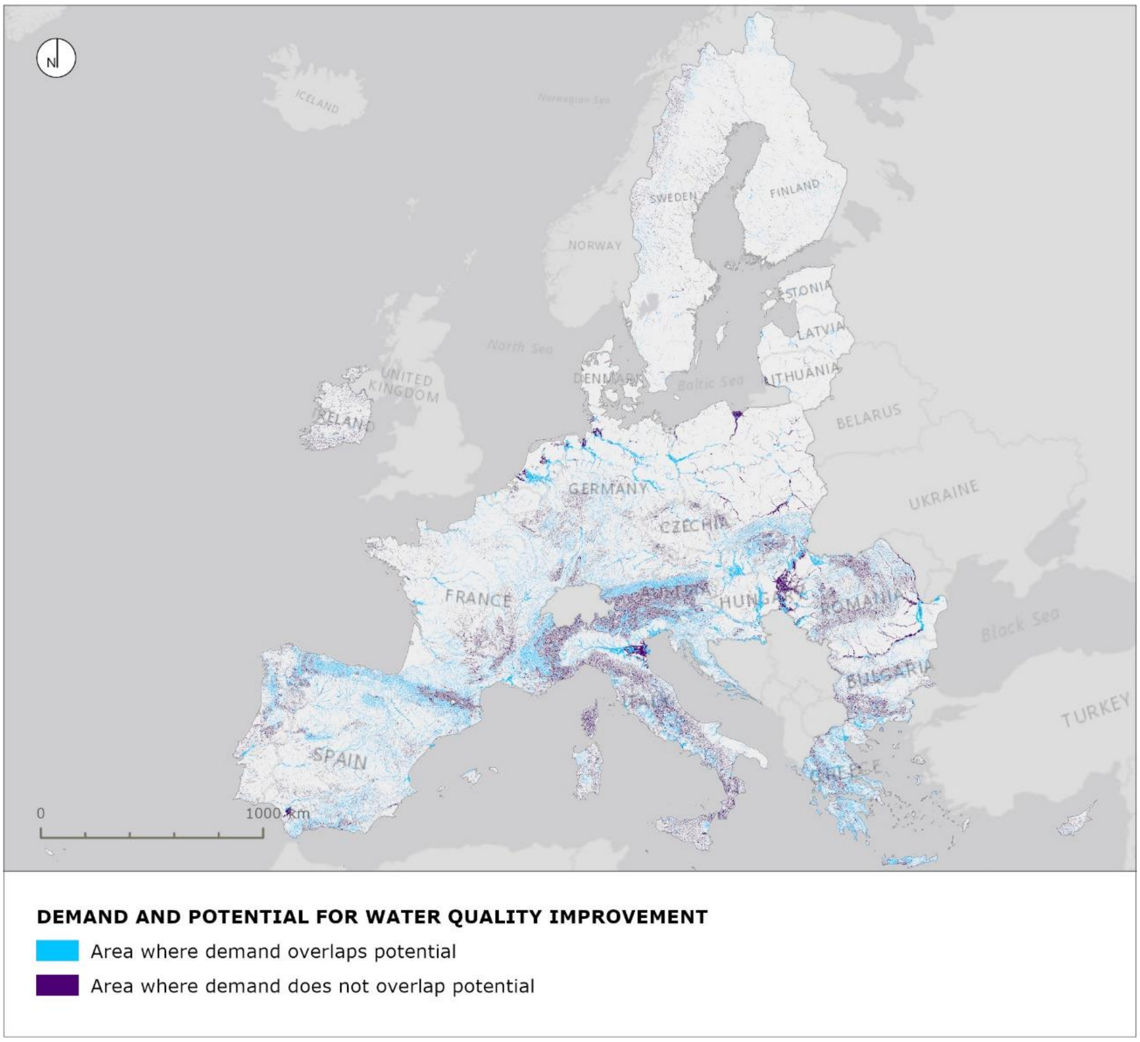

Figure 7. Areas where the demand for water quality improvement overlaps with the potential for two selected large-scale NbS with characteristic features to meet the demand (floodplain restoration and retention basins).

The area where potential meets demand is 300,000 km^2, which means that 339,000 km^2 of the total demand (639,000 km^2) must be met by other types of solutions to effectively address the demand for water quality improvement.

Water quality improvement is a complex issue, and half of the demand (53 %) may need to be addressed through alternative types of NbS or other more structural solutions such as targeted agricultural management practices that offer more tailored and adaptable approaches to mitigating water quality issues. These solutions can be tailored to specific environmental conditions and land uses, allowing for more targeted interventions that address the root causes of poor water quality.

5.2.3 Areas with a demand for groundwater management

The total area with a demand for NbS to improve groundwater management is shown in Figure 8. The demand area is around 2,199,000 km^2 (just over 50 % of the total area of the EU). The results are extracted from a study on groundwater vulnerability to floods and droughts.

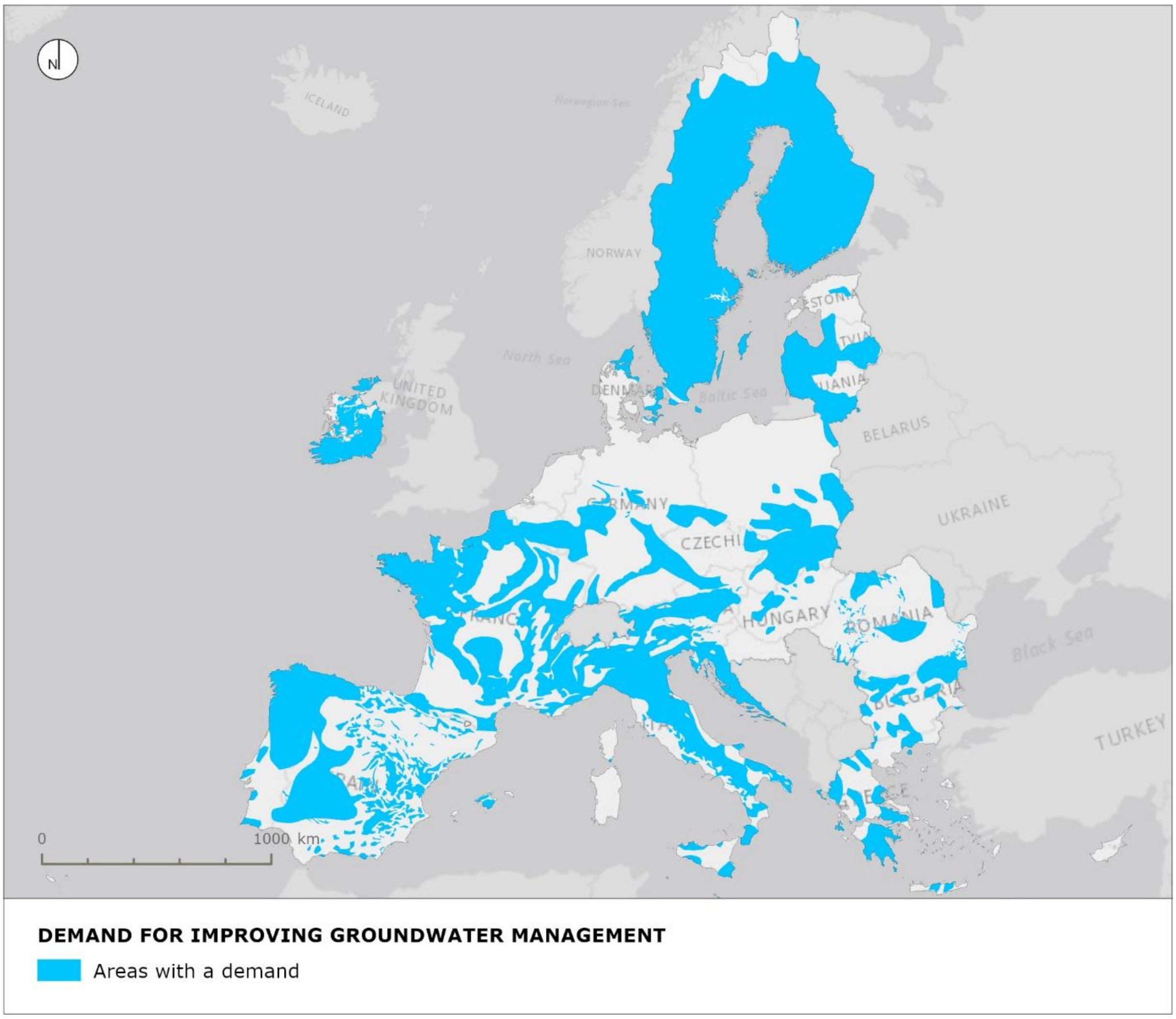

Figure 8. Spatial result for the analysis for areas with a demand for improving groundwater management. The total area with a demand is 2,199,000 km^2.

Results show that the largest areas in need of groundwater management are in Finland, Sweden, Ireland, Latvia, Lithuania, France, Spain, Italy, Poland, Croatia, Slovenia, and Slovakia. Generally though, most EU countries to some extent face the demand for groundwater management. The demand typically arises in regions where groundwater resides in local and shallow aquifers, aquifers in carbonate rocks or aquifers in fluvial deposits of large rivers. In these regions the groundwater will be much more vulnerable to atmospheric events such as droughts and floods compared to regions where groundwater resides in major groundwater basins (e.g., much of Poland, Germany, Denmark, Netherlands, and Hungary).

It is worth noting here the difference between the *potential location* for NbS and the *demand*. These results do of course not assume that NbS should occupy half of Europe's area. NbS may only occupy 1 % (or even less) of the area in Figure 8, but there is a *demand* to improve groundwater management in the mapped area.

The study wherefrom the data are extracted lists some analysis constraints. The biggest constraint in the construction of global groundwater vulnerability maps is data scarcity. Data scarcity affects the scale and objectives of the map and is reflected in the restricted number of groundwater vulnerability parameters that were suitable for constructing the global map (Vrba & Richts, 2015). Due to these constraints and data resolution, these results are assumed to be overestimated.

For comparison and validation, results from the EU Water Framework Directive show that the chemical and quantitative status in 29 % of the total groundwater body area lacks sufficient capacity to meet the needs of ecosystems and people, owing to deterioration of groundwater quality or quantity (European Environment Agency, 2023). To produce a more accurate map, more national and/or regional data layers are beneficial, e.g., depth to groundwater table, and thickness and permeability of the unsaturated zone.

A potential solution for meeting this demand effectively can be the implementation of floodplain restoration. Floodplains have various advantages in that it provides good opportunities for groundwater recharge and promotes natural filtration and attenuation processes. Also, as the demand for groundwater management typically arises in areas with shallow aquifers, aquifers in carbonate rocks or aquifers in fluvial deposits of large rivers, it is deemed unlikely that forest buffers, afforestation and/or retention basins will have the right conditions to grow into effective and efficient solutions.

Figure 9 shows the regions where the demand for groundwater management is met by the potential for floodplain restoration.

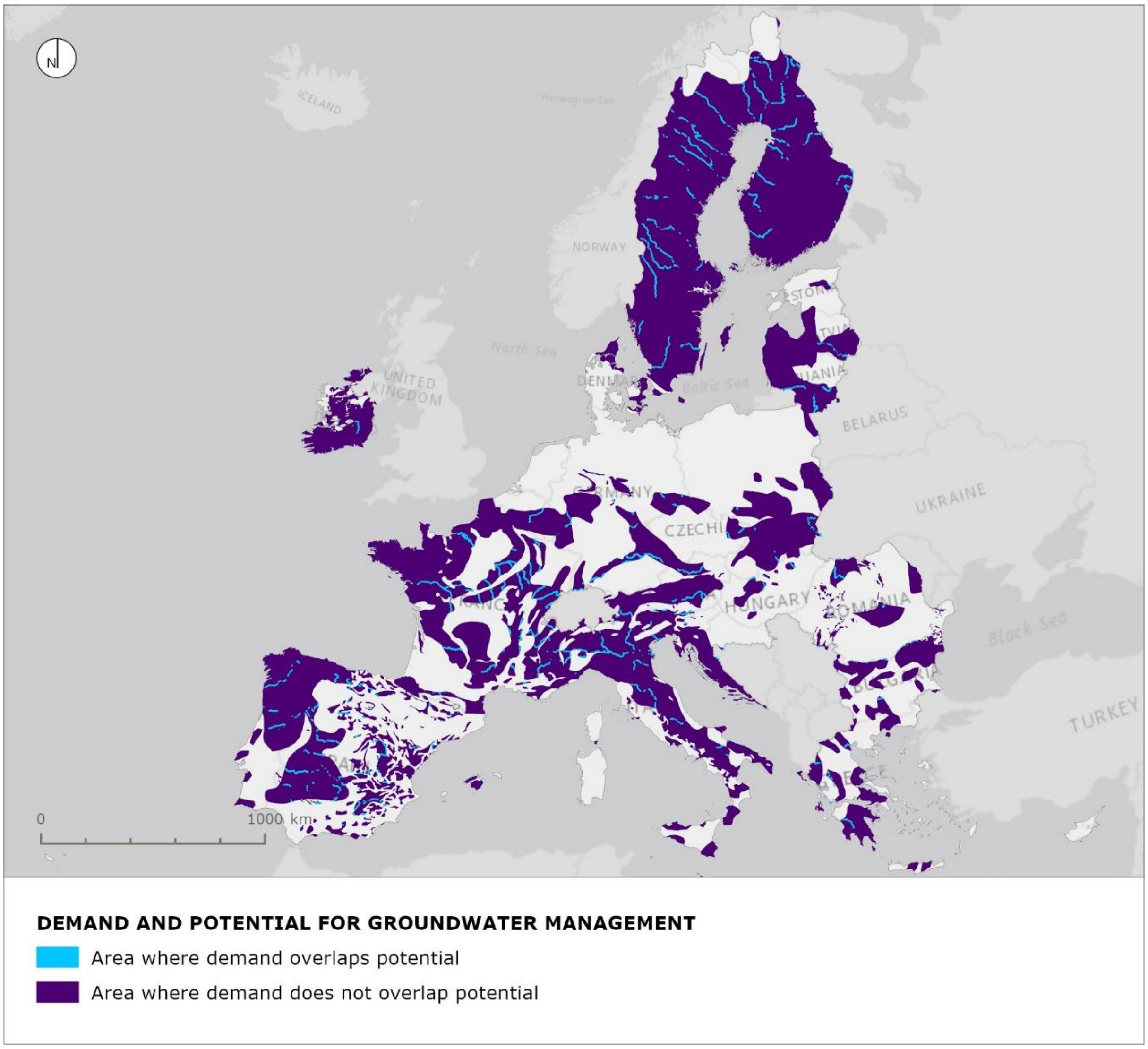

Figure 9. Areas where the demand for groundwater management overlaps with the potential for floodplain restoration.

Based on these overall assessments, the area where potential meets demand is only 19,000 km^2, which means that 2,180,000 km^2 of the total demand (2,199,000 km^2) must be met by other types of solutions that effectively meet the demand for groundwater management.

As the potential for improved groundwater management is limited to the extent of possible locations for floodplain restoration as much as 99 % of the demand must be addressed through other solutions. Other solutions include small-scale NbS and community-based conservation initiatives, but also in particular governance policies for sustainable land management practices, investments in water-efficient technologies, and groundwater monitoring programs may be essential in optimising groundwater management.

It may also be worth noting again that, the analysis is done on an EU scale and only major features (in this case major rivers) are accounted for.

5.3 Results for Nature-related parameters for demand

5.3.1 Areas with a demand to maintain and enhance biodiversity

The total area with a demand for NbS to maintain and enhance biodiversity is shown in Figure 10. The demand area is around 915,000 km^2 (just over 20 % of the total area of the EU), and results are based on the location of areas expected to encompass significant biodiversity in the World Database on Protected Ares (WDPA). In comparison, 26.4 % of EU land are covered by protected areas (Biodiversity Information System for Europe (BISE), 2024), and as such the excluded areas in the dataset such as “landscape park” or “nature monument” may account for about an additional 6 % of protected areas not considered in this analysis.

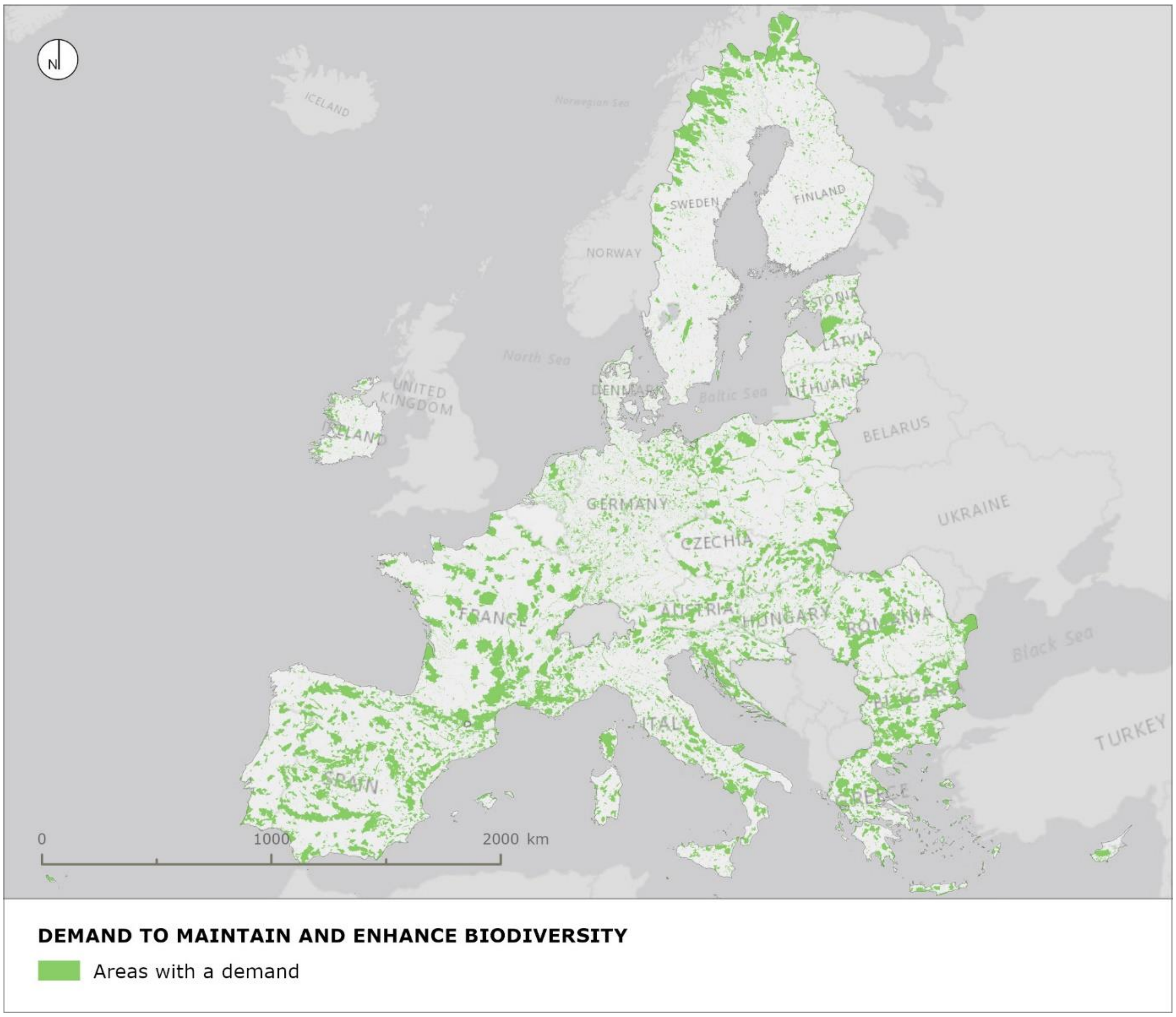

Figure 10. Spatial result for the analysis for areas with a demand to maintain and enhance biodiversity. The total area with a demand is 915,000 km^2.

As stated in section 4.2.1, biodiverse areas face a myriad of potential threats that augments the demand to maintain and/or enhance biodiversity such as agriculture, climate change, and pollution, and therefore, all EU Member States in general show a demand to maintain and enhance existing biodiversity. Given these findings, it is evident that European countries must do more to preserve and rejuvenate their biodiversity through stringent conservation policies, and sustainable land use practices.

As the demand is more or less present in all Member States there are many opportunities for twinning and knowledge exchange. As stated in section 4.2.1, this analysis has some epistemic uncertainty in that the filtered typologies from the WDPA dataset serve as proxies for biodiversity and it's unclear what the filtered areas encompass. In further studies, it may be beneficial to map the different types of diversity to focus collaboration efforts on regions that face comparable demands within the field of biodiversity.

In regard to the potential for meeting the demand it is evaluated that all four selected large-scale NbS can maintain and enhance biodiversity. All four NbS will enhance biodiversity if measures are implemented to reduce the threats from e.g., agriculture, natural disasters, and pollution. Figure 11 shows the regions where the demand to maintain and enhance biodiversity is met by the potential for the four identified large-scale NbS.

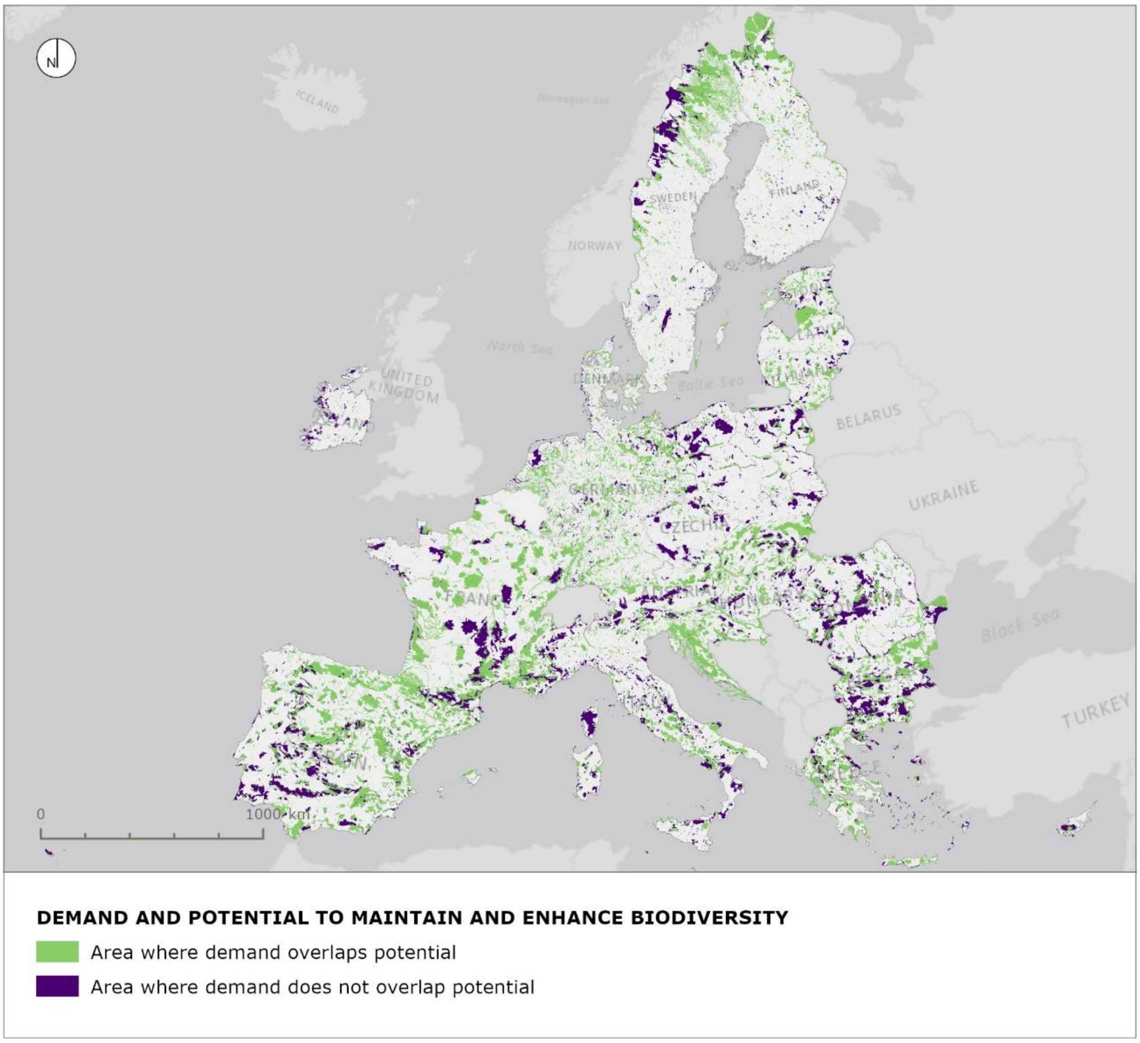

Figure 11. Areas where the demand to maintain and enhance biodiversity overlaps with four large-scale NbS (forest buffers, afforestation, floodplain restoration, and retention basins) with characteristic features to meet this demand.

Based on these overall assessments, the area where potential meets demand is 438,000 km^2, which means that 477,000 km^2 of the total demand (915,000 km^2) must be met by other types of solutions to effectively address the demand for maintaining and enhancing biodiversity. As stated previously, large-scale NbS, while valuable, face limitations due to land availability, and in particular for biodiversity many small-scale solutions such as green corridors and urban green infrastructure will also contribute significantly to enhanced biodiversity and as such should also be considered in future plans for biodiversity conservation.

5.3.2 Areas with a demand for habitat provision and distribution (quality)

The total area with a demand for NbS to improve quality in habitat provision and distribution is shown in Figure 12. The demand area is around 3,892,000 km^2 (just over 90 % of the total area of the EU), and results are based on existing reporting on Article 17 of the Habitats Directive (the conservation status of habitats and species).

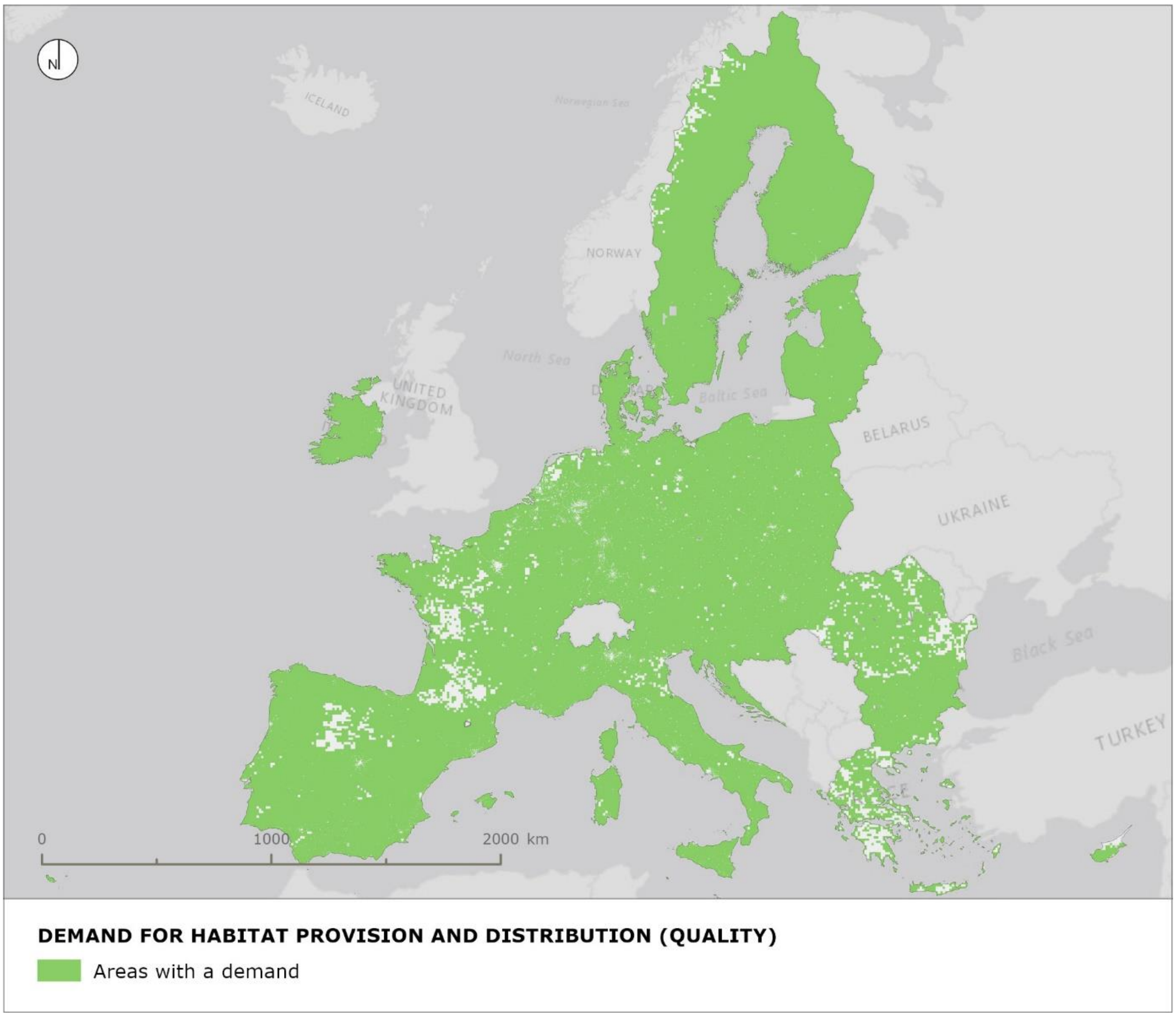

Figure 12. Spatial result for the analysis for areas with a demand for habitat provision and distribution (quality). The total area with a demand is 3,892,000 km^2.

Results in this analysis show a demand for NbS to improve habitat provision in all the European Member States. Due to the resolution of the background data, almost all areas are considered habitats, including cities, which is why areas in major cities were subtracted from the results. Nonetheless, spatial results are still assumed to be overestimated, and more regional and local analyses are recommended to target the benefits of NbS.

A potential solution for meeting the great demand for habitat provision effectively can be forest buffers, afforestation, and retention basins. These solutions are highly effective at improving habitat provision and distribution due to their unique ecological characteristics and functions. Forest buffers and afforestation provide diverse habitats for wildlife, including nesting sites and food sources, whilst retention basins offer aquatic habitats. Compared to floodplain restoration, these three solutions are often more localised in their habitat provision and can be strategically placed to maximise connectivity and complement larger-scale restoration efforts. Furthermore, the exposure to perilous flooding of potential biodiverse habitats is elevated in floodplains due to their inherent susceptibility to periodic flooding, which can disrupt and displace species.

Figure 13 shows the regions where the demand for habitat provision is met by the potential for forest buffers, afforestation, and retention basins.

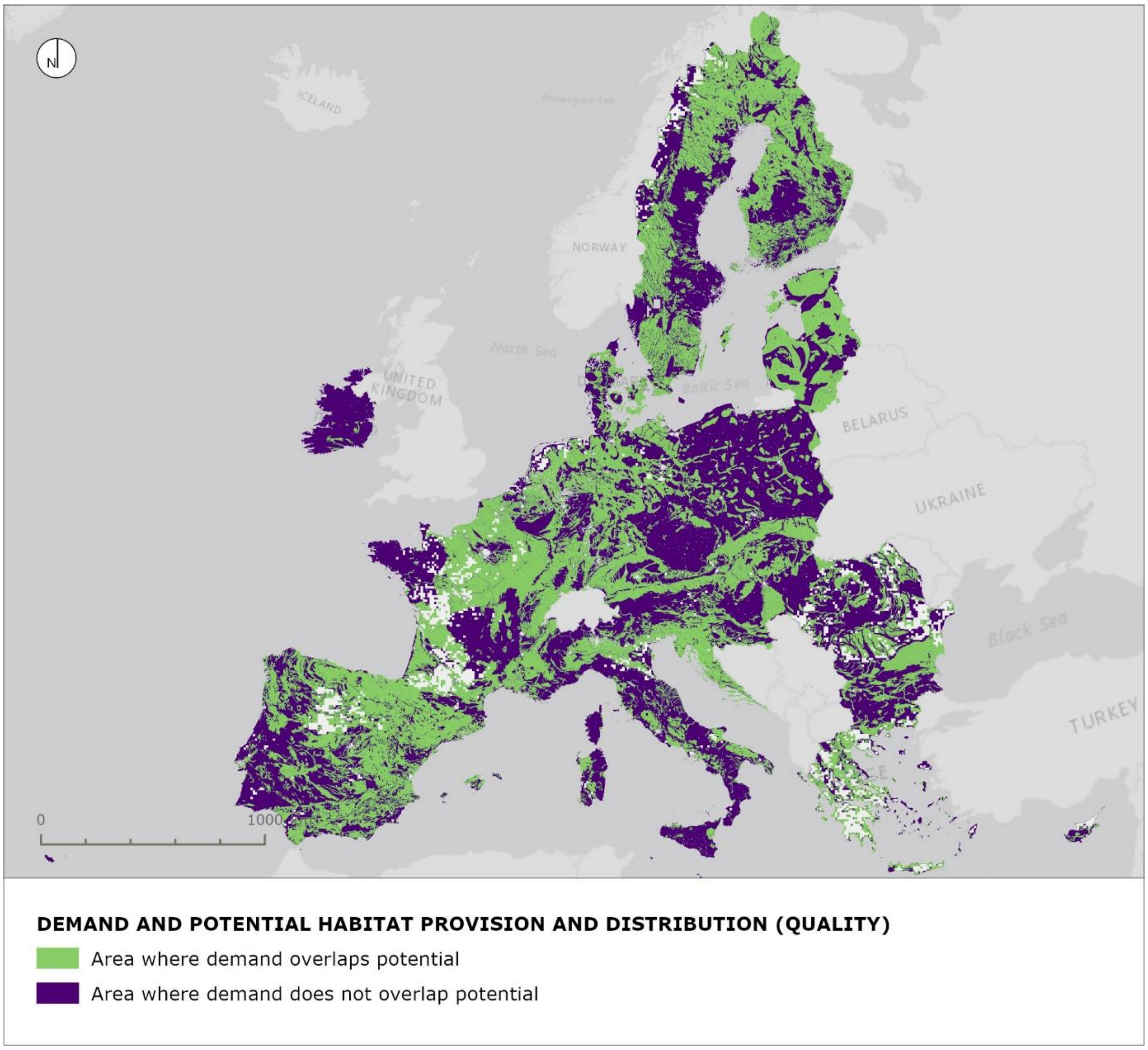

Figure 13. Areas where the demand to increase habitat provision overlaps with the potential for large-scale NbS with characteristic features to meet the demand (afforestation, forest buffers, and retention basins).

Based on these overall assessments, the area where potential meets demand is 1,816,000 km^2, which means that 2,076,000 km^2 (53 %) of the total demand (3,892,000 km^2) must be met by other types of solutions that effectively meet the demand for habitat provision. Smaller-scale solutions such as wildlife corridors, and species-specific conservation measures can complement large-scale efforts by addressing localised habitat fragmentation and enhancing ecological connectivity. In addition, governance policies are essential for ensuring the success of habitat provision initiatives.

5.3.3 Areas with a demand to increase habitat area (quantity)

Spatial results for areas with a demand for NbS to increase habitat area (quantity) are shown in Figure 14. The area is 1,381,000 km^2 (just over 30 % of the total area of the EU) and is based on areas in the Corine Land Cover dataset with less than 30 % green (nature) or blue (aquatic) areas.

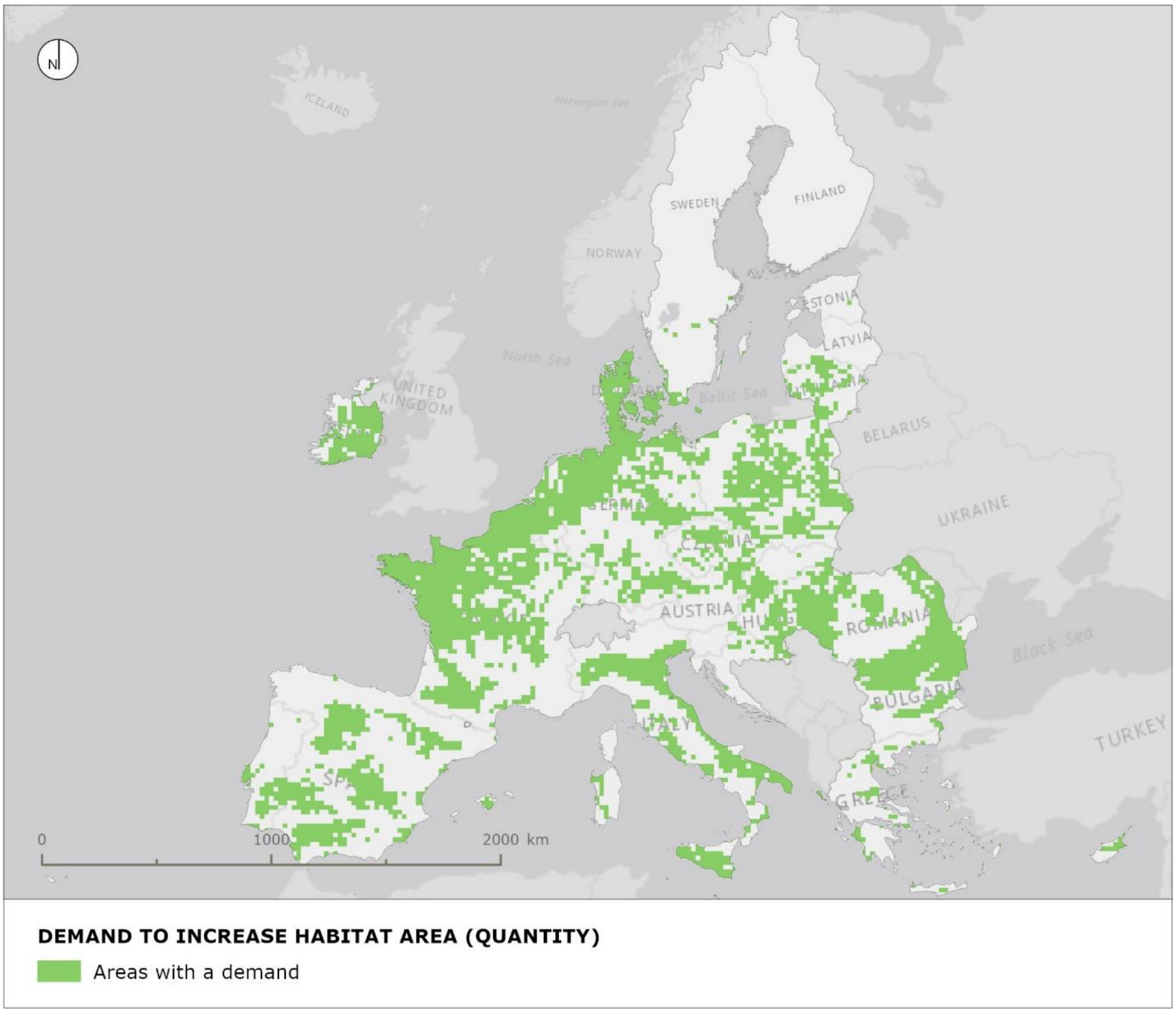

Figure 14. Spatial result for the analysis for areas with a demand to increase habitat area (quantity). The total area with a demand is 1,381,000 km^2.

These results based on the Corine Land Cover dataset are assumed reasonable, and it is worth noting, that in many areas these results are close to the inverse results from the analysis for maintaining and enhancing biodiversity. This is reasonable as areas with a lack of habitat areas will not show a demand to protect the (non-existent) biodiversity in the area. As such these analyses help validate each other, even though the analyses are based on different datasets. There is for instance a demand to increase habitat areas in particularly in northern France, Belgium, Netherlands, and Denmark. These areas also have little demand to maintain biodiversity (see Figure 10). Similarly, there is a large demand to increase habitat areas in northern Italy, Spain, Hungary, and south-east Romania. More scattered areas with a demand are also present in southern Italy, Germany, Poland and most of the eastern European Member States.

After having identified areas with a demand to increase habitat area, results are evaluated against the potential for NbS that effectively address these demands. It is evaluated that all four selected large-scale NbS can increase habitat area. All four NbS offer and support natural and aquatic habitats for a wide range of plant and animal species. Hence, the potential areas for all four NbS are dissolved and overlayed with the demand to increase habitat areas. Figure 15 shows the results of the overlay analysis.

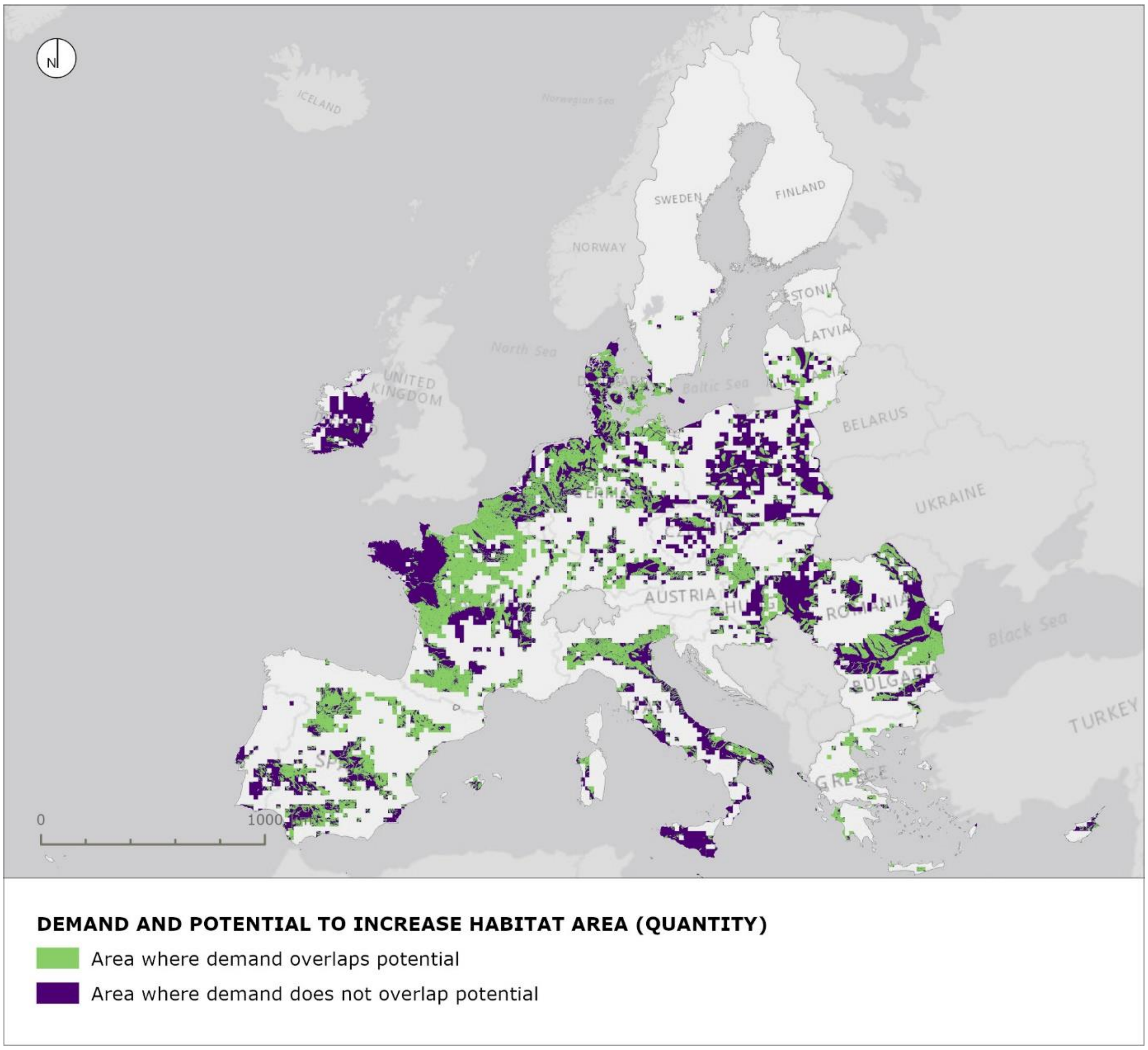

Figure 15. Areas where the demand to increase habitat area overlaps with the potential for large-scale NbS with characteristic features to meet the demand.

Based on these overall assessments, the area where potential meets demand is 632,000 km^2, which means that 749,000 km^2 of the total demand (1,381,000 km^2) must be met by other types of solutions that effectively meet the demand to increase habitat areas. As the analysis is based on locations with limited blue and/or green infrastructure, much of the demand stems from urbanised areas where the potential for large-scale solutions is limited. In these areas smaller-scale solutions should be considered.

5.4 Results for People-related parameters for demand

5.4.1 Areas with a demand to stimulate/increase economic benefits

Spatial results for areas with a demand for NbS to stimulate economic benefits are shown in Figure 16. The area is 1,023,000 km^2 (about 24 % of the total area of the EU). Any overlapping areas that arise when assessing the demand from both flood risk reduction, landslide risk reduction, and increased tourism, have been dissolved and are only counted once.

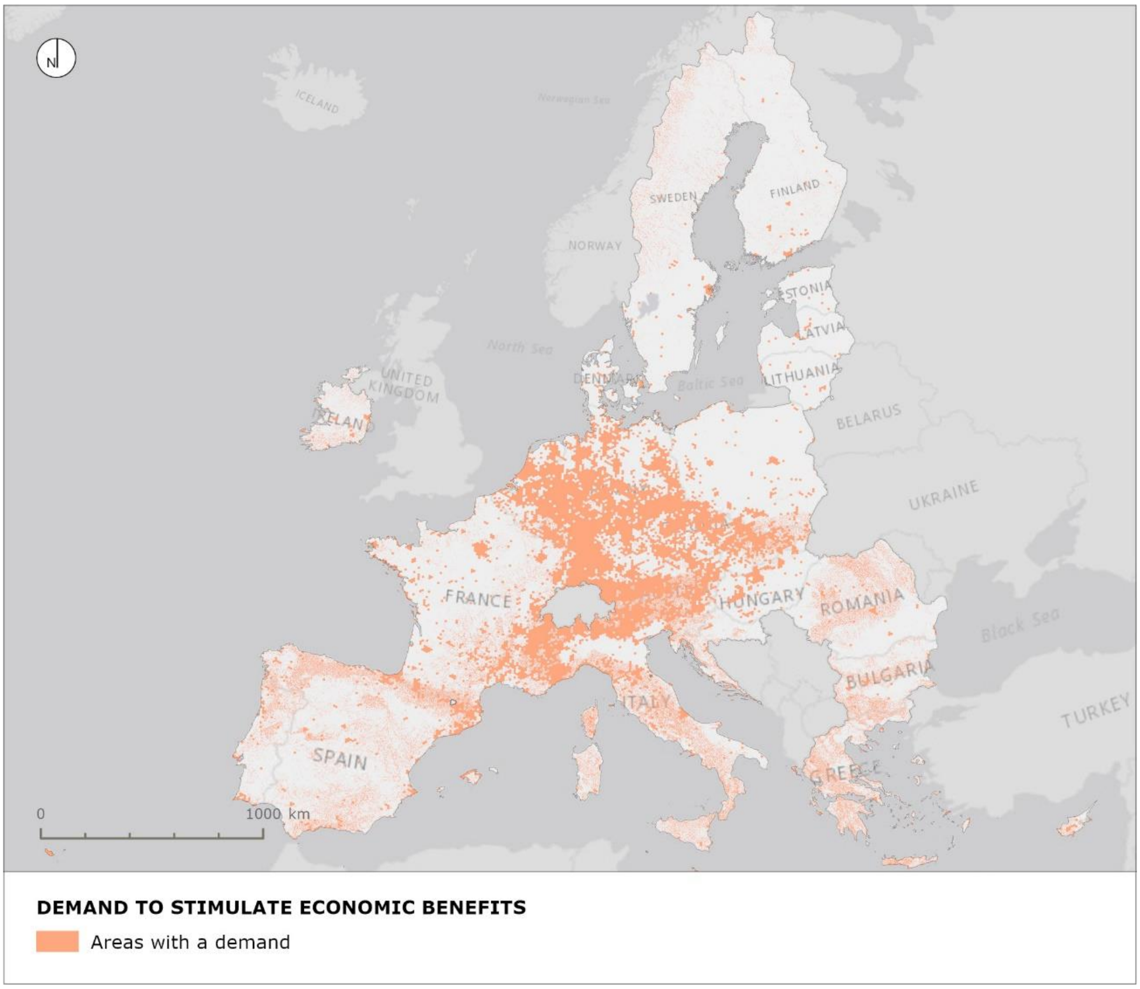

Figure 16. Spatial results for areas with a demand for NbS to stimulate economic benefits. The total area of the high-lighted locations is 1,023,000 km^2.

The main contributor to this large result is the potential for economic stimulation related to tourism. As described in the methodology (section 4.3.1), the demand is analysed by counting the number of existing tourist attractions within a 100 km^2, and if there are more than 50 existing attractions, it is assumed that the implementation of an NbS may stimulate economic benefits from tourism further by attracting more (eco)tourists and providing incentives to stay longer. Again, it is worth noting here the difference between the *potential location* for NbS and the *demand*. These results do not suggest that a potential NbS should occupy the space of 100 km^2. An actual NbS in this area may only occupy 1 % of the area, but an NbS in the area can affect and stimulate the economic benefits in the whole area, and as such the demand arises from the whole area.

The fact that 24 % of the area of the EU has a demand for NbS to stimulate economic benefits is significant for several reasons. Firstly, it underscores the potential that nature holds in fostering sustainable economic growth across the European landscape. This substantial portion of land signifies not only the need but also the opportunity to harness the power of natural resources and ecosystem services to boost various sectors, including tourism, and climate adaptation. Furthermore, it reflects a growing awareness of the link between environmental conservation and economic prosperity, aligning with global efforts to transition towards more sustainable and resilient societies. Some of the triggering factors for demand in this analysis may (instead of NbS) be managed with traditional grey infrastructure and improved land use regulations, but these mechanisms will not stimulate benefits from tourism or the co-benefits green infrastructure in flood and landslide management give rise to.

Note, that this analysis does not consider whether the area already has an NbS and/or other green areas, that may minimise the effect of a new NbS. A more detailed analysis may exclude some of the highlighted areas and reduce the area results in this analysis. Meanwhile, inclusion and assessment of other parameters such as economic benefits from improved recreational activities and carbon sequestration may lead to a greater demand and extend the spatial areas in Figure 16. It is therefore believed, the demand for economic stimulation is underestimated in this approach, as there are many unmapped opportunities compared to limitations.

After having identified areas with a demand to stimulate economic benefits, results are evaluated against the geographic, characteristic features of NbS that effectively address these demands. As with the demand for flood risk reduction which can be met by all four NbS, it is evaluated that all four NbS are also highly effective in stimulating economic benefits as one of the contributors for the demand is a risk of flooding. I.e., the geographic, potential span for all four NbS are dissolved and overlayed with the demand. Figure 17 shows the results of the overlay analysis.

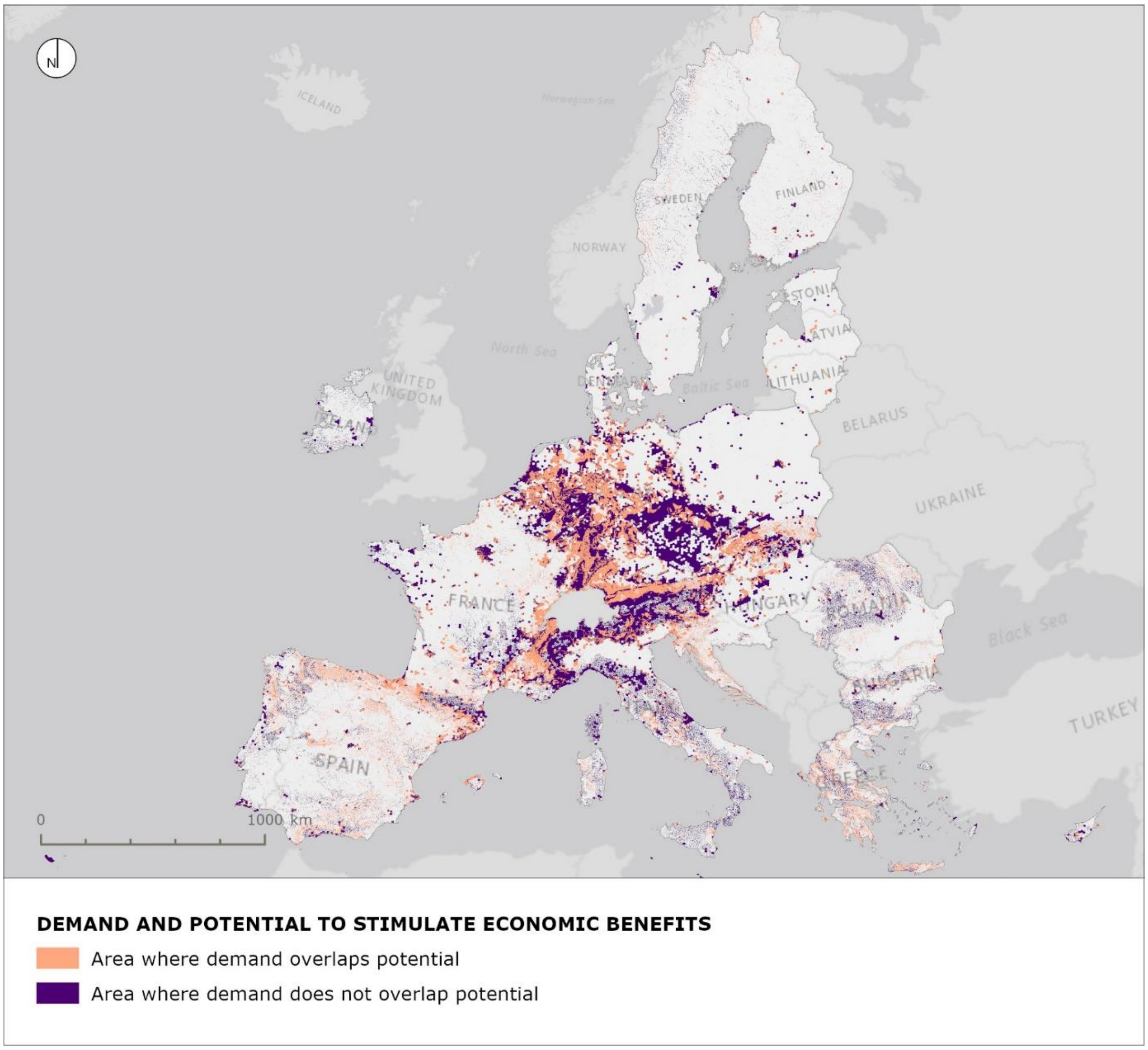

Figure 17. Areas where the demand to stimulate economic benefits overlaps with the potential for large-scale NbS with characteristic features to meet the demand.

Based on these overall assessments, the area where potential meets demand is 439,000 km^2, which means that 584,000 km^2 of the total demand (1,023,000 km^2) must be met by other types of solutions that effectively meet the demand to stimulate economic benefits.

As with flood risk reduction, much of the demand is in developed environments and therefore, much of the demand must be either be met with smaller-scale solutions or large-scale solutions upstream, beyond the areas with immediate demand, to mitigate the downstream risks.

5.4.2 Areas with a demand to increase recreational opportunities

The total area with a demand for NbS to increase recreational opportunities is shown in Figure 18. The demand area is around 89,000 km^2 (around 2 % of the total area of the EU). As stated in section 4.3.2, the results are found by overlaying areas with more than 2,000 persons/km^2 with areas that have less than 10 % green or blue areas suitable for recreational purposes.

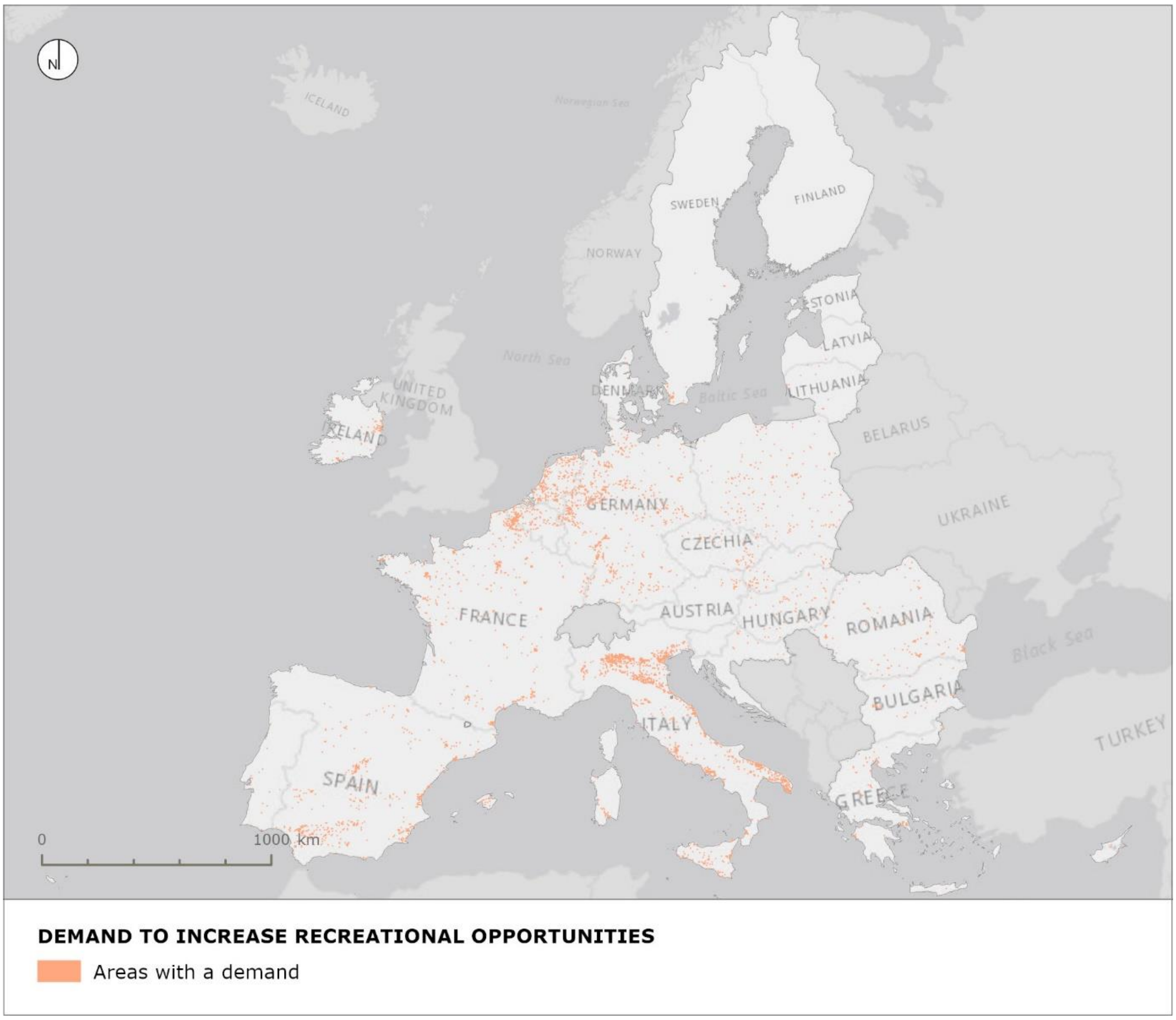

Figure 18. Spatial result for the analysis for areas with a demand to increase recreational opportunities. The total area with a demand is 89,000 km^2.

The results show a demand to increase recreational opportunities in particular in heavily populated areas in Netherlands, Belgium, Italy, and central and southern Spain. Specifically in these areas the planning of NbS should therefore ensure to integrate recreational design elements that not only benefit the more obvious beneficiaries, nature and water, but also people. On the other hand, countries such as Sweden, Finland, Portugal, Slovenia, Slovakia, Romania, and Bulgaria generally have lower population densities than central Europe and higher concentrations of blue and green areas, and as such the demand for recreational opportunities defined by these thresholds is already met.

At this level, these results are assumed reasonable. Further demographic studies may help focus the selection and design of the relevant NbS. Furthermore, it is worth mentioning that walking and in general adventure tourism is a fast-growing market in Europe. A market growth of 11.9 % is expected from 2019 to 2026 in the adventure tourism market in Europe (CBI, 2021). As such the demand for recreational opportunities may grow in the near future with the rise of ecotourism and growth in adventure tourism.

It is evaluated that all four selected large-scale NbS can contribute to increasing recreational opportunities. All four NbS may offer scenic views, shaded areas, and trails for walking, jogging, and cycling, enhancing the aesthetic value of landscapes and promoting human well-being. Figure 19 shows the results of the overlay analysis.

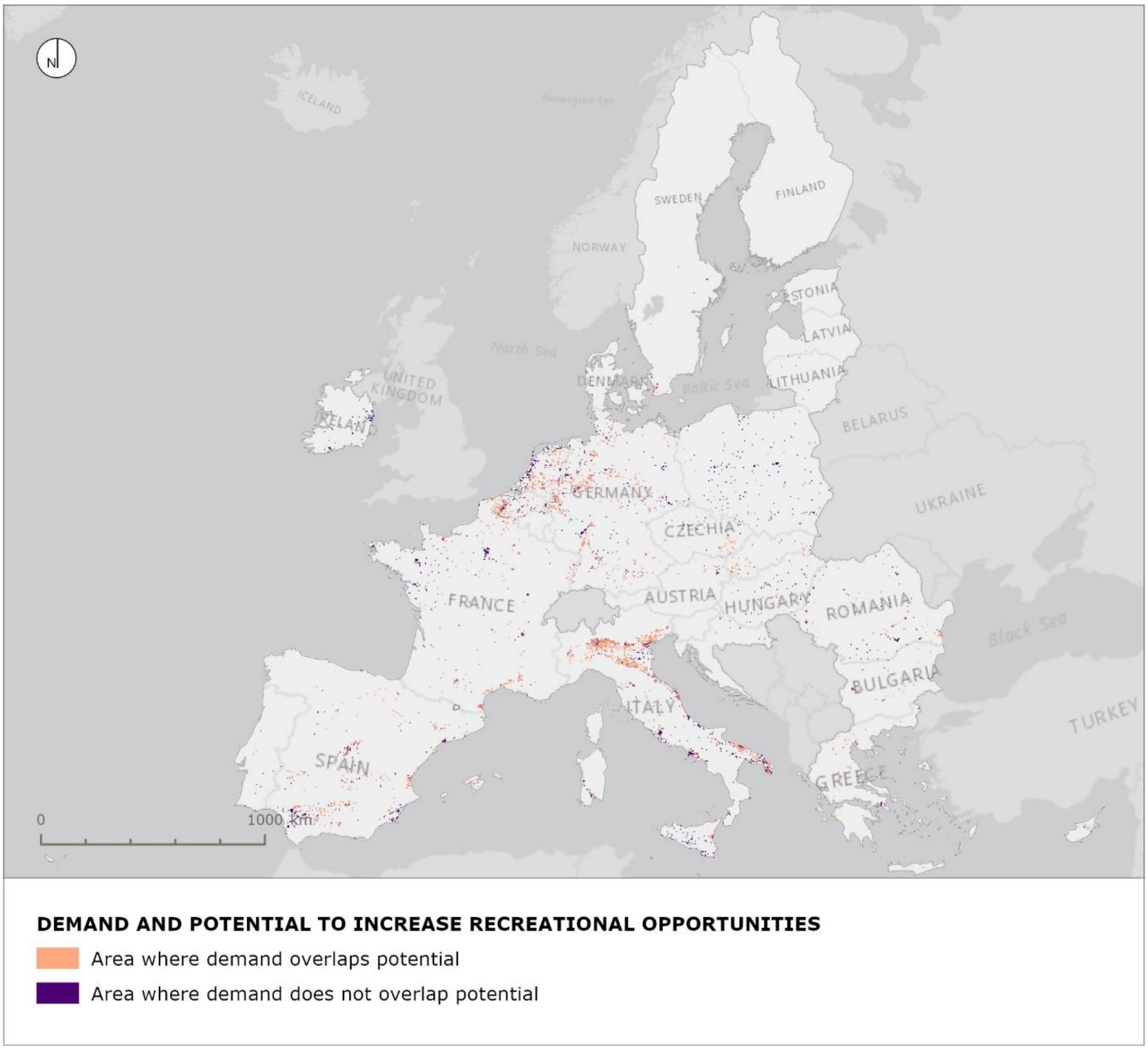

Figure 19. Areas where the demand to increase recreational opportunities overlaps with the potential for large-scale NbS with characteristic features to meet the demand.

Based on these overall assessments, the area where potential meets demand is 40,000 km^2, which means that 49,000 km^2 of the total demand (89,000 km^2) must be met by other types of solutions that effectively meet the demand to increase recreational opportunities. Other potential solutions, such as the creation of urban green spaces, development of recreational trails, and promotion of community-based recreational initiatives, can complement large-scale NbS efforts.

Again though, it's important to note that the implementation of large-scale NbS (or other solutions) is not necessary across the entire area of demand. Solutions that span smaller areas, such as 2 km^2, can mitigate the larger demand for recreational opportunities.

5.4.3 Areas with a demand to maintain and enhance cultural values

Spatial results for areas with a demand for NbS to enhance cultural values are shown in Figure 20. The area is 33,000 km^2 (a little under 1 % of the total area of the EU). Any overlapping areas that arise when assessing the demand from culturally significant areas in both World Database for Protected Areas and OpenStreetMap data have been dissolved and are only counted once.

Figure 20. Spatial results for areas with a demand for NbS to enhance cultural values. The total area of the highlighted locations is 33,000 km^2.

At an overall glance the identification of 33,000 km^2 as having the potential for NbS to enhance cultural values signifies a vast canvas of opportunities for harmonising nature and heritage. These areas speak to the wealth of natural landscapes and ecosystems that can be strategically managed to both preserve and celebrate the cultural tapestry of Europe. The recognition of this potential can emphasise the EU's commitment to nurturing the relationship between nature and culture, and safeguarding the legacy of diverse communities. It also signals a transformative approach towards harnessing the power of nature to invigorate cultural experiences, fostering a deeper sense of belonging and shared heritage among Europeans.

As described though in the methodology sections for this mapping exercise (section 4.3.3), conducting a GIS analysis on the EU level to map areas with a demand for enhancing cultural values may yield very uncertain results due to the inherent complexity and diversity of cultures across the region. Attempting to generalise cultural values and demands at the continental scale overlook the nuances and local intricacies that define identities and communities. As such these results are deemed very uncertain, and more local and context-specific assessments are recommended.

It is evaluated that all four selected large-scale NbS can contribute to maintaining and enhancing cultural values. All four NbS offer potential for cultural experiences, improved community connections, and spaces that both preserve and celebrate Europe's cultural history and communities. Figure 21 shows the areas where the potential location of the four selected NbS overlap with the demand for maintaining and enhancing cultural values.

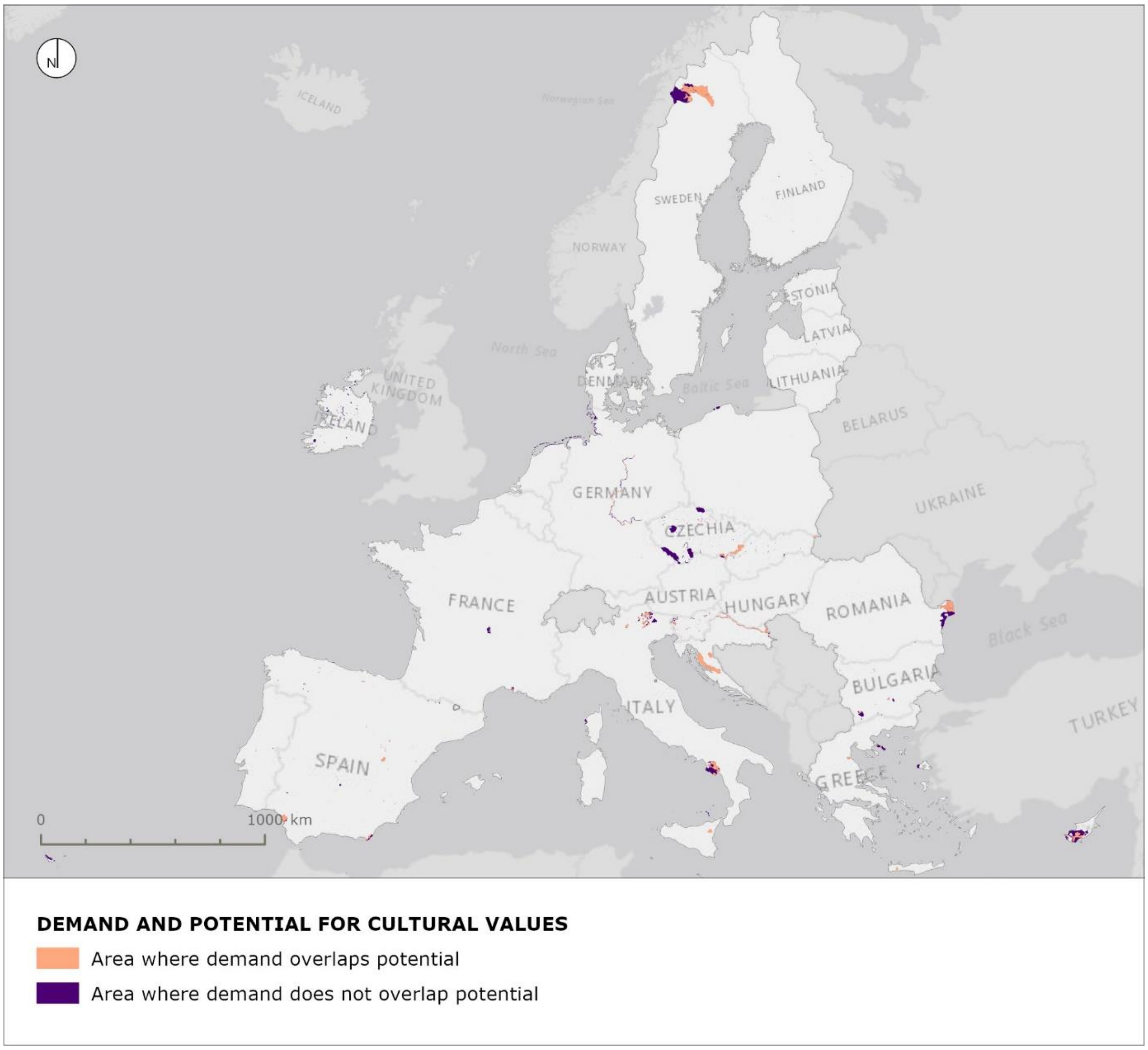

Figure 21. Areas where the demand to maintain and enhance cultural values overlaps with the potential for large-scale NbS with characteristic features to meet the demand.

Based on these overall assessments, the area where potential meets demand is 14,000 km^2, which means that 19,000 km^2 of the total demand (33,000 km^2) must be met by other types of solutions that effectively meet the demand to maintain and enhance cultural values. As with the analysis for demand, the results are very uncertain, and a more local approach involving stakeholders and communities is needed for ensuring that NbS interventions are culturally relevant and impactful.

6 Conclusions and building the evidence base for NbS

The results of this comprehensive GIS analysis paint a picture of the multifaceted demand for Nature-based Solutions (NbS) within Europe. The revelation that 99 % of areas within Europe show a plausible demand for the implementation of NbS is a compelling testament to the urgency and relevance of these approaches. This comprehensive coverage underscores the pervasive need for NbS in addressing a myriad of environmental and societal challenges. It not only provides a stark reminder of the intricate interdependence between human well-being and the health of ecosystems but also strengthens the evidence base for NbS.

Such overwhelming and overlapping demand across diverse regions and ecosystems shows the potential effectiveness of NbS in mitigating issues like climate change, biodiversity loss, and natural resource degradation. Whilst some of the demands can be met with traditional engineering solutions, traditional solutions lack the inherent capacity to deliver the same array of co-benefits present in NbS. These results reinforce the viability and significance of NbS, catalysing further support, investment, and informed policy decisions to harness the transformative potential of these solutions in building a sustainable, resilient, and harmonious future for Europe.

The demand for NbS providing benefits for nature, encompassing 96 % of the EU, underscores the continent's need to conserve and restore ecosystems, which are fundamental to sustaining life on Earth. This wide-reaching demand aligns with global conservation objectives and highlights Europe's role in safeguarding biodiversity and ecosystem services.

Simultaneously, the need for NbS supplying water-related benefits, apparent in about 60 % of the EU, emphasises the vital importance of sustainable water management and the preservation of aquatic ecosystems. This demand underscores the necessity to tackle water-related challenges, including flood risk reduction, water quality improvement, and groundwater management, through nature-based approaches and form a compelling case for the integration of NbS in EU policies and strategies.

Finally, the fact that about 26 % of the EU displays a demand for NbS benefitting people underscores the importance of the intrinsic link between human well-being and nature. These findings reflect a need to commit to enhancing the quality of life for EU citizens through access to green spaces, improved recreational opportunities, and preservation of cultures and history.

By comparing the results for demand for NbS against the potential for NbS, the analysis shows that for all demands, alternative solutions to large-scale NbS must be considered. Large-scale solutions in most cases overlap demands for NbS implementation about 40 % to 50 % of analyses. The remaining demand must be met by smaller-scale solutions, governance policies, and/or other solutions. It must also be stressed though, that the implementation of large-scale NbS is not necessary across the entire area of demand. Solutions that span smaller areas can effectively mitigate the demand for larger areas, i.e., the residual results do not reflect the spatial need for solutions.

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