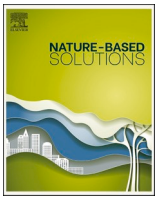
Nature-Based Solutions 4 (2023) 100097

Contents lists available at ScienceDirect

Nature-Based Solutions

journal homepage: www.elsevier.com/locate/nbsj



Reducing hydro-meteorological risks through nature-based solutions: A comprehensive review of enabling policy frameworks in the European Union

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ARTICLE INFO

Keywords:
Nature-based solutions
Horizon 2020
Climate-change adaptation and mitigation
Resilient societies
Disaster risk reduction
Sustainable development

ABSTRACT

The international community, particularly across the European Union (EU), is increasingly recognizing and promoting Nature-based Solutions (NBS) as long-term and sustainable measures against hydro-meteorological hazards such as flooding, coastal erosion, heat waves and landslides. Yet, scaled implementation of NBS at EU and global level presently remains a challenge due to often complex and lengthy permitting procedures. While efforts have been made to highlight the explicit and implicit role of NBS in major global and European policy frameworks, uncertainty remains when it comes to the level of coherence across government levels, from international to national and local scale. This paper attempts to address this gap by introducing an open-access online policy catalogue pertaining to the implementation of 740 NBS projects globally to mitigate the impact of hydro-meteorological phenomena. Based on a policy screening of 88 NBS projects in Europe and an in-depth analysis of the NBS permitting paths across seven Open-Air Laboratories in European countries, we examine the linkages between European and national legislation and policies. Understanding these linkages will help promote NBS mainstreaming as the NBS agenda is set at EU and global level while implementation is heavily dependent on national-scale governance. We identify a common permitting path for NBS paved by the EU in several directives, as well as some divergence in the implementation of these directives at national level which can pose significant challenges to the uptake of NBS. The NBS policy catalogue provides a valuable resource for further analysis of the NBS policy context from local to global levels towards increasing uptake and acceptance of NBS in Europe and beyond.

1. Introduction

The European Commission defines Nature-based solutions (NBS) as 'solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience [1]. The concept of NBS as adaptive measures against hydro-meteorological hazards, such as heatwaves, floods, and landslides - which can cause considerable loss of life and serious economic damage [2,3,4] - continues to gain momentum and shape public discourse in the context of climate change adaptation and disaster risk reduction. However, NBS are still a fairly new concept to the policy arena, and as such have not yet been effectively integrated in terms of policy instruments [5]. In Europe, there is a growing recognition of the potential of nature to provide sustainable solutions to a wide range of societal challenges as evidenced by recent European Union (EU) policy developments aimed at advancing the ambitious European Green Deal and positioning NBS at the forefront of climate change adaptation strategies. At the global level, increased awareness of the importance of

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https://doi.org/10.1016/j.nbsj.2023.100097
Received 31 March 2023; Received in revised form 7 October 2023; Accepted 5 November 2023
Available online 8 November 2023

healthy ecosystems in boosting climate resilience is reflected in the reinforcement of linkages between biodiversity and climate change themes in major policy mechanisms, such as the recently (2021) launched UN Decade for Restoration [6]. While the integration of NBS concepts into global and European policy frameworks has been documented in several publications [7,8,9], uncertainty remains when it comes to how these policies are transposed at the national level. The degree of NBS uptake largely depends on the initiative and commitment of Member States as there is a lack of mandatory standards and measures across EU policies [5]. Moreover, the application of NBS is heavily dependent on national governance and regulatory frameworks which vary significantly among EU Member States. The effective use of NBS may involve multiple legal processes, from environmental impact reviews and consultations, to permitting procedures across government levels [10]. National governments can help expedite these processes by setting enabling conditions and regulatory frameworks (in alignment with international/EU policies) that foster NBS implementation at local level. Advancing action in this respect, requires a thorough review of existing NBS-related policy instruments from global to national level.

To address this need, the present paper introduces an NBS policy catalogue that aims to provide an overview of existing policy frameworks relevant to the implementation of NBS around the globe. The policy catalogue (comprising over 2000 policy documents from international to national and sub-national level) was developed within the EU-funded OPERANDUM project and has been integrated into an open access online knowledge platform, GeoIKP (Geospatial Information Knowledge Platform [11]). OPERANDUM has been funded as one of several projects during the period of 2018 – 2022 to consolidate the NBS knowledge base and collect evidence on the effectiveness of NBS operationalisation in reducing hydro-meteorological risks in European and non-European territories. The project achieves these aims by delivering NBS-related tools, methodologies, and validated approaches to enhance societal resilience while providing strategic plans for upscaling and replicating NBS. The OPERANDUM approach is based on seven Open-Air Laboratories (OALs) in predominantly rural territories that offer concrete, flexible and transportable frameworks to expand the adoption of NBS across Europe and to implement them in emerging economies and developing countries.

The analysis of relevant policy frameworks in the results section is based on NBS interventions around the world with a focus on the OAL countries across Europe (Fig. 1). However, the findings are considered relevant to other geographical contexts and may hold the potential to support a wider uptake of NBS beyond the scope of the selected case studies.

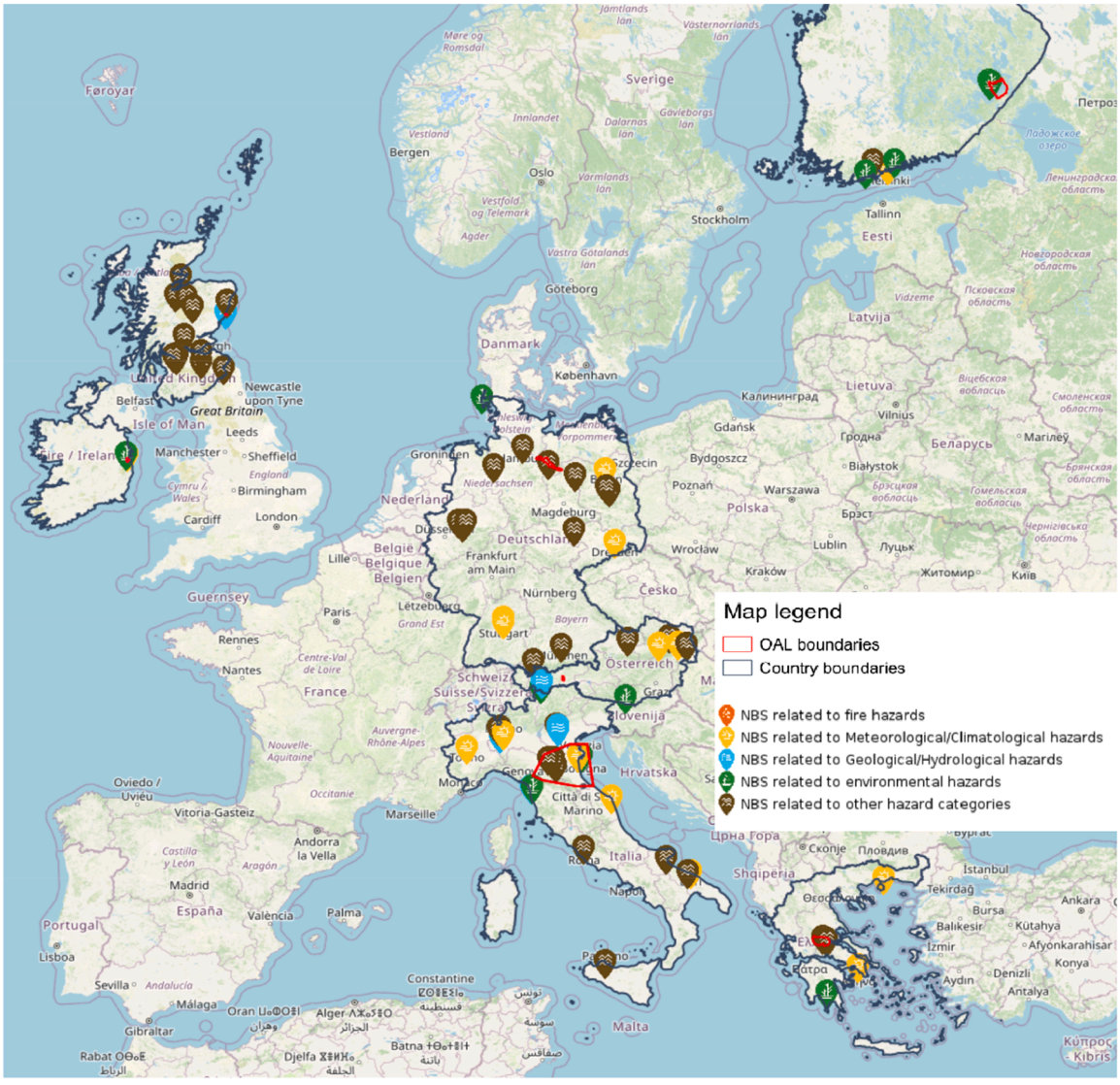

Fig. 1. Map of reviewed NBS case studies across selected European countries and OPERANDUM Open-Air Laboratories (OALs), source: GeoIKP (https://geoikp.operandum-project.eu/data/map).

Within the period of 2011–2021 > 300 NBS projects were funded through various EU funding mechanisms, such as the Seventh framework programme (FP7), Horizon 2020, BiodivERsA, Interreg and LIFE [12]. Numerous case studies with various geographical and socio-economical settings provided empirical evidence of NBS efficacy all over Europe [13]. In terms of policy analyses, much work has been focused on exploring the role of NBS in the global and EU context [7], however research at national and sub-national levels has been limited to the case study scale. Major efforts have gone into developing and implementing NBS at city scale, leading to the integration of NBS values into urban resilience and human well-being: (CONNECTING Nature (Horizon 2020), Nature4Cities, LIFE-PLETERA (LIFE)). The city of London (BRIDGE, FP7), Valencia (Grow Green, Horizon 2020) and Brussels (URBINAT, Horizon 2020) among others acted as open-air laboratories for NBS co-creation. Leveraging a vast network of local and national decision- and policy-makers, governance and policy settings and implementation processes were analysed (CONNECTING Nature, Horizon 2020). However, a limited number of projects focused on catchment-scale NBS in rural areas (OPERANDUM, RECONECT, PHUSICOS, Horizon 2020) which drove the present research and included in-depth investigations of predominantly rural case studies.

2. Material and methods

2.1. NBS and policy database

The OPERANDUM NBS-catalogue integrated within the GeoIKP represents a comprehensive, geo-referenced, database of currently 740 NBS projects designed to mitigate the risk and impacts of hydro-meteorological hazards, under various environmental settings and hazard categories [14]. The GeoIKP adopts a multi-stakeholder approach through the integration of multiple modules related to science, policy and practice enabling diverse stakeholders and end-users to improve their knowledge of NBS for reducing the risks of floods, droughts, heat waves, coastal erosion, storm surges and other hydro-meteorological hazards. NBS projects were collected from various resources, including knowledge platforms, such as Climate-ADAPT (European Climate Adaptation Platform), Oppla, Think Nature and PANORAMA databases, as well as other referenced scientific articles, technical reports, OPERANDUM OALs, etc. Each NBS is characterized through a comprehensive set of parameters, including the type of hazard and ecosystem, the societal challenges and enabling policies linked to it, the type of intervention and its spatial coverage, among many others [15].

The NBS policy catalogue [16] represents a sub-module of the GeoIKP's NBS-catalogue and consists of international/EU, national and local policies relevant to the implementation of each NBS project. Following the definition by the European Environmental Agency (EEA) in its 2021 report on NBS in Europe, a 'policy' refers to "a set of ideas or plans that is used as a basis for making decisions in politics and usually includes instruments for its implementation; these can be a regulation, strategy, action plan, agenda or global agreement, decision, resolution or framework" [6]. The policy review was performed between mid to end of 2021 and relied on both explicit and implicit qualitative content analysis rather than a strict keyword-based analysis. The policy catalogue consists of more than 2000 policy documents attributed to 740 NBS cases and drawing from existing open-access information services on environmental legislation and regulations including the FAOLEX database [17] on national legislation, policies and bilateral agreements on food, agriculture, the environment and natural resources management, the Convention on Biological Diversity's country profiles [18], the Biodiversity Information System for Europe [19], the Climate-ADAPT database of country profiles [20], the European Commission's published country reports of the Environment Implementation Review (EIR, 2019) [21] and the ECOLEX database [22] for national and EU and international environmental legislation. The policy catalogue currently comprises 2.369 policies from global to local level (status: March 2023), the majority of which (62,3 %) pertains to the national level (see Fig. 2a). National policies are assigned to a total of 111 countries from various regions (Fig. 2b): Africa (24,3 % of collected policies), Asia and the Pacific (22,5 %), Western Europe and North America (20,7 %), Latin America and the Caribbean (18,8 %) and Eastern Europe (13,5 %).

Additionally, as a basis for further analyses, each of the 740 NBS case studies was associated with one or more key societal challenges outlined in Table 1. These challenges were defined based on a review of the 2030 Agenda for Sustainable Development and its goals (SDGs), the Eklipse Expert Working Group report to support planning and evaluation of NBS projects [23] and the OPERANDUM catalogue of existing NBS projects around the world.

2.2. Comprehensive analysis of European NBS cases

The level of support and integration of NBS in global and EU policy frameworks has been highlighted in several publications [6,7,8] and has been evidenced in this study through a screening of all NBS case studies (total of 88) uploaded on the GeoIKP that were deployed in OPERANDUM OAL countries (as of March 2023) including Italy (28 NBS), Ireland (2 NBS), Scotland (18 NBS), Finland (10 NBS), Austria (6 NBS), Greece (5 NBS) and Germany (19 NBS). The NBS interventions range from single/local scale (e.g. green roof) to catchment-scale (e.g. floodplain restoration).

The screening is based on information collected from the GeoIKP's policy catalogue where policies were reviewed for their explicit inclusion of NBS terms and for any subject matter linkages e.g. with respect to the environment, nature, ecosystems and biodiversity. The results also build on in-depth analyses of NBS permitting paths engaged at the seven OALs (in predominantly rural environments) to assess the regulatory and policy context at national level as well as related lessons learned. The national policy context was reviewed by local implementing partners as well as national, regional and local experts engaged and consulted in the framework of NBS policy dialogues during the OPERANDUM project's lifetime. These dialogues brought together policymakers, scientists and practitioners to discuss current NBS-specific regulatory and policy frameworks based on the local NBS projects and

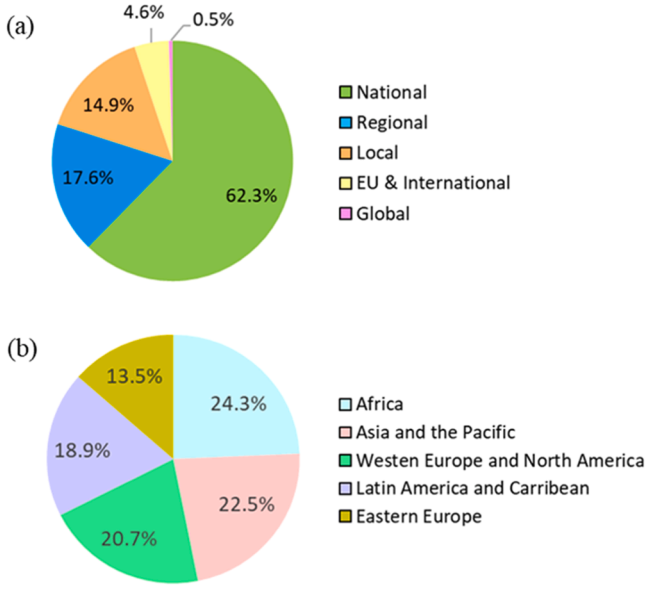

Fig. 2. NBS-related policies collected for all case studies within the GeoIKP's NBS catalogue (status: March 2023). (a) Percentage of NBS policies (total=2369) covering different administrative levels from global to local, (b) percentage of countries (total=111) covered in the policy collection grouped by geographic region.

Table 1
Connection between NBS-related societal challenges and SDGs.

Societal challenges		Relevant SDG
Macro-category	Sub-category	
Climate action for adaptation, resilience and mitigation	Climate change adaptation and resilience	SDG 13
	Climate change mitigation	SDG 13
Water management	Water management, protection of water related ecosystems and water quality	SDG 6
	Flood management	SDG 6
Coastal resilience and marine protection	Coastal resilience	SDG 14
	Marine protection	SDG 14
Environmental quality	Air quality	SDG 13
	Waste management	SDG 12
Green space, habitats and biodiversity	Green space management	SDG 15
	Habitat conservation and restoration	SDG 15
	Biodiversity	SDG 15
Rural regeneration, land-use and soil	Rural regeneration and land-use	SDG 15
	Soil management and soil quality	SDG 15
Cultural heritage and cultural diversity	Cultural and natural heritage	SDG 11
	Cultural diversity	SDG 11
Economic development and employment	Economic development	SDG 8
	Employment including green jobs	SDG 8
Public health and well-being	Quality of life	SDG 3
	Health and safety	SDG 3
Participatory planning and governance	Stakeholder engagement	SDG 16
	Participatory governance and access to information	SDG 16
Sustainable consumption and production	Sustainable food and water	SDG 12, 2
	Sustainable energy	SDG 7, 12
Social justice, inequality and social cohesion	Social context	SDG 10
	Social cohesion	SDG 10
Urban development and emergency response	Urban development	SDG 11
	DRR, emergency & public services	SDG 1

related permitting paths. The discussions addressed existing challenges and opportunities for replication and upscaling of NBS while providing occasions for establishing cross-sectoral partnerships.

3. Results

The following sections present the results of the policy review at global, EU and national level including linkages between policies across government levels and possible gaps and opportunities for further fostering the mainstreaming of NBS.

3.1. Global policy frameworks and societal challenges

At the global level, there are several important policies associated with the development and deployment of NBS [7], notably, the Sendai Framework for Disaster Risk Reduction (2015–2030) [24], the Paris Agreement (of 12 December 2015) and the 2030 Agenda for Sustainable Development [25]. Besides these three major frameworks, several other policy and legal instruments linked to the global environmental agenda are relevant to NBS, either explicitly mentioning associated terms or supporting them to a certain degree (e.g. the UN Convention on Biological Diversity, the UN Convention to Combat Desertification, the Ramsar Convention on Wetlands) [26]. Most of these policies take the form of general frameworks which can be adapted at the regional, EU, national or local level.

Adopted by the UNGA in 2015, the 2030 Agenda aims to provide a blueprint for peace and prosperity for people and the planet, now and into the future. The 17 SDGs which lie at the heart of the 2030 Agenda are an urgent call for action by all countries in a global partnership [27]. The focus on DRR, Climate Change and NBS is highly present in the 2030 Agenda for Sustainable Development (whether directly or indirectly). As shown in Table 1, NBS for hydro-meteorological risk reduction (and OPERANDUM objectives) address a number of societal challenges and contribute to several of the SDGs. The list of societal challenges covers 13 macro-categories, each comprising sub-categories which are in turn linked to the corresponding SDGs. NBS concepts addressing societal challenges are directly connected to the SDGs even though the Goals do not refer to NBS explicitly but instead make reference to ecosystem management, DRR and CCA [6].

A review of all 740 NBS projects globally within the GeoIKP's NBS catalogue reveals that the societal challenges most frequently addressed through nature-based interventions include (Fig. 3):

- Climate action for adaptation, resilience and mitigation (climate change adaptation and resilience (72 %); climate change mitigation (22 %))
- Water management (flood management (48 %), water management, protection of water related ecosystems and water quality (43 %)
- Green space, habitats and biodiversity (biodiversity (49 %), habitat conservation and restoration (46 %), greenspace management (35 %)

Correspondingly, the SDGs most relevant to analyse NBS cases include (Fig. 4):

- SDG 13: Climate action (76 %) addressing the challenge of combating climate change and increasing the resilience and adaptive capacity of socio-ecological systems.
- SDG 15: Life on land (73 %) addressing the need to protect and restore terrestrial ecosystems, to combat desertification and halt land degradation and biodiversity loss.
- SDG 6: Clean water and sanitation (61 %) aiming to protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.

The above-mentioned global policy frameworks work hand in hand, and their objectives can also be seen reflected and implemented at the European and national level in various legislation and policy instruments. The assessment of 88 NBS cases in Europe (within the 7 OAL countries) accordingly showed the referenced international policy and legal instruments as being strongly implicated: The 2030 Agenda for Sustainable Development was most frequently associated with these NBS projects, being implicated in 86 cases. The UNFCCC and the Sendai Framework were implicated in more than 75 % of the NBS projects assessed.

3.2. EU policy frameworks

The competencies of the EU as a supranational organization include several areas linked to NBS and its policies support to varying degrees the uptake and implementation of NBS. Before discussing NBS-related EU policy and legal frameworks, it may be useful for some readers to explain broadly the functioning of the EU legal system. The legal system of the EU is characterized by primary EU law such as the treaties and instruments that have established the EU and its functioning, as well as by secondary EU law such as regulations, directives, decisions, recommendations, and opinions. This secondary EU law allows the EU to legislate in more specific policy areas. EU Directives set objectives that while binding for Member States are left to the individual Member States to choose how to achieve these objectives. The EU does not regulate institutional and procedural administrative laws and the implementation of EU law is governed autonomously by each member, although the EU supervises the compliance of national laws with its principles and objectives. The majority of the regulatory sectors implicated by NBS are governed by directives, such as environment, water and flood management, allowing a certain degree of policy freedom due to institutional and procedural autonomy [5,28]. The review of 88 NBS projects in Europe (within the 7 OAL countries) reveals that a large number of EU policy and legal instruments relevant to NBS are strongly implicated.

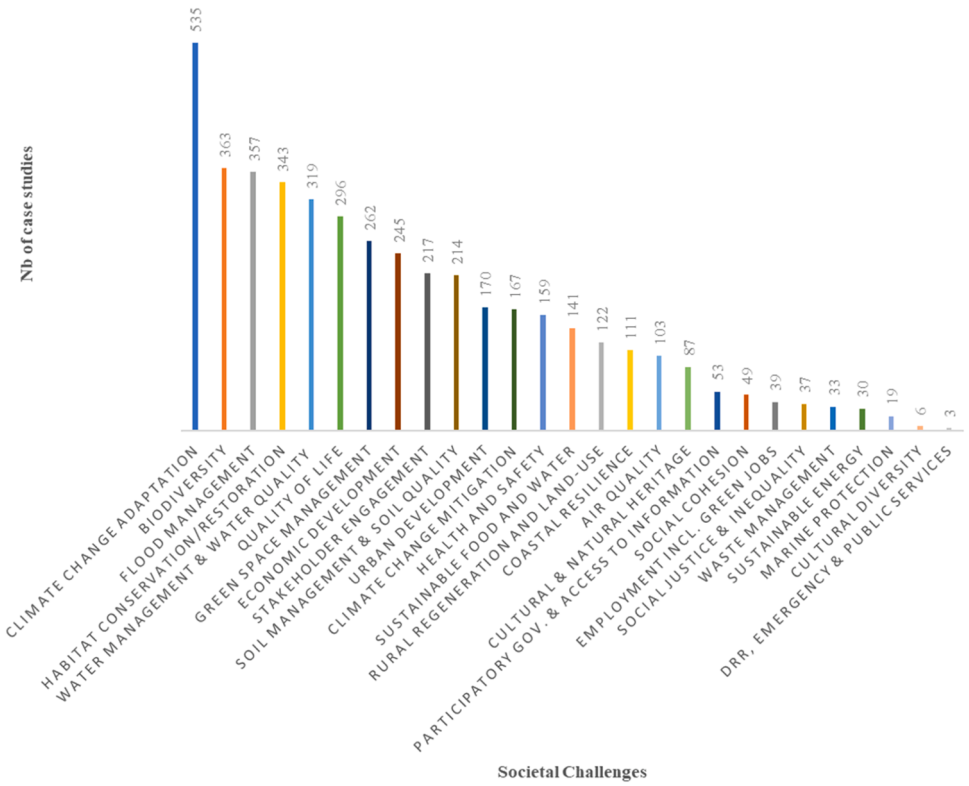

Fig. 3. NBS-related societal challenges most frequently addressed by NBS projects (total of 740) within GeoIKP.

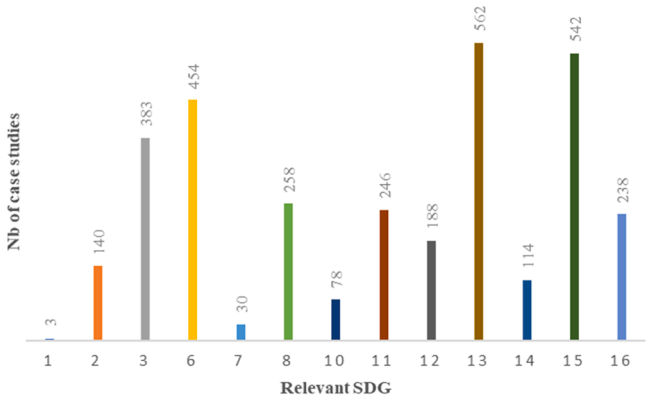

Fig. 4. SDGs most frequently addressed by NBS projects (total of 740) within GeoIKP.

Some of the policies listed in Table 2 are clearly meant to implement their global counterparts at the EU level such as the EU Action Plan on the Sendai Framework [29]. Beyond this, through an analysis of the subject-matter of these policy instruments, clear linkages to global and international policies can be observed. In its broadest sense, these policies pertain to the environmental protection sector where the strongest links are shown between global, EU, national and local level policies that apply to NBS.

While some of these policies deal with the environment and environmental protection more generally such as the EU EIA Directive [30], the EU SEA Directive [31], the Green Infrastructure Policy [32] and the 7th Environment Action Programme (EAP) [33], others are more subject-matter specific. Some deal with biodiversity, such as the EU Habitats Directive [34] and the EU Biodiversity Strategy [35]. The EU Strategy on adaptation to climate change deals with climate change [36], while the EU Floods Directive [37] and EU Water Framework Directive [38] deal with water and floods specifically. These subject-matter areas are easily seen reflected at the global, national and local levels.

The EIA and SEA Directives are key instruments of the EU's environmental policy, and together with their implementing legislation and policies at national and local level, are important for any proposed NBS project as they can require certain prescribed information, reporting, and documentation. While NBS are not explicitly mentioned in the EIA Directive, it does mention the possibility to consider rational alternatives encouraging planners to use solutions that take into account both the development needs and the effects of the project on the environment [39]. These instruments have important implications for the timeframe of proposed NBS projects as they move through the assessment process or for the ultimate approval or rejection of such projects.

The EU EIA Directive lays out clear rules and procedures pertaining to the assessment of the environmental effects of certain public and private projects.[1] The screening and the EIA procedure have clear rules and require the production of specific project documentation by project proponents which have to be assessed by the competent authorities. The EU EIA Directive contains procedures on mandatory EIAs based on the type of project, or discretionary EIAs based on screening thresholds and criteria. The determination of whether a project should be made subject to an EIA through the discretionary screening must be made through a case-by-case examination, thresholds or criteria set by the Member State or a combination of these approaches. Member States have a certain degree of discretion in the implementation of this Directive. This leads to several procedural differences across the EU especially in the way that the screening process is carried out [5].

The EU SEA Directive is an analogous process that assesses the effects

[1] For more information on mandatory and discretionary EIA and on the minimum content of an EIA, see: OPERANDUM, D2.1, OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks: Synthesis report of authorization/permission requirements at national level (2019) at 21-24.

Table 2
[1]EU level policy and legal instruments* implicated in 88 EU OPERANDUM NBS projects.

EU Policy	Nb of projects (total=88)
7th Environment Action Programme (EAP) (Decision 1386/2013/EU)	75
A Blueprint to Safeguard Europe's Water Resources	60
Environmental Impact Assessment (EIA) Directive (2011/92/EU)	76
EU Action Plan on the Sendai Framework for Disaster Risk Reduction (SWD(2016)205)	70
EU Biodiversity Strategy (COM/2011/0244 final)	64
EU Birds Directive (2009/147/EC)	6
EU Decision on land use, land use change and forestry (529/2013/EU)	27
EU Floods Directive (2007/60/EC)	54
EU Habitats Directive (92/43/EEC)	64
EU Marine Strategy Framework Directive (2008/56/EC)	19
EU Regulation (1305/2013) on support for rural development	9
EU Strategy on adaptation to climate change (COM/2013/0216 final)	75
EU Thematic Strategy for Soil Protection (COM/2006/0231 final)	19
EU Water Framework Directive (2000/60/EC)	67
Green Infrastructure (GI) — Enhancing Europe's Natural Capital (COM/2013/0249)	46
Urban agenda for the EU (EC, 2016)	37
Strategic Environmental Assessment (SEA) Directive (2001/42/EU)	50
Common Agricultural Policy (CAP) (EC, 2013)	36

* More recent EU policies while highly relevant to NBS such as the Biodiversity Strategy for 2030, Strategy on Adaptation to Climate Change, and Forest Strategy – representing key pillars of the European Green Deal are not included as their time of release exceeds the NBS implementation and review period.

[1] All policy documents and/or legal instruments that were implicated in less than five NBS projects were removed from the table, this amounted to four policy documents and/or legal instruments. For more information and a full list of policies reviewed under the OPERANDUM project please visit "Policies for NBS, Policy & Legislation explorer", online: GeoIKP Platform for Nature -based Solutions <https://geoikp.operandum-project.eu/policy/catalogue>; note that the EU Biodiversity Strategy (COM/2011/0244 final) has been updated as the (COM/2020/380 final) *EU Biodiversity Strategy 2030: bringing back nature in our life*.

of certain plans and programmes, including NBS projects, which are likely to have significant effects on the environment (i.e. on land use, transport, energy, waste, agriculture). The Directive applies to public plans and programmes, i.e. which are subject to preparation and/or adoption by an authority and which are required by national legislative, regulatory or administrative provisions [5]. According to article 3 of the EU SEA Directive, an environmental assessment is applicable for all plans and programmes, prepared in the fields of agriculture, forestry, fisheries, energy, industry, transport, waste management, water management, telecommunications, tourism, town and country planning or land use. If the plan or programme is likely to have a significant effect, the assessment must be carried out during the preparation of the plan and in any case before its approval [5]. Plans and programmes which fulfil the above requirements but "determine the use of small areas at the local level or represent minor modifications to the […] plans and programmes" [40], are not automatically assessed; thus, Member States have to determine, through case-by-case examination or by specifying types of plans and programmes, or by combining both approaches, which plans and programmes have to be subject to an environmental assessment as they are likely to have significant environmental effects [5].

Additionally, any plan or project likely to have a significant effect on a Natura 2000 site should be subject to the requirements of the EU Habitats Directive, which ensures the conservation of a wide range of rare, threatened or endemic animal and plant species, complemented by the more specific EU Birds Directive [5]. The Water Framework Directive (WFD) primarily pertains to the quality of European waters which includes river basin management. The priorities are defined according to four objectives: ecological status, quantitative status, chemical status and protected area objectives. Ecological status and protected areas may be more specifically related to NBS which can have positive or negative impact on them [41].

At the EU level, as it pertains to NBS, a common permitting path is visible. This includes a 'Europeanized' environmental impact assessment, comprising the EU EIA/SEA Directives, the EU Habitats Directive, and the EU Water Framework Directive [5]. Nevertheless, there remains a certain degree of freedom in the hands of Member States which have the fundamental task of setting clear criteria for specific procedures that must be followed.

As opposed to the environmental protection sector which is characterized by a strong EU presence, legislations and regulations in the field of land use, landscape protection, urban planning, civil engineering, and building and cultural heritage sectors, are embedded in Member State specific historical paths and cultures and therefore are generally governed by national and regional laws [5]. A common framework as provided by the SEA/EIA/Habitats Directives for ecosystems, is not given in this context. [5]. The strong basis in national law found in these sectors translates into several differences between Member States regarding which institution is regulating as well as which authority is responsible for implementing the relevant legal acts [5].

3.3. National policy frameworks

The 88 NBS projects reviewed across the selected European (OAL) countries highlight clear subject-matter linkages between EU and national legislation and policies e.g. in the areas of climate change, biodiversity or with those instruments dealing with water resources and flooding. Table 3 presents for each country, examples of national policy and legal instruments that were strongly implicated across different case studies and have clear EU linkages or counterparts.

Although there are many differences between relevant national legislations in each country, a common path paved by the EU can be identified. To highlight key EU policies that were applied at case study scale and in what way, an analysis of the NBS permitting paths was performed across the 7 OAL projects. The NBS permitting path can engage both national and local level policies and legislation, which can have both general and specific obligations related to NBS implementation in a particular country. The key elements determining which laws and regulations are applicable include a) the national and regional context characterized by different types of governmental organizations, b) the scope, nature and size of the project, c) the location, with the inclusion of, for example, ecologically-sensitive areas, and d) the hazards addressed by the NBS intervention [5]. Table 4 summarizes the main policy and legal instruments considered critical for the implementation of NBS at each of the OALs. As highlighted, the EIA Directive and the Habitats Directive are the most frequently applied instruments across the OAL sites.

Out of the seven OALs, only OAL Ireland underwent an SEA (indicating that the NBS was evaluated under plans and programmes of a public authority while the other six interventions were categorized as projects), in addition to a preliminary EIA. As in the case of OALs Germany, Greece and Italy, OAL Ireland was able to undergo a simplified pre-procedure screening and avoid a full EIA procedure. In certain countries (notably Greece and Italy), the system for evaluating environmental impacts defines two types of projects: those that may cause significant adverse environmental impacts and require an EIA, and those projects with lower or non-adverse local environmental impacts which may allow for somewhat simplified environmental permitting processes rather than needing to perform a full EIA. In this case the competent authority is often the relevant local institution [5].

In countries where thresholds are used in the EIA screening

Table 3
*Examples taken from NBS case study review (total of 88) of most relevant NBS policy and legal instruments at national level with EU linkages.

Country	NBS-related national policy instruments with strong EU linkages
Austria	• EIA Act 2000 (UVP-G 2000): Federal Act on Environmental Impact Assessment; • Austrian Strategy for Adaptation to Climate Change; • Climate Change Adaptation Water Management - Pluvial Flood/ Surface Runoff • The Austrian Strategy for Sustainable Development; • Austrian Biodiversity Strategy 2020+ (BMLFUW, 2014); • Water Act 1959 (Wasserrechtsgesetz);
Finland	• Act on Environmental Impact Assessment Procedure 252/2017 - Transposing the EIA Directive • Act on the Assessment of the Effects of Certain Plans and Programmes on the Environment 200/2005 - Transposing the SEA Directive • National Strategy for Adaptation to Climate Change (2005); • National Climate Change Adaptation Plan 2022; • Nature Conservation Act (1096/1996, latest amended in 2016) • National Biodiversity Strategy; • Act on the Organization of River Basin Management and the Marine Strategy (No. 1299 of 2004) - National Implementation of the WFD 2000/60/EC • Government Decree on Water Resources Management (No. 1040 of 2006) • Decree on River Basin Districts (1303/2004) • Finnish Water Act (No. 587 of 2011);
Germany	• German Environmental Impact Assessment Act • Federal Climate Protection Act Germany (2019) • German Strategy for Adaptation to Climate Change • Federal Nature Protection Act Germany: Bundesnaturschutzgesetz • National Biodiversity Strategy and Action Plan Germany • Federal Republic of Germany: Gesetz über die Umweltverträglichkeitsprüfung • Federal Water Management Act: Gesetz zur Ordnung des Wasserhaushalts • Groundwater Protection Ordinance Germany 2016 (GrwV)
Greece	• Law 4014/2011 - Implementation of the EIA Directive in Greece • Greece National Adaptation Strategy (2016); • National Strategy for Biodiversity (2014), Ministerial Decision 40,332/2014. • Basic Act No. 3937 on the Conservation of Biodiversity • Law 1650/1986 on the protection of the environment. • Law 3199/2003 (2003) - Water protection and management (Implementing the WFD 2000/60/EC)
Ireland	• Regulation S.I. No. 538/2001; S.I. No. 473/2011 - European Union (EIA & Habitats) Regs 2011; S.I. No. 246/2012 - Transposing the EIA Directive • Regulations 2004 (SI No. 435 of 2004)) as amended by SI 200 of 2011; the Planning and Development (SEA) Regulations2004 (SI 436 of 2004), as amended by SI 201 of 2011 - Transposing the SEA Directive • National Climate Change Adaptation Framework (2012) • National Adaptation Framework (2018) • Biodiversity Action Plan for 2017–2024 • Environmental Protection Agency Act, 1992 • European Communities (Natural Habitats) Regulations (SI No. 94 of 1997) under Regulation 31 (Annex 1.2) - Implementing the Habitats Directive
Italy	• D.lgs. 104/2017 modifying and integrating D.Lgs 152/2006 - Implementing the EIA Directive • D.lgs.152/2006 (Codice dell'Ambiente) – D.lgs. 128/2010 - Implementing the SEA Directive (2001/42/EC) • Regolamento D.P.R. 1997 n. 357 modified and integrated by D.P.R. 120 del 2003 - Implementing the Habitat Directive (92/43/CEE) • Strategia Nazionale per la Biodiversità • Italian National Adaptation Strategy to Climate Change (NAS) - 06/2015 • Decree (DM 39/2015) - RBMPs : Transposing the Water Framework Directive • Legislative decree 49/2010 - Transposing Directive 2007/60/EC (Floods Dir.)
Scotland (UK)**	• The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017; • UK Climate Change Act 2008; • Climate Change (Scotland) Act 2009; • Scottish Climate Change Adaptation Programme; • Biodiversity Scotland - Restoring Ecosystems; • The Conservation of Habitats and Species Regulations 2010; • Flood Prevention (Scotland) Act 1961; • Natural Flood Management Handbook (SEPA, 2015) – Scotland;

* The policies reflected in this table were identified as part of the OPERANDUM project and this table reflects this project material. Some of these policies may have since been updated. The authors have not independently verified the project material on which this table is based. For a more complete list of national/local policies reviewed under the OPERANDUM project please visit "Policies for NBS, Policy & Legislation explorer", online: GeoIKP Platform for Nature -based Solutions ⟨https://geoikp.operandum-project.eu/policy/catalogue⟩".

** With the UK's exit from the EU, EU law would no longer be directly applicable to projects within the UK except insofar as they have been implemented by UK legislation. As part of the UK's withdrawal many laws originating from the EU were enacted into UK legislation. As such, clear linkages can still be observed between global, European and national legislation and policies.

procedure it is important not only to understand these thresholds but also to consider them in the planning phase of NBS. While many Member States have set thresholds for the same project types, the levels at which they have been set can vary significantly between countries [5]. Specific simplified procedures were also applied in the OAL in the UK (contested land which is commonly 'owned'); in Finland (sustainable forest management which is usually exempted from an EIA, with the majority of the forest areas privately owned) and in Austria (private land requiring the consent of landowners so long as the initial conditions of the site can be restored). It is worth noting that the simplified procedures were partly enabled due to the relatively limited scale of the projects. However, the findings suggest a certain flexibility in applying the EIA Directive which indicates a willingness by the respective authorities to consider approaches that can expedite the permitting procedure. The largely naturalistic approach of NBS seems to typically enable a higher degree of flexibility in applying the legislation.

Six out of seven OALs include Natura 2000 sites and three of them mentioned the need to conduct an Appropriate Assessment under the Habitats Directive (art. 6). As illustrated by the Italian NBS project, specific circumstances may grant the possibility of undergoing a simplified Appropriate Assessment (pre-VINCA) under Italian legislation which, similar to the pre-EIA screening, can expedite the permitting procedure. As in the case of the EIA, NBS were evaluated by the appointed authority as an added value. While most of the OALs include water areas, the Water Framework Directive was specifically mentioned only by the German and Austrian OALs [5]. Since floods are one of the main hazards addressed by NBS across reviewed projects, the water-related legislation is frequently related to floods.

4. Discussion

The NBS case study review highlighted the way in which NBS are governed by global, EU, national regulations across the selected European countries (Austria, Finland, Germany, Italy, Greece, Ireland, UK). The EU Directives, which are the most common form of EU legal acts relevant to NBS implementation, require Member States to achieve certain results based on their country-specific laws and regulations. The implementation of these directives, in particular within the environmental sector, into national systems differs according to the political organization of each country with some systems (i.e. federal states) delegating more power to the regions or local governments (Austria, Germany), other countries centralizing environmental issues at central governments (Greece, Finland) and again some countries integrating a combination of the two systems (Italy, Ireland and UK). Managing the

Table 4
Comparison of legislations relevant to NBS implementation across 7 OALs. n.m.= not mentioned [5].

OALs	Austria	Finland	Germany	Greece	Ireland	Italy	UK
Hazard	Landslide	Floods	Floods, droughts	Floods, droughts	Floods	Coastal erosion, floods	Landslides, coastal erosion
Description	5.5 km^2; 5% agri / pastures; buildings	About 1017 km^2; 92% forestry, 7% agri, 1% built environment	568 km^2; 34% agri, 22% forest; water & residential	1660.9 km^2; River; 32% agri, 66% nature,2% residential	Mudflats next to Dublin in port and dodder river basin	Delta of Po river; Adriatic coast; micro impacts;	Small-scale ca. 0.4 km^2; agri; residential
Pre-EIA	-	n.m.	✓	✓	✓	✓	-
EIA screen.	✓	✓	✓	-	-	?	-
Full EIA	-	-	?	-	-	-	-
SEA	-	-	-	-	✓	-	-
Natura 2000 included	-	✓	✓	✓	✓	✓	✓
Appropriate assessment	✓	-	n.m.	✓	✓	?	-
Birds directive	-	n.m.	✓	n.m.	✓	n.m.	-
Water Directive	✓	n.m.	✓	n.m.	n.m.	n.m.	-
Floods leg.	-	n.m.	✓	✓	n.m.	n.m.	-
Forest legislation	✓	n.m.	n.m.	✓	n.m.	n.m.	-

environment at regional or local level may facilitate addressing local specific issues, however, differences between Member States' political organization can cause incongruences in terms of efficiency. The common trend seems to be marked by a push for decentralization with a delegation of powers to the regions. Moreover, in many of the countries reviewed, certain aspects of the environmental issues, in particular pertaining to permits, are managed by governmental agencies dealing with the environment or even more specific agencies [5].

For the reviewed NBS across different European countries there is a common identifiable path in terms of permitting procedures which closely follows the direction set by the EU in several directives. Most of the assessed NBS cases engaged the European EIA and SEA Directives which are crucial in the project design and permitting stage. The fact that the EIA Directive grants Member States a certain degree of discretion in its implementation leads to several procedural differences across the EU especially in the way that the screening process is carried out.

Further progress should be made in the harmonisation of the EIA/SEA procedures across EU countries in order to facilitate transnational projects and to ensure that results are coherent across the continent [5]. Moreover, as it is challenging to guarantee permitting paths and outcomes where they are dependent on subjective assessment and interpretation by individuals or agencies, it is important to integrate the concept of NBS more expressly into legislation and policy such as the EU EIA Directive and the EU SEA Directive as well as at the national level.

The fact that the NBS concept includes topics beyond the environment which are more closely related to urban and landscape planning and building adds further complexity. These sectors show marked differences across Member States regarding which institution is regulating as well as which authority is responsible for implementing the relevant legal acts.

It is worth noting, that in some countries such as Austria, the environmental assessment and the construction permitting path are included in the EIA procedure. The outcome of the EIA thus constitutes a single permit decision covering all relevant permitting issues for a specific project, including the construction permit, which avoids several different sectoral proceedings in order to obtain an overall permit and can significantly shorten the duration of the process. This so-called one-stop-shop assessment integrating permits for all development projects is not widely applied across European countries but could arguably facilitate the work of developers, at least in regard to NBS [5].

The OAL case studies demonstrate that informal practices may emerge around NBS projects based on a certain degree of flexibility shown by national and local authorities in permitting these projects. As an example Finland's OAL did not require an EIA procedure as all the conceivable NBS measures "follow recommendations of sustainable forest management". Indeed, NBS are characterized by the sustainability of measures and their symbiotic interaction with the surrounding ecosystems [5]. These aspects can constitute an added value of NBS which can increase support by public authorities and facilitate their permitting procedures [5]. It follows that NBS can be decisive in determining a simplified permitting path with considerable advantages in terms of timing and resources [5]. However, providing for legislative and policy guidance on dealing with NBS, and possible simplified permitting and assessment procedures could provide greater assurances of future outcomes.

The OAL cases also highlight the strong role of local authorities, as well as stakeholders, in the successful implementation of a project. These stakeholders and authorities can play a major role in providing permissions, policy support, project acceptance and engaging the broader local community in projects [42]. It is therefore strongly recommended that proponents identify potential stakeholders and relevant authorities early on. This can help proponents identify potential partners, manage expectations, and build relationships early on, which may prove important to the successful implementation of projects. Similarly, it is considered advantageous for project proponents to identify and review the relevant legislation and policies that will govern the permitting path as well as the local implementation and the legal status of a proposed NBS site early in the inception phase of an NBS project to accurately anticipate timelines and costs. Clear definitions and benchmarks can enable effective transfer of NBS approaches from pilot or project scales to significantly larger scales while elevating NBS to becoming integral in planning and implementing society's responses to environmental, social and economic challenges. To this end, there is a need for robust knowledge and tools to guide the implementation of NBS, as well as more explicit guidance and integration of NBS within international, EU, and national level policies and legislation [42].

5. Conclusions

Fostering the integration and mainstreaming of NBS in Europe requires a clear overview of how NBS can contribute to achieving policy objectives across different policy areas, and a better integration of NBS provisions into legislation and policy at EU and national level. This paper presents an extensive online policy catalogue for the implementation of NBS to manage hydro-meteorological hazards. Relevant policies from global and EU to national level were collected and linked to NBS cases across the globe. The NBS projects (total of 740) were also assessed in terms of their contribution to major societal challenges

linked to CCA and DRR under the paradigm of sustainable development (and SDGs), highlighting the fact that NBS can play a key role in increasing climate resilience while providing wider benefits to society. Policies relevant to the implementation of NBS projects within the GeoIKP were reviewed at global level, as well as at EU and national level across the 7 OAL countries (total of 88 cases). To strengthen the national policy analysis, the permitting paths of 7 NBS projects deployed at OALs across Europe were considered which further highlighted the policy linkages between the national and EU level.

The European Union has become a major source for environmental law and policy throughout Europe and environmental policy is one of the most regulated policies within the EU with national policies becoming increasingly linked to the evolution of EU decision-making [5]. For the reviewed NBS cases across different EU countries there is a common identifiable path which follows relatively closely the direction set by the European Union with the EIA/SEA Directives, the Habitats directive and the Water Directive. However, differences emerge when it comes to how these EU directives are implemented at Member State level. These differences in implementation can constitute a limitation not only for the protection of the environment but also for the functioning of for example transnational NBS projects and hazard management. To help facilitate the implementation of NBS, further effort is required towards harmonizing national policies through clear rules, provisions and criteria.

Other sectors relevant to NBS implementation that go beyond environmental protection such as land management, landscape planning and building regulations are less directed by a common EU framework. These sectors are commonly rooted in Member States' traditions and histories with the origin of some of the laws and regulations dating back centuries. The strong basis in national and regional law within these sectors translates into several differences between Member States regarding which institution is regulating as well as which authority is responsible for implementing the relevant legal acts [5]. This article attempts to identify relevant legislation related to NBS from global to national level and to highlight the linkages across government levels. Clear linkages could be observed between global, European and national legislation and policies, particularly in policy areas such as environmental assessment, biodiversity, water and climate adaptation and mitigation.

Key factors influencing the NBS permitting path include country, region, scope, nature and size of the project, location and hazards addressed. NBS can be considered an added value for development projects introducing alternative and innovative practices that offer sustainable solutions to cope with climate change mitigation and adaptation challenges. NBS-related practices thus have the potential to be positively evaluated by authorities and to be decisive in determining a simplified permitting path with considerable advantages in terms of timing and resources. Local authorities across all OALs expressed favourable standpoints towards the NBS approaches and in some cases, simplified regulatory procedures could be applied.

The reviewed OAL case studies highlighted the fact that mainstreaming NBS into strategies and planning requires the support of decision-makers across sectors and the collaboration of local stakeholders to ensure policy support, project acceptance and the engagement of the broader local community [24]. Moreover, NBS adoption at the sub-national level can be supported through enabling conditions and regulatory frameworks put in place by national governments and through a better alignment between relevant EU and national policies [41]. The findings of this paper highlight gaps and opportunities within the current NBS policy landscape focusing on mutually reinforcing policies at global, EU and national levels based on an analysis of NBS case studies and associated policies and permitting paths. The NBS policy catalogue provides a valuable resource for further analysis of the NBS policy context and coherence across government levels towards increased uptake and improved operationalization of NBS in Europe and beyond.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

Acknowledgments

This work is carried out under the framework of OPERANDUM (OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks) project, which is funded by the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No: 776848. The authors also wish to thank UNESCOs Disaster Risk Reduction team, including Léa Bécue and Eirini Glynou Lefaki, for research support, as well as all OPERANDUM OAL partners for consultations and insights on the local and national policy context of the implemented NBS projects, and regional consultants, Victor Rana Shinde and Yazidhi Bamutaze, for review of the GeoIKP's NBS case studies.

Funding sources

This work was supported by the European Union's (EU) Horizon 2020 research and innovation program. It was funded by and carried out within the framework of the OPERANDUM (OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks) project (Grant No. 776848).

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.nbsj.2023.100097.

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