# OPERANDUM

## OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks

## Mapping, characterization and critical evaluation of existing NBS

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| Short Description |
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| This deliverable covered the benefits of NBS in tackling hydrometeorological extremes - flooding, drought, landslides, etc. and barriers that hindering the wider uptake of NBS and presents approaches to help overcome existing social and political barriers. The outcome of this deliverable, will serve as a strong foundation for project activities relating to the design and implementation of NBS such as WP2 and WP3, their evaluation in WP4 and WP5 and evidence to the users in WP7, and WP8 as well as establishing the basis for their market uptake and exploitation activities in WP9. This deliverable is divided into 12 sections. This report contains 215 pages, 15 figures, 32 tables and two annexes. |

| Dissemination level | | |
|---|---|---|
| PU | Public | x |
| CO | Confidential, only for Members of the Consortium, including the EU Commission Services | |

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# List of Acronyms and Abbreviations

| Abbreviation | Description |
|---|---|
| BISE | Biodiversity Information System for Europe |
| BR | Biosphere Reserve |
| CBD | Convention on Biological Diversity |
| CC | Climate Change |
| CCA | Climate Change Adaptation |
| CIRA | Centro Italiano Ricerche Aerospaziali |
| CMEMS | Copernicus Marine Environment Monitoring Service |
| COP | Conference of Parties |
| CORDIS | Community Research and Development Information Service |
| CSE | Catchment Systems Engineering |
| CSO | Civil-Society Organizations |
| DRC | Democratic Republic of the Congo |
| DR-NBS | Data Requirement for NBS |
| DRR | Disaster Risk Reduction |
| EA | Environment Agency |
| EBA | Ecosystem based adaptation |
| EBM | Ecosystem based mitigation |
| EC | European Commission |
| ECOBAS | Eco-engineered coastal defence integrated with sustainable aquatic food production |
| EE | Ecological Engineering |
| EEA | European Economic Area |
| EIA | Environmental Impact Assessment |
| EIP | European Innovation Partnerships |
| EMA | Ecosystem based Management Approaches |
| EPA | Ecosystem Protection Approaches |
| EPO | European Patent Office |
| ERA | Ecosystem Restoration Approaches |
| ES | Ecosystem Services |
| ESS | Ecosystem Services |
| EU | European Union |
| FEBA | Friends of Ecosystem-based Adaptation |
| GA | Grant Agreement |
| GCCA+ | Global Climate Change Alliance Plus |
| GEBCO | General Bathymetric Chart of the Oceans |
| GeoIKP | Geo-Information Knowledge Platform |
| GFDRR | Global Facility for Disaster Reduction and Recovery |
| GHG | Greenhouse Gas |
| GI | Green Infrastructure |
| GIS | Geographic Information System |
| GSHHS | Global Self-consistent, Hierarchical, High-resolution Geography Database |
| HMH | Hydro-Meteorological Hazard |
| HMR | Hydro-Meteorological Risk |
| HZG | Helmholtz-Zentrum Geesthacht Zentrum fur Material und Kustenforschung GmbH |
| ICZM | Integrated Coastal Zone Management |
| IDS | Input Data Set |
| IEA | Issue-specific Ecosystem-related Approaches |

| | |
|---|---|
| IFI | International Financial Institutions |
| IGO | International Governmental Organisation |
| IISD | International Institute for Sustainable Development |
| INSPIRE | INfrastructure for SPatial Information |
| IPBES | Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services |
| IPCC | Intergovernmental Panel on Climate Change |
| IRA | Infrastructure Related Approaches |
| ISO | International Organization for Standardization |
| IUAV | Università Iuav di Venezia |
| IUCN | International Union for Conservation of Nature |
| IWRM | Integrated Water Resource Management |
| LCC | Lancaster City Council |
| MAE | Ministry of the Environment of Ecuador |
| MStAG | Medmerry Stakeholder Advisory Group |
| NAT | Naturalea Conservacio SL |
| NBS | Nature-Based Solution |
| NC | Natural Capital |
| NGO | Non-Governmental Organisation |
| NI | Natural Infrastructure |
| NOAA | National Oceanic and Atmospheric Administration |
| NTS | Natural Treatment System |
| NWRM | Natural Water Retention Measures |
| OAL | Open-Air Laboratory |
| OGC | Open Geospatial Consortium |
| OPERANDUM | OPEn-air laboRAtories for Nature baseD solUtions to Manage environmental risks |
| OPPLA | Open Platform |
| PA | Paris Agreement |
| PEDDR | Partnership for Environment and Disaster Risk Reduction |
| PET | Physiological Equivalent Temperature |
| PM USA | Philip Morris United States of America |
| R | Results |
| QE | Quality Elements |
| RSO | Regional Support Offices |
| RSPB | Royal Society for the Protection of Birds |
| SDG | Sustainable Development Goals |
| SEI | Stockholm Environment Institute |
| SES | Social-Ecological Systems |
| SFDRR | Sendai Framework for Disaster Risk Reduction |
| SFP | Sendai Framework Priorities |
| SLR | Systematic Literature Review |
| SME | Small and Medium-sized Enterprises |
| SO | Specific Objectives |
| SST | Sea surface temperature |
| SUDS | Sustainable Urban Drainage Systems |
| SWB | Soil and Water Bioengineering |
| UK | United Kingdom |
| UN | United Nations |
| UNCCD | United Nations Convention to Combat Desertification |
| UNDP | United Nations Development Programme |
| UNECE | United Nations Economic Commission for Europe |
| UNEP | United Nations Environment Programme |

| | |
|---|---|
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNIBO | University of Bologna |
| UNIDR | United Nations Institute for Disarmament Research |
| UNISDR | United Nations International Strategy for Disaster Reduction |
| UN-SPIDER | United Nation SPace-based Information for Disaster-management and Emergency Response |
| UoG | University of Glasgow |
| UoS | University of Surrey |
| UPM | Universidad Politécnica de Madrid |
| WMO | World Meteorological Organisation |
| WP | Work Package |
| WWF | World Wide Fund for Nature |

## IPR: Intellectual Property Rights

# Executive summary

The ambition of OPERANDUM is to provide science-based evidence for the usability of nature-based solutions (NBS) ranging from local to landscape scales, and to foster the market opportunities, upscaling and replication of NBS in Europe and other non-European territories. It is important to develop a set of co-designed, co-developed, deployed, and demonstrated innovative NBS (e.g., green, blue and hybrid approaches) to manage hydro-meteorological risks in European rural and natural territories. Such solutions can be promoted by better translating available scientific expertise and political support into practice. Therefore, the aim of this deliverable (D1.1) is to map, characterise and foster existing NBS globally and on the market through a systematic literature review (SLR). The outcome of *D1.1* is dedicated to including multiple aims tailored to satisfy the key background needs of co-design, co-development and implementation of NBS (in WP2 and WP3) across various OALs while a collection of existing NBS enriched by a classification matrix developed in this report allows querying the geo-catalogue designed in WP7. This deliverable brings together grey and peer-reviewed literature from science, policy and practice to provide an overview of the current state of awareness on the effectiveness and application of NBS and their potential for hydro-meteorological risk mitigation and adaptation and co-benefits in landscape areas.

As for the *best practices of NBS in Europe and worldwide,* the review of the existing literature, case studies, websites and platforms that compiles lessons learned in terms of implementation of NBS and understandings of which approaches were needed to increase the acceptance of NBS in Europe and worldwide are presented. The results of this review are useful for the OPERANDUM project in the context of establishing and monitoring the NBS implemented across 7 OALs. One of the challenges in the wider uptake and acceptance of NBS is a lack of principles, standards, and guidelines. However, recently many studies and projects begun addressing this gap, for instance, the seven set of principles endorsed by the IUCN, the five qualification criteria for Ecosystem-based Adaptation (EbA) published by Friends of EbA (FEBA), the seven voluntary guidelines published by the Convention for Biological Diversity (CBD) and comprehensive guidance for the implementation of NBS proposed by the World Bank against flood risk are some of recently emerged principles. All these principles are closely interrelated and partially overlap, but they are relevant to accelerate the wider uptake and acceptance of NBS globally. The above-stated principles are ways to promote and increase the acceptance of NBS in practice, however the policymakers tend to support the implementation of traditional engineering solutions for hydro-meteorological risk adaptation and mitigation instead of investing in NBS due to lack of solid evidence base showcasing benefits of NBS. An extensive review of five major NBS platforms, have identified a large number of NBS case studies and projects implemented around the world. Most of the NBS found in those platforms are designed for reducing risks resulting from flooding and erosion in the river and coastal areas, improving forest and wetland ecosystem, and reducing impacts of climate extremes in landscape areas. Lack of practical knowledge was identified as the main barriers in NBS case studies since the project ideas were new to the implementing agencies who did not have prior practical knowledge of implementing and maintaining NBS projects. It was often emphasised that specialists or experts from different fields should be involved to avoid future project failures.

As for the *categorisation of the hydro-meteo risks in OPERANDUM*, risk assessments related to NBS as planned in OPERANDUM need to address the three dimensions: hazard, exposure, vulnerability. Within the project, the definition of risk and the related terms will be adapted to fulfil the

OPERANDUM objectives. The preliminary definitions, presented here, comprise climate change. The implementation of a risk assessment consists of several steps and contains the assessment of the occurrence of hydro-meteorological events. To consider climate change information in risk assessments calls for local climate change information with a robustness assessment. Here we propose a methodology for assessment of the robustness of projected climate changes based on statistical methods and expert judgment. This expert judgment on robustness comprises six categories.

As for the *critical evaluation of existing policies and guidelines* on NBS, many (non-) European documents were reviewed and analysed. For instance, the seven policies and agreements those have been recognised at the global and international level on the issue of linking NBS and Disaster Risk Reduction (DRR) were critically reviewed and analysed. All these agreements are very important for the newly launched OPERANDUM project, particularly for two specific objectives; namely, SO3 and SO5. For example, of the four priorities of Sendai Framework for disaster risk reduction, three of them are addressed in the OPERANDUM project (i.e., fostering the wider uptake of NBS, linking the NBS with policy-makers and land regulations). The Paris Agreement for Climate Change is also closely related with the aim of OPERANDUM project for the role of ecosystems in climate change mitigation and adaptation. Still, there are the gaps such as the lack of systematic mainstreaming of NBS and fragmented climate policy mainstreaming, which OPERANDUM project aiming to address.

The lack of *early overview of market opportunities of NBS* such as explicit assessment of specific comparisons of the effectiveness and benefits against hard structures hindering their acceptance and widespread uptake of NBS. The reviewed studies show that the systematic uptake of NBS in practical situation is still at its beginning, and how to integrate them with existing systems has not been properly addressed. We also pointed out as lack of researches and uncertainty about long-term maintenance, performance and cost-effectiveness both independently and as compared to purely grey approach solutions hinders its wider uptake. In line with the above gaps the following main gaps were are outlined: (1) NBS is not included in the early planning stage of the project as the main solution; (2) lack of experience in implementing NBS and (3) lack of strong evidence on NBS. Therefore, as the main solutions most of the studies proposed to develop manuals, guidelines and quality criteria using past experience and knowledge from published and unpublished literature, increasing awareness via workshops etc. for practitioners in collaboration with science. The other important points need to consider by designers and users of NBS is that Bioengineering strategies also have limitations in terms of their effectiveness against some risks, because of the characteristics and properties of vegetation. Therefore, in this case hybrid approach, which make use of engineering and ecosystem functions together is more effective solution.

As for the *mapping of stakeholders***,** OPERANDUM aims to set-up OALs backed by multi-stakeholder communities. In fact, to increase the awareness and usage of NBS in response to hydro-meteorological risks, the definition of new networks and the development of trans-disciplinary and inclusive partnership amongst different policy areas and sectors are necessary. Furthermore, the involvement of citizens and organizations throughout the life cycle of NBS projects (before and beyond the project implementation phases – planning, execution, monitoring and evaluation) is fundamental to create trust, ownership and stewardship. Due to the cross-cutting nature of NBS projects, the identification of the complex structure of stakeholders requires specific efforts. In OPERANDUM, the main groups/categories of stakeholders, relevant for the implementation of NBS,

have been identified and represented in the OPERANDUM value chain. The mapping of stakeholders at the local, national and global level has been undertaken to foster the adoption of user-centric methods for co-creating and co-designing and the deployment and testing in real-life settings of NBS.

To make NBS competitive and more acceptable in DRR, one need to develop indicators to measure the (cost-) effectiveness of NBS against hydro-meteorological risk. These indicators can be social, economic and environmental performance indicators. In OPERANDUM these indicators are properly defined to comply with quality criteria that are verified and monitored at several stages of the project for each OALs. However, to develop such performance indicators many gaps such as knowledge and data gaps with respect to long-term benefits make it difficult. These gaps can be filled and enhanced the measurability of NBS effects against hydro-meteorological risks by the approaches and protocols developed in section 7. Based on the literature review we have clustered the performance indicators into five groups: (1) Integrated environmental performance indicators (i.e., regulating heatwaves, air pollution, flooding); (2) human health and well-being related indicators (i.e., related to co-benefits such as physical and mental health, cultural services); (3) citizen involvement related indicators (i.e., the number of citizens engaged in greenery); (4) Indicators related to the transfer of model projects into general practice and monitoring of projects (i.e., measured by the number of stakeholders); and (5) engineering and finance related indicators (i.e., such as aspects related to the job market, the cost-effectiveness of the NBS and the impact on natural resources).

As for the matrix development to fill data gaps in this report, we have also outlined the methodology for assessing data gaps for OPERANDUM NBS or components of NBS. A "Data Adequacy Report" will document input data gaps to the implemented solutions that will show the way for improvements during and after the end of the project. The OPERANDUM Platform will be the ideal means for storing such information and make it accessible to the international community.

As for the hydrometeorological hazards geo-catalogue development, the reviewed case studies and platforms revealed that a wealth of information on NBS is already available; however, still a need for further collection of case studies and their dissemination through databases, reports and publications. To address this gap the second specific objective (SO2) of OPERANDUM project is well formulated and executing in WP7. The OPERANDUM GeoIKP – which is under development (2018 - 2022) in WP7 is collecting case studies, datasets both hydro-meteorological hazards and NBS and implementing as well as sharing them, for more theoretical details, refer to deliverable 7.1. GeoIKP also provides an inventory of hydro-meteorological extreme datasets for both historical and model simulated (including EURO-CORDEX, ERA5, satellite and many others) under current and future climate scenarios. In this geo-catalogue, one can also explore hydro-meteorological hazards such as flooding, droughts, landslides and others along with their potential NBS, the policies and regulations, summary statistics, etc. GeoIKP also stores various reference data sets from many regional and global databases, i.e., INSPIRE, EM-DAT, Copernicus, Climate-ADAPT, etc.

# 1 Introduction

## 1.1 Background

The conception of Nature-based solutions (NBS, see section 1.2 for definition) was introduced towards the end of the 2000s by the World Bank (MacKinnon et al., 2008) and the International Union for Conservation of Nature (IUCN, 2009) to focus on the importance of variety conservation for climate change mitigation and adaptation. NBS were proposed by IUCN within the goals of the climate change agendas in Paris "as some way to mitigate and adapt to climate change, secure water, food and energy supplies, decrease poverty and drive economic process (IUCN, 2014)". IUCN prompt 8 strategies (see section 3) including the crucial of this concepts, together with cost-efficiency, harnessing each public and private funding, simple dissemination and upscaling of the approaches (van Ham, 2014). Particularly, these guidelines pointed out the importance of NBS to handle international challenges. Specific weight is employed on merging policy effect with activities in the implementation of NBS (IUCN). The European Commission refined the conception of "NBS for its research programme Horizon 2020 (EC, 2015)" with a definite targeting on urban areas while upscaling and replicating to landscape areas is the main focus of the OPERANDUM project. To sum up, Maes and Jacobs (2015) stated NBS "as any transition to using of ecosystem services with decreased input of non-renewable natural capital and redoubled investment in renewable natural processes".

The notion of NBS is mainly entrenched in the broader discussions on climate-related adaptation and mitigations, ecosystem approaches and green and blue infrastructures (Kabisch et al. 2016). The risk from hydro-meteorological hazards is further exacerbated by climate change. While NBS provides multiple hazard regulating functions, for example, managing problems such as global warming, water availability, food security, or risks driven by the other natural hazards. NBS approaches are often cost-effective, have multiple benefits and can become progressively valuable in the face of more intensive and/or severe extreme events such as flooding, coastal erosion and storm surge, increase nutrients and sediment loading, drought, heatwaves and landslides. Usage or restoration of floodplains and upland areas to decrease flood risk in downstream areas, green and blue approaches in landscape areas to reduce run-off during high-intensity precipitation events and forest management aiming to reduce heatwaves or landslides are just a few of the many examples. Furthermore, mixed (hybrid-green) green with grey approaches, such as roofs and walls with vegetation and wall installations for extreme temperature management (Castleton et al., 2010), can be another example of potential NBS used against hydro-meteorological risks. The pros of these combined system (hybrid) is that they can be introduced as a supporting/addition to the already existing approaches and that they make it possible to use places that typically are not green (Enzi et al., 2017). Particularly, by harmonizing and upscaling NBS such as green and blue approaches, hybrid-green (green with a grey component) and hybrid-blue (blue with a grey component), in landscape areas, multiple benefits associated to climate change mitigation and adaptation are more recognised as powerful determinants of human health and well-being (Barton and Grant 2006; Hartig et al. 2014). Leuzinger et al. (2010) mentioned that green infrastructure in cities and landscape areas such as parks, trees/forests and, etc. can have an effect on extreme temperatures/heatwaves, surface runoff, land degradation/erosion, decreasing downstream flooding, droughts, mass movements (landslides) by increasing infiltration, delaying flood peaks and probability of occurrence; and many others.

Therefore, NBS can be utilised as complementary and/or alternative approach than engineering structure regularly do not manage the origin of risk and even can escalation the susceptibility of inhabitants/humans over the long-term (failure can generate social and ecological catastrophic impacts downstream). At the worldwide scale, climate change is even expected to accentuate hydro-meteorological hazards such as extreme temperature, torrential rains, flooding, droughts, sea level rise and other hydro-meteorological extremes in terms of frequency, intensity and magnitude (IPCC, 2018). For instance, Rosenzweig et al. (2011) projected that over the coming century urban and non-urban regions will have to manage the intensified hydro-meteorological extremes as a result of climate change. In addition, progress and execution approaches that are flexible, adaptive and can take into account change are essential in domain of nonstationary and uncertainty (Milly et al., 2008). In these circumstances, engineering structures such as dykes, embankments, dams, levees, storm barriers, and seawalls amongst others tend to have challenging risks, and are usually not cost-benefits, nor align simply into long-term sustainability goals. At the same time, the execution of purely green approaches at the small-scale level for hydro-meteorological risks management, might not be adequate to fulfil the scale of predicted future hydro-meteorological hazards (Kabisch et al., 2016).

Nowadays, many studies are supporting the applications of NBS to overcome the above limitations associated with purely grey approaches. For example, as the best solution, Kabisch et al. (2016) proposed that one ought trust on a combination of grey, green and blue infrastructure solutions (hybrid approach) which balance traditionally built infrastructures with more NBS, particularly to increase the management of river flooding, heat stress and other hydro-meteorological hazards related risks. Instead of turning to hard engineering structures as the default solution, local and national designers should systematically evaluate and examine options for restoring and expanding ecosystems to provide hybrid, more flexible and sustainable approaches to hydro-meteorological risks management across all landscapes.

However, the effectiveness/performance of each NBS are dependent on the location, architecture, typology, environmental conditions and the vegetation features such as leaf area index and canopy form, where thin crowns with big leaves have the great potentials of reducing extreme temperatures. Different types of vegetation systems combined with hard engineering structures such as green roofs and green walls can also alter the energy balance of landscapes. For example, Cameron et al. (2014) confirmed that green walls have the potential in reducing wall temperatures. Indeed, the effectiveness of these green measures depends on the type of species with different species having diverse temperature reduction capacity and diverse types of cooling, i.e., evaporative or shade cooling (Cameron et al. 2014), plus control variables such as irrigation and water resources in the substrate (Song and Wang 2015; Hunter et al. 2014). Furthermore, wetlands and alluvial plain habitats such as forests are usually extremely important recreational areas (Kabisch et al., 2016) providing many benefits for urban residents, for instance, clean air and moisture as well as many cultural and place-based values. They are very effective spaces for flood and substance regulation, air pollution and storm water collection. Especially for thick spaces in landscape, they characterise almost perfect NBS for hydro-meteorological management. They can also be used as a defence against extreme temperature/heatwaves and offer moisture in the course of heatwaves.

Many past studies have analysed that vegetation combined with roofs have not only great potential in reducing rainwater floods but also delays the flood waves (Bengtsson 2005; Stovin et al. 2013;

Stovin 2010). However, Bengtsson (2005) noted that due to limited storage capacity, a thin green roof have decreased effectiveness for persistent or heavy rainfall. Some alternative approaches to cope with floods due to rainwater if space is available are bioswales, biofilters or rainbeds or other types of planted retention beds. Unlike roofs, ground-based systems could be constructed with thicker substrates which simplifies the use of large perennial shrubs and small trees. Practically, these approaches also have an efficiency for infiltration and evapotranspiration (Daly et al. 2012; Muthanna et al., 2008).

Therefore, to achieve an effective solution it is important to emphasise on the selection of the right NBS in reducing any hydro-meteorological hazards. For instance, the present choice of vegetation material and planting plan has to be modified to cope with the changes in future climate. In this line, Vico et al. (2014) presented a reasonable planting plan, e.g., with tree distances of 7.5m in together with penetrable concrete or uncovered soil spreading to the canopy extension can attain good reduction in extreme temperature and low water stress. Speak et al. (2013) also showed that plants combined with roofs can decrease the heatwaves about 1°C; even the effectiveness was increased at night by 50% concur with the time when extreme temperature becomes the strongest. As suggested by the Lundholm et al. (2010) the vegetation types and species or useful variety can influence the degree of evapotranspiration, infiltration and reduction of river flooding.

Overall, NBS such as green roofs, rain gardens, salt-marshes, bioswales and many others have been shown to have potential in reducing hydro-meteorological hazards such as flooding, heatwaves, droughts, landslides, storm surge and coastal erosion, economic damage and distress at storm events with medium or frequent return periods. However, it is crucial to underline that most of NBS implemented against hydro-meteorological hazards so far are at small-scale, so they will have small effect on the large-scale hydro-meteorological hazards such as fluvial and coastal flooding, and others that cause the extreme damage to small-scale infrastructure communities and ecosystems. Therefore, there is a requirement to study and work on urban and landscape spatial scales like OPERANDUM project, to adapt to risks resulted from hydro-meteorological hazards.

Moreover, the use of NBS is emerging as a cost-effective option to reduce the impacts of hydro-meteorological hazards (Temmerman et al., 2013). In many cases, they could represent a more cost-effective approach than traditional ones, such as grey approaches (EC, 2015). Nowadays numerous body of literature and practitioners perceives NBS efficiency for adaptation and mitigation of HMRs. For example, IUCN (2016) noted that NBS is an approach that delivers several multi-benefits ranging from local to global environmental protections (i.e., regulating carbon and floodplain) in cost-effective manner. Similarly, Depietri and McPhearson (2017) compared the performances of green, blue and hybrid infrastructures with grey approaches through literature review in the view of tackling problem of heavy rain and surface runoff in the city scale and concluded that, among the types of NBS at a small scale, mixed solutions (i.e., green-blue-grey) are the best methods for HMR management and response to global warming.

Moos et al. (2017) assessed the performance and efficacy of green infrastructure – forests in decreasing damages to the mountainous area due to hydro-meteorogical risks, finding that forests are highly efficient and effective to reduce hydro-meteorogical risks by reducing their onset probability, propagation probability, and intensity. Keesstra et al. (2018) investigated the application of hybrid/mixed approaches for soil water conservation and restoration in various environmental

conditions such as in Ethiopia, Mediterranean basin; Slovenia; Iceland; southern Portugal and Sweden and concluding that NBS are an efficient long-term approach in both managing hydro-meteorogical risks and benefit to cost ratio.

Narayan et al. (2016) compared the importance of seagrass/kelp beds, mangroves, coral reefs, and salt marshes with submerged breakwaters in reducing flood wave height and coastal erosion using 69 case-studies. Green approach (i.e., coastal habitats) reduce coastal flooding between 35 -71%; however, this effectiveness varied with the habitats and the location (Narayan et al., 2016). For instance, across all habitats, salt marshes and coral reefs revealed the highest overall performance in decreasing floodwaters by 70% (with 95% confidence interval: 54-81%) and 72% (95% CI: 62-79%). They highlighted that the costs of measures based on salt marshes and mangroves could be two to five times cheaper as compared with engineering structures for flood waves ~ up to 50cm. Others have also indicated that these habitats are reduced coastal flooding and erosions significantly (Ferrario et al., 2014; Pinsky et al., 2013).

Reguero et al. (2018) compared the cost-effectiveness of different adaptation measures to compact coastal flood risks. Comparison of costs (benefit to cost ratio – green bars) vs benefits (total benefit – green bars) of NBS with grey infrastructure and non-structural solutions (i.e., spatial planning) for current and future risks. The NBS measures oyster reef and wetlands restorations provides the maximum cost-benefits (benefit-cost ratio) and even jointly offers the maximum total loss reduction (total benefit) compared with grey and policy measures. However, structural (i.e., levees and dykes) might provide the highest loss decrease, however, they are costly to build over bigger spaces and are not cheaper generally. In the same time, sandbags are cheap and the best profitable; but, overall they provide less hydro-meteorogical risks management (Reguero et al. 2018). Overall comparison of NBS with grey and policy measures revealed about 85% of the profitable hydro-meteorogical risks management can be prevented using NBS, for a total of $49 billion. By 2050, the profitable of NBS could be more impressive as compared to grey and policy adaptation measures (Reguero et al., 2018). However, specific comparisons of the cost-effectiveness and effectiveness against hard structures are still not well covered.

NBS is a complex process of nature that requires a range of methods and tools aligned with all possible procedures such as design, co-design, implementation, evaluation and monitoring, policies and regulations. In practice, a good mainstreaming could generate interaction by supporting novelty in sector-specific policies, linking and aligning sector-specific funds and sustainable development goals (SDG), and motivating more effective use of skilled human, physical and economic assets (Lafferty and Hovden 2003; Adelle and Russel 2013; Rauken et al., 2014; Runhaar et al., 2014; Dewulf et al., 2015; Persson et al. 2015). Since the concept of NBS newly emerged into science and practice, so (1) the lack of systematic mainstreaming of NBS and (2) fragmented policy mainstreaming are hindering its full potential in reducing hydro-meteorological hazard (Wamsler et al., 2016a). For instance, Wamsler et al. (2016a) suggested that practitioners should focus on the need for a good understanding and the efficient application of NBS to enhance resilience (i.e., to solve the existing attention on grey approaches in practice) as the ways to overcome these limitations. Policy fragmentation can hamper the effectiveness of NBS, as sustainable development goals require integrated planning policy and practice. For a wider uptake, upscaling, replication and the systematic execution of NBS, Wamsler and Pauleit (2016b) have noted that organizations, policy-makers, decision-makers and end-users have to modify their: administrative structures, strategies and

guidelines, etc. For instance, Wamsler et al. (2016a) suggested that practitioners should focus on the need for a good understanding and the efficient application of NBS to create resilience societies and economy as the ways to overcome these limitations.

Nowadays, a large number of NBS databases/platforms have been employed across Europe (EU) and worldwide (see section 3.3). However, we are just at the beginning of systematically analyzing their (long-term) impacts, effectiveness for natural hazards (hydro-meteorological risks) reduction and the ability of supplying co-benefits. Still, more research work and knowledge to foster the wider uptake of NBS, quantifying the efficiency and how the existing indicators can be interpreted into management policies and policy tools are needed. For example, OPERANDUM project along with all expected outputs from ten WPs (e.g., the newly launched Geo-Information Knowledge Platform (GeoIKP) in WP7 and others), are aiming to address these gaps.

## 1.2 Concepts and definition of NBS

*Definition of NBS* by IUCN and the European Commission: IUCN defines NBS as: "… actions to protect, sustainably manage and restore natural or modified ecosystems, which address societal challenges (e.g., climate change, food and water security or natural hazards) effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits." (Cohen-Shacham et al. 2016). The European Commission understands: "… nature-based solutions to societal challenges as solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more and more diversity, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions." (EC, 2018).

The expert group of the "Nature-Based Solutions and Re-naturing Cities" of the European research programme Horizon 2020 defined "NBS as actions inspired by, supported by or copied from nature; […] [that] use the features and complex system processes of nature, such as its ability to store carbon and regulate water flows, in order to achieve desired outcomes, such as reduced disaster risk and an environment that improves human well-being and socially inclusive green growth (EC 2015, p. 24)". The concept, therefore, is focused on supplying the human needs by using the principles of nature (see section 3) in different ways as discussed above. Regarding the landscape surroundings, the concept is to promote multifunctional green and blue infrastructure such as green spaces, roadside greeneries, wetlands restoration; installation of grass and riparian buffers; forest trees; stream restoration; rivers, lakes, ponds, oceans and seas, etc. to improve human health and human well-being. This can also include complementary solutions that mix the advantages of grey approaches infrastructure and green and blue infrastructure, which is hybrid infrastructure/missed approach, e.g., bioswales; porous pavement; green roofs; rain gardens; constructed wetlands; soil water conservation (SWC) practices in landscape areas (e.g., gabion with trees).

## 1.3 Characterisation of existing NBS

The NBS concept aims to offer multiple benefits for society with a notation of “nature” (Nesshöver et al., 2017). However, current studies on NBS and the lack of a methodological approach for their implementation is preventing to take advantage of their full potential for building resilience to HMSs (EC, 2015c). In this line, Nesshöver et al. (2017) noted that a central challenge in the concept and characterization of NBS, what is standard and what is considered as NBS. For instance, are artificially modified biota or bioengineering categorised as NBS? There is also a large number of approaches that can utilise the wider components of NBS. For example, conservation and land management (in urban and landscape), restoration of floodplains, green and blue approaches mixed with hard engineering structural (e.g., green rooftops and walls, stormwater garden, sustainable urban drainage systems and bioswales) to decrease river flooding in landscapes, restoration of lakes, wetland restoration/construction or large-scale climate adaptation and mitigation approaches (i.e., forestation and bioengineering) are planned to increase our adaptive capacity and decrease hydro-meteorogical risks. The definition provided in section 1.2 encompasses most of the aforementioned examples, except bioengineering concepts. The availability of many ways to design and utilize the benefits of NBS is not a problem, provided that every case is clear in its reason and a specific clarification of NBS (Nesshöver et al., 2017).

As different hydro-meteorogical hazards need different adaptation measures (Section 3), the types of NBS adopted to tackle each hydro-meteorogical hazard needs a logical approach to distinguish the appropriate solutions while avoiding undesirable, and economically damaging, aspects of the selected approach. Table 1 summarises past studies that have categorised NBS focusing on: (1) supporting policymaking; (2) managing problems related to climate change, food and water availability, or hydro-meteorogical risks reduction; (3) location; and (4) functions, e.g., production of goods; habitat and human well-being. However, in some of the studies documented in Table 1, the classification schemes may be unclear and/or not explicitly considering the concepts of NBS. In this section, we thoroughly reviewed the existed classification schemes of NBS and their application to hydro-meteorogical hazards reductions. At the same time, we also conceptualised the broadest view of NBS.

**Table 1**: Classification schemes and categories of NBS identified through the literature review.

| Old types of NBS | Association to NBS | Classification schemes | New types of NBS | References |
|---|---|---|---|---|
| Ecosystem services (ES) | To take into account solutions through NBS design and assessment, ES concept can be excellent way. Nevertheless, ES application is not limited to little ES and their beneficiaries. | Based on management concepts and approaches to human needs. | Green<br>Blue<br>Hybrid | Nesshöver et al. (2017) |
| Green and blue infrastructures | In some areas similar to NBS and can sometimes be synonymous through differences between "infrastructures" vs. "solution". | | Green<br>Blue | |
| Ecological engineering (EE) and Catchment Systems Engineering CSE) | EE and CSE are subsets of NBS: Both aim at tackling societal challenges but CSE particularly targets on mesoscale protect societies from floods. | | Hybrid | |
| Ecosystem based adaptation (EBA) and mitigation (EBM) | In its concept, EBA is not comparable to NBS, but its principles can be used in the framework of NBS to enhance various end-users and to equalise the needs of stakeholders. | | Green<br>Blue<br>Hybrid | |
| Ecosystem Approach (EA) | The objective is focused on the dealing about the balance of preservation and services for societal demands. EA is not exactly the same of NBS, however its concepts could be applied in the planning of NBS. | | Green<br>Blue<br>Hybrid | |
| Natural capital (NC) | Conceptually NC help to show the potential of nature in fulfilling societal needs, and therefore taking into account NBS against various kind of interferences. | | Green | |
| Ecosystem protection approaches (EPA) | EPA is sub-part of NBS and ideally, area-based conservation approaches including protected area management (e.g. rainforests and mountain areas). | Based on benefits and its applications in risk adaptation and mitigation. | Green | Cohen-Shacham et al. (2016) |
| Ecosystem restoration approach (ERA) | ERA is focused on protecting ecosystem and biodiversity that has been degraded, damaged. ERA is a version of NBS that aims at addressing societal challenges. | | Green<br>Blue<br>Hybrid | |
| Infrastructure related approaches (IRA) | IRA encompasses natural infrastructure (NI), Green infrastructure (GI) and Blue Green infrastructures (BI). | | Green<br>Blue<br>Hybrid | |
| Issue-specific ecosystem-related approaches (IEA) | IEA approach contains: EBA, and EBM, climate adaptation services. Therefore, IEA is part of NBS and has broader view than others approaches but it is not equivalent to NBS. The concepts of IEA could be applied in the planning of NBS to enhance the range of community engagement and to equalise various demands. | | Green<br>Blue<br>Hybrid | |
| Ecosystem based management approaches (EMA) | Combined coastline protection and sustainable utilisation of water balance are placed under EMA. This approach considers the entire ecosystem, including humans, and conducted at smaller spatial scales. EMA has similar target to NBS but especially designed to target on aquatic and water resource problems. | | Green<br>Blue<br>Hybrid | |
| Indoor plants; Green roofs; Green facades and Green and blue landscaping including trees, gardens, parks and water futures. | Four of them are part of NBS family and has similar application and benefits. However, their aims are more focused green and blue infrastructure while the concept of NBS broader in its view and serves as an umbrella concept that covers an entire range of ecosystem related approaches. | Based on the location of the urban greenery. | Green<br>Blue<br>Hybrid | Xing et al. (2017) |
| Better use of natural/protected areas | Focused on batter utilizing the available r partially modified ecosystems, to provide multiple benefits. | Based on the use of nature in tackling challenges, i.e., climate change, disaster risk management. | Green<br>Blue | Balian et al. (2014) |
| Sustainability and multifunctionality of managed ecosystems | Focused on the definition of management rules to develop sustainable and multifunctional ecosystems and better deliver selected ecosystem services. | | Green<br>Blue | |
| Design and management of new ecosystems | The concept is to manage environments in very invasive approaches or generating totally new environments. | | Green<br>Blue<br>Hybrid | |
| Enhancing the soil health and soil functions via ecosystem services | Soil solutions is a subset of NBS and aim to improve the soil health and soil productivity using indigenous habitat or natural resources. | Based on the application to tackle hydrological risks and environmental issues. | Green | Keesstra et al. (2018) |
| Landscape solutions (i.e., increasing infiltration – reducing flood risk, increasing soil moisture and reducing droughts and soil erosion). | Landscape solutions mainly focus on soil and water conservation. The concept is similar to NBS, but limited in its applications. For example, using landscape solutions, high infiltration rate and less surface runoff, this decreases risk of flooding, improves crop productivity and managing dry spells and land degradation. | | Green | |
| Green and blue approaches (restoration of ecosystems, various types of EBA). | Principally green approaches constitute by well-functioning biophysical systems. Blue approaches contains full components of water bodies. Both relies merely on ecosystem functions and merges the three types of NBS. | Based on the application, to adapt climate change impacts. | Green<br>Blue<br>Hybrid | Depietri and McPhearson. (2017) |
| Disaster risk reduction and climate change adaptation. | Mixed solutions integrates both green, blue and grey approaches together. | | Green<br>Blue<br>Hybrid | |
| Ecosystem-Based Adaptation (EBA) | It is a subdivision of NBS that is explicitly focused on global warming management by the use of nature. | Based on applications to societal challenges and human benefits, i.e., well-being. | Green<br>Blue | Pauleit et al. (2017) |
| Green space, habitats and biodiversity. | Green Infrastructure (GI) could give planned information for harmonizing NBS in designing multi use green areas at numerous ranges. | | Green | |
| Ecosystem Services (ES) | To take into account solutions through NBS design and assessment, ES concept can be an excellent way. Nevertheless, ES application is not limited to little ES and their beneficiaries. | | Green<br>Blue<br>Hybrid | |

Many researches have classified the typology of NBS based on their functions and services; for instance, in managing societal challenges such as hydro-meteorogical risks, wellbeing and application for policy and decision makers (e.g., Kabisch et al., 2016; Pauleit et al., 2017; Nesshöver et al., 2017, Cohen-Shacham et al., 2016). Pauleit et al. (2017) stated that NBS are an umbrella term that incorporates a broader concept, e.g., green and blue approaches as well as many other services provided by ecosystem. In summary, NBS could be used as an envelope for other all components of NBS those are gaining more focus at the level of policymaker and research. Table 1 presents a summary of the NBS concepts, classification schemes, and types of NBS those are closely similar and somewhat corresponding each other. For instance, recent studies highlighted that all NBS related definitions (concepts) have a wider extent and they are analysed and utilized in a different way in practice (Pauleit et al., 2017; Cohen-Shacham et al., 2016; Wamsler and Pauleit, 2016). Cohen-Shacham et al. (2016) described NBS as an envelope notion that address an entire domain of ecosystem-related concepts all of which tackling human and environmental problems. They placed NBS into five main categories (Table 1). All of them also have numerous correspondence, e.g., in terms of hydro-meteorogical hazards they are tackling and the categories of interference they comprise. The concept of NBS has been critically harmonised on the basis of its benefactions to feasible development in European cities and categorised into six main categories using management and approaches to human needs (Nesshöver et al., 2017), Table 1.

Nesshöver et al. (2017) also evaluated how NBS can be applied in practice with existing solutions and highlighted its applications to support policymakers. These six types of NBS along with their concepts and relationships to the broader concepts of NBS are presented in Table 1. The green approach integrated outlined system of natural and modified regions along other ecosystem characteristics planned and managed to provide a lot of environmental benefits and services (EC, 2013). Thus, green infrastructure contains all greenery and blue spaces for marine environments, and other physical characteristics in terrestrial and marine areas (Cohen-Shacham et al., 2016). UNEP (2014) elaborated the terms “green” and “natural” infrastructures are usually used interchangeably; however, they refer to designing and protection work in various environments and at many scales. For example, natural infrastructure is a process of restoring, functioning and composition of the ecosystems to provide ecosystems services, while green infrastructural enhance the aspects of ecosystems to provide these services (Cohen-Shacham et al., 2016). Moreover, a green infrastructure operates at urban and landscape scales whereas natural infrastructures are used only at a landscape scale. Xing et al. (2017) identified four meta-types of NBS metropolitan actions based on the site of the metropolitan greenery (Table 1).

We have conceptualised NBS classification schemes in Figure 1 following the literature and our elaboration, for the following reasons: (i) NBS are a complex system processes of nature, wider in its concept and range of application (EC, 2015), comprising many components, which may interrelate non-linearly with each other (i.e., self-regulating systems) and result in both triggering and regulating natural hazards. Therefore, they require a classification that can contain all components of ecosystem and their interaction with each other (i.e., geosphere/lithosphere, hydrosphere and atmosphere; Figure 1); and (ii) while the classification of NBS in previous literature is overlapping and limited to

green infrastructure, we attempted to classify NBS into three main components (see Table 1): namely, green, blue and hybrid (green with a grey component, blue with a grey component and a combination of both green-blue) approach within the domain of ecosystem (Figure 1).

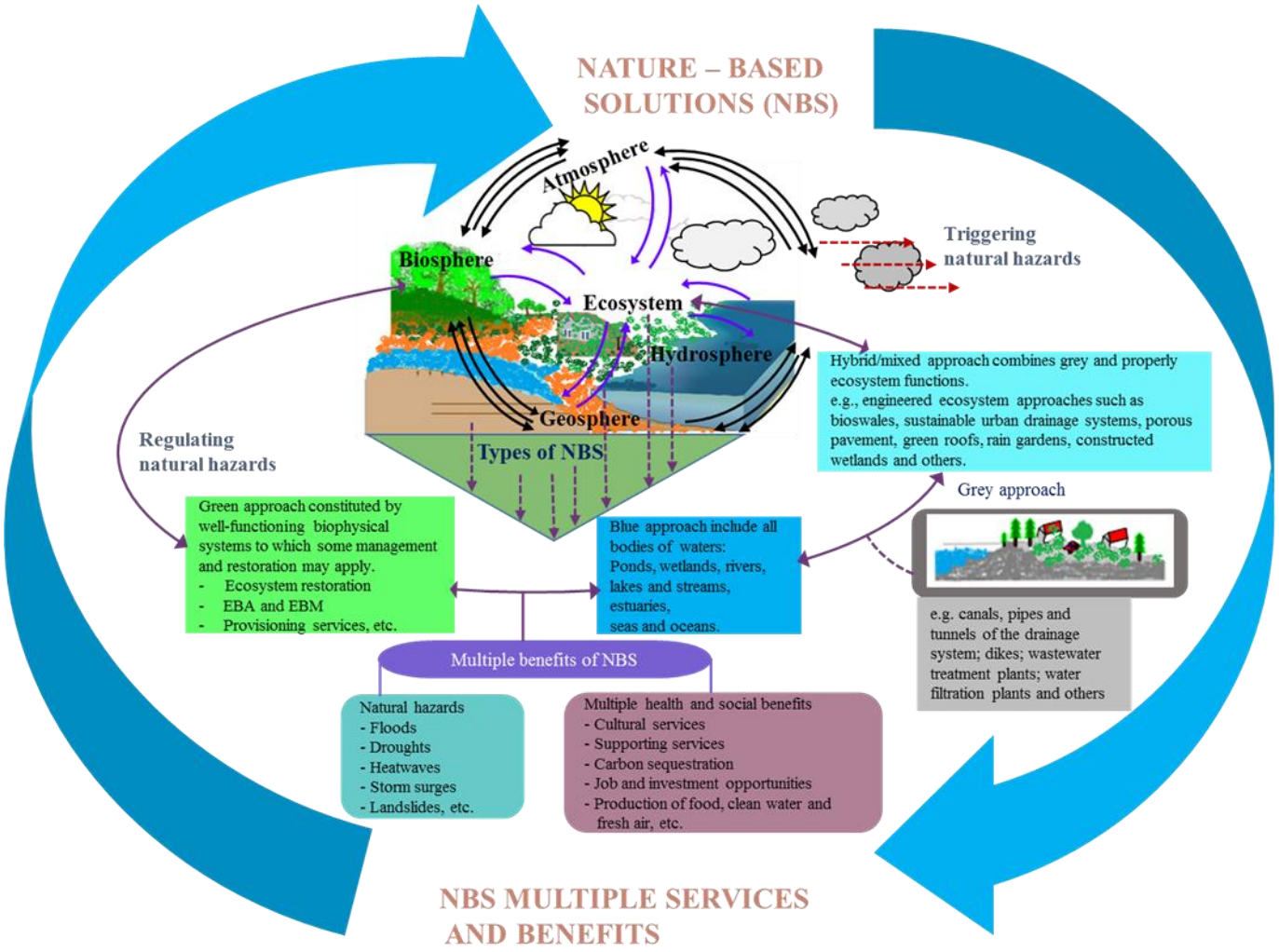


Figure 1: Conceptualizing NBS as an umbrella term for ecosystem-related approach and use of grey approach with ecosystem functions together in managing hydro-meteorological.

Figure 1 shows the overall framework and aim of NBS in managing hydro-meteorological risks posed by hydro-meteorological hazards such as floods, drought, storm surge, landslides and heatwaves through a wide range of green, blue and hybrid approaches. These challenges are features of Earth system as a part of nature and associated with forcing mechanisms of the four main components of earth system: atmospheric, oceanographic/hydrosphere (all blue infrastructures), biosphere (all green infrastructures) and geosphere/lithosphere/pedosphere components (Figure 1). The main components are interconnected by many non-linear processes at different scales, interlaced by complex mechanisms (Figure 1). Following the definition of NBS (see section 1), which is defined as a complex system processes of nature, supported and governed by many non-linear processes of nature (EC, 2016). This complex system is composed of many elements, which may interact with each other and cause a feedback loop (Figure 1). For example, as described in Figure 1 natural hazards are part of nature and triggered by natural phenomena, i.e., natural processes in the atmosphere,

hydrosphere, biosphere, or geosphere/lithosphere. Changes in natural processes that trigger hydro-meteorological hazards are the result of a positive feedback mechanism, while changes that lead to a compensating process and mitigate the hydro-meteorological hazards triggering factors constitute a negative feedback mechanism (Lahellec and Dufresne, 2013). In general, positive feedback triggers natural hazard formation whereas NBS keeps the natural processes stable. For instance, NBS can be serve as a sink for carbon sources and manage hydrological cycle, in order to accomplish expected results e.g., decreasing hydro-meteorological risks and some surroundings that enhance societal welfare and sustainable development (EC, 2016). Therefore, NBS considered as an envelope that incorporates the feedback between the four components of Earth system that triggers societal challenges and regulates these challenge through the process of interactions, and remotely connected complex systems (Figure 1). More details on existing NBS case studies, projects, platforms (e.g., OPPLA, PANORAMA and others), and websites is presented in section 3.

# 2 Methods, scope and outline of the report

This deliverable aims to map, characterize and critically evaluate the existing NBS in Europe and worldwide. In doing so, we performed comprehensive literature searches to achieve a significant statistics of case studies. Searches were performed in Google Scholar, Web of Science, Scopus and ResearchGate. We also used cross-references. Any NBS projects, case studies, platforms and websites in Europe and worldwide as well as projects of adaptation in nature conservation were reviewed. We confined ourselves to implemented NBS projects, case studies and their websites/platform at the regional, country and national level. We focused on the existing data available from numerous published sources including both grey, peer-reviewed, standard reports, and a combination of desk studies (meta-analysis, policy analysis). In addition, this report is also based on expert interviews and focus group discussions such as stakeholders and OALs. Specifically, in section 3, we have focused on scientific literature, reports and platforms that compile NBS projects and related documents found on them. For the former, Scopus was selected as a comprehensive database of scientific literature. Keywords were selected to (1) characterise NBS and all the approaches falling under this umbrella concept and (2) capture acceptance and lessons learnt from previous NBS applications.

The final string of keywords selected was: TITLE-ABS-KEY ((“public acceptance” OR “stakeholder acceptance” OR “political acceptance”) AND ("nature-based solution" OR "eco-engineering" OR "ecological restoration" OR "ecological engineering" OR "forest landscape restoration" OR "ecosystem-based adaptation" OR "ecosystem-based mitigation" OR "climate adaptation services" OR "ecosystem-based disaster risk reduction" OR "natural infrastructure" OR "green infrastructure" OR "integrated coastal zone management” OR "integrated water resources management" OR "protected area management" OR "ecosystem-based management" OR "social-ecological") AND NOT (non-native OR invasive OR ozone OR seismic* OR earthquake OR contaminant OR antibiotic OR pesticide OR marine OR nuclear OR pm OR bacteria* OR toxic* OR metal*) AND NOT TITLE (economy OR species* OR urban OR city OR pollution) AND (PUBYEAR > 1990)). This search returned 22 papers and 17 of them were deemed to be relevant for this review after reading the abstracts. Other term combinations were tested but yielded larger numbers of papers (>1,000) and when screening some of the papers, it became evident that acceptance and lessons learned were not central to the reported research or discussion. In parallel to the scientific literature review, various databases/platforms addressing NBS projects were surveyed and information related to acceptance and lessons learnt were extracted. The reviewed databases were: OPPLA (2019), Climate-ADAPT (2019), PANORAMA (2019), Think-Nature (2019) and Natural Hazards - Nature-Based Solutions (2019). Most of the findings reported in section 3 come from the review of projects in databases where a wealth of information was found.

Following the fact that NBS is a newly emerged concept in science, policy and practice, this deliverable is dedicated to foster a better awareness of NBS via exchanges of the knowledge base, policy developments and implementation among decision-makers, policy and science experts and practitioners in the disaster risk reduction communities. The report also describes the market opportunity for NBS, identifies data gaps and develops background on geo-catalogue for hydro-meteorological hazards. The report covers the main hydro-meteorological hazards (flooding, coastal erosion and storm surge, increase nutrients and sediment loading, drought and landslides and others) focused in OPERANDUM OALs along with the broader concepts of NBS used to mitigate the associated hydro-meteorological risks.

The report is structured as follows. Section 3 establishes the knowledge of the best practises of NBS in Europe and elsewhere (subtask 1.1.1). In this section, the 'degree of acceptance' of NBS for developing the understanding of already established acceptance level in each country is assessed. The link between existing NBS projects and platforms (e.g., OPPLA, PANORAMA, and ThinkNature) has been reviewed along with networking/cooperating with those in operation currently and customising their OALs. The main focus is at the OAL partner countries, although NBS implemented in other EU and non-EU countries are also considered. Section 4 gives an overview of recommended steps for a climate risk assessment, whereby the results of the risk assessment are typically presented in a risk matrix (task 1.1.2). The categorisation of the hydro-meteo risks can be performed for current and future climate change conditions.

Section 5 starts with a detailed overview of existing policies and guidelines relevant to linkages between hydro-meteorological risk reductions and NBS at global, European and national levels. Specifically, this section maps and analyses policies and guidelines on NBS in general and more specifically related to bio-engineering practices (subtask 1.1.3). The primary focus is on, but not strictly limited to, European policies and guidelines regarding NBS. The link of NBS to the Sustainable Development Goals (Section 5.2), the Sendai Framework (Section 5.3) and the Paris Agreement (Section 5.4) is illustrated and all major frameworks, conventions and organisation (Section 5.5) are listed at global and EU level. Lastly, related legal frameworks, protocols, guidelines and policies at EU Level (Section 5.6) are assessed on their reference to NBS and categorised by hazard. This work contributes to the achievement of OPERANDUM specific objectives SO3 (improving NBS acceptance) and SO5 (strengthening NBS policies adoption). Simultaneously, it also aims at (1) identifying and assessing barriers related to their social and cultural acceptance, policy regulatory frameworks and proposing ways to overcome them; and (2) developing methodologies, tools and practices enabling the replication and upscaling of NBS, two of OPERANDUM specific challenges.

Section 6 describes an early overview of market opportunities (subtask 1.1.4) i.e., uncertainty about long-term maintenance, performance and cost-effectiveness in comparison to purely grey infrastructure solutions to enhance the wider uptake of NBS. In addition to highlighting market opportunities, the section also outlines (i) limitations in specific skills of people (e.g., construction direction, ability to understand particular circumstances, ability to check materials and quality, issue regarding safety and health control), (ii) preparedness of the enterprises to face with daily bioengineering challenges, and (iii) the extent to which the classical stages in soil and water bioengineering process are actually carried out by enterprises.

Section 7 focuses on the mapping of primary and secondary stakeholders by identifying groups and then categorising them as per their characteristics, interests, attitude, influence and relevant knowledge for the project regarding uptake of NBS (subtask 1.1.5). First, a broad overview of stakeholder's analysis is presented explaining in general who stakeholders are and why it is important to include them in projects (Section 7.1). Next, it describes successful experiences from previous DRR and NBS related projects and summarizes important lessons learned from them in terms of stakeholders' mapping and analysis. Lastly, it reports OPERANDUM stakeholders' mapping (Section 7.2) which is mainly aimed at gathering relevant information on the most important industrial companies and research centres as well as other innovation actors, organizations and policymakers that are performing international innovation, research, and business activities related to OPERANDUM. The outcome of this analysis will provide the base for operationalization of NBS (WP3),

strategies for stakeholders' engagement (WP8) and dissemination of results (WP9).Section 8 summarises data gaps for developing social, economic and environmental performance indicators (subtask 1.1.6). Section 9 deals with data development of matrix to fill data gaps (subtask 1.1.7). In particular, assessment of monitoring/modelling system required to find the impact of NBS for different OAL will be undertaken following an ISO methodology developed for the first time by the EMODnet (DGMARE) Checkpoint project.

Section 10 presents the structure of the OPERANDUM geo-catalogue (Subtask 1.1.8), which was developed in WP7 (deliverable 7.1). The main components of GeoIKP along with descriptions were documented in deliverable 7.1. Therefore, for further details we will refer to deliverable 7.1. Here we will present a brief descriptions of the structures of the geo-catalogue and their functionalities, for example, storing hydro-meteorological variables datasets for both historical and future climate conditions, climate indicators and performance indicators, etc. The outcome of this section is a collection of conceptual Data/User-Driven themes that will allow to technically map users, policies and hazards at different levels (EU to local) to NBS solutions in WP7. Finally, section 11 summarises findings from the previous sections and identifies specific opportunities for further enhancing coherence between NBS and hydro-meteorological risk reductions in policy and practice. The report also summarises the main challenges, gaps and barriers for NBS design/co-design, development/co-development and deployment and highlight opportunities for future developments, thus leading to overall recommendations for NBS implementation for hydro-meteorological risks.

Overall, the outcomes of this deliverable serve as a foundation for the various tasks in the WPs of OPERANDUM. For example, some of the definitions and concepts developed in sections 3 and 7 will be used in WP2 for co-designing and co-development of NBS. The information developed in section 3 will be used in WP7 as the basis for OPERANDUM GeoIKP by exposing a collection of existing NBS case studies across Europe and worldwide. The definition of risks and hazards and analysis of climate indicators presented in section 4 will be used and continued in WP4 and WP5. The preliminary analysis presented in section 4 will also serve as a basis for the tasks documented in WP6 (i.e., Task 6.1). In section 5, three Sendai Framework priority areas were analysed, which will serve as a basis of the work carried out in WP3, WP6, WP7 and WP8. The early overview of market opportunities of NBS developed in section 6 will be useful in other OPERANDUM WPs, particularly in WP9 which delivers the tools required for wider dissemination, communication and exploitation of the project outputs. The stakeholders shown in section 7 have had input to WP1 (Task 1.3), WP3 (Task 3.2), WP8 (Task 8.1) and WP9 (Task 9.1). The analysis and results documented in section 8 interact with WP3 (Task 3.4), which gives criteria and indicators for monitoring the reduction and prevention of risks related to natural hazards. This section also has a connection with WP6 (Task 6.1 - Review of vulnerability and risk assessments). The outcome of section 9 will directly serve OPERANDUM GeoIKP, for quality control during metadata preparation. In addition to this, it will also be used for data quality control in WP4 and WP5. The structure of hydro-meteorological hazards geo-catalogue developed in section 10 is the foundation for OPERANDUM GeoIKP initiated in WP7 (Task 7.1). This geo-catalogue also has linkage with WP2 (Task 2.1.4 - Design and the implementation of NBS). Apart from this, D1.1 is contributed to the achievement of OPERANDUM specific objectives S01 (R2, R6), SO3 (R14), SO4 (R18, R20), and S05 (R22).

# 3 Best practices of NBS in Europe and worldwide

In the past couple of decades, an increasing number of projects falling under the umbrella of NBS have been implemented around the world. These may not have originally been labelled as NBS (which has only been defined in the past few years) but belonged to approaches such as Ecosystem-based Adaptation (EbA) or Ecosystem-based Disaster Risk Reduction which now fall under the NBS umbrella (Cohen-Shacham et al., 2016). This section of the report presents a review of the existing literature to compile lessons learned in terms of implementation of NBS and understand which approaches were needed to increase acceptance of NBS in Europe and globally. The objective is for this knowledge to be useful for the OPERANDUM project in the context of establishing and monitoring the NBS implemented in 7 OALs.

## 3.1 Emergence of principles and guidelines

One of the bottlenecks for a wider acceptance of NBS (and the approaches falling under it) globally has been the lack of principles, standards, and guidelines (e.g. Renaud et al., 2016). In the last two-three years, this gap has begun to be addressed. Cohen-Shacham et al. (2016) presented the first set of principles on NBS and endorsed by the IUCN. These principles state that NBS:

- Embrace nature conservation norms (and principles);
- Can be implemented alone or in an integrated manner with other solutions to societal challenges;
- Are determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge;
- Produce societal benefits in a fair and equitable way, in a manner that promotes transparency and broad participation;
- Maintain biological and cultural diversity and the ability of ecosystems to evolve over time;
- Are applied and upscaled at a landscape scale;
- Recognize and address the trade-offs between the production of a few immediate economic benefits for development, and future options for the production of the full range of ecosystem services; and
- Are integral part of the overall design of policies, and measures or actions, to address a specific challenge

These principles are fairly generic but important for stakeholders to understand what NBS should encompass and what an NBS solution should look like. At the time of writing, the IUCN has launched a global consultation for the development of NBS standards which, when combined with the above principles, will provide further robustness to the implementation of NBS globally.

In parallel to the development of the IUCN NBS principles, the World Bank proposed comprehensive guidance for the implementation of NBS to reduce flood risk (World Bank, 2017). This guidance document proposed five overarching principles whereby NBS should:

- Take a system-scale perspective;
- Go through an assessment risk and benefit of the full range of solutions (i.e. not limit oneself to green solutions alone);
- Undertake a standardized performance evaluation;
- Be integrated with ecosystem conservation and restoration; and

- Incorporate adaptive management.

These principles overlap partially with those proposed by Cohen-Shacham et al. (2016), but there are also additional elements proposed, in particular in terms of performance evaluation and in terms of management. In addition, eight-step implementation guidance is proposed, which provides useful information to practitioners willing to implement NBS in the context of flood risk reduction.

Also in 2017, Friends of EbA (FEBA) published a framework for qualification criteria and quality standards for Ecosystem-based Adaptation (EbA) which is one of the ecosystem-based approaches falling under the NBS umbrella, and which consisted in a first attempt in providing guidance as to what EbA should be and what it is not. One of the main concerns of the authors was that EbA should demarcate itself to "business as usual" when it came to climate change adaptation through ecosystem-based approaches. Five, so-called "qualification criteria" were proposed whereby EbA should (FEBA, 2017:5-6):

- Reduce social and environmental vulnerabilities;
- Generate societal benefits in the context of climate change adaptation;
- Restore, maintain or improve ecosystem health;
- Be supported by policies at multiple levels; and
- Support equitable governance and enhance capacities.

The overlaps with the IUCN principles are clear, but FEBA went further by proposing a framework to assess these criteria through quality standards, here again providing practitioners with tools for the implementation of EbA on the ground. Finally, in late 2018, the Convention for Biological Diversity (CBD) endorsed and published voluntary guidelines for ecosystem-based approaches to climate change adaptation and disaster risk reduction (CBD, 2018). These voluntary guidelines, endorsed by the parties of the CBD, focus on EbA and ecosystem-based disaster risk reduction (Eco-DRR) and provide:

- A 6-step framework for planning and implementing EbA and Eco-DRR;
- A set of 10 principles addressing the following key elements:
- Building resilience and enhancing adaptive capacity through EbA and Eco-DRR;
- Ensuring inclusivity and equity in planning and implementation;
- Achieving EbA and Eco-DRR on multiple scales;
- Achieving effectiveness and efficiency for EbA and Eco-DRR.
- A set of 9 safeguards to consider when planning and implementing EbA or Eco-DRR.

All these partially overlapping and at times complementary sets of principles and guidelines are relevant to the acceptance of NBS at global scale because they address knowledge gaps and provide clear guidance to decision-makers as to what is meant and what it entails to plan for and implement NBS in the context of climate change adaptation and disaster risk reduction. However, NBS are not yet at the stage when they can compete with the long-established approaches and standards used in the civil engineering domain, but the above publications are a first step and necessary to achieve that goal.

## 3.2 Results from the scientific literature

The review of the literature returned a group of papers that addressed a broad diversity of NBS-related issues. In the end, only 10 papers had content of direct relevance to OPERANDUM and some of the main points in terms of lessons learnt and acceptability are summarised below.

Three papers focused on urban environments and are relevant for a few of OPERANDUM OALs. Flakne and Keller (2012) discuss an approach to efficiently create and implement a Natural Resources Plan at the community level in an urban environment (link to Green Infrastructure development). The example they provide is from the USA (the village of Glenview in the suburb of Chicago). Although the circumstances of Glenview are particular in the sense that a Naval Air Station was decommissioned thus offering opportunities to develop the area, some general lessons have been drawn on what worked and what did not in terms of planning and subsequent plan implementation (Flakne and Keller, 2012, p.42-43):

- Appointed a commission with well-defined priorities and with members embedded in the local political context;
- A well-researched plan that incorporates findings from detailed studies;
- Achieving multiple objectives through the planning process and subsequent implementation;
- Ensure consistency with regional (or other larger scale) planning;
- Ensure cooperation at the local level, in particular with private landowners (incentives and recognition) and to ensure habitat protection;
- Achieve peer recognition (e.g. through receiving awards for the work being carried out);
- Community outreach (publications, meetings, events, etc.) to keep everyone informed; and
- Adopting an implementation plan.

Clements et al (2015, p.272) highlighted that municipalities often struggle to put in place a process for prioritizing selection and placement of green infrastructure in an urban environment (discussed in the context of green infrastructure to manage storm runoff). To facilitate this, Clements et al (2015, p.274-275) proposed a set of criteria covering both technical and ancillary benefits characteristics of various measures and included:

- Technical criteria: Land use, Topography/terrain/slope, Flow volume reduction, Combined Sewer Overflow reduction potential, Impervious area, and Soil suitability;
- Ancillary benefits criteria: Parcel ownership, Partnership opportunity, Public amenity and acceptance, Flexibility, Visibility, Existing infrastructure, Cost, and Economic benefit.

Using these criteria facilitated planning at the municipality level (Clements et al., 2015). Generally speaking, most of these criteria are applicable in non-urban environments with the exception of combined sewer overflow reduction potential and impervious area. Cameron and Blanusa (2016) highlighted the fact that more attention needs to be paid to species used in urban green infrastructure contexts, going beyond criteria based on aesthetics and survivability. The argument put forward is that various species will provide different types and levels of ecosystem services and that the provision of these ecosystem services should be a priority in terms of species selection. Examples are provided as to how bees are attracted by different flowering plants, how different tree species change air and land surface temperatures under their canopies, the effects of different vegetated facades on mean air temperature, etc. The capacity to deliver important ecosystem services, therefore, needs to be accounted for when developing GI with a specific objective in mind

implying that in some cases, efforts need to be made to provide a favourable environment for specific species to be able to grow well within GI solutions (Cameron and Blanusa, 2016). This applies to non-urban environments where optimising ecosystem services delivery is also a priority.

The above three examples focus on urban environments but provide relevant information beyond these environments and also showcase a range of factors that need to be considered for NBS to work: in terms of planning and implementation, in terms of specific approaches for planning purposes and in terms of technical details. Also highly relevant for the OPERANDUM project is the use of models as communication tools. Olsson and Andersson (2006) discuss this issue in the context of catchment nutrient transport but some of the lessons and recommendations are relevant for the many modelling activities carried out in OPERANDUM. Olsson and Andersson (2006) highlight that a trust gap can arise between modellers and the public at large as models are built with assumptions and priorities of the modellers themselves and one could add, of the project objectives. Stakeholders not directly involved in the modelling will criticise/accept the modelling results depending on what is at stake, their own knowledge (including of modelling), and the trust they place on the institution/individuals involved in the modelling (Olsson and Andersson, 2006:101, see Figure 2 below). Other criteria include the way results are communicated, education, age of stakeholder, etc (Figure 2).


Figure 2: Factors affecting stakeholders' trust in modelling results (redrawn from Olsson and Andersson, 2006).

Olsson and Andersson (2006, *p.*103-107) propose conditions for improved model result acceptance (when used as communication tools):

- User relevance and friendliness (in particular, the model results should answer questions of interest to stakeholders);
- Preparedness to address unexpected reactions from stakeholders;
- Transparency over the modelling framework and clear communication of uncertainties;
- Showing mutual respect during the dialogue;
- The strong institutional framework within which the dialogue can be conducted;
- Allocation of sufficient time for the dialogue.

One way to approach this is described by Chuenpagdee et al (2006). In a context that seems far from NBS as framed in OPERANDUM, i.e. ecosystem-based management of fisheries, Chuenpagdee et al (2006) propose an approach to increase stakeholder acceptance that is relevant to the OPERANDUM project: the combination of scientific knowledge (ecosystem modelling) and capturing stakeholders' preferences (public choice models). Using this approach, Chuenpagdee et al. (2006) developed future ecosystem scenarios and combined it with a stakeholder preference survey to allow for prioritizing policy options.

Nunneri and Hofmann (2005) highlight the difficult negotiation process involved in solving a transboundary nutrient enrichment problem in a river basin (Elbe River) and the need to reconcile conflicting interests. In this context, understanding different priorities and economic and socio-cultural differences between different actors need to be understood. To improve acceptability of management measures, some pre-conditions are proposed: agricultural cooperation between farmers in the landscape is essential to improve environmental protection; farmers should be supported in this process, and the costs to them should be minimized (Nunneri and Hofmann, 2005). This implies taking a landscape perspective not only in the geographical sense of the term but also in the social and economic dimensions. Jungmeier et al (2013) propose a set of 12 indicators to monitor a Biosphere Reserve (BR) in Austria. The indicators cover 4 dimensions:

- Ecological - Population trend of Tetrao urogallus (wood grouse) in the BR; Population trend of Nigritella rhellicani (flowering plants from the orchid family) in the BR; Development of the coarse woody debris share in the forests.
- Economic - Development of the visitor tax in the BR; Development of the local tax in the four municipalities of the BR; Development of the agricultural land use forms in the BR.
- Socio-cultural - Personal perception of the potential for active participation in political and social decision processes; Personal satisfaction with the Biosphere Reserve; Migration balance.
- Management performance - Development of visitor numbers; Development of media presence; Development of research activities within the BR.

Some of the proposed indicators above could be of relevance to some of the OPERANDUM OALs particularly those linked to biosphere reserves. In order to inform restoration efforts, Petursdottir et al (2013) recommend evaluating the short term ecological effects of different restoration treatments combined with a study of public perception of aesthetic and recreational values of the restored landscape. In their experiments, Petursdottir et al (2013) showed that there were both social and ecological rationales for not selecting non-native species in their restoration strategies as these performed less well in terms of ecological successions and were also the least appealing to the public. The importance to experiment within an NBS project is something that was mentioned in many NBS projects reviewed (see next section) as it provides the means to showcase to stakeholders what works and what does not and also to test stakeholder perceptions of different solutions.

To increase public acceptance of restoration efforts, Pueyo-Ros et al (2018) recommend considering the cultural dimension of ecosystem services. Using the case of a wetland restoration initiative in Spain, Pueyo-Ros et al (2018) found that the public generally focuses on the recreational value of the restored landscape but rarely note services that are less visible, such as regulating services (examples given are flood protection and water purification). Emphasising these services could increase public acceptance of restoration efforts. Pueyo-Ros et al (2018) also note that removing a landmark that is

recognised by the public could, on the other hand, lead to project rejection. Finally, Mejía et al (2015): compared the concepts behind Green Infrastructure and Landscape Planning in Germany. Their main conclusion was that the GI approach incorporates many of the landscape planning concepts but that considering some GI principles in the latter could allow to:

- Bridge spatial scales to develop habitat networks: landscape planning is at the state level in Germany and GI concepts could allow going beyond this political boundary; and
- Emphasise the concept of ecosystem services embedded in GI as landscape planning focuses on landscape functions. This is particularly useful for communication strategies (see the point made by Pueyo-Ros et al (2018) above).

The above points to some lessons learnt and some approaches to increasing NBS acceptance. There are however limitations to this review as it focuses on a few papers which were returned from our keyword search. This was however compensated by the fact that in parallel we were reviewing project documentation included in some major NBS or NBS-equivalent databases which contained a wealth of information as seen below and in ***Annex 1***.

## 3.3 Results from the NBS databases

An extensive review of five major online platforms on NBS projects (Natural Hazards – Nature-based Solutions, OPPLA, thinknature, Climate-Adapt and PANORAMA), has identified a large number of NBS case studies and projects implemented around the world. Most of NBS are related to multifunctional green infrastructure for reducing risks resulting from flooding and erosion in river and coastal areas, improving forest and wetland ecosystems, and reducing impacts of climate extremes in urban areas. Among the relevant NBS case studies identified within the databases, most of them focus on natural hazards such as river flooding (including urban flooding), coastal flooding, drought/water scarcity, river/coastal erosion, and heatwave/extreme temperature (Table 2). Other NBS address urban air pollution, forest conservation, wetland management, biodiversity conservation, landscape planning, and various agriculture sectors. In a majority of cases, adaptation to climate change remains the overall goal, with practical measures taken in response to hazards that are increasing in prevalence and intensity, such as extreme rainfall or heatwaves. The NBS take various forms depending on the geographical location, and the environmental, socio-economic and institutional contexts. Major types of NBS more frequently adopted are presented in Table 2. Most NBS are developed with multifunctional objectives in mind, emphasizing on enhancing the state of the natural environment as well as fulfilling social needs. While mitigation of the impacts of natural hazards is targeted, the conservation of ecosystem services is integrated into the projects as well.

**Table 2**: Natural hazards and other environmental issues targeted by NBS.

| Natural hazards and other environmental issues | No. of NBS case studies [1] |
|---|---|
| River flood (including Urban flooding) | 121 |
| Coastal flood and storm | 62 |
| Drought/ water scarcity | 47 |
| Erosion (river/coastal/landslides) | 46 |
| Heatwave, urban heat island effect | 33 |
| Urban environmental quality issues (air, water, aesthetic) | 31 |
| Deforestation and loss of biodiversity | 20 |
| Wetland ecosystem degradation | 8 |

*[1] Out of 288 case studies. Some case studies focus on multiple issues.*

**Table 3**: Major types of NBS interventions more frequently adopted in the reviewed case studies.

| Natural hazards and other environmental issues | Major types of NBS interventions more frequently adopted in the case studies |
|---|---|
| River flood (incl. urban flooding) | River channel restoration; rainwater garden; floodplain restoration; create room for the rivers; urban wetland and river channel restoration; using wildlife (e.g., beavers) to create natural dams in river channels; green-blue corridor in an urban area |
| Coastal flood and storm | Coastal wetland restoration; afforestation; sediment control with coastal mangroves; creating dunes & beaches;<br>beach nourishing with sand pumping; channel restoration |
| Drought/water scarcity | Rainwater harvesting; restoring traditional water retention structures; restoration of natural water channel; wetland conservation; alternative agriculture; afforestation; conserving natural forest |
| Erosion (river/coastal/landslides) | Afforestation; creating dunes & beaches;<br>beach nourishing with sand pumping; grassland management; |
| Heatwave, urban heat island effect | Urban green space; green roof; green wall, green corridor; vertical garden; community garden; school garden |
| Urban environmental quality issues (air, water, aesthetic) | Urban green space; green roofs; green walls, green corridors; vertical gardens; community gardens; school gardens; rainwater gardens; lake creation |
| Deforestation and loss of biodiversity | Afforestation/re-reforestation, community forestry, agroforestry; green land bridge over road crossings; biodiversity conservation; developing alternative livelihoods; stone bund for water storage; |
| Wetland ecosystem degradation | Wetland restoration in floodplains; biodiversity conservation; restoration of connectivity of water channels; |

In terms of geographical distribution, a majority of NBS case studies (201 out of 288) are documented from European countries, in particular United Kingdom (91), Netherlands (20) and Germany (13) (Figure 3). Flood mitigation, either for riparian or coastal regions, was the main objective of most of the NBSs in European countries. Some projects focused on extreme temperatures, storms, erosion, drought and sea level rise. With respect to the countries where OPERANDUM OALs are located, very few NBS case studies were documented in the databases, except for the United Kingdom (Table 4). It is important to note that the fact that most of the case studies were placed in Europe is most likely due to an artefact linked to the databases searched, some of which have a European focus.

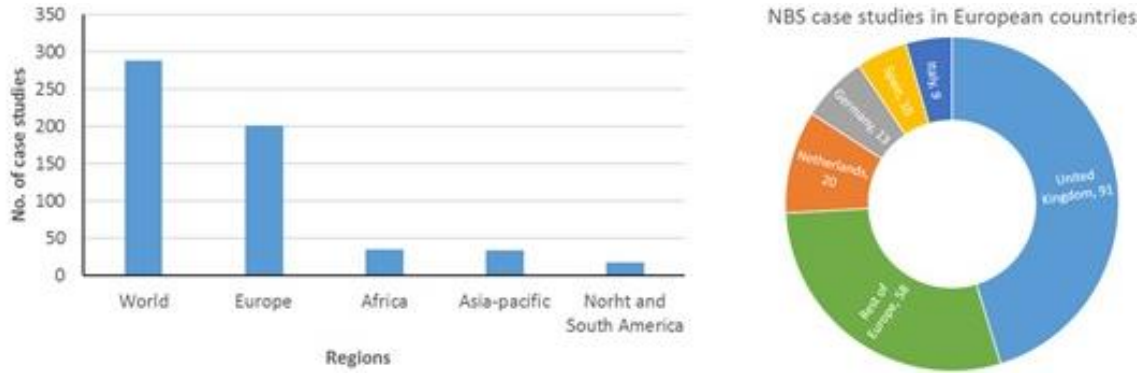


Figure 3: Distribution of NBS case studies in various regions of the world (Source: Natural Hazards – Nature-based Solutions, OPPLA, thinknature, Climate-Adapt and PANORAMA databases).

**Table 4: NBS case studies in countries where OALs of the OPERANDUM project exist.**

| Countries linked to OPERANDUM project | No. of case studies |
|---|---|
| Australia | 0 |
| Austria | 4 |
| China | 6 |
| Finland | 2 |
| Germany | 13 |
| Greece | 2 |
| Ireland | 1 |
| Italy | 9 |
| United Kingdom | 91 |

## 3.4 Lessons learnt from NBS case studies

Several lessons can be taken from NBS implemented around the world, particularly in terms of their planning, implementation and monitoring or follow-up of the projects. According to the reviewed project reports and information contained in databases, most of them are successfully implemented, although scientific evaluation of the projects is often not available.

The case studies highlighted that community/stakeholder engagement in the planning and implementation process of the NBS projects was the key factor for success. Local government authorities often played a major role in providing policy support, financing, and engaging communities in the projects. The interest of the local authorities and, above all, their leaders (e.g., city mayors) is therefore vital to initiate proactive planning and implementation of NBS projects.

Inadequate policies and funding for the NBS projects are seen as major limitations that hinder replication of the projects. Co-financing from government authorities and not-for-profit organizations can be a suitable approach to eliminate financial constraints, as observed in many NBS projects e.g., NBS for greening the city and increasing resilience in Amsterdam (https://oppla.eu/node/18009), NBS for urban green connectivity and biodiversity in Berlin (Oppla, 2019). Co-financing is effective as it creates ownership and benefit sharing among the stakeholders, which enhances the chances of long-term project sustainability. Besides policy and funding, the involvement of scientists/experts was also recognised as key, especially for those projects requiring flood risk analysis, geotechnical studies (soil condition) for building new structures and other types of technical evaluation. Many projects have emphasised the importance of bringing together scientific as well as local/traditional knowledge sources to provide technically sound, adapted, and socially acceptable NBS. Lack of practical knowledge was identified as a bottleneck in NBS case studies since the project ideas were new to the implementing agencies who did not have prior knowledge of practical implementation, operation and maintenance related to NBS. It was often emphasised that specialists or experts from different fields should be involved to avoid future project failures.

Further, the physical condition of existing landscapes puts limits to implementing new NBS projects, particularly in cities where local authorities are keen to create new green spaces with the aim of reducing urban heat island effect and air pollution – here the bottleneck is a lack of space, particularly in cities with high-density buildings. The city authorities are also facing the challenge of maintaining numerous fragmented green or open spaces (e.g., City of Bari, Italy). Engaging local communities and organizations in the NBS projects can be an option to support the local authorities for proper maintenance of the projects in the long term. NBS projects also have the potential of creating green jobs and engaging the local community in city planning and decision making.

Many projects have emphasised the importance of monitoring and evaluation during the project implementation but also beyond. This allows to not only track progress but also practice adaptive management as lessons are learnt as the project is being implemented. One bottleneck is often limited or lack of funding for this activity, particularly after project implementation.

Overall, NBS case studies suggest that the engagement of stakeholders including the local authorities and political leaders is vital for the success of projects. Funding could be a major limitation for the NBS projects; however, this constraint can be eliminated by taking a co-financing approach to involve

stakeholders. Furthermore, the NBS projects have the potential to create green job opportunities. Adequate policy supports are required to promote the NBS projects at the local and national scales. Also, the monitoring and evaluation of the NBS projects are important so that the lessons learnt from the projects can be used to practice adaptive management.

## 3.5 Acceptability of the NBS projects

NBS such as natural water retentions basins, coastal wetland restoration, sand dunes, urban green spaces, green roofs, community gardens are implemented in many countries which reflects the global acceptability of the NBS despite some variations at local scale. According to the case studies, most of the NSBs are accepted by the communities and local authorities, but only when stakeholder engagement is carried out from inception until the end of a project. In some cases, there were conflicts between the local community and the implementing agency at the initial stage, because of a lack of understanding and mutual trust. Often, conflicts were resolved by shared understanding and participating in the project implementation. For instance, in 'Medmerry, West Sussex coastal flooding' project (ThinkNature, 2019), the UK Environment Agency (EA) at the beginning faced resistance from the local community for building new inland defences from the existing coastline. Then, the EA formed the Medmerry Stakeholder Advisory Group (MStAG) with a group of self-elected representatives from among the wider group to represent local views, interact with the project team and report back to the community. Involving the community in an organized way helped the EA to implement the project smoothly. This approach has created a wider acceptance of the project and ownership of the community.

Since the NBS are new innovative ideas/technologies, acceptance of these requires long term interaction. People more readily accept the solutions once they see and understand the tangible and intangible benefits these may bring. Several reviewed projects have highlighted that "making the case" for the projects, in terms of benefits, was crucial for their acceptance. Strategies are to develop solutions that can provide benefits from short to long timescales. Smaller scale demonstration sites or testing various alternatives or species within the projects has been flagged as a way to gain stakeholders' trust. Government's policy and financial supports are also necessary to enhance wider acceptability of the NBS projects. National and local level government policies and regulations need to incorporate the NBS ideas as mainstream agenda so that the government's development programmes and funding are designed accordingly. This would help to create greater awareness of NBS in the society including businesses and industries, and acceptability of the NBSs. For example, 'green roofs' construction technology was first introduced in many cities of Switzerland in the 1970's. Many green roofs were created in the 1980s as pilot projects, which provided a foundation of knowledge and experience for later initiatives. Following the EU year of Nature Conservation campaign in 1995, Basel city started the first green roof campaign in 1996. With the government's legal and financial support, the total number of green roofs resulted in 1711 extensive green roof projects and 218 intensive green roofs in the city in 2006, which is approximately 23% of Basel's flat roof area. For developers, installing green roofs is now considered routine, and developers raise no objections to installing them (Basel, Switzerland: Green roofs: Combining mitigation and adaptation on measures (ThinkNature, 2019). Other case studies have shown a similar approach of enhancing the acceptability of the projects. Long term strategies and institutional practice should be adopted to increase awareness and acceptability of the NBS projects. A summary of lessons learnt and acceptability of some important NBS projects is provided in ***Annex 1***. Further, a brief summary of

acceptance of NBS projects in the countries where OALs of OPERANDUM project exist is presented in Table 5.

**Table 5**: Acceptability of the NBS projects in OAL countries.

| OAL Country | Acceptance of NBS projects |
|---|---|
| Austria | The NBS case studies in Austria suggests that the lack of adequate policy hinders the success of implementing NBS (e.g. urban green space project). Acceptance of NBS interventions in some projects (e.g. flood management) was achieved through continuous stakeholder engagement in the event of higher magnitude of hazards (e.g. high flood). |
| Finland | NBS projects in Finland are related to urban green space for urban climate control, and urban constructed wetlands for reducing flood, drought and erosion. Along with the interest of local community, the municipalities are interested to implement NBS projects. |
| Germany | Germany is one of the pioneer countries implementing NBS projects. High level of stakeholder engagement was achieved in some projects. The NBS projects were accepted by the community and local government authorities. Some citizen led initiatives (e.g. Green walk) was later adopted by the city council. National initiatives like 'Zukunftsstadt' were taken to promote green infrastructure projects in Germany. |
| Greece | Very few NBS projects, mainly related to wetland management and river bank protection are recorded in Greece. These NBS projects were accepted by the community and government. There is high potential of implementing NBS in Greece. |
| Ireland | In Ireland, NBS projects are located mainly in Dublin City Council. The council has high interest to promote the city's green infrastructure. NBS projects could be implemented in other areas of Ireland. |
| Italy | Italy has long experience in implementing NBS in various fields (e.g. flood management, urban green space, coastal erosion). In most cases, local communities and local authorities have accepted the NBS projects. The local government authority such as City of Milan has adopted NBS in city planning agenda. On the contrary, another city council has shown less interest to NBS projects due to lack of political commitment. |
| United Kingdom | Many NBS projects have been implemented in the UK by the local municipalities, water management and nature conservation agencies. As mentioned in the case studies, stakeholders including local communities and the institutions have accepted the NBS projects. Some cities such as London, Bristol have adopted green infrastructure policies for implementing NBS for reducing natural hazards and risks. |
| China | Although a limited number of NBS case studies are found in China, they have reported acceptance of the NBS achieved through partnership of local communities and local governments. |
| Australia | NBS projects in Australia are not well-documented in the NBS database platforms. Therefore, acceptance of NBS could not be evaluated. However, Australia has developed a wide range of environmental conservation policies and regulation that would facilitate acceptance NBS among the stakeholders. |
| Hong Kong | NBS project in Hong Kong are not well-documented in the NBS database platforms as well. Hong Kong is one of the cities considered as case site of Urban Nauture Labs (UNaLab) project (2017-2022) funded by European Commission (Horizon 2020) (www.unalab.eu). NBS concepts are introduced to the stakeholders through this project. The city has growing interest in NBS projects. |

# 4 The categorisation of the hydro-meteo risks focused in OPERANDUM

This section is dedicated to Task 1.1.2 about the categorisation of the hydro-meteo risks in OPERANDUM. Risk assessments for each OAL are foreseen in WP6. The assessments will be conducted at the regional scale and for the present state. In terms of finding long term efficient NBS to reduce the identified risks, it is needed to give indications to the stakeholders on the evolution of the hydro-meteo hazards associated with climate change in each OAL.

In a risk assessment, a risk matrix is used to present the systematic assessment and evaluation of risks. Risk matrices compare the probability of occurrence of events (risk) with the extent of the damage. Regarding climate change in risk assessments, risk matrices require information on the likelihood of the occurrence of hydro-meteorological hazards. However, it is not possible in climate research to calculate probabilities of occurrence of hydro-meteorological events such as "number of days with precipitation > 20 mm". On the other hand, it is possible to determine a confidence level from so-called ensemble data sets.

We present here a categorization of expert judgment for the robustness of the needed climate change information, representing the requested confidence level, to support a risk assessment in the context of climate change. The categorization is applicable for all hydro-meteorological hazards.

In the course of coordination with WP6, it is necessary to review definitions of the term ‘risk’ and associated terms such as ‘hazard’, ‘vulnerability’ and ‘exposure.’ Therefore, an internal OPERANDUM discussion have been initiated to obtain a consensual usage these terms in OPERANDUM. The current stage of the discussion is documented in this section.

In order to demonstrate where and how to appropriately account for local climate change information in a risk assessment, we give an overview of recommended steps for a climate risk assessment. Further, we present how to conduct a robustness assessment for projected climate changes and present a categorisation for the levels of robustness, representing the requested confidence level. This is needed when examining and communicating the possible future climate conditions for a certain region because it is highly relevant for assessing the possible risks a region is facing.

## 4.1 A Comment to “UN SPIDER”

In the description of work (DoW) for Task 1.1.2, the ‘UN-SPIDER Knowledge Framework’ is named as a reference for a risk matrix concept. At this point we would like to point out that, there is no framework or concept provided by the United Nations Platform for Space-based Information Disaster Management and Emergency Response (UN-SPIDER) for developing a risk-based matrix, as mentioned in the DoW. In any case, the UN-SPIDER provides space-based information to support Disaster Risk Management. According to the information on the UN-SPIDER Knowledge Portal http://www.un-spider.org/, the UN-SPIDER, established in 2006, promotes the use of space-based information in all phases of the disaster management cycle. UN-SPIDER was active within the Hyogo Framework for Action and has continued its efforts under the Sendai Framework. UN-SPIDER works with its network of Regional Support Offices (RSO) and other partners to support countries in the use of space-based information and technologies in Priority Areas 1 and 4 of the Sendai Framework such as:

1) Understanding disaster risk;
2) Strengthening disaster risk governance to manage disaster risk;
3) Investing in disaster risk reduction for resilience;
4) Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation, and reconstruction.

For these purposes, the UN-SPIDER Knowledge Portal provides a so-called Space-Application-Matrix. The UN-SPIDER Newsletter February 2013 - Vol 1/13, gives a brief description for this Space Application Matrix: “Our Space Application Matrix (un-spider.org/space-application-matrix) in the Space Application section of the Knowledge Portal refers you to hundreds of case studies, research papers or other interesting documents. The Matrix is an interactive search engine designed to lead the way to results tailored exactly to your needs. By choosing a hazard ([...].. 12 in total, of interest for OPERANDUM: flood, drought, temperature, severe storm, mass movement; others: epidemic, insects, volcano, tsunami, fire, pollution, and earthquake]), a phase of the disaster management cycle (ranging from mitigation to recovery) and a space technology (satellite communication, satellite navigation or Earth Observation/Remote Sensing), you will be led to documents relevant to your specific situation, expertise or area of interest. Apart from the hazards covered in the Matrix, you can also look up documents relating to human aspects such as health, infrastructure, humanitarian issues or security by clicking this option on the bottom of the Matrix wheel.” Nonetheless, the UN-SPIDER activities can be of interest for the OPERANDUM work. For instance, the development of the planned GeoIKP (WP7) in OPERANDUM could profit from it as satellite information helps, for e.g., to support the outline of hazard areas. WP4 describes the current status of climatic conditions and hazards for each OAL which could also be based on satellite data.

## 4.2 The many facets of the term ‘risk’ and related terms

The term risk instinctively has many meanings, at least the emphasis is usually on the notion of chance or possibility. Within the Disaster Risk Reduction environment, the focus is on the consequences in the sense of potential losses. How the term risk has changed, especially for Disaster Risk Management, is evident in the development of definitions used within the UNISDR (United Nations International Strategy for Disaster Reduction) and IPCC (Intergovernmental Panel on Climate Change) community. Regarding this development, shown in Table 5, an increasing specialization is recognizable. It begins with a very general understanding on the part of UNISDR 2009 and includes the capturing of risks of climate change impacts since the IPCC AR5 2014.

Particularly in the area of climate-related risks, the confusion between risk and hazard is common. The Oxford Dictionary defines a hazard as a ‘danger or risk’ hereinafter as 'A potential source of danger'. Therefore, it is feasible to use hazard in the sense of a potential occurrence of climate-related events. A risk is therefore associated with probabilities that such hazardous events will occur. However, it is hardly possible to calculate probabilities for the occurrence of climatic hazard events. Therefore, risk assessment in connection with climate information is much more complicated than a risk assessment for an operational procedure. In GIZ and EURAC (2017, p.13), the following conclusion is given:

“Risk is something where the ‘outcome is uncertain’. In a risk assessment, this uncertainty can be addressed in different ways. An explicit evaluation of the likelihood for specific consequences based on an event of defined magnitude, as it is common in a risk assessment on discrete hazardous events

(e.g. Hurricane category 4), is hardly feasible for the risks related to the manifold potential changes in future climate conditions. However, we propose to make the likelihood explicit wherever possible, especially in the selection of hazard indicators. [….]".

Hazard, vulnerability, and exposure are crucial factors in a risk assessment. However, the risk assessment in OPERANDUM needs proper definitions of these terms. To use the same interpretation of the terms throughout the OPERANDUM consortium, an OPERANDUM-Glossary is currently under construction. For the glossary, the known definitions mainly from latest IPCC reports, such as the IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels (SR1.5, released 2018) and the IPCC Fifth Assessment Report (AR5, released 2014) are used and adapted - if necessary - so that they are applicable across all OPERANDUM WPs and OALs. The work is in progress, and the agreements reached so far are preliminary. Nevertheless, negotiations in the consortium are currently underway on the following adjustments to the definitions:

*Risk (hydro-meteorological) [taken from: IPCC AR5]*

The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as a probability of occurrence of hazardous events or trends multiplied by the impacts of these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. In OPERANDUM, the term risk is used primarily to refer to the risks of hydro-meteorological hazards for the present and under climate change conditions.

*Hazard [taken from IPCC AR5 and UNISDR Terminology Glossary]*

The potential occurrence of a natural or human-induced physical event or trend or condition that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, environmental resources and social and economic disruption.

*Exposure [taken from IPCC AR5]*

The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected. Exposure needs to be linked with duration, e.g. extreme precipitation has impacts that increase with exposure of a vulnerable object.

*Vulnerability [taken from IPCC AR5]*

The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

*What does it mean for OPERANDUM?*

- With regards to risk management, climate change is nowadays established in the risk definition.

– Until now, the discussions in the OPERANDUM consortium have shown that the current definitions of risk may need to be adapted to fulfil the OPERANDUM objectives. This is a work in progress under WP5.

**Table 6**: Different definitions of 'Risk' and 'Disaster Risk' used within the two interest groups UNISDR and IPCC in temporal comparison.

| Source | Term |
|---|---|
| IPCC SR1.5 2018 (IPCC, 2018) | *Risk*<br>The potential for adverse consequences where something of value is at stake and where the occurrence and degree of an outcome is uncertain. In the context of the assessment of climate impacts, the term risk is often used to refer to the potential for adverse consequences of a climate-related hazard, or of adaptation or mitigation responses to such a hazard, on lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure. Risk results from the interaction of vulnerability (of the affected system), its exposure over time (to the hazard), as well as the (climate-related) hazard and the likelihood of its occurrence. |
| UNISDR 2017 | *Disaster Risk*<br>The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. |
| IPCC AR5 2014<br>i.e. Version: IPCC, 2014: Annex II: Glossary of Climate Change 2014: Impacts, Adaptation, and Vulnerability, Part B. | *Risk*<br>The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values.<br>Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. In this report, the term risk is used primarily to refer to the risks of climate-change impacts. |
| IPCC SREX 2012 (IPCC, 2012) | *Disaster risk*<br>The likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery. |
| UNISDR 2009 | *Risk*<br>The combination of the probability of an event and its negative consequences. |

## 4.3 General steps towards a climate risk assessment

Climate risk assessments are widely used to identify potential measures for risk reduction as well as for finding appropriate adaptation measures for a region against climate change. With so many varying definitions of risk and related terms (see above), there is also a variety of guidelines with different methodologies aiming to address them (e.g. GIZ 2014, Buth et al, 2017, etc.)

Within OPERANDUM, the challenge is to tailor the climate risk assessment linked to NBS, the OALs and also to account for climate change. WP 6 in OPERANDUM is especially dedicated to analyse the exposure, vulnerability and risk of coupled social-ecological systems to hydro-meteorological hazards within the OALs. The first Deliverable 6.1 'Review on vulnerability and risk assessment specific to NBS' provides an overview of vulnerability and risk assessments specifically linked to NBS assessments based on a structured literature review of peer-reviewed scientific publications, including a review of existing grey literature as well of risk assessments that were previously conducted in the OALs.

Recently, A guideline for a standardised risk assessment based on the IPCC concept of risk was developed: the so-called 'Vulnerability Sourcebook' (GIZ 2014) and the accompanying 'Risk Supplement to the Vulnerability Sourcebook' (GIZ and EURAC, 2017) was published by the 'Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and developed jointly by Adelphi and Eurac Research, Institute for Earth Observation (EURAC) Research. These guidelines have been applied in more than 20 contexts and have been successfully adjusted to Ecosystem-based Adaptation (EbA) (GIZ, EURAC & UNU-EHS, 2018).

Each risk assessment takes place in a unique setting and serves specific purposes. All risk assessments have in common that they need to define the scope of the assessment, the possible risks addressed and how to quantify the risk and present the results. The Vulnerability Sourcebook and further publications (GIZ 2014; GIZ and EURAC; 2017; GIZ; EURAC & UNU-EHS; 2018) describe in detail the modules for a standardised climate risk assessment from the preparation to the presentation of the risk assessment. These nine modules allow a straightforward, guided and profound assessment of the risks for a region of interest. Each module consists of a set of steps (see Table 6).

The presentation of the outcomes of the risk assessment is typically done in a risk matrix with a 'traffic light'-colour scale (green, orange, red) representing the levels of the low, medium and high risk (see e.g. EEA 2015). However, there are many possibilities on how to illustrate the findings of a risk assessment regarding colour, visual designs and presentation. A decision that needs to be taken is if only the aggregated risk factor will be displayed or if the presentation should include the results of the three components (hazard, vulnerability, exposure) as well as the composite risk indicator. However, how to visualise and present the output of the risk assessment in terms of graphical presentation, content, style and language is determined by what is most appropriate for the target audience.

*What does it mean for OPERANDUM?*

- Each risk assessment is unique and tailored for a certain region and serves specific purposes;
- Risk assessments need to address the three dimensions: hazard, exposure, vulnerability and it's up to the target group how the assessment is visualised, e.g. in a risk matrix;
- A risk assessment following the presented modules can serve not only to better understand the risks a region is facing, but can also help to identify potential NBS to reduce potential risks.

Table 7: Modules including step-by-step guidance for a standardised climate risk assessment (taken from GIZ (2014), GIZ and EURAC (2017), GIZ, EURAC & UNU-EHS, (2018) with slight changes).

| List of modules for climate risk assessment | List of steps of each module |
|---|---|
| *Module 1*: Preparing the risk assessment<br>→ This module aims to prepare the risk assessment, i.e. to assess the initial situation of the analysis, to define objectives and the scope of the climate risk assessment. An additional part is to plan the implementation of the risk assessment. | Step 1: Understand the context of the risk assessment<br>Step 2: Identify objectives and expected outcomes<br>Step 3: Determine the scope of the risk assessment<br>Step 4: Prepare an implementation plan |
| *Module 2*: Developing impact chains<br>→ This module helps to define the risks addressed in the risk assessment and for that, an impact chain will be developed. This exercise helps to better understand the cause-and-effect relationships determining the risk of concern. Impact chains can also support the brainstorming on potential NBS to reduce the hydro-meteorological risks. | Step 1: Identify climate impacts and risks<br>Step 2: Determine hazard(s) and intermediate impacts<br>Step 3: Determine the vulnerability of the social-ecological system<br>Step 4: Determine exposure of the social-ecological system<br>Step 5: Brainstorm adaptation measures/NBS solutions (optional) |
| *Module 3*: Identifying and selecting indicators for risk components<br>→ This module is dedicated to select indicators to quantify of the factors determining the risk. | Step 1: Selecting indicators for hazards<br>Step 2: Selecting indicators for vulnerability and exposure<br>Step 3: Check if you have your indicators are specific enough<br>Step 4: Create a list of provisional indicators for each risk factor |
| *Module 4*: From data, acquisition to risk assessment<br>→ This module is about how to acquire, review and prepare the data you need. | Step 1: Gather your data<br>Step 2: Data quality check<br>Step 3: Data management |
| *Module 5*: Normalisation of indicator data<br>→ This module explains how to normalise the different indicator datasets into unitless values with a scale between 0 and 1. | Step 1: Determine the scale of measurement<br>Step 2: Normalise your indicator values |
| *Module 6*: Weighting and aggregating indicators<br>→ This module shows how to weigh indicators and aggregate individual indicators to the three risk components. | Step 1: Weighting indicators<br>Step 2: Aggregating indicators |
| *Module 7*: Aggregating risk components to risk<br>→ This module is proposing one method for aggregating the three risk components to a one composite 'risk indicator'. | Step 1: Aggregating the three risk components (hazard, exposure, vulnerability) to a one composite 'risk indicator'.<br>Comment: the aggregation of the three risk components to an overall risk is done here in one step by applying an arithmetic aggregation method. A disadvantage is a lack of control over the combined effects. However, it is still possible to choose an evaluation matrix with risk class values between very low to very high by for example showing the degree of hazard (y-axis), vulnerability (lower x-axis) and exposure (upper x-axis) at different axes. |
| *Module 8*: Presenting and interpreting the outcomes of the risk assessment<br>→ This module describes ways how to summarise and present results of the risk assessment. | Step 1: Plan your climate risk assessment report<br>Step 2: Describe your assessment<br>Step 3: Illustrate your figures |
| *Optional: Module 9*: Identifying adaptation options<br>→ This module shows how climate risk assessment can support the identification of adaptation options. In the case of GIZ, EURAC & UNU-EHS (2018) this dedicated to ecosystem-based adaptation (EbA). However, this step can also be extended to find NBS as part of the overall adaptation strategy of a region. | Step 1: Identifying potential co-benefits<br>Step2: Identifying potential unintended consequences or drawbacks |

## 4.4 Robustness of projected climate changes: a categorisation of expert judgement to represent confidence levels

Many risk assessments claim to account for climate change (see for e.g. Module 2 above). Most often the information about changes in the climate is anticipated and/or are derived from global change information reports (GIZ, EURAC & UNU-EHS, 2018). However, the global climate has different local effects (e.g. coastal community faces different climatic problems than a mountain community). Therefore it is necessary to develop user-tailored solutions for the individual need for climate information. Only very few guidelines for climate risk assessment (e.g. Buth et al, 2017) explicitly call for the analysis of climate projections tailored to the risk assessment and region of interest.

In order to understand how the climate may change in a region, it is necessary to evaluate regional climate projections for the region under consideration. This analysis is a basis that needs to be considered at the different steps of a climate risk assessment. Already at the preparatory step (see Module 1 above) for determining the scope of the assessment and objectives, it can be helpful to consider local information about climate change in a region. This will give an indication of how much a region may be affected by climate change. In this context, it is also necessary to determine which methods and tools should be used. This is essential for analysing the possible impact chains for an area in a meaningful manner (see Module 2 above). A later step of the climate risk assessment is dedicated to data acquisition (Module 4 see above). At this stage, it is necessary to collect the climate data in addition to other data sets which are needed and appropriate for the risk assessment. Depending on the geographical scope of the area under review, regional climate datasets may be available. There is often a lack of local climate information. It is essential that the most suitable data sets (preferably regional climate projections) are selected, analysed and provided with robustness information.

### 4.4.1 Analysis of data on climate change and the meaningfulness of the results

For the analysis of the climate projections, it is absolutely vital to use an ensemble of climate model simulations. The challenge in analysing climate projections is to provide not only the mean projected climate changes but also information on the robustness of the results. The terms ‘uncertainty’ and ‘robustness’ and their underlying concepts are firmly anchored in research, but scientists often encounter difficulties when communicating them. Various approaches of ensemble compositions, model output statistics and visualization methods have been developed. Here we present a selection, separately for large-scale and local analysis of climate projections.

### 4.4.2 Selected presentation of robustness for large regional to global analyses

To obtain a first glance about the expected changes of the climate in the region, a large-scale spatial presentation of climate change including a robustness assessment can be useful. As an example, the European FP7 project IMPACT2C investigated the impacts of a 2°C global warming. Therefore, robust changes were requested for the accounted climate indicators such as mean and extreme temperature, precipitation, wind and surface energy budgets. By using a simple metric of the agreement of the individual model simulations with respect to the direction of the predicted change an indicator of robustness is achieved. This is represented by a number of models which agree on the sign of the change for a particular climate change signal (Preuschmann et al, 2017).

Another way of presenting the robustness of results can be found in the summary for policymakers of the Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC AR5) presenting mean projected climate changes from an ensemble of global climate change simulations. The results are presented in maps with stippling and hatching indicating the level of robustness of the results. Stippling represents where the model agreement is large and where the natural internal variability is small compared to the multi-model mean change and hatching of regions where the natural internal variability is large compared to the multi-model mean change (IPCC AR5).

Maps overlaid by hatching or stippling can be difficult to read. It is indeed a challenge to reduce the complexity of such figures to make them understandable also for non-climate experts while keeping at the same time the robustness information. Here, we present a method called 'Climate Signal Maps' (Pfeifer et al. 2015) to derive and display the robustness of climate changes projected by an ensemble of regional climate change simulations. It can be used to identify regions where robust climate changes can be derived from an ensemble of climate change simulations. Robustness is in this case defined as a combination of model agreement and the significance of the individual model projections. The Climate Signal Maps do not show all information available from the model ensemble but give a condensed view to be useful for non-climate scientists who have to assess climate change impact during the course of their work. As a consequence, the robustness of the model results is tested for one direction of change which is assumed to be the one with the largest importance. The ensemble spread is not visualised in this method. Since the goal of the Climate Signal Maps is to reduce complexity, only values with highest priority and interest can be displayed at once.

The climate model output is tested for robustness in two ways:

- First, it is assessed how many model simulations show the same sign regarding the projected change (increase or decrease). This case is only fulfilled if at least 66% of all simulations agree in the direction of change.
- Second, it is investigated whether or not the future distribution of a specific parameter significantly differs from the distribution for present-day climate. The significance is analysed using the U-test, because, (a), by using ranks, the test attains robustness versus possible distributional shapes of the sample data, which also makes it applicable for right-skewed distributions, such as for precipitation and, (b), it is intuitively comprehensible and widely used in many scientific disciplines. It is very important, however, to ensure the independence of the data in one sample. This has to be guaranteed for the significance test to function. To establish significance across an ensemble, at least 66% of all simulations have to show significant change.

The results of the robustness tests are displayed in maps. Different colours present the signal strength in case it is robust, e.g.: green – small changes, orange – medium changes and red – large changes, and grey for areas without a robust signal (see Figure 4). The threshold used to define a small, medium and large change have to be adapted according to each user individually. Regions in white are those areas in which the climate ensemble would project no change or the opposite direction of the climate change signal. The definition of the ranges assigned to each colour has a sustained impact on how the changes are perceived, so this is yet another aspect worthy of thorough discussion with the intended user.

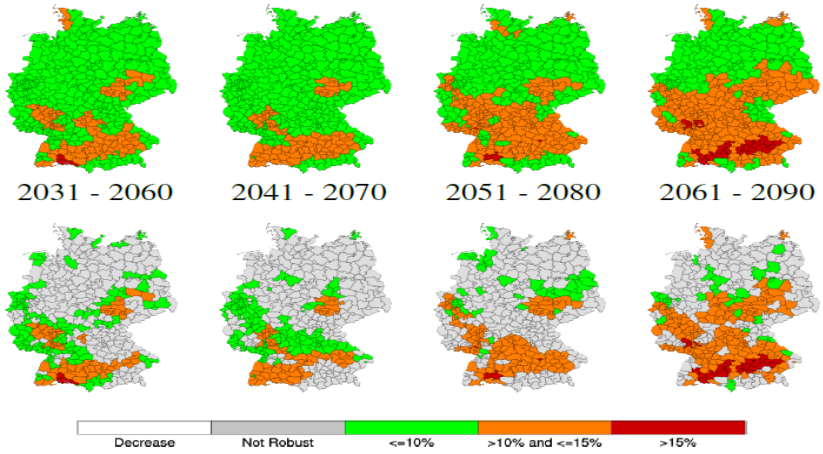


Figure 4: Example for GERICS Climate Signal Map, published in Pfeifer et al. (2015). The figure shows the increase in winter precipitation (in %) for four different time periods in comparison to the reference period 1971-2000. At the top row: no robust testing was applied to the data. Bottom row: robustness testing were applied. Data basis: Ten regional climate model simulations from the EURO-CORDEX RCP4.5 simulations. For more information see Pfeifer et al. (2015).

### 4.4.3 Presentation of robustness for regional to local analysis

The heart of a climate risk assessment is to identify which major climate impacts and risks affect the system of concern. For this step local climate change information is crucial. However, local information about climate change without information about the reliability of the analysis of climate projections is of less use. Therefore, the local climate change information seeks an easily understandable way of communicating the results of the robustness assessment. When it comes to the analysis of projected climate change on a local scale, maps are not a useful tool for visualising the results of the robustness assessment. The presentation of the robustness assessment needs to be adapted for local purposes. One way to do this is to provide each calculated climate indicator with a symbol summarising how robust the results are. Here we present a categorisation that transforms the robustness assessment of the Climate Signal Maps into symbols that can be used for presenting the expert judgement on the local scale.

We propose six categories to present the expert judgment of the robustness of the results (see Figure 5):

- Similar to the Climate Signal Maps, if more than 66% of the underlying climate projections show a statistically significant increase or decrease, the change is robust (category: ‘increase’ or ‘decrease’).
- If the majority of the models show no statistically significant changes, but a clear direction, there is a tendency to decrease or increase (category ‘tendency towards an increase’ or ‘tendency towards a decrease’).
- If the climate models show both an increase and a decrease in roughly equal proportions, there is no clear change (category’ ‘no clear change’).
- If the majority of the simulations project non-significant increase or decrease with no preferred direction of change, the results are classified as ‘no changes’.

In contrast to the Climate Signal Maps, these six categories allow for presenting both directions of change of the climate projections: increase and decrease, and the categories also take into account the case when there is no clear change. The categories are illustrated by arrows (see Figure 5). The

first group of three symbols is fully coloured and as they present significant results which can show either a projected increase (arrow showing up), projected decrease (arrow showing down), or 'no clear changes' (arrows pointing up and down). The other group of symbols contains the same type of illustration but the symbols are transparent because the majority of the simulations produce non-significant results. The results can, therefore, be classified into a 'tendency towards an increase', 'tendency towards a decrease' and 'no changes'.

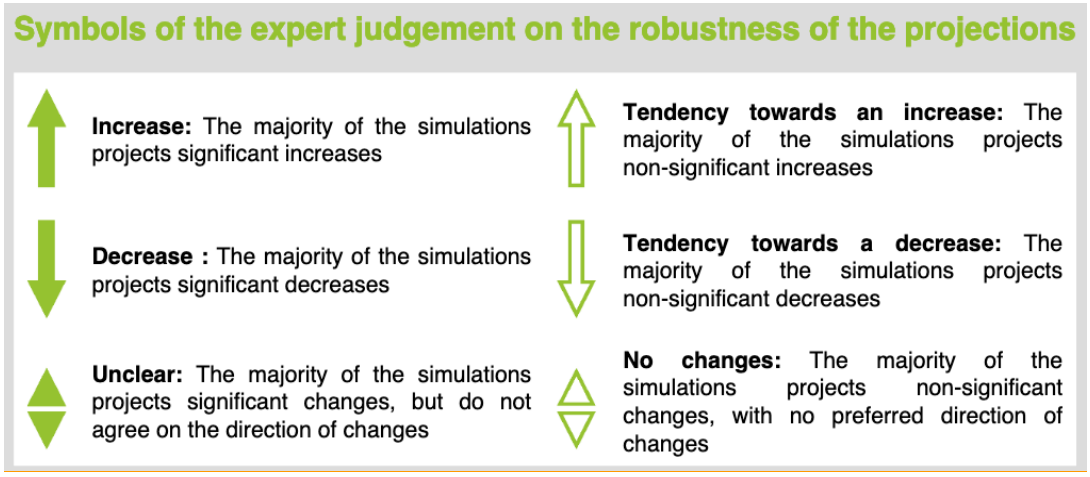


Figure 5: Categories with symbols indicating the expert judgment on the robustness of the projections.

Following the robustness assessment of Pfeifer et al. (2015), the statistical significance of the simulated changes of each simulation is calculated and the agreement of the simulations in the direction of the projected changes. The statistical significance is determined based on the Mann-Whitney-Wilcoxon-Test and the U-Test. The null hypothesis is tested that the distribution of a climate indicator for today's climate simulated by an individual climate model deviates from the projected distribution of the climate parameter for future climate conditions. It is good practice for the presentation of the robustness of climate projections to provide, in addition to the mean change of a climate indicator, also the range of the ensemble (see e.g. EURO-CORDEX guidelines for 'Guidance for EURO-CORDEX climate projections data use', available online).

Before starting the analysis of projected climate changes for a climate risk assessment, it is necessary to distinguish between a hazard that is a climate event and a climate-related direct physical impact such as floods. A climate event, e.g. a heavy rain event, may lead to a direct physical impact, e.g. a flood, causing a sequence of intermediate impacts, which finally lead to the risk (GIZ and EURAC, 2017). In the context of a climate risk assessment presented above, it is assumed that a hazard represents an external climate signal, which does not depend on exposure or vulnerability. For the analysis of the projected climate change, it is necessary to determine the climate signal that poses a hazard. For example in the case of a flood, it is necessary to identify the climate event leading to this direct physical impact. The identification of climate events is the basis for the analysis of the climate projections to determine how a region might be affected by climate change.

The first steps towards the analysis of the local climate change information tailored to each OAL have been undertaken. In a survey, initiated by WP5, information was collected on which climate indicators can be used to characterise the climate events for each OAL. A climate indicator helps to understand the past and current climate events and climate changes. It is a calculated value that can be used to describe the state and the changes in the climate system. For example, the climate indicator 'Hot days' is defined as the number of days per year with daily maximum temperatures of at least 30°C. A group of consortium members - who are dealing with climate information and the analysis of climate data in the project - has built a task-force to ensure the harmonisation of climate data analysis within OPERANDUM. The current outcome is that we have the first set of climate indicators that are of interest for each OAL: seven temperature-related, six precipitation-related, three others. The regional climate projections will be analysed for this set of climate indicators and each climate indicator will be provided with a robustness assessment according to the proposed categorisation (see Figure 5). The full analysis of the regional climate projections tailored for each OAL will be reported in Deliverable 5.1 'Report on baseline weather and future climate conditions for all OAL sites.', that is due in September 2019.

*What does it mean for OPERANDUM?*

- Climate risk assessment needs to take into account local climate change information including the results of a robustness assessment;
- The assessment of the robustness of project climate changes is based on statistical methods and expert judgment;
- We propose a categorisation of the expert judgment for the robustness of climate change information into the following categories:
    - Increase
    - Decrease
    - No clear change
    - The tendency towards an increase
    - The tendency towards a decrease
    - No changes

This categorization corresponds to the part of a risk matrix that requires the occurrence probabilities of hydro-meteorological events. A quantified description of the probability for the climate change signals is not possible. By using an ensemble of regional climate model simulations and calculating a confidence level, it is possible to present and communicate in a scientifically sound and state-of-the-art way how the climate may change.

- For each OAL, the identification of the climate events leading to a hazardous situation is the basis for analysing the future climate conditions each OAL may be facing.

# 5 Critical evaluation of existing policies and guidelines on NBS

This section reports on the evaluation and mapping of policies and guidelines on NBS.

This analysis contributes to WP1 objectives (1) to map existing policies to fill in data gaps, (2) to determine a matrix to fill in data gaps, and (3) to analyse both enabling factors and potential barriers towards the implementation of NBS in the OALs. The primary focus is on, but not strictly limited to, European policies, frameworks and guidelines, as this is where most of OPERANDUM OALs are located. Overall, this evaluation contributes to the achievement of OPERANDUM specific objectives SO3 (improving NBS acceptance) and SO5 (strengthening NBS policies adoption). Simultaneously, this also helps with (1) identifying and assessing barriers related to their social and cultural acceptance and policy regulatory frameworks, proposing ways to overcome them; and (2) developing methodologies, tools and practices enabling the replication and upscaling of NBS.

It should be noted that the analyses slightly vary from the DoA description. In particular, less focus was paid to "NBS policies related to bioengineering practices". Although bioengineering techniques is nowadays highly encouraged in the European Community and in many countries world-wide (often promoted through various incentives such as the European Commission, 2013), it is seen as a technique part of NBSs. This statement is supported by the view of the International Union for the Conservation of Nature (IUCN). IUCN is proactively endorsing the use of nature-based solutions for disaster risk reduction (EcoDRR) and includes bioengineering as a technique to protect against natural hazards (Furuta et al., 2016; Renaud et al., 2016).

After analysing available policy guidelines and frameworks, it was concluded that focussing particularly on bioengineering is not feasible at this stage, as it is minimally referred to in policy documents (assumingly because it is a fairly specific and recent technique, and thus not yet included often). Therefore, for this research, the same definition has been adopted as IUCN's, where bioengineering is seen as one technique of many for the development of NBSs rather than a NBS in its own right. Consequently, the focus of this analysis will remain on hydro-meteorological NBS in general, instead of more specifically focussing on bioengineering.

## 5.1 Link with international and European policies

In 2015, several major international UN agreements were made, all of significant importance for the development of the OPERANDUM project, including the 2030 Agenda for Sustainable Development, the Sendai Framework for Disaster Risk Reduction, and the Climate Change Agreement, also known as the Paris agreement (Kelman, 2017). These frameworks are also significantly intertwined, as climate change has a significant influence on disaster risks, which in turn affects the ability to achieve sustainable development. They do not only recognize, but also support each other.

OPERANDUM has been developed to answer a call by the European Union's Horizon 2020 "Protection of the environment, sustainable management of natural resources, water, biodiversity and ecosystems", aiming to find solutions contributing to climate change adaptation, disaster risk reduction, and sustainable development. Therefore, the scope and related services of OPERANDUM are considered as a great contribution to various goals and targets of the before mentioned (and other) main agreements/frameworks. How exactly, will be illustrated in the following sections of the report.

## 5.2 Link with Sustainable Development Goals

The 2030 Agenda for Sustainable Development was adopted by all United Nations Member States in 2015. It aims to provide a blueprint for peace and prosperity for people and the planet, now and into the future. The 17 Sustainable Development Goals are the main outcomes of this agenda, which are an urgent call for action by all countries – developed and developing – in a global partnership. The focus on DRR, Climate Change and NBS is highly present in the 2030 Agenda for Sustainable Development. Consequently, OPERANDUM is contributing to obtaining the Sustainable Development Goals (hereafter SDG) in various ways, both directly and indirectly. They are built on decades of work by global countries and the UN, starting from the Earth Summit in Rio de Janeiro, Brazil in 1992.

In *deliverable 7.1* (Catalogue of NBS Including Location, Classification and Basic Information), an overview of all the SDG directly related to OPERANDUM was already listed. Here, the most relevant SDG and targets to OPERANDUM will be highlighted, namely Goals 6, 13 and 15.

Goal 6 focusses on water problems, this directly relates to OPERANDUM's focus on hydro-meteorological risks. The strongest references to NBS, disaster risk, capacity building and climate change are made in the following targets:

- Target 6.6: By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes;
- Target: 6.a By 2030, expand international cooperation and capacity-building support to developing countries in water and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies;
- Target: 6.b Support and strengthen the participation of local communities in improving water and sanitation management.

A particular and strong reference is made in Goal 13, which urges action to combat climate change and its impacts by strengthening resilience and adaptive capacity to climate-related hazards and natural hazards in all countries. Here, three targets make a direct reference to one or more of OPERANDUM's keywords:

- Target 13.1: Strengthen resilience and adaptive capacity to natural and climate-related hazards in all countries;
- Target 13.2: Integrate climate change measures into national policies, strategies and planning;
- Target 13.3: Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.

The strongest contribution of OPERANDUM will be to Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. Especially in:

- Target 15.1: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.
- Target 15.3: By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation neutral world.

## 5.3 Link with Sendai Framework

Being the successor instrument to the Hyogo Framework for Action 2005-2015, the Sendai Framework 2015-2030 has been adopted by United Nations (UN) Member States at the third UN World Conference on Disaster Risk Reduction on March 2015. Endorsed by the UN General Assembly, it is a voluntary instrument that provides a global approach to disaster risk management policy and operations. It represents a shift in focus from disaster management to disaster risk management, which means shifting from developing response measures to developing minimizing/prevention measures. The overall goal is to "Prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience" (UNISDR, 2015). For this purpose, the Sendai Framework defined four Priorities for Action and seven Targets (UNISDR, 2015). While contributing (in some way) to all four Priorities for Action, OPERANDUM meets three priorities specifically: Priority 1 – Understanding disaster risk; Priority 2 – Strengthening disaster risk governance to manage disaster risk; and Priority 3 – Investing in disaster risk reduction for resilience. Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction. For priority 1, OPERANDUM works on increasing the understanding and assessing the level of exposure, vulnerability and risk of coupled social-ecological systems (SES) in the proposed OALs. This in view of constructing a robust framework for their upscaling, replication and further exploitation. This objective has been described in WP6.

As far as priority 2 is concerned, OPERANDUM contributes to this in two manners, captured in WP 8 and 7, respectively. The first manner in which it contributes is through the creation of a framework for cooperation between global and EU policymakers, national and regional stakeholders and the civil society by emphasizing structured forms of information exchange for mutual benefits. In particular, here OPERANDUM will (1) foster the implementation of major international frameworks through knowledge exchange and understanding the role of NBS in general and in climate change adaptation, (2) mainstream NBS in land use planning, landscaping and territorial policies through the provision of appropriate tools and best practices to assist, among others, decision makers and competent authorities.

The second way OPERANDUM contributes to priority 2 is with the development of the GeoIKP platform. Its objective, in line with the EU strategy in the single market and digital industry, is to provide lead-users (scientists, technical users) and end users (industry, public authorities and citizens) with a flexible, interoperable, user-friendly and open platform. It will include easy and controlled online access to facilities, resources and collaboration tools for the assessment of NBS and facilitation tools for its exploitation and market uptake. Focussing on Priority 3, the identified need to invest in disaster risk reduction for resilience, take action in the demonstration of attuned NBS based risk reduction in the seven OALs exposed to different hydro-meteorological hazards. This directly contributes to the "disaster risk prevention and reduction through structural and non-structural measures" as described in priority 3. A comprehensive framework for the comparison of various NBS for risk prevention and reduction solutions will be developed within OPERANDUM. This objective has been captured in WP3.

## 5.4 Link with Paris Agreement

The Paris Agreement for Climate Change, under the UNFCCC, is the successor to the Kyoto Protocol. During COP21 in Paris, 2015, this legally binding agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future, was reached by parties of the United Nations Framework Convention on Climate Change (UNFCCC). The Paris Agreement – for the first time – brought together all nations into a common cause to undertake actions to combat climate change. The central aim is to strengthen the global response to the threat of climate change by minimizing the global temperature rise, while strengthening the ability of countries to deal with the impact of climate change, including developing countries (UNFCCC, 2019). Most important for OPERANDUM, the Agreement emphasises the role of ecosystems in climate change mitigation and adaptation. It calls on countries to conserve and enhance natural carbon sinks and reservoirs of all types – forests, oceans as well as other terrestrial, coastal and marine ecosystems. Moreover, research by the Nature Conservancy and 15 other institutions (Griscom et al., 2017; The Nature Conservatory, 2017), demonstrates that NBS provides up to 37% of the emission reductions needed by 2030 to keep global temperature increase under 2$^{o}$C. This firmly links the Paris Agreement with the OPERANDUM project.

## 5.5 Global Frameworks and Organisations

On a global level, there are several frameworks related to the implementation of the SGD, Sendai Framework, the Paris Agreement and OPERANDUM's key objectives. A selection of the main related legal frameworks is listed in Table 8. In Table 8, a selection of the main related organisations is listed.

**Table 8**: Overview of a selection of main legal frameworks related to most relevant SDG's, Sendai Framework Priorities (SFP) and Paris Agreement (PA) for OPERANDUM.

| Frameworks | SDG 6 | SDG 13 | SDG 15 | SF P1 | SF P2 | SF P3 | PA | OPERANDUM |
|---|---|---|---|---|---|---|---|---|
| Sustainable Development Goals (UNDP, 2015) | - | - | - | x | x | x | x | x |
| Sendai Framework (UNISDR, 2015) | x | x | x | - | - | - | x | x |
| Paris Agreement (UNFCCC, 2015) | | x | x | | x | x | - | x |
| Ramsar Convention (Ramsar Convention, 1994) | x | | x | x | | x | x | x |
| Convention on Biological Diversity (CBD, 1992) | x | | x | | | x | x | x |
| Water Convention (UNECE, 1992b) | x | x | x | x | | | x | x |
| United Nations Convention to Combat Climate change (UNFCCC, 1992) | | x | x | | | x | x | x |
| United Nations Convention to Combat Desertification (UNCCD, 1994) | | | x | x | | x | x | x |
| Espoo Convention (UNECE, 1992b) | | x | x | | | | x | |
| Convention on the Transboundary Effects of Industrial Accidents | x | x | x | | | | | |

Table 9: Overview of a selection of main organisations related to the most relevant SDG's, Sendai Framework Priorities (SFP) and Paris Agreement (PA) for OPERANDUM.

| Organisations | SDG 6 | SDG 13 | SDG 15 | SF P1 | SF P2 | SF P3 | PA | OPERANDUM |
|---|---|---|---|---|---|---|---|---|
| Partnership for Environment and Disaster Risk Reduction (PEDDR, 2016) | x | x | x | x | x | x | x | x |
| The International Union for Conservation of Nature (IUCN, 2017) | x | x | x | | | x | x | x |
| UN Environment Programme (UNEP, 2018) | x | x | x | | | x | x | x |
| Stockholm Environment Institute (SEI, 2015) | x | x | x | | | x | x | x |
| United Nations Development Programme (UNDP, 2018) | x | x | x | x | | x | | x |
| The International Institute for Sustainable Development (IISD, 2018) | x | x | x | x | | x | | x |
| The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2016) | x | x | x | | | x | x | x |
| European Union | x | x | x | x | x | x | x | x |
| World Meteorological Organisation (WMO, 2015) | x | x | x | x | | x | x | x |
| UN Water (UN water, 2014) | x | x | x | | | x | | x |
| The United Nations Economic Commission for Europe (UNECE, 2016) | | x | | x | | x | x | x |
| The Global Climate Change Alliance Plus (GCCA+, 2015) | | x | | | | x | x | x |
| United Nations Institute for Disarmament Research (UNISDR, 2017) | | x | x | x | x | x | x | x |

## 5.6 NBS Related Legal Frameworks, Protocols, Guidelines and Policies on EU Level

In this section, the EU level frameworks, protocols, guidelines and policies are assessed in more detail. In Table 9, the main EU protocols, frameworks, guidelines, action plans, and policies have been recorded and analysed on references to or mentions of specific hydro-meteorological hazard and NBS in general. The source of the document has also been recorded which will contribute to the geo-catalogue developed in WP7.

**Table 10**: Overview selection of main EU protocols, frameworks, guidelines, action plans, and policies in place regarding NBS for disaster risk reduction for hydro-meteorological hazards, environmental management and climate change adaptation and mitigation (OPERANDUM). For each document it has been noted down which hazard it focuses on specifically or whether it focuses on hydro-meteorological risks at all ("NA" = no mention of hydro-meteorological risks, "0" = no focus on one specific hydro-meteorological risk), to what extent it refers to NBS ('0' = no mentioning of NBS, '-' weak or indirect reference to NBS, '+' = moderate reference to NBS, '++' = strong reference to NBS), while in the last column the source has been recorded.

| EU Legislations | Hydro-meteorological hazard | Reference to NBS | Source |
|---|---|---|---|
| Action Plan on the Sendai Framework | 0 | ++ | https://ec.europa.eu/echo/sites/echo-site/files/1_en_document_travail_service_part1_v2.pdf |
| Key European action supporting the 2030 Agenda and the Sustainable Development Goals | 0 | ++ | https://ec.europa.eu/europeaid/sites/devco/files/swd-key-european-actions-2030-agenda-sdgs-390-20161122_en.pdf |
| The EU Strategy on Green Infrastructure | 0 | ++ | https://eur-lex.europa.eu/resource.html?uri=cellar:d41348f2-01d5-4abe-b817-4c73e6f1b2df.0014.03/DOC_1&format=PDF |
| The EU Strategy on adaptation to climate change | NA | ++ | https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0216:FIN:EN:PDF |
| The Water Framework Directive (2000/60/EC) | Floods, Droughts, nutrient and sediment loads | 0 | [https://eur-lex.europa.eu/resource.html?uri=cellar:5c835afb-2ec6-4577-bdf8-756d3d694eeb.0004.02/DOC_1&format=PDF |
| The Groundwater Directive (2006/118/EC) | NA | - | https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:372:0019:0031:EN:PDF |
| The Floods Directive (2007/60/EC) | Floods | - | https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007L0060&from=EN |
| Common Implementation Strategy For The Water Framework Directive (2000/60/Ec) And The Floods Directive (2007/60/EC) | Floods | + | http://ec.europa.eu/environment/water/water-framework/objectives/pdf/Work%20Programme%202013-2015.pdf |
| Strategic Environmental Assessment Directive (2001/42/EC) | Droughts | 0 | https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32001L0042&from=EN |
| Marine Strategy Framework Directive | NA | + | https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0056&from=EN |
| 2012 Blueprint to safeguard Europe's water resources | NA | + | https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0673&from=EN |
| Roadmap to a Resource Efficient Europe | NA | + | https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0571&from=EN |
| EU Biodiversity Strategy to 2020 | 0 | + | https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0244&from=EN |
| The ICZM Protocol | Floods, droughts | - | https://www.pap-thecoastcentre.org/pdfs/Protocol_publikacija_May09.pdf |
| The Barcelona Convention | Coastal erosion | 0 | https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010D0631&from=EN |
| United Nations Convention To Combat Desertification | Droughts | - | https://www.unccd.int/sites/default/files/relevant-links/2017-01/UNCCD_Convention_ENG_0.pdf |
| EU Work Programme 2018-2020: 12. Climate action, environment, resource efficiency and raw materials | 0 | ++ | http://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-climate_en.pdf |
| EU Biodiversity Strategy | 0 | ++ | https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0244&from=EN |

As can be seen in Table 10, the extent of focusing on specific hydro-meteorological hazards varies among the documents. The distribution is fairly even among the three groups: No mention = 5, not focused = 6, focussed = 7. Moreover, reference to NBS (and related terms) varies significantly across the organizations, frameworks and policies. Only some recent policies directly refer to NBS, while most (50%) only have a weak to moderate reference. The remaining 17% do not refer to NBS at all. This is partly because most policies date back to a time when NBS was yet a poorly understood concept. Almost all newer documents do contain references to NBS. Therefore, the documents and guidelines in which significant improvement can be made in terms of the involvement of NBS, are the ones that focus on (a specific) hydro-meteorological risk without yet referring to NBS as a way of reducing disaster risks. This would be a relatively simple but very effective improvement to be made, especially when older guidelines/policies are already in the process of being updated in regards to the most recent scientific recommendations and technical innovations.

OPERANDUM addresses the need of enhancing policies with regards to in particular two specific objectives, namely; SO3 (OPERANDUM will improve the acceptance of NBS based implementation) and SO5 (Strengthening the adoption of NBS in national policies for DRR land planning and European Innovation Partnerships on Water to address major European and global water challenges). Throughout the entire OPERANDUM project's duration (and beyond), several actions are foreseen to achieve these objectives within most of WPs.

# 6 Early overview of market opportunities

Some NBS practice can have the same engineering results like the grey solutions (e.g., resistance against flood, soil stability) but have a better capacity to adapt to climate change effects (e.g., temperature variation, irregulars precipitations, and etc.). Soil and water bioengineering is a specific discipline in the engineering that promotes the use of NBS to mitigate the current hydrometeorological risk. This discipline has a big potential to expand the business but users need further knowledge and formation (design, construction) to select NBS instead of classical grey protection measurements. This section will:

- Assess the specific skills people are lacking (construction direction, ability to understand particular circumstances, ability to check materials and quality, the issue regarding safety and health control), the preparedness of the enterprises to face with daily bioengineering challenges;
- To what extent the classical stages in soil and water bioengineering process are actually carried out by enterprises.

## 6.1 Assessment of current bioengineering challenges

NBS are gradually entering in all the civil, gardening and conservation work. The public administration is starting to invest in NBS in front of the classical solutions because of their multiple benefits like the reduction of the quantity of CO2, more job opportunities, energy saving, low maintenance and the work of primary products (less quantity of materials). However, the use of NBS still being small and have to cope with complexities, uncertainties and trade-offs, like the lack of preparedness and specific skills from people and enterprises to face daily bioengineering challenges. That is why OPERANDUM has to promote these solutions to increase their use.

### 6.1.1 Need for a global standard

Without a clear definition and benchmarks that enable effective transfer of NBS approaches from pilot or project scales to significantly larger scales, there is a risk that NBS will remain a general metaphor. Additionally, NBS may stay solely within the conservation sector, thereby marginally contributing to solving societal challenges rather than becoming integral to planning and implementing society's responses to such challenges. Furthermore, if NBS implementation is not guided by robust knowledge and tools, this may pave the way for further overexploitation and unsustainable use of our planet's natural resources. While NBS hold real potential, the absence of comprehensive guidance may promote ill-considered interventions which subsequently fail to deliver. This then further undermines government and investor confidence in NBS.

In this section, we will identify the main gaps that the trade lacks to find solutions and possible actions to have global guidance for the specific skills and preparedness of enterprises. With respect to the constructive stage, the following tables summarize the main gaps so far identified and propose a list of possible solutions, specifically in terms of:

1) Lack of NBS in the planning and design stage of the projects (Table 11);
2) Lack of experience to implement NBS (Table 12); and
3) Absence of strong evidence on NBS (Table 13).

**Table 11**: Assessment of the lack of NBS in the planning and design stage.

| Gap | Causes | Reasons | Main Solutions |
|---|---|---|---|
| Lack of NBS solutions in the planning and design stages of the project | High systematization of classical engineering | Tradition in using classical engineering | Investment in monitoring the NBS |
| | Ease of execution and standard solutions of classical engineering | Less specialization in the NBS sector | Training courses to improve the labour |
| | Lack of information on benefits from executed projects | Lack of dissemination | Meetings, conferences, congress and workshops to disseminate executed projects |
| | NbS application need more detailed design work and is more difficult to use standard solutions | More technical work | Authorities should ask for precise design works to attend their needs |

**Table 12**: Assessment of the lack of experience to implement NBS.

| Gap | Causes | Reasons | Main Solutions |
|---|---|---|---|
| Lack of experience to implement NBS | No traceability between designers and executors | Lack of practical experience | Practical formation to the enterprises |
| | Need of skilled labour | Complexity in the construction stage | Training courses |
| | Absence of comprehensive guidance | Lack of research in the constructive stage of NBS | Protocols, manuals, guidelines etc. |

**Table 13**: Assessment of the absence of strong evidence on NBS.

| Gap | Causes | Reasons | Main Solutions |
|---|---|---|---|
| Absence of strong evidence on NBS | Lack of economic and scientific studies that demonstrate the benefits and co-benefits of NBS | Lack of investment in the sector | More public investment |
| | Lack of case studies with documented implementation phase | Lack of public involvement in management and financing | Share costs and risks between the private and the public sector. |

The above assessment was further refined in order to differentiate between skills that enterprises are lacking and those lacked by the larger community and therefore propose more targeted suggestions for improvement.

**Table 14**: Specific skills lacked by enterprises and workers.

| Lack of specific skills | |
|---|---|
| Enterprises | Workers |
| Lack of capacity to attract clients | Lack of knowledge about NBS |
| Lack of skilled labour | Lack of practical experience |
| Lack of investment in the sector | Lack of understanding the NBS like practical solutions |
| Lack of public helps and fiscal benefits | No traceability between designers and executors |
| Lack of specialization | Lack of studies promoting the benefits of NBS |
| Absence of strong evidence on NBS | Lack of academic knowledge of the benefits of NBS |
| Absence of comprehensive guidance | Lack of standards to follow-up an implementation of NBS |

**Table 15**: Solutions for specific skills lacking in enterprises and workers.

| Solutions for these specific skills | |
|---|---|
| Enterprises | Workers |
| Dissemination of NBS | Training courses |
| Training courses | Minimum qualification to work |
| Promote public investment | - |
| Redaction of protocols, guidelines, etc. | - |

After analysing the specific skills missing and the preparedness of the enterprises (see Figure 14) we can see that there is a clear need of specialisation at the design stage, which means that it must provide the generation of new or updated design tools (see Figure 15) (protocols, manuals, guidelines, websites, software, etc.) that must be accredited, shared and disseminated within the sector.

This new design tools can be shared with training courses organised by the professional organizations, by the universities, by soil and water bioengineering experts (EFIB) and by other institutions. Most frequent events are the following ones:

- Specific and updated university training courses aimed at the postgraduate training level.
- Strong dissemination activity related to the field application of soil and water bioengineering, aiming to inform NGOs, local governments, insurance companies and standardization committees.

Even though most of the companies and professionals are aware they need specific training in this sector to face the daily bioengineering challenges, about the half of them does not know about

training courses in their country. The consequences of that fact are that a big rate of the works has a design stage, but there are many others without a design stage.

### 6.1.2 Investment

The public administration had been spending public money to construct necessary infrastructural works with grey solutions (flood mitigation berms, potable water pipelines and others). Nowadays, the public administration is beginning to invest in NBS to face different hydrometeorological hazards such as slope stabilisation, flooding, atmospheric pollution, stormwater management instead of using the grey solutions. This change is occurring because NBS can solve the same problems and provide multiple benefits like improving the landscape, the health from people etc.

To have an idea of the investment in the sector, nature's contribution to the global economy is worth more than $125 trillion annually (WWF, "Living Planet Report 2018: Aiming Higher", 2018). Building conservation and NBS into projects represents a massive opportunity: from lowering operational costs, to unlocking new revenue streams to increasing customer engagement to delivering public environmental goods.

### 6.1.3 NBS implementation cases

As a good practice and showing the potential benefits and vast applications of NBS, many case studies those implemented NBS have been profiled in the last years (see section3). There are some important investment projects with the use of NBS to mitigate hydrometeorological risks. As an example, here we will discusses the case of green infrastructure for urban resilience in Greece, Athens and Cheonggyecheon Restoration and downtown revitalization in Seoul, South Korea.

*First example: Athens (Greece)*

*Types of implemented NBS*: Green corridors, planting of trees, shrubs parks and urban gardening/farming, resident planting, green roofs, green walls, greening of grey surfaces, permeable parking, rain gardens, ecosystem based flood protection, sustainable urban drainage systems, retention basins and watershed management.

*Description:* The NCFF (Natural Capital Financing Facility) loan will finance and support the integration of green components into the restoration of public squares and streets create green corridors between greened areas and contribute to the natural restoration of Athens's second landmark hill after the Acropolis, Lycabettus hill. Thus reducing urban heat islands, increasing water infiltration, increase attractiveness of project areas. Support from the NCFF: A EUR 5 million NCFF loan to the Municipality of Athens. The EUR million loan is attached to a EUR 55 million loan for resilient urban renewal and development.

*Second example: Cheonggyecheon Restoration and downtown revitalization in Seoul, (South Korea)*

*Types of implemented NBS*:

- Increased area of greenery: Creation of an ecological biotope and environment increasing the number of species, green spaces (small parks) and planting trees.
- Location near water: Enhancement of the river, water stream and lakes.

- Far distance from industrial production & transport pollution: Urban points of attraction located far from hazardous industries.
- Technical protection measures: Cleaning of drains, air quality control, protection of ecology and fauna.

*Description:* The Cheonggyecheon restoration project was centred on revitalizing the Cheonggyecheon Stream that had been covered for decades by a highway overpass. The city of Seoul used its own resources to bring new life to the downtown by enhancing the urban environment. The restoration of the Cheonggyecheon Stream led to the revitalization of central Seoul, unleashing the potential for green public space. The overall budget allocated for this project is 1 billion EUR.

There are hundreds of examples of NBS implementation around the world that are giving positive solutions, for example, the way of managing stormwater and the gardening in towns. Conventional gardens are replaced by rain gardens and wildlife gardens to promote more green areas with less maintenance and better treatment of the stormwater. Other examples belong to the soil and water bioengineering discipline which has increased in the last years.

## 6.2 Use of classical stages in soil and water bioengineering enterprises

Soil and water bioengineering (SWB) is a technical and scientific discipline that combines technology and biology, making use of plants and plant communities for protecting soils and infrastructure, and contribute to landscape development. This discipline provides different functions that can be translate into NBS services (see Figure 16).

**Table 16**: Relations between SWB function and NBS services.

| SWB functions | NBS services |
|---|---|
| 1. Erosion control<br>2. Slope/riverbank stabilisation<br>3. Hydraulic/hydrological process regulation<br>4. Coastline protection<br>5. Temperature regulation<br>6. Habitat creation/recovery<br>7. Recreation area reservation | 1. Land/coastline/infrastructure protection<br>2. Watershed management<br>3. Flood/rainwater management<br>4. Shoreline management<br>5. Climate change mitigation/adaptation<br>6. Biodiversity increase<br>7. Social health/well-being |

This engineering domain developed from the rediscovery of traditional building and management techniques that use predominantly living plants and vegetation communities as building materials. Nowadays, it presents a strong evolution with the development of new materials and plant/material combinations, building techniques and innovative domains of application. This domain of engineering combines classical areas of civil engineering (e.g., structures, materials, construction, geological engineering) with biology, integrating a wide diversity of disciplines and specialization domains.

In the initial phase, it is frequented to combine living materials with non-living building materials, which may, in some cases, ensure more or less temporarily, most of the supporting functions. The use of organic materials is preferred, because parallel to the development of the vegetation and its increasing stabilization ability, these materials will rot and be reincorporated in the natural

biogeochemical cycles. It is important to note that bioengineering strategies also have drawbacks in terms of their effectiveness and application limits because of the characteristics and properties of the vegetation:

- The first one is that only a limited available number of plants from a given habitat have the necessary technical characteristics. This constrains the potential use of the aimed technical solutions.
- Secondly, plants, as living organisms, do not behave in a standardized way, limiting the ability to precisely calculate the technical effectiveness of the interventions.
- Finally, plants have limited ability in terms of root growth, hindering their capacity to stabilize soils to depths larger than 1.5–2 m, depending on the species. These limitations imply the need for the use of complementary structures to help overcome—temporarily or permanently—the local adverse conditions.

This situation determined the development of a particular segment of the industry related to complementary materials (e.g. organic geotextiles). Its main aim is at reducing the impact of water and soil erosion in the initial development phases of the construction and interventions, and to the conception of construction techniques (see figure 6) using classical civil engineering approaches and materials in combination with the advantages brought by vegetation.

Figure 6: Slope stabilisation with classical methods (gabion) (left) and with bioengineering techniques (right) (Cribwall Krainer).

Currently, there are some studies (Tardio, et al., 2018. The Use of Bamboo for Erosion Control and Slope Stabilization: Soil Bioengineering Works). DOI: 10.5772/intechopen.75626) which are trying to demonstrate that soil and water bioengineering techniques can be effective from the first moment and can substitute the classical techniques from the initial phase.

# 7 Mapping of stakeholders

This section aims to pave a strong foundation for project activities related to the co-design, co-development and implementation of NBS (WP2 and WP3) their evaluation (WP4 and WP5) and evidence to the users (WP7 and WP8) as well as establishing the basis for their market uptake and exploitation activities (WP9). In particular, the outcome of the stakeholder mapping (Section 7.2) will provide the base for operationalization of NBS (WP3), strategies for stakeholders' engagement (WP8) and dissemination and communication as well as exploitation strategies and actions (WP9).

## 7.1 Who exactly is a stakeholder, and how can stakeholders be identified in environmental related projects?

Sustainability and environmental challenges are cross-cutting subjects which have economic, social and political impacts and require trans-disciplinary approaches. Coping with these challenges in an efficient and effective way often requires transdisciplinary, community-based, interactive, or participatory research approaches where many different actors are involved (Lang et al., 2012). These actors are defined as stakeholders. More in detail, stakeholders are any group or individual who can affect or is affected by the achievement of the project objectives (Freeman, 1984). In other words, a stakeholder is anyone who holds a stake in the object under investigation, who are affected by the decisions and actions taken, and who has the power to influence the outcome (Reed et al., 2009).

In the field of national and international environmental policy and sustainability challenges, public participation is becoming increasingly embedded in policy-making process. Furthermore, a research collaboration between scientists from different disciplines and non-academic stakeholders from business, government, and the civil society is strongly recommended (Lang et al., 2012, Reed et al., 2009). As a result, the involvement of many different stakeholders with differing opinions, values, and stakes is of great importance for the achievement of project objectives. In addition to the multitude of stakeholders, also multiple scales of intervention and different levels of decision-making have to be taken into account.

This is in line with the Sendai Framework for Disaster Risk Reduction (section 5). In fact, the Framework encourages a more people-centred preventive approach, built on the understanding that DRR practices, to be efficient and effective, need to be multi-hazard and multi-sectoral, inclusive and accessible (UNISDR, 2017). Furthermore, the need for increased understanding and action both vertically between local, national, regional and global levels, and horizontally, between communities, local administrations and private institutions is highlighted (UNISDR, 2017). The Framework also outlines the need for all-of-society engagement to prevent and reduce disaster risk through coordination mechanisms within and across sectors and with relevant stakeholders at all levels (i.e., local, national and global level). In addition, it encourages collaboration with government institutions and the private sector in order to pursue an integrated implementation of inclusive economic, social, cultural, technological and institutional measures.

Due to the evident complexity of the subject, DRR related projects must deal with several scenarios and scales as far as stakeholders are concerned. Indeed, both the small communities deciding to protect the local territory (e.g., realization of OALs in OPERANDUM case), and the national and global protagonists in the debate on the worldwide adoption of new solutions for the disaster risk reduction

management (e.g., adoption of NBS to manage hydro-meteorological risks in OPERANDUM case) have to be taken into consideration for a successful implementation of the project. A not exhaustive list of key stakeholders' groups concerned with or impacted by capacity development for DRR is reported in the Strategic Approach to Capacity Development for Implementation of the Sendai Framework for Disaster Risk Reduction (UNISDR, 2017). The list consists of the following groups:

- National Government (including elected leaders, parliamentarians, and line ministries);
- Local and Sub-national Government;
- Private Sector and Professional Organizations;
- Nongovernmental and Civil-Society Organizations (NGOs and CSOs);
- Education and Research Institutions;
- Individuals and Households;
- Media;
- Regional Organizations including IGOs;
- The UN, International Governmental Organisation (IGOs), and International Financial Institutions (IFIs).

The complexity is not only related to the identification of stakeholder groups, but also to the assessment and the analysis of their motivation and needs. Indeed, different stakeholders are likely to make differing contributions and require different levels of communication at each key stage of a project (Durham et al., 2014). For this reason, not all stakeholders will need to be engaged all of the time, or in the same way, and the degree of engagement is likely to vary throughout the project. This aspect is further investigated in Deliverable 8.1 – Multi stakeholder's engagement strategy. Previous projects and studies already dealt with the stakeholder mapping and engagement in DRR, ecosystem services and NBS and some guidance and tools are available (ESPREssO, 2018; Durham et al., 2014; Hauck et al., 2016; Lovens et al., 2014). As an example, a new interesting tool is now available as a result of the EU funded project Think Nature that developed a multi-stakeholder communication platform (ThinkNature, 2019) supporting the understanding and promotion of NBS. Among the others, the platform allows a continuous dialogue and interaction on NBS through forums and debates, identifies regulatory, economic and technical barriers; fosters collaboration at local, regional, national and EU levels, and develops synergy with other projects on NBS. Similarly, the open platform OPPLA has been developed as part of a joint activity between the EU funded projects OPERAs (OPERAs, 2019) and OpenNESS (OpenNESS, 2019). OPPLA aims to bring together knowledge about natural capital and ecosystem services from around Europe. The platform favours the establishment of community of practice that shares resources, new ideas and practical experience. Furthermore, it aims to function as a marketplace, enabling members to find consultants specialising in natural capital and ecosystem services, to help with their own projects. In general, some important aspects to be considered when dealing with stakeholders in environmental projects, especially those related to DRR - can be summarised as follows (ESPREssO, 2018):

- An accurate selection of stakeholders' categories has to be performed, since all institutions, organizations and citizens are potential stakeholders. Therefore, to ensure the effectiveness of the planning, not all potential stakeholders, but the right ones have to be considered.
- The creation of web-based online platform for building common understanding, commitment and consensus is strongly recommended, since this tool also encourages bottom-up communication from local level to national level and increases the participation of local stakeholders in decision-making process.

- The cooperation between governments and local stakeholders is strongly encouraged, since it allows better risk assessment through the incorporation of local knowledge of risk and vulnerabilities into risk management policies.

## 7.2 Who are OPERANDUM stakeholders?

OPERANDUM pursues a co-design and co-develop approach and foresees the set-up of OALs in which user-centric method, characterized by the active participation of the stakeholders, is promoted. Starting from the local community, the project aims at involving stakeholders at the national and international level to leverage widest possible NBS acceptance, to promote its diffusion as a good practice, and to push business exploitation. Therefore, in OPERANDUM a stakeholder analysis and mapping have been undertaken keeping in mind two of the main objectives of the project:

- Develop co-designed and co-deployed solutions in a trans-disciplinary multi-stakeholder and participatory context;
- Enhance market demand for nature-based solutions for hydro-meteorological risk reduction and climate change adaptation.

### 7.2.1 Classification

Due to the complexity of the project and the multiple levels of engagement, in OPERADUM stakeholders are classified according to two main definitions:

- Geographical coverage: depending on the extension of the area of influence of their activity, stakeholders can be distinguished in local, national, and global as represented in Figure 7;
- Level of engagement: depending on the level of engagement in the OPERANDUM project, three types of stakeholders are identified:

  - *Primary Stakeholders:* all the organisations directly involved at OAL level within the OPERANDUM project.
  - *Secondary Stakeholders:* organizations selected by OALs at all three geographical levels that are interested in NBS and punctually involved/consulted for OPERANDUM related tasks.
  - *Tertiary Stakeholders:* all those organizations, not directly involved in the project through OALs, that have interests in the NBS field and OPERANDUM project results.


Figure 7: Stakeholders' definition according to their geographical coverage (own source).

### 7.2.2 Definition of the OPERANDUM Value-chain

Stakeholders were initially identified using focus groups with OAL leaders to ask which groups and organizations have an interest in and influence over OPERANDUM. This brought to the definition of the OPERANDUM value-chain that is aimed at classifying and clustering all the relevant categories of stakeholders listed in Table 16. The OPERANDUM value-chain, as presented in Figure 8, was validated/integrated by the consortium partners during internal brainstorming.

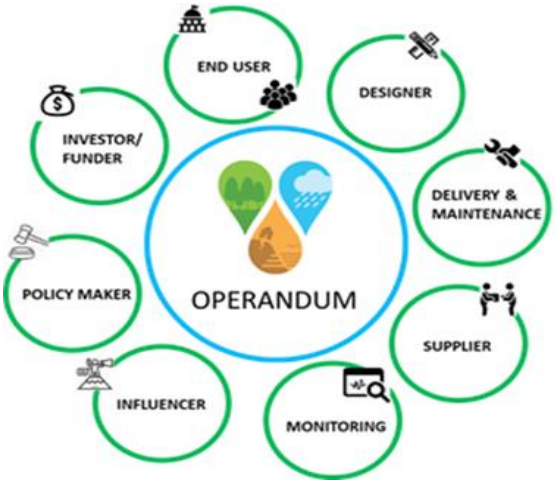


Figure 8: OPERANDUM value chain (own source).

All these categories of stakeholders are important in order to fulfil the objectives of OPERANDUM. However, during internal brainstorming some considerations about the value chain emerged. Due to the diversity among OALs (e.g., different technology readiness level of the NBS to be implemented, socio-economic conditions of the area of intervention, community awareness) not all the categories of stakeholders will necessarily be involved since the beginning of the project. Furthermore, the same stakeholder can cover multiple roles in the value chain (e.g., local municipality can be at the same time end users, investors and policymakers).

**Table 17**: Stakeholders' target group and reasons for engagement.

| Target Group | Reason to involve the stakeholders |
|---|---|
| Designer | They perform research on new methodology and approaches and design the NBS to be implemented |
| Delivery & Maintenance | They are responsible for the implementation of the NBS according to the design. They can also provide post- implementation maintenance |
| Suppliers | They provide technologies and materials for the implementation of the NBS |
| Monitoring | They monitor impacts and performances of implemented NBS |
| Influencers | They raise awareness, advocacy and motivation of society on NBS |
| Policy makers | They define the regulatory framework to be compliant with when implementing NBS solutions |
| Investors & funders | They finance the project realisation |
| End-users | They benefit of innovative NBS solutions adopted to manage hydro-meteo risks |

### 7.2.3 Primary and secondary Stakeholders at OALs level

The mapping of primary and secondary stakeholders has been conducted at OAL level. Each OAL representative has been asked to indicate all the stakeholders involved at OALs level in the OPERANDUM project and to classify them by level of engagement in the project (i.e., either primary or secondary stakeholder), type of organization, and area of interest, geographical coverage and role in the value-chain. A total of 105 stakeholders, 38 classified as primary and 67 classified as secondary, has been mapped at OALs level. Among them, 79% acts at local level, 23% acts at national level and 3% acts at global level. Furthermore, the OPERANDUM partner UNESCO provided contacts of focal points of UNESCO's premises, acting at global level and mainly involved as influencer and monitoring stakeholders. A full list of primary and secondary stakeholders is reported in ***Annex 2***.

Starting from the information provided by OALs, it was possible to classify stakeholders according to the following main categories:

- Associations: this category mainly includes influencers, monitoring, funder/investors, end-users;
- Companies: this category mainly includes designer, delivery and maintenance, supplier, monitoring;
- Public Bodies/Policymakers: this category mainly includes influencers, policymakers, investor/funder, end-user;
- Research Organizations (including Universities): this category mainly includes designer and monitoring.

Furthermore, analysis allowed the identification of several areas of interest for stakeholders such as agriculture, fisheries and forestry; engineering; environment; governance; media and communication; research and development; society and culture; tourism. Overall results of primary and secondary stakeholders' mapping at OAL level are reported in Figure 9.

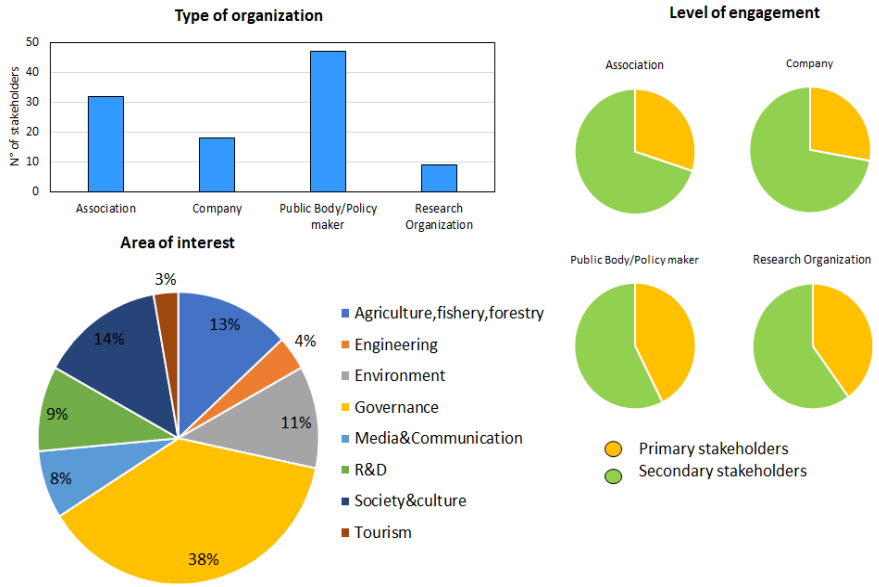


Figure 9: Mapping of stakeholders at OALs level (own source).

### 7.2.4 Mapping of tertiary stakeholders at global level

Tertiary stakeholders' mapping is aimed at gathering relevant information on the most important companies (SMEs or large industries), research centres and organizations that are performing international innovation, research, and business activities. The mapping provides OPERANDUM with an overview of key players in the related fields, which is used to develop dissemination, communication and exploitation activities (WP9). The methodology used for mapping tertiary stakeholders is based on a proprietary methodology that has been designed, developed, implemented and validated by the OPERANDUM partner PNO in more than 10 EU-funded collaborative projects (Akil et al., 2017), and make use of semantic tools and software (Innovationplace, 2019; Wheesbee, 2019) entirely developed by PNO. The following steps have been followed:

- Identify the main keywords to be used for the searches presented in Table 29 (2) – ***Annex 2.***
- Screen of databases (CORDIS-based) through PNO proprietary IT Tools for EU projects containing the identified keywords in the timeframe 2008-2019. After a first search, a refinement was achieved manually by CiaoTech (TP PNO), analysing the single projects and excluding projects that were not relevant for OPERANDUM.
- At the end of this refinement process, 70 EU projects were selected, corresponding to a total of almost 700 unique stakeholders. A hierarchy of the relevant stakeholders was defined as performing a statistic of the 70 EU projects to identify the most active project partners. In particular, the following stakeholders were added to the list:

– *Universities, research centres, and other organizations involved in at least 4 of the selected EU projects;*
– *Companies involved in at least 2 of the selected EU projects.*

- The screening of databases (WIPO or EPO-Espacenet based) through PNO proprietary IT Tools for patents containing the identified keywords: 13 patents related to NBS were selected, and stakeholders involved in these patents were added to OPERANDUM stakeholders list.
- Integration of the stakeholders lists by adding a target group or consortia working in specific areas of interest related to NBS.
- In parallel, CiaoTech (TP PNO) asked all partners to identify further relevant tertiary stakeholders to be inserted in the list.

After this procedure, a list of 194 tertiary stakeholders was filled in as reported in ***Annex 2***. The stakeholders cover the whole of Europe and some countries outside the EU. The identified stakeholders have been grouped as follows:

- *Innovators:* mainly research centres and universities working on NBS related projects. They can be addressed by partners for exchanging information and results, discussing advanced knowledge in the field of NBS, and finding synergies for dissemination and exploitation activities;
- *Patent owners of technologies and methodologies related to the project.* They can be addressed for discussing possible exploitation strategies for OPERANDUM results and discussing best practices.
- *Investors.* They represent an important group of stakeholders potentially interested in the OPERANDUM results as potential business drivers for the technologies. This category mainly includes environmental and engineering companies.

– *Policy makers and Associations.* They will be crucial for the discussion of future policies and dissemination of OPERANDUM and its future potential developments.

Although the list of stakeholders is by no means exhaustive, it provides information about the type, area of interest, geographical coverage and role in the value-chain of a large number of organizations dealing with NBS and related fields of expertise. Overall results of tertiary stakeholders' mapping classified per type of organization and area of interest are reported in Figure 10.

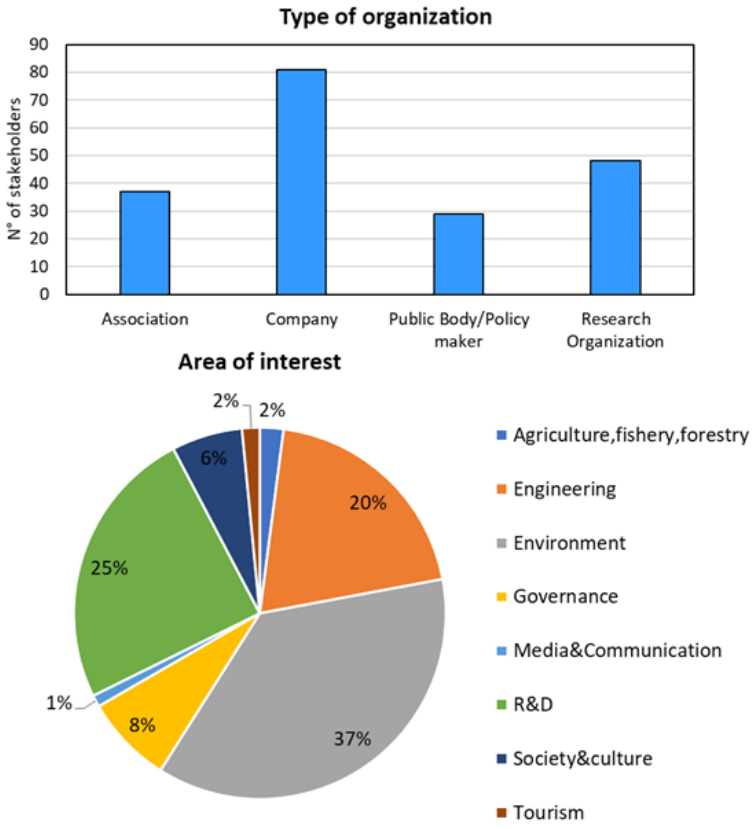


Figure 10: Mapping of Tertiary Stakeholders (own source).

It is important to highlight that the OPERANDUM stakeholders' list is a living document that can be continuously updated throughout the entire project duration. Based on mapping results, the stakeholder engagement strategy has been designed (WP 8 –Deliverable 8.1 – Multi-stakeholder engagement strategy). Furthermore, results of stakeholder mapping will be used as a database of contacts for dissemination and exploitation activities (WP9).

# 8 Data gaps for developing social, economic and environmental performance indicators

## 8.1 Knowledges gaps of NBS benefits

The positive effects of NBS for climate change mitigation and adaptation have been documented in several papers and reports (Kabisch et al., 2016, Locatelli et al., 2011). However, there are still knowledge gaps with respect to long-term benefits. It is possible to classify these gaps into different categories:

- Effectiveness of NBS;
- Relationship between NBS and society;
- Design of NBS;
- Implementation aspects.

Moreover, another issue is related to the fact that knowledge of NBS is mainly based on urban interventions, while the present purpose is looking at non-urban NBS. The first category (Hartig et al., 2014) focuses on the effectiveness of a NBS with respect to incomplete evidence of benefits. For example, although many studies demonstrated beneficial health effects, others could not identify any association between general health improvements and green space availability. In other words, these relationships need more strong evidence regarding the degree of causality and effectiveness. Moreover, data on the impacts of climate change on biodiversity and related ecosystem is limited because biodiversity in cities is exposed to multiple factors simultaneously, for example, high levels of pollution. For this reason, the knowledge of the effectiveness of NBS in cities is still limited. It is unclear which approaches would be more effective in the long term and which would be more beneficial immediately after implementation.

The second group (Gobsters, 1998) is about the relationship between NBS and society. A first issue is about the question if all residents in a certain area could benefit from an NBS or if advantages will be only accessible to a selected part of the population. Another related issue is about the identification of a suitable way for the communication of the positive and negative aspects of an NBS.

The third group (Santamouris, 2014) is about the design of NBS and, in particular, to define how the technical knowledge of engineers can be used to integrate a NBS into existing grey infrastructure. It would be important to identify the technical knowledge and skills required for multifunctional urban planning. Moreover, it should be understood the way to interlink this knowledge with expertise on environmental systems, in order to obtain the best synergies. Considering that OPERANDUM OALs are in no-urban areas, the presence of grey infrastructure must be considered in a different context and spatial scale.

The fourth group (Pauleit et al., 2011) is about issues related to the implementation of NBS. In fact, there could be a lack of information regarding legal instruments, requirements, possible conflicts of interest, i.e. contending land uses to different targets of landowners. Moreover, the growth of population and the need for more residential space poses the question about how much green space could be created. Finally, there is a need for introducing new strategies aimed to quantify the cost/benefit ratio of NBS in comparison to conventional engineered approaches.

## 8.2 Definition of performance indicators

In order to fill the gaps listed in the previous subsection, it is recommended that the introduction and development of indicators that can help to assess and demonstrate the usefulness of NBS and increase the measurability of their effects. Moreover, indicators can foster the evaluation of NBS implementation projects and increase comparability and measurability. In fact, the success of a NBS is related to the fact that they are characterized by an integrated approach, with intensive participation of stakeholders, private and public participation, simultaneous achievement of social benefits and biodiversity, and of course reliable economic evaluation. In other words, the benefit gains achieved with NBS have social, economic and environmental components. Evaluating the impacts and benefits of NBS requires the analysis of environmental performance, human health and well-being impacts, stakeholder involvement, and the longevity of the action (Keniger et al., 2013).

Currently, there is a lack of some specific indicators for NBS and others related to the interaction of NBS with social science and humanities. An indicator is defined as a measure based on certifiable data able to condense a variety of information and to convey information (Haase et al., 2014). Indicators could be used for measuring, analyzing, monitoring, and communicating not only the effectiveness of NBS, but also their main characteristics. In terms of communication, indicators could help to track how green spaces in cities provide benefits for adaptation to climate change, and for the support to human well-being. Indicators may also inform actions by providing arguments for decision makers in urban administrations to consider NBS in budget allocations. The SDGs and associated targets, indicators and evaluation metrics (UN-Habitat, 2016) represent an internationally-accepted framework for the evaluation of sustainability at a global level. In particular, as already specified in previous sections, OPERANDUM is contributing in obtaining the SDG in various ways, both directly and indirectly. More specifically, OPERANDUM is focusing on Goal 6 (water problems and hydro-meteorological disaster risks), Goal 13 (to reduce impacts of climate change by strengthening resilience and adaptive capacity to natural hazards) and Goal 15 (to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, and combat desertification). The comprehensive systems based on SDG represents an internationally accepted standard of targets, indicators and metrics for the evaluation of progress toward sustainability and resilience to climate change. Anyway, the alignment between the SDG targets and the multitude of individual indicator frameworks developed to evaluate specific actions at a local or regional scale must be better clarified (Wendling et al., 2018).

## 8.3 Classification of Performance indicators

As already preliminarily discussed in OPERANDUM D7.1, the indicators identified can be grouped into five categories. The first two groups of indicators are closely related to SDG targets, as they touch major SDG subjects such as climate change, environmental degradation, sustainable development and human health and well-being. The next two are related to the acceptance and transferability of NBS, while the last one refers to the engineering and economical aspect of NBS.

*Integrated environmental performance indicators* predominantly relate to regulating ecosystem services, such as climate regulation (temperature reduction), air quality regulation (decrease of pollutants), and flood control by mitigating extreme events. Some indicators refer to biodiversity, for example, the share of vegetation cover. Indicators related to ecosystem disservices of green and blue

infrastructure can be considered, defining an ecosystem disservice as an ecosystem function that is negatively perceived for human well-being. Related indicators are increasing numbers of mosquitoes or increasing number of plants emitting allergic pollen, increased air humidity.

*Indicators related to human health and well-being* are related to co-benefits of NBS and include physical and mental health indicators, as well as the spatial availability of green spaces. Physical and mental health indicators measure the number of people participating in outdoor sports activities and specific health benefits, such as reduced rates of respiratory diseases or obesity. The positive effects of living in proximity to green spaces have been described in Hartig et al. (2014). Happiness indicators can be used for measuring mental health.

*Indicators related to citizen involvement* relate to the number of citizens involved in green implementation projects or citizens owning a green space. These indicators comprise quantities about how information on NBS is provided to a community. A possible indicator could be derived from new media (i.e. Facebook) and the number of "likes" put on posts related to NBS.

*Indicators related to the transfer of model projects into general practice and monitoring of projects.* This set is measured by the number of stakeholders belonging to different sectors involved in planning and implementation. Another indicator could be the number of planners that employ the concept of NBS for policy practice. Further indicators are related to the administrative budget of a city, including the budget percentage for green space-planning, implementation, monitoring of projects and strategies.

*Indicators related to engineering and finance.* These set of indicators includes aspects related to the job market, the cost-effectiveness of the NBS and the impact on natural resources. For the job market, an indicator could be the number of professionals of the construction sector involved in the process of the design and implementation of NBS (e.g., engineers, contractors, technology providers). The cost-effectiveness of the NBS could be measured by evaluating the cost of the NBS per unit (e.g. meter of length, square meter of area, number) both for the construction and operation and maintenance. The impact on natural resources could be evaluated by considering the ratio of the reuse of existing natural materials for the construction of the NBS and the energy consumption for the construction of the NBS.

**Table 18**: List of performance indicators for NBS, grouped into five categories.

| Category | Examples |
|---|---|
| Indicators for integrated environmental performance | Temperature reduction; PET reduction; heat wave risk reduction; decrease in air pollutants; decrease in carbon emission; air quality parameters (NOx, CO); Annual mean level of fine particulate matter (PM2.5 and PM10); share of vegetation cover; biodiversity increase; reduction of areas and populations exposed to flooding; runoff coefficient in relation to precipitation; percentage of energy reduction for cooling; increase of drinking water provision; indicators related to ecosystem disservices; increase of production of food; increase of pollinator species; Noise reduction rate (dB per meter square). |
| Indicators of human health and well-being | Accessibility (measured as distance or time) of urban green spaces for population; physical and mental health indicators; increase in walking and cycling areas; number of people participating in outdoor sports activities (cycling and walking); reduced rates of respiratory diseases or obesity; decline of death rate of elderly people in hot summers; happiness indicators (by survey); weighted recreation opportunities provided by Urban Green infrastructure; reduced number of deaths from air, water and soil pollution and contamination. |
| Indicators for public involvement | Number of people involved in green implementation projects. Number of "likes" put on social network posts related to NBS |
| Indicators of transferability | Number of stakeholders involved in the implementation, budget percentage for green space planning, the number of member states representatives informed. Percentage of the budget allocated to green spaces. Integrated governance approach. |
| Engineering and financial aspects | Number of professionals of the construction sector involved in the process; cost of unit of the NBS (construction and operation and maintenance); ratio of the reuse of natural materials for the NBS; energy consumption for the construction of the NBS; monetary value of air pollution reduction; monetary value of: urban forests (including air quality), runoff mitigation, energy savings; number of jobs created; gross value added. |

In Table 17, PET stands for Physiological Equivalent Temperature and is defined to be equivalent to the air temperature that is required to reproduce in a standardised indoor setting and for a standardised person the core and skin temperatures that are observed under the conditions being assessed (VDI, 1998; Höppe, 1999). A heatwave is defined as a period of time when the weather is much hotter than usual.

Moreover, an indicator that simultaneously considers social, environmental, and economic sustainability are generally accepted indicator systems for national and regional urban development (SCOPE, 2007).

Furthermore, EEA has defined a core set of indicators able at first to provide a manageable and stable basis for indicator-based assessments of progress against environmental policy priorities. The core set covers six environmental themes and four sectors. All of the indicators in the core set are either descriptive or performance based. Some of those indicators (not identified yet at this stage of OPERANDUM implementation) could also be used to demonstrate the usefulness of NBS and to increase the measurability of their effects, especially those connected with Climate Change (e.g., GHG emissions) and Biodiversity (e.g., Threatened and protected species). So, it is important to integrate and upgrade these indicators in collaboration with the social and economic partners involved in OPERANDUM.

# 9 Matrix development to fill data gaps

The assessment of gaps for specific applications is a major research topic in different communities. It is no exception for NBS solutions, which are new applications in the search for sustainable development technologies and services. We would like to use concepts from ISO 9001:2000 clause 5.6.1:". a quality management system, at planned intervals, should devise methods to evaluate suitability, adequacy, and effectiveness of the system."

OPERANDUM has to set up criteria and methodologies for the evaluation of the NBS suitability/effectiveness and adequacy. Definitions of these terms are difficult to find (http://9001quality.com/9001quality/, Nenadal, 2016) but we need to find something that is useful for our applications. We argue that suitability/effectiveness/adequacy of NBS solutions have been encapsulated in section 8 (8.1, 8.2 and 8.3) where knowledge gaps and performance indicators have been devised for the NBS itself.

Here we specifically want to find "data" gaps. All the OPERANDUM NBS are science-based applications and they need "input environmental or socio-economic data" to be collected, produced for the NBS. Our final aim is to understand if the performance/quality/effectiveness of NBS is somewhat connected to a gap in the input data.

The NBS data are components of the 'Universe of Discourse' defined as a 'view of the real or hypothetical world that includes everything of interest' (ISO 19101). The concept behind the quality of a dataset from a user point of view is shown in Figure 11. In our case, the universe of discourse provides the model to assess the effectiveness/quality of data that fits the OPERANDUM NBS needs.

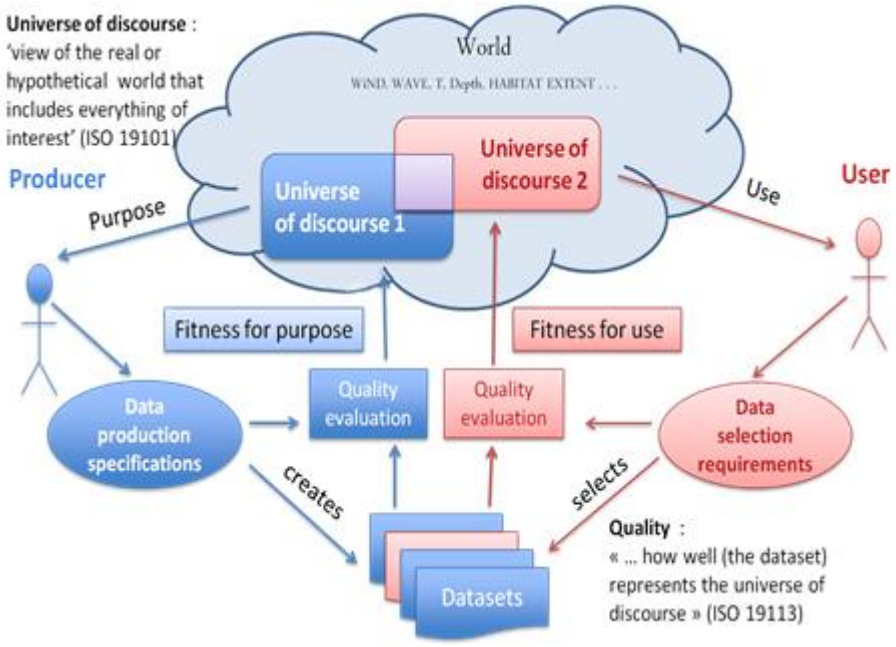


Figure 11: Concept behind data quality principles from the user side, as described in ISO 19113 (source: INSPIRE, 2019).

Fitness for use is different from fitness for purpose: 'purpose' describes the rationale for creating NBS products or services, while 'use' describes the rationale for selecting a dataset. The producer of NBS translates the purpose into production specifications, while the user translates user requirements into selection specifications, which may differ from the production specifications.

The fitness for a purpose is evaluated by the producer according to the specifications of the quality expected for the NBS. The fitness for use of a dataset is evaluated by the user according to the specifications of the quality expected for its use in the NBS. The purpose of this exercise is to provide an evaluation of the fitness for use of the datasets used by the NBS. In this framework, the fitness for purpose criteria of the NBS has been defined in section 8 (8.1, 8.2, and 8.3).

## 9.1 Definition of the "Data Adequacy" methodology

This section proposes a potential methodology for assessing the "data adequacy" or "fitness for use" of data as input to the OPERANDUM NBS. This methodology has been developed for the EMODnet infrastructure (EMODnet, 2019). The assessments there are called "Checkpoints" and the methodology is described in Pinardi et al. (2017). We outline the process of finding the "data adequacy" in Figure 12 – a catalogue of the "input data set" used by the different NBS should be set up, NBS requirements specified in relation to input data sets and finally a "Data Adequacy Report" is produced.

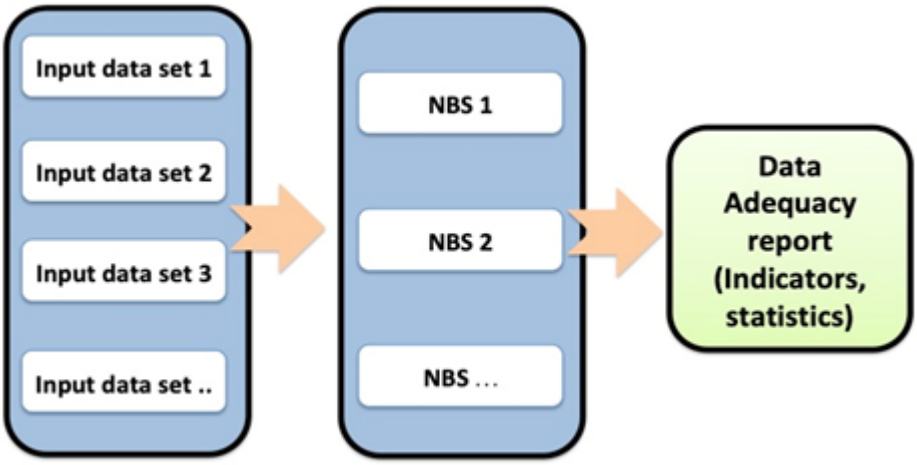


Figure 12: The overall process from input data sets to "Data Adequacy Reporting".

The proposed definition of "Data Adequacy" is then:

"Data adequacy" can be defined as the fitness for use of the data for a particular user or for a variety of users. Since different applications require different properties associated with the data itself, 'adequacy' should be defined objectively using standardized nomenclature and methods. In other words, adequacy is here intended as 'sufficient to satisfy a requirement or meet a need' (Random House Unabridged Dictionary, Random House Inc, 2006). Thus, 'adequacy' relates to meeting both requirements as well as needs and is normally applied within the framework of an ISO 9001 based Quality Management System.

The primary goals of this exercise will be to:

1) Document the input data sets to OPERANDUM NBS;

2) Develop NBS input data quality requirements;
3) Develop fitness-for-use indicators to show the performance, accessibility and usability of data for NBS products and services;
4) Identify gaps and prioritize the needs in order to optimize the system throughout the value chain (i.e. data collection, in situ and satellite data assembling, data management and networking, modelling and forecasting, geo-infrastructure) and release recommendations for future developments to better meet the application requirements.

In order to achieve these goals we need to:

1) Establish a framework for the collection of information related to input data sets required by the NBS and NBS data requirements. A NBS input data sets meta database should be produced;
2) Define objective assessment criteria for the production of 'adequacy' indicators;
3) Produce an analysis of the fitness for use of the input datasets with respect to the different NBS.

The Metadatabase to be constructed will be part of the OPERANDUM Platform and will be discussed later in the deliverables under WP7.

## 9.2 Quality elements and indicators

The assessment criteria are subdivided into two 'Territories' that need to be evaluated in terms of NBS requirements. They are:

4) *Territory 1: Appropriateness* - What is made available to the NBS and what the inherent properties of such data sets are; and
5) *Territory 2: Availability* - How the input data sets are made available to users.

The 'fitness for use' or 'adequacy' is established with indicators based on these two assessment criteria. Territory criteria provide the degree of conformity of data to the NBS requirements and needs. Table 18 lists the assessment elements of the two Territories.

**Table 19**: Appropriateness and Availability assessment criteria.

| Territory 1: Appropriateness | Territory 2: Availability |
|---|---|
| • Completeness<br>o Horizontal coverage<br>o Vertical coverage<br>o Temporal coverage<br>• Thematic accuracy<br>o Horizontal resolution<br>o Vertical resolution<br>o Temporal resolution<br>o Thematic accuracy<br>• Temporal validity | • Visibility<br>• Accessibility<br>o Service<br>o Data policy<br>o Pricing policy<br>o Formats<br>o Service interoperability<br>• Performance<br>o Responsiveness<br>o Reliability |

### 9.2.1 Availability indicators

For the availability territory, the listed elements take a certain number of pre-set values for each Input Data Set (IDS). Such values should be listed in the metadatabase describing each IDS potentially useful for the NBS. The experts working on each NBS should select the specific values for their IDS. In order to provide a visual indication of the input data availability, a coloured table for each indicator should be produced.

**Table 20**: Colour code and indicator values.

| Name of indicator | Indicator values and meaning |
|---|---|
| AV-VI-1- Easily found | "*Red*": "Cited in peer-reviewed paper or grey literature but no info on how to access" or "Information retrieved upon specific request to the data source<br>"*Yellow*": "Use of the social network, community of practices sharing information, Portals of an organization where no search is organized by an engine"<br>"*Green*": "Use of open search engines, searching by the name of either the data provider or the characteristics" or "Search via a reference catalogue is possible" |
| AV-VI-2-INSPIRE Catalogue service | "*Red*": "Data sets are not referenced in a catalogue or are referenced in a non-public catalogue"<br>"*Yellow*": "The datasets are referenced in a public catalogue, in an international catalogue service "<br>"*Green*": "The datasets provide a full EU INSPIRE catalogue service " |
| AV-AC-1- Policy visibility | "*Red*": "There is no information at all on data policy adopted by data providers"<br>"*Yellow*": "There is information, but details are available only on request"<br>"*Green*": "There is detailed information provided to understand data policy" |
| AV-AC-2- Delivery mechanism | "*Red*": "No information was found on data delivery mechanisms" or "Order form/invoice is requested"<br>"*Yellow*": "Online downloading services "<br>"Green": "Online discovery and downloading services" or "Online discovery + downloading + viewing services (Advanced services)" |
| AV-AC-3- Data Policy | "*Red*": " Not or not well documented"<br>"*Yellow*": "Restricted"<br>"*Green*": "Unrestricted" |
| AV-AC-4- Pricing | "*Red*": "Not or not well documented" or "Commercial cost charge"<br>"*Yellow*": "Distribution charge" or "Collection charge" or "Free of charge for academic institutions and uses"<br>"*Green*": "Open and Free, No charge" |
| AV-AC-5- Readiness | "*Red*": "Format not or not well documented" or "Proprietary format and not well documented " or "Not proprietary format but content not clearly specified "<br>"*Yellow*": "Proprietary format but content clearly specified "<br>"*Green*": "Not proprietary format and content clearly specified (eg auto-descriptive eg ODV, NetCDF CF) or at least with appropriate documentation" |
| AV-PE-1- Responsiveness | "*Red*": "No information is found on response time" or "More than 1 week for release"<br>"*Yellow*": "Less or equal to 1 week for release"<br>"*Green*": "Online downloading (i.e. a few hours or less) for release" |

The eight availability indicators are classified on the basis of a colour code with the following meaning:

- **Red:** *urgent actions are required to provide datasets and services fitting for use – totally inadequate.*
- **Yellow***: limited actions are required to provide datasets and services fit for use – partly adequate.*
- **Green:** *actions and services are fit for use and should be maintained – fully adequate.*

The colour code refers to selected values for each indicator, detailed in Table 19.

### 9.2.2 Appropriateness Indicators

The basic methodology for appropriateness assessment is based upon specific metadata information and measures associated with quality elements. Metadata information is related to:

1) The Data Requirement for NBS (DR-NBS) and
2) The Input Data Set (IDS) description;

The assessment methodology consists of two fundamental steps: the first is the choice of the quality measures that characterize DR-NBS and IDS, and the second is the definition of the appropriateness indicators based upon these quality measures.

The DR-NBS metadata are a precise technical description of the input data requirements for the NBS. The IDS metadata contain the same quality elements of the DR-NBS but this time it is the precise technical description of the actual data used in the NBS. While the DR-NBS only defines how the data input to NBS should be, the IDS specify which input data was actually used. The DR-NBS and IDS elements, once defined, should be completed by the NBS experts. The quality elements recommended for DR-NBS and IDS are listed in Table 20.

The basic idea of appropriateness indicators is that they are related to "errors" related to the Quality Elements just defined. Appropriateness corresponds then to "low" errors in the specific quality element. "Errors" for quality elements are defined as the difference between what has been realized and what was "required". DR-NBS includes the requirements or expectations while IDS is the actual input data set used. Considering this concept of "errors", for every DR-NBS and IDS quality element (QE), we can write:

$$\delta_{\mathrm{IDS}} = \mathrm{QE}_{\mathrm{IDS}} - \mathrm{QE}_{\mathrm{DR-NBS}} \qquad (1)$$

where is the error with respect to the DR-NBS requirements. These errors can be positive or negative depending on if the input data quality element is sufficient with respect to the DR-NBS requirements (positive) while errors are negative if the QE is deficient with respect to requirements. The appropriateness indicator for a specific QE is then defined on the basis of these errors in percentage:

$$\delta_{IDS}^{\%} = 100\left(\frac{\delta_{IDS}}{\mathrm{QE}_{\mathrm{DR-NBS}}}\right) \qquad (2)$$

NBS experts will insert relevant values for each QE in the meta database and the indicators will be computed by the algorithm (2).

**Table 21**: List of quality elements for appropriateness indicators.

| QE # | ISO Quality element | Appropriateness measure name | Name of quality measure | definition of quality measure | Units of quality measure |
|---|---|---|---|---|---|
| 1 | Completeness | XXX.AP.1.1 | Horizontal Spatial Coverage | Horizontal coverage extent of the input data set | $Km^2$ |
| 2 | Completeness | XXX.AP.1.2 | Vertical Spatial Coverage | Vertical coverage extent of the input data set | metres |
| 3 | Completeness | XXX.AP.1.3 | Temporal Coverage | Temporal coverage extent of the input data set | days |
| 4 | Thematic accuracy | XXX. AP.3.1 | Horizontal resolution | Averaged horizontal mesh size or equivalent value for the given scale of input data set | metres |
| 5 | Thematic accuracy | XXX.AP.3.2 | Vertical resolution | Average vertical sampling and description of specific vertical sampling schema of the input data set (100 words max) | metres + " _" text |
| 6 | Thematic accuracy | XXX.AP.3.3 | Temporal resolution | Temporal sampling interval of input data set | days (real number, i.e. 1 hour is equal to 0.04167) |
| 7 | Thematic accuracy | XXX.AP.3.4 | Thematic accuracy | Description of error concept for the input data set (100 words max) and value in percentage | percentage " _" text |
| 8 | Temporal quality | XXX. AP.4.1 | Temporal validity | Max elapsed time between last input data records update and NBS creation date | days |

## 9.3 Existing examples of data adequacy assessments

The methodology for Data Adequacy described in section 9.2 has been developed for the EMODnet Data Portals (Pinardi et al., 2017) and applied partially to the H2020 AtlantOS project results. The EMODnet Mediterranean Sea, the Black Sea and Atlantic Checkpoints give the most complete account of the Data Adequacy methodology applied to “Challenges” or specific products for societal benefit. EMODnet Checkpoint has collected information about data sets in a meta database based upon the Sextant technology (https://sextant.ifremer.fr/eng/) and an example is given in Figure 13. The data set under question is the satellite chlorophyll data and, among the different attributes of the data set, the “availability” criteria are listed (see Table 18).

**Chlorophyll pigment concentrations in water bodies | Concentration of chlorophyll-a {chl-a CAS 479-61-8} per unit by synthesis from multiple satellite sensors | Copernicus Marine Environment Monitoring Service | Mediterranean Concentration from Multi Satellite observations Reprocessed (ESA-CCI) (1997-2012)**

Environmental Monitoring - To advance the scientific understanding of marine ecosystems, and provide information, knowledge, and advice on the sustainabl affecting, and affected by, marine ecosystems - To develop tools for the evaluation of the environmental status -To implement the principles and objectives pu Framework Directive (MSFD)

INPUT DATASET INFORMATION

| | |
|---|---|
| **Challenges** | Marine environment |
| **Characterics** | Concentration of chlorophyll-a {chl-a cas 479-61-8} per unit volume of the water body by synthesis from multiple satellite sensc |
| **Data Provider** | Copernicus marine environment monitoring service |
| **Environmental Matrix** | Marine water |
| **Policy Visibility** | There is detailed information provided to understand data policy |
| **Processing Level Of ...** | High level analyzed |
| **Production Mode** | Delayed |
| **Purpose Of Character...** | This product is meant for use for educational purposes and for the managing of the marine safety marine resources marine and and seasonal studies |
| **Validation** | Submitted |

VISIBILITY

| | |
|---|---|
| **Easily found** | Search via reference catalogue (eg myocean geoss geoportal...) |
| **EU catalogue service** | The datasets are provided through an eu inspire catalogue service (ogc) |

ACCESSIBILITY

| | |
|---|---|
| **Data Delivery Mecha...** | Online discovery downloading viewing services (advanced services) |
| **Data policy** | Accessible under moratorium |
| **Pricing** | Open and Free. No charge |
| **Readyness** | Format not proprietary and content clearly specified (eg autodescriptive like odv netcdf cf) or at least with appropriate documen |

DATA FORMAT AND PERFORMANCE

| | |
|---|---|
| **Data formats** | Netcdf |
| **Responsiveness** | a:5:{i:0;s:57:"Online downloading (i.e. a few hours or less) for release";i:1;s:7:"2500000";i:2;s:7:"2500000";i:3;s:0:"";i:4;s:0:"";} |

Figure 13: Screenshot of Sextant EMODnet Catalogue page for a satellite Chlorophyll data set.

As an example of the appropriateness indicators for the evaluation of gaps in different input data sets (currents, wind fields, SST, coastline and bathymetry) for the generation of oil spill hazard maps is reported here in Table 21.

This work was done in the framework of AtlantOS H2020 project (Sepp-Neves et al., 2019, https://www.atlantos-h2020.eu/targeted-product/oil-spill-hazard-mapping/). Table 21 shows the different quality elements of input data sets used by the oil spill hazard mapping product compared to the 'Requirements', i.e. the 'Data Requirements for NBS'. In this case, the indicators scale consisted only of two colours, red and green, depending on if the error was positive (red) or negative or zero (green).

**Table 22**: Appropriateness indicators evaluation for oil spill hazard mapping input data sets as developed for the AtlantOS H2020 product for oil spill hazard mapping.

| Measure | Current fields | Wind fields | SST | Coastline | Bathymetry | Requirements |
|---|---|---|---|---|---|---|
| Horizontal extent | 840000 km$^2$ *Ice-free Atlantic basin* | 840000 km$^2$ *Ice-free Atlantic basin* | 840000 km$^2$ *Ice-free Atlantic basin* | *Not applicable* | 840000 km$^2$ *Ice-free Atlantic basin* | 840000 km$^2$ |
| Temporal extent | 3650 days *From 2007 onwards* | 3650 days *From 1979 onwards* | 3650 days *From 2007 onwards* | *Not applicable* | *Not applicable* | 3650 days *From 2007 onwards* |
| Vertical extent | 1 *Surface ocean fields are delivered (at 0.4m)* | 1 *Wind fields at sea surface/shoreline are given (10m winds)* | 1 *Temperature at the sea surface are given (0.4m)* | 58 *All countries bordering the Atlantic had their coastlines (0m) included in the dataset.* | 1 *Bathymetry dataset covers sea-land interface.* | 10 m below or above the sea surface |
| Horizontal resolution | 9000 meters *Global CMEMS Mercator fields.* | 80000 meters *ERA-Interim spatial resolution.* | 9000 meters *Global CMEMS Mercator fields* | 180 meters *Average length of coastal segments in the NOAA GSHHS dataset* | 30 meters *GEBCO spatial resolution: 30''* | 100 to 25 meters |
| Vertical resolution | *Not applicable* | *Not applicable* | *Not applicable* | *Not applicable* | *Not applicable* | *Not applicable* |
| Temporal resolution | 1 days *Daily* | 0.25 days *6hourly fields* | 1 days *Daily* | *Not applicable* | *Not applicable* | 90 days |
| Temporal validity | 1 days *Ocean fields are updated every one day.* | 0.25 days *Winds fields are updated every 6 hours* | 1 days *Water temperature fields are updated every day* | *Not applicable.* | *Not applicable* | 90 |

## 9.4 Proposed Tiers of implementation

Data Adequacy for NBS should be assessed in three tiers. During the first tier, the meta database with the relevant quality elements for availability and appropriateness should be set up on the OPERANDUM Platform developed in WP7. The second tier will analyse the 'Availability' territory for each NBS input dataset. Here each of the NBS is considered as an 'autonomous universe of discourse', with its own specific input data. Adequacy assessments will be based on the transformation of the input metadata into an ordered set of indicators outlined in Table 19. The third tier should consider the 'Appropriateness' indicators, defined as (2) for each NBS and input data set.

# 10 Hydrometeorological hazards geo-catalogue development

Geospatial data are often stored in databases or in a filesystem and served through standard web services defined by the Open Geospatial Consortium (OGC). These data are usually ignored by search engines and thus not discoverable in the mainstream web. Catalogue (discovery) service describes data with a set of metadata. Catalogue service is often used as a gateway from the web to geospatial data. Catalogue services are often used within the implementation of Spatial Data Infrastructure (SDI) to facilitate discovery and use of geospatial data (Shvaiko, 2010). An example of a project which had as a main goal enable easier discoverability of geospatial information was the research project "Borderles Geospatial Web (BOLEGWEB). Within the BOLEGWEB project, a global wide and user-friendly platform of OGC resources available on the web has been developed. The main goal of the platform was to ensure and enhance the use of GI within a multidisciplinary context and to bridge the geospatial web from the end-user perspective, thus to open its borders to more web communities (Kliment et al., 2016; Cetl et al., 2016). Also, catalogues are used in various multidisciplinary projects since there is a large amount of data which needs to be described with metadata in order to facilitate their easier discoverability and usability (Köhler et al., 2006; Tzotsos et al., 2015). The OPERANDUM project is also a large project which requires various types of data related to the hydro-meteorological hazards and NBS. For this purpose, a geo-catalogue will be implemented, and it will represent a crucial part of GeoIKP since it will enable easier discoverability and usability of geospatial and non-geospatial data related to the NBS.

KAJO is continuously identifying and collecting both OAL specific and large-scale reference datasets necessary to start building the first prototype of GeoIKP. The collection of the basic spatial features related to OPERANDUM OALs are ongoing. The first spatial datasets, depending in the advancements in each single OAL, are already available in the geo-catalogue to OPERANDUM partners. In terms of non-OAL specific data, the prime focus has been on the data sets providing a harmonized picture of the critical parameters (e.g., hydrological hazard & risk) at EU scale and reference datasets related to main conceptual attributes and components of NBS as defined in D7.1. KAJO has also analysed various existing large data stores to identify the latest trends in technology and data organization (e.g. Copernicus Data Store). Based on this review process, the candidate technologies for GeoIKP were identified and also the first data model is being produced.

KAJO is currently processing the collection of about 80,000 legislative and scientific documents relevant for the NBS. This collection will serve to extract knowledge on large amounts of the legislative documents (textual data) in the GeoIKP as well as their semantic enrichment with NBS/OPERANDUM related metadata. GeoIKP will also offer an inventory of the extreme events catalogue classified according to OPERANDUM hazard categories. Hazard classification follows the INSPIRE directive and adopts the same specifications provided in the INSPIRE theme “Natural risk zones”. If needed this classification will be expanded. Currently, there are 17 types of hazards in the NBS catalogue: cyclone; droughts; erosion; extreme temperature/heatwaves; flood; forest wild fire; gully erosion; landslides; salt intrusion; sea level rise/ storm surge; slope stabilization; storm water; strong wind; water salinization and water scarcity.

The full catalog of the NBS collected through the course of the project will be exposed as well in GeoIKP as a dedicated service. User will be allowed to browse the existing NBS by selecting any of the OPERANDUM key elements (e.g. hazard, ecosystem, risk, intervention type, and target). Data

related to the NBS will be made available in accordance with INSPIRE Regulation on Network Services through a series of standard OGC web services (discovery services, view services, download services) (Figure 14).

The key elements of the OPERANDUM geo-catalogue were identified in Deliverable 7.1. The key elements of geo-catalogue are: Hazard, Risk, Ecosystem, Target and Indicators. Hazard types are taken from the INSPIRE directive. Each hazard can be related to a certain level of risk which is expressed by a set of risk indicators. Level of risk is a complex data type with a definition taken from INSPIRE data type level or intensity. Key element Ecosystem is related to the habitat EUNIS classification. Key element Target types are initially taken from an EKLIPSE Export Working Group report but will be replaced with more appropriate framework developed in OPERANDUM at later stages of the project. Various indicators represent a very important piece of information of the geo-catalogue, however, at this moment indicators are included only at a conceptual level and will be updated in the next release of the geo-catalogue.

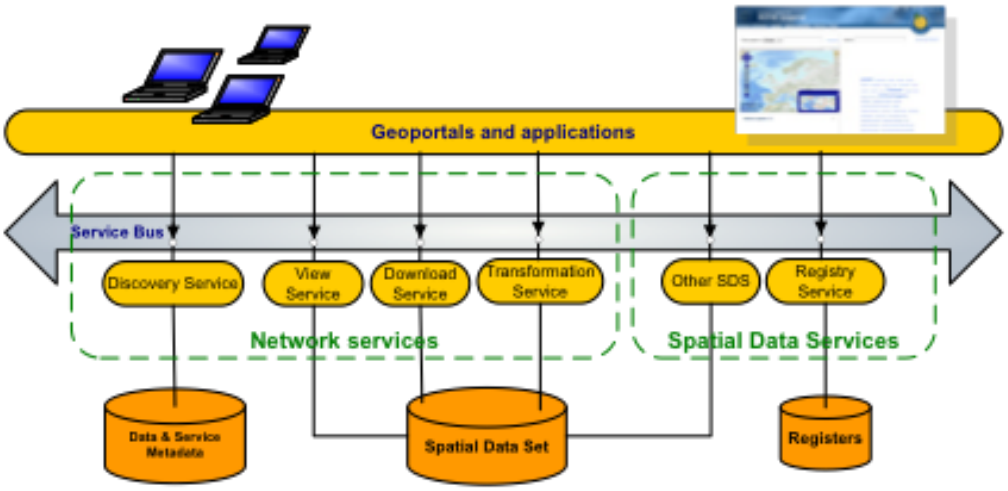


Figure 14: INSPIRE Network Services architecture.

The proposed schema of the geo-catalogue is shown in Figure 15 and aims at enabling easy retrieval of information about key elements of the NBS from several entry points. For instance, one would be able to retrieve information about certain existing NBS by selecting one or more targets as searching criteria through the geo-catalogue (e.g. by selecting the target <<water management>>, all NBS case studies dealing with this target will be retrieved from the geo-catalogue). Vice versa, the selection of certain types or case studies of NBS would enable retrieval of the set of targets they specifically address. In similar fashion, the selection of one or more categories of hazards, with certain levels of risk, and/or a given type of habitats, would enable the retrieval of a subset of NBS which specifically address those categories of hazards and/or that are suitable for implementation in (and have impacts on) such given habitats; and vice versa (source: OPERANDUM Deliverable 7.1).

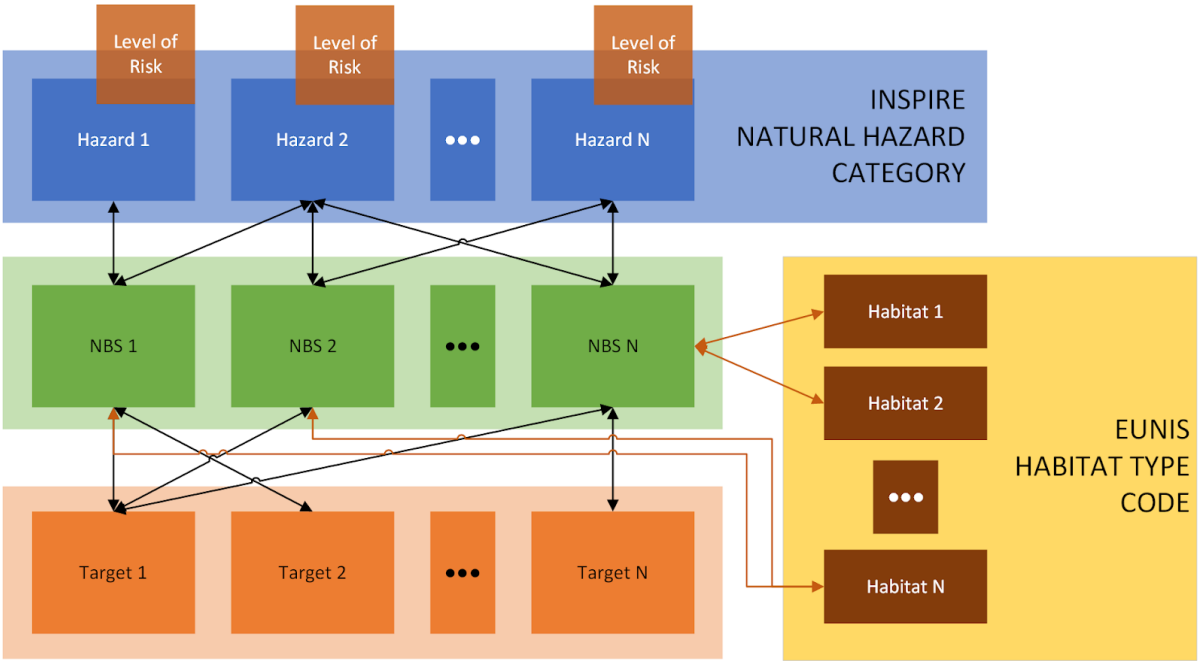


**Figure 15**: OPERANDUM geo-catalogue structure **(**source: OPERANDUM Deliverable 7.1**).**

The geo-catalogue will also link data about policies to the NBS and permitting path recognized in Deliverable 2.1.4. In this manner, by choosing certain NBS one could get all information related to that NBS: key elements, related policies and required permitting paths. This information can be used as a template to design and implement new NBS. In the geo-catalogue optional relationship between OAL and NBS is defined. This relationship allows relating NBS to OAL which would allow fetching information about NBS designed/implemented by OALs. Also, one can monitor the progress of NBS implementation by OALs. GeoIKP will follow the structure of the geo-catalogue. Additionally, GeoIKP will store various reference data sets from the following sources:

1) INSPIRE Geoportal (http://inspire-geoportal.ec.europa.eu/overview.html?view=themeOverview&theme=nz),
2) International disaster database EM-DAT (https://www.emdat.be/index.php),
3) NatCatSERVICE (https://www.munichre.com/touch/naturalhazards/en/natcatservice/natcatservice/index.html),
4) Climate-ADAPT (https://climate-adapt.eea.europa.eu/),
5) Joint Research Centre (JRC) Data Catalogue (http://data.jrc.ec.europa.eu/collection),
6) Copernicus (https://emergency.copernicus.eu/mapping/list-of-components/EMSN028),
7) PREVIEW-GRDP (https://preview.grid.unep.ch/index.php?preview=home&lnaturang=eng),
8) Eurostat (https://ec.europa.eu/eurostat/data/database) and
9) European Environmental Agency (https://www.eea.europa.eu/).

These reference data sets will be available in GeoIKP for viewing or downloading, depending on the type of data. When these data sets will be made available within the GeoIKP it will be possible to reference them to the NBS. Besides reference data sets, GeoIKP will store data produced by OPERANDUM WPs and OALs. For instance, harmonized data sets or various sets of indicators. Indicators will enable to benchmark the performance of the NBS and OALs.

# 11 Conclusions

This deliverable outlines an in-depth review of NBS case studies and platforms, policies, the acceptances and market opportunity of NBS, stakeholder characteristics, gaps and barriers of NBS and the structure as well as the functionalities of GeoIKP. These are a wealth of information relevant to develop a set of co-designed, co-developed, deployed and demonstrated innovative NBS (e.g., green, blue and hybrid approaches) to manage hydro-meteorological risks in European rural and natural territories. We reviewed some of the existing literature to summarize lessons learned in terms of planning and implementation of the NBS projects and understand the approaches that were recommended to ensure acceptability of NBS in Europe and globally. Both scientific and grey literature along with the online platforms of NBS project database were reviewed. In the last few years, new principles and guidelines have been developed and published for the NBS concept itself (Cohen-Shacham et al., 2016), for the implementation of NBS to reduce flood risk (World Bank, 2017), the framework for qualification criteria and quality standards for Ecosystem-based Adaptation (EbA) (FEBA, 2017), and voluntary guidelines for ecosystem-based approaches to climate change adaptation and disaster risk reduction (CBD, 2018). These guidelines are relevant to the acceptance of NBS globally as they address a knowledge gap and provide guidance to decision-makers for planning and implementation of NBS in the context of climate change adaptation and disaster risk reduction.

The review of the scientific literature and of the online platforms of NBS database such as Natural Hazards – Nature-based Solutions, OPPLA, Thinknature, Climate-Adapt and PANORAMA revealed a wide range of NBS projects implemented around the world. As documented in the databases, a majority of NBS case studies (201 out of 288) are from European countries (70%), in particular, from the United Kingdom (45.3%). However, this is an artefact linked to the types of database reviewed which were predominantly European-focussed. Among the relevant NBS projects, a majority of the cases focused on natural hazards such as river and urban flooding, coastal flooding, drought/water scarcity, river and coastal erosion, and heatwave/extreme temperature. Other NBS projects addressed issues such as urban air pollution, forest conservation, wetland management, and biodiversity conservation. Climate change adaptation was considered as an overall goal in most of the cases. Various types of NBS were implemented to address natural hazards and other environmental issues, with a primary focus on restoring/preserving river channels, wetland and forest/ green spaces in floodplains, coastal areas and urban areas. Regarding hydro-meteorological hazards, flood mitigation was the main target of most of the NBS in Europe. There are also some projects focused on extreme temperatures/heatwaves, storms, erosion, drought and sea level rise. In terms of lessons learned, the NBS case studies suggest that stakeholder engagement (in various forms) is a key factor for successful implementation of the projects. Like many other activities, funding for NBS project is a limiting factor, which can be addressed by establishing co-financing mechanisms and partnerships experience from existing NBS case studies also suggests that adequate policy support is crucial for promoting NBS initiative at a local and national scale. In some cases, the physical condition of existing landscapes put limits to implementing new NBS projects, particularly in cities where local authorities are keen to create new green spaces with the aim of reducing urban heat island effect and air pollution but face a lack of space particularly in cities with high-density buildings.

In addition, monitoring and evaluation of the NBS projects help to generate important lessons from project implementation, and thus informing adaptive management. These were some elements that were highlighted repeatedly in many reviewed documents and therefore form essential elements for OPERANDUM to consider. Details on these and other important lessons learnt are provided in the ***Annex 1***.

A further review of acceptance of the NBS in the same papers and websites showed that many NBS approaches are now implemented globally, notably natural water retention basins, sand dune restoration, urban green spaces, and green roofs indicating high levels of acceptability. The NBS are accepted by the stakeholders (local authorities and communities), but only when the stakeholders are engaged throughout the planning and implementation of the project. Shared understanding and participating in the project implementation was identified as a key instrument to resolve conflicts among the stakeholders. As the NBS are new ideas to many stakeholders including implementing agencies, acceptance of these requires a long term interaction and a clear demonstration of tangible and intangible benefits provided by the NBS. Government policies and regulations need to be in place to support NBS ideas to be considered in mainstream development programmes and funding.

The climate risk assessments linked to NBS in OPERANDUM will need to address the dimensions hazard, exposure and vulnerability and will have to take into account climate-related changes. In the context of a climate risk assessment, it is crucial to assess the occurrence of hydro-meteorological events that lead to a hazardous situation. In general, it is not possible to predict precisely when and where hydro-meteorological hazards will occur in the future. However, with the aid of climate models, the identified climate-related events can be analysed under future climate conditions. With a robustness assessment of the regional climate model simulations, it is possible to provide a statistically sound expert judgment on the tendency of a climate event to change. The categories of the robustness assessment support the weighting and aggregation of the three risk components. The results of a climate risk assessment can be visualised by a risk matrix which is one method of presenting the results of such a climate risk assessment.

Scientific and policy attention for the issue of linking NBS and DRR has been recognised at international (e.g., the Sendai Framework for Disaster Risk Reduction of UNISDR, and the Paris Agreement of UNFCCC), and European level (e.g. the EU Action Plan on SFDRR 2015-2030, and the European Forum for Disaster Risk Reduction). All these agreements are of significant importance for this newly launched OPERANDUM project that aims to address (1) Improvement of acceptance of NBS based implementation and; (2) strengthening NBS policies adoption. Of the four priorities of Sendai Framework for disaster risk reduction, three of them are addressed in the OPERANDUM project (i.e., fostering the wider uptake of NBS, linking the NBS with policymakers, and land regulations and development of GeoIKP). The review on legal framework, protocols, guidelines and policies across EU and worldwide (see section 5) revealed a lack in the systematic mainstreaming of NBS, a fragmented climate policy regarding NBS, and an open problem in the application of NBS.

In relation to the aim of OPERANDUM project such as increasing the awareness, and evidences that shows the (cost-) effectiveness and benefits of NBS, which improves the acceptability in the wider community. There are some gaps such as lack participations of end-users in the early constructive stage hinders its full potentials against hydro-meteorogical risks. Therefore, the results from our literature review show that there is a clear need of specialisation at the design stage, which must be

improved by updating design tools (protocols, manuals, guidelines…). Furthermore, dissemination of these design tools through training courses, conferences etc will help to improve the application of NBS. We also identified to what extent the classical stages in soil and water bioengineering enterprises are used in hydro-meteorogical risk reduction.

Since OPERANDUM aims at developing co-designed and co-deployed solutions in a trans-disciplinary multi-stakeholder and participatory context and at enhancing market demand for nature-based solutions for hydro-meteorological risk reduction and climate change adaptation, the stakeholders' mapping and analysis are of great importance. In this deliverable, OPERANDUM stakeholders have been mapped according to three different levels of engagement (i.e., primary, secondary and tertiary) and their geographical coverage. As a result, the relevant stakeholders' group have been identified and categorized. The results of this activity will be mainly used to provide the base for operationalization of NBS (WP3), to elaborate the multi-stakeholder engagement strategy (WP8), and to develop dedicated dissemination and communication as well as exploitation strategies and actions (WP9).

In addition to the aforementioned gaps, there are still lack of solid evidence and research in the area of short and long-terms expected return of a NBS execution. In order to fill these gaps, a number of indicators used to demonstrate and quantify the effectiveness of a NBS have been introduced and discussed. These indicators will be integrated and upgraded in collaboration with the social and economic partners involved in OPERANDUM. Indicators are defined as measure data able to condense a variety of information. They could be used for analyzing, monitoring, and communicating not only the effectiveness of NBS but also their main characteristics. Indicators are also used to track how green spaces in cities are combating the impact of climate change and support decision makers. Indicators have been clustered into five categories, the first two closely related to SDG targets, the next two related to the acceptance and transferability of NBS, while the last one refers to the engineering and economical aspect of NBS.

As many solutions to environmental problems, NBS needs quite sophisticated input of environmental or socio-economic data, the quality of which may hinder an adequate NBS fitness for purpose. The question addressed is: can we assess the quality of NBS in relationship to the input data adequacy and/or gaps? How can we objectively assess input data adequacy and gaps? To decrease uncertainty about performance, management, economic and avoiding unwanted, or even potentially and economically harmful, aspects of the chosen solution, any NBS data build must pass through a quality assessment procedures. For this purpose, the EMODnet Checkpoint assessment methodology is proposed for assessing the "data adequacy" or "fitness for use" of data as input to the OPERANDUM GeoIKP – in the category of NBS. The data adequacy follows the structure of ISO 9001 based Quality Management System standards.

The assessment methodology for the appropriateness contains two fundamental steps 1) the choice of the quality measures that characterise data requirement for NBS (DR-NBS) and 2) input data set (IDS); and definition of the appropriateness indicators based upon these quality measures (QE).For the sake of simplicity the process of data. The basic concept of appropriateness indicators are to show the differences between what has been realized and what was "required" – model minus inputs, the minimum values are QEs/quality datasets. So, NBS practitioners will apply the relevant values for each QE in the metadatabase and indicators will be computed using IDS as numerator and

DR-NBS as the denominator. In general, in OPERANDUM GeoIKP data adequacy for NBS should be assessed in three main steps: (a) building the metadatabase with relevant QE for availability and appropriateness (involving WP6 and WP7); (b) entering and analyzing the availability indicators; and (c) computing the appropriateness indicators for each NBS and input datasets.

OPERANDUM GeoIKP will expose data about both existing and OPERANDUM NBS. The GeoIKP is based on the structure of the geo-catalogue and will enable publishing of data about key elements of the NBS, as well as policies, permitting paths and indicators related to the NBS. GeoIKP reference datasets will enable putting NBS data into a broader context and some basic statistical analysis. The GeoIKP will try to fill the gaps recognized in this deliverable by relating data sets to the NBS. Displaying all available data related to the NBS will provide the possibility to use these data as a template or a guideline to design/implement a new NBS. Indicators will enable benchmarking of the NBS and these data can be used then to decide if NBS is acceptable.

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# ANNEX 1 – Summary of lessons learnt and acceptability of the NBS projects

## ANNEX 1A NBS Best Practice Examples: Case studies from PANORAMA database

PANORAMA – Solutions for a Healthy Planet is an online database created through international partnership to document and promote examples of nature-based solutions to disaster risk and other environmental issues. Only projects presented in the English language and addressing directly an existing environmental hazard were considered. We did not review green measures for buildings, or purely conservation or restoration efforts with no explicit DRR objective. The short descriptions of the projects were extracted from the summary description on the PANORAMA project's page. Lessons learned and acceptance were taken, when possible, from the "building blocks" sections of the project's page where these are addressed directly. Early contributions to PANORAMA did not have detailed information and were therefore not reviewed.

**Table 23** (1A): Lessons learned and acceptation of NBS projects (case studies from PANORAMA database).

| NBS project | Short description of NBS project | Lessons learned | Acceptance |
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| Building with Nature for safe, prosperous and adaptive coastlines in Indonesia https://panorama.solutions/en/solution/building-nature-safe-prosperous-and-adaptive-coastlines-indonesia | Combination of civil engineering (using wood for permeable dams) and mangrove restoration to protect 20 km of eroding coastline in Central Java, Indonesia. This is combined with activities around sustainable land management and socio-economic development activities. | A pilot testing phase was essential to learn lessons on how best to design the structures to trap sediment and what best material to use for these structures.<br>Collaboration and agreement between communities and government authorities put in place for the management of reclaimed lands.<br>Integration of the proposed approach into the regional master planning and policies as well as endorsed in local village development planning and regulations on land use rights. | The project ensured that full ownership of the structures would be with the communities.<br>It is noted that stakeholders want to replicate the approach in other areas not covered by the project. |
| Ecosystem-based coastal protection through floodplain restoration in Vietnam https://panorama.solutions/en/solution/ecosystem-based-coastal-protection-through-floodplain-restoration | Flood, storm surge and erosion protection by restoring floodplains and rehabilitating mangrove forests in coastal Vietnam. This is done by constructing permeable bamboo breakwaters and rehabilitating mangroves on the restored floodplains. | For the modelling phase, and in order to ensure long term commitment locally, it was essential to share coastal engineering know-how and facilitation. Sharing the modelling results with technical stakeholders was also important.<br>For the design and implementation phase of the permeable breakwaters, it was essential to involve many different take holders; use of natural and locally available construction materials to keep costs low; supervision of construction work.<br>A strong monitoring programme is required to ensure the solution works but also, whether or not the solution has negative | Not clearly indicated but as the solution worked, people saw directly a stop to coastal erosion that was previously threatening them. |

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| | | impacts outside the area. Subsequent protection of restored mangrove forest is needed. For this, clear understanding of mangrove ecology and of coastal processes and morph dynamics is required. | |
| Integrated Mangrove Fishery Farming System in Tamil Nadu, India https://panorama.solutions/en/solutions/integrated-mangrove-fishery-farming-system-imffs | Adaptation to coastal hazards such as sea-level rise by combining brackish water aquaculture and mangroves/halophyte plantations. | Use of participatory and GIS to communicate with local communities.<br>Establishment of village management committees which contributed to build trust, confidence and partnership between the communities and the implementing organisation. Ensuring gender balance in these committees was essential. Training was also very important.<br>It is essential to protect the created fish ponds against future climate-related threats.<br>Monitoring was essential for adaptive management. | Not clearly indicated but results seem to have improved communities' livelihoods. |
| Connecting a coastal Reserve with its Surroundings https://panorama.solutions/en/solution/connecting-coastal-reserve-its-surroundings | The approach is used to address flood hazards in an area of Guatemala. | Understanding processes that link ecosystems, species and conservation values inside the Reserve through participatory interactions. It is important to take a landscape perspective.<br><br>The inclusion of actors that match all scales of actions is critical. | |
| Isar-Plan: Improving flood protection and recreational opportunities by redesigning the Isar https://panorama.solutions/en/solution/isar-plan-improving-flood-protection-and-recreational-opportunities-redesigning-isar | The aim was to restore the Isar river in Munich (Germany) from its artificial canal bed to a more natural shape and function in order to improve flood control, biodiversity and recreational opportunities. | Extensive stakeholder interaction using various approaches, and finding compromises between opposing designs.<br>Using modelling to inform design.<br>Combine engineered (called technical bank protection in the case study) with natural features worked well. | The stakeholder engagement was one of the main successes of the project, in particular to reconcile different views and designs. |
| At the water's edge: Enhancing coastal resilience in Grenada https://panorama.solutions/en/solutions/at-the-water-s-edge- | Installation of artificial reef structures, restoration of coastal vegetation, and community resilience planning to reduce coastal erosion and flooding in Grenada | To select relevant options, participatory processes are essential. Establish partnerships with various groups. Build capacities broadly. This leads to grounding analyses in local contexts.<br>Understanding the dynamics of organizations and agencies as it relates to information sharing. | Community embracing the project as their own and committed to become better stewards of their environment. |

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| enhancing-coastal-resilience-in-grenada | | Prioritizing clear communication about the project with partner agencies to ensure that project aims, objectives and potential benefits are fully understood.<br>To implement the NBS need accurate data.<br>Employing local community members to implement parts of the solution. | |
| Coral Gardening for Climate Change Adaptation in Vanuatu https://panorama.solutions/en/solution/coral-gardening-climate-change-adaptation-vanuatu | Restoration of damaged coral reefs to contribute to climate change adaptation (e.g. to sea-level rise) and eco-tourism revenue. | Trial different coral varieties to select the best ones.<br>Engage with women who are efficient stewards of the restoration process and who have different perspectives on the role of coral reefs than men.<br>Use the NBS implementation process to educate school children.<br>Involve tourists in the implementation of the NBS – it also provides additional revenues. | Deemed a great achievement by local communities. |
| Applying ecosystem-based disaster risk reduction through a ridge to reef approach https://panorama.solutions/en/solution/applying-ecosystem-based-disaster-risk-reduction-through-ridge-reef-approach | Ridge to reef approach in Haiti to address storm surges and coastal flooding in Haiti, including implementation of revegetation and sustainable vetiver farming | Combine observations and modelling to start proposing appropriate solutions.<br>Detailed monitoring to inform an adaptive management process.<br>Strengthen community-based organizations with sustained capacity development support.<br>Capacity development efforts are occasionally constrained by absences and rapid staff turnover in organizations. Important to work closely with the more permanent, technical Municipal Government staff and to engage with multiple agencies. | Not explicitly mentioned but the project managed to inform on the development of Haiti's first Marine Protected Areas. |
| Ecosystem-based erosion control in Azerbaijan https://panorama.solutions/en/solution/ecosystem-based-erosion-control-azerbaijan | Implementation and testing of stabilization of slopes and river beds, setup of hay-meadows, afforestation, orchard management and construction of a tree nursery to prevent erosion in Azerbaijan | Strong understanding of the social structure of the community, as well as the local environment, is essential.<br>Measures need to be adapted locally and provide visible results. Demonstrating different measures is important.<br>Community involvement in implementation. However, a broad stakeholder engagement is necessary throughout the process. Moderators can play a key role in conflict mitigation.<br>Crucial to involve women who are the main users of natural resources.<br>All sources of knowledge should be combined.<br>Hands-on training is essential. | - |
| Reforestation and rehabilitation of sandy coastal protection | Reforestation and rehabilitation of the coastal protection forest along with livelihood | Need to provide tangible examples of what works.<br>Essential to have the support of local authorities. | Not clearly discussed but awareness-raising went |

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| forest along with short-term livelihoods development for the local community (Vietnam) https://panorama.solutions/en/solution/reforestation-and-rehabilitation-sandy-coastal-protection-forest-along-short-term | development activities for communities in order to reduce risk of strong storms, sea encroachment, sand moving, drought and coastline erosion | Need to be patient as convincing stakeholders may take time.<br>Local communities should have space to raise their voices.<br>Ensure good quality material (seedlings) is used.<br>Monitoring and evaluation plan is essential.<br>Proposing livelihood enhancement strategies is important to bridge the time gap necessary for NBS solutions to start delivering (reconciliation of time scales). | beyond the area covered by the project. |
| Ecosystem-based flood and drought management in river basins https://panorama.solutions/en/solution/ecosystem-based-flood-and-drought-management-river-basins | Watershed-scale interventions with living weirs in Thailand to mitigate floods and droughts. | Difficult to access all datasets which means that sometimes only partial analyses are possible, increasing uncertainties.<br>Find solutions with the communities and propose approaches that are linked to local wisdom. However poor scientific understanding on how to build and where to locate the solutions will lead to failure.<br>Support local structures such as local river basin committees.<br>Need to emphasise that solutions need to be adapted to each geography.<br>External experts need to understand local knowledge management in local institutions. | Local communities worked together to put in place living weirs, solving their water shortage problem. |
| Forest protection and restoration for buffering extreme droughts in Ha Tinh province, Vietnam https://panorama.solutions/en/solution/forest-protection-and-restoration-buffering-extreme-droughts-ha-tinh-province-vietnam | Forest protection and enrichment at the catchment scale to reduce drought risk. | To achieve rapid economic gains, some farmers are willing to cut natural forest cover and replace it with fast-growing trees. To address this, there needs to be a close collaboration with local authorities to protect natural forests and engage farmers who are active in protecting it (role models). Ensure all farmers have a voice.<br>Initiate project-related activities at a small scale first. Close monitoring is required.<br>Liaise with local institutions that will ensure long term sustainability and replicability. | Not clearly stated, at least beyond the few farmers involved. |
| Rainwater harvesting for facing drought and soil moisture reduction and promoting ground water recharge, Peru https://panorama.solutions/en/node/1210 | Combination of green infrastructure with cultural, social and environmental practices as part of a program to recover Andean dry farming agriculture. | Reconciliation of different world views with respect to interaction with nature.<br>Communal and local organizations strengthened for improved conservation of the natural environment.<br>Understand how local culture perceives and interact with nature.<br>Reinforcing values of traditional knowledge and wisdom. | - |

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| Promotion of agrobiodiversity and riparian restoration in the Sixaola binational river basin https://panorama.solutions/en/solution/promotion-agrobiodiversity-and-riparian-restoration-sixaola-binational-river-basin | Combination of dialogue, capacities, knowledge, alliances and field work to promote agrobiodiversity and reforest the basin to mitigate droughts, high temperatures and floods. Bordering region between Costa Rica and Panama. | Self-diagnosis of vulnerabilities in the face of climate change is important.<br>Community of practice to take ownership of EbA practice.<br>Mix of traditional and scientific knowledge streams.<br>Promotion of demonstrative "integral farms" at the landscape scale, which produced a high diversity of products.<br>Agrobiodiversity Fair for knowledge exchange.<br>Secure institutional commitment. Work with existing structures and governance bodies.<br>Identification of spokespersons and leaders amongst men, women and youth is key. | There seems to have been an enthusiastic endorsement of the approach |
| Strengthening community leadership for mangrove restoration and food security of the Paz River, El Salvador https://panorama.solutions/en/solution/strengthening-community-leadership-mangrove-restoration-and-food-security-paz-river-el | EbA measures to restore coastal and mangrove forests to mitigate decreasing water flows and coastal hazards. | Working with local institutions. Local stakeholders become efficient disseminators of the measures.<br>Biophysical studies are critical to provide information for efficient monitoring and evaluation. This needs to be combined with local knowledge.<br>Advocacy and dissemination are required.<br>Stakeholders need permanent negotiation spaces. | Other communities became interested in what was happening downstream, leading to the creation of Mangrove alliance for the entire national coast. |
| Strengthening water security and water governance of indigenous communities in Guatemala https://panorama.solutions/en/solution/strengthening-water-security-and-water-governance-indigenous-communities-guatemala | Promotion of EbA through governance strengthening and action learning to diversify productive practices and restore degraded ecosystems for greater food and water security of communities. The region also suffers from increased landslides. | Rely on existing institutions locally.<br>Local empowerment is a basis for sustainability. Local leadership is essential. Improvement of local women leadership skills was also critical.<br>Open, equitable, respectful, and effective participation at all stages.<br>Use a strategy that allows showing rapid results.<br>Valuation of ecosystem services. | High level of participation, in particular of women. |
| Applying Ecosystem-based Disaster Risk Reduction (Eco-DRR) for the sustainable and resilient development planning in the Koh-e Baba mountains, Afghanistan | Promotion of improved ecosystem management through a bottom-up landscape approach to reduce flood and avalanche risks | It is preferable to influence existing development processes instead of generating new ones.<br>Need to take a landscape perspective, even if it was not possible in this project.<br>Capacities need to be developed.<br>Access to public lands needs to be ensured. | At the end of the project, there were multiple requests to replicate the nursery establishment once the benefits were demonstrated. |

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| https://panorama.solutions/en/solution/applying-ecosystem-based-disaster-risk-reduction-eco-drr-sustainable-and-resilient | | Clear economic benefits need to be demonstrated.<br>Dialogue and multi-stakeholder engagement are necessary. | |
| Applying ecosystem-based disaster risk reduction (Eco-DRR) in Integrated Water Resource Management (IWRM) in the Lukaya Basin, DRC https://panorama.solutions/en/solution/applying-ecosystem-based-disaster-risk-reduction-eco-drr-integrated-water-resource | Combination of ecosystem-based approaches to reduce soil/gully erosion and flood risk in two sites (upstream and downstream) in the Lukaya Basin, RDC and improving livelihoods and income. | Community-based approaches are essential, in particular for planning when national-level institutions are not too present.<br>Build on the presence of existing local organizations to bring the right stakeholders around the table.<br>Clearly, demonstrate the multiple benefits brought about by the measures.<br><br>Conflicts can arise between project and non-project areas, particularly if pilot tests are successful.<br>Capacity building is essential, in particular through learning by doing. Expand training to what the communities really need (i.e. go beyond pre-identified training needs). | Strong community uptake of the interventions.<br><br>Neighbouring communities were interested in replicating piloted approaches.<br><br>Government of promoted ecosystem-based approaches during preparatory discussions of the SFDRR. |
| Food security and disaster resilience through sustainable drylands management https://panorama.solutions/en/solution/food-security-and-disaster-resilience-through-sustainable-drylands-management | Hybrid solutions (including re-vegetation and ecosystem protection) to increase food security in the context of droughts and flash floods, Sudan. | In conflict/fragile localities, having strong partnerships is essential.<br>Need to match communities' schedules and not put too much time demand on them.<br>Clear evidence of benefits needs to be rapidly demonstrated. If rapid benefits cannot be shown, good dialogue and awareness raising is required.<br>Rotating monitoring system was needed to protect the green infrastructure. Unpalatable trees and shrubs could be prioritised in the future.<br>Stakeholder dialogue is important. Include national authorities.<br>Capacity development at multiple scales is essential to ensure sustainability. | National Agenda for Action included IWRM principles. |
| Resilient livelihoods, flood & drought protection through sustainable use of natural resources | Introduction of measures for the sustainable management of forest and fisheries resources in Mono delta (Togo and Benin) to help reduce flood and drought risks. | Multi-actor dialogue is essential.<br>Training of decision-makers is important, in particular on ecosystem services benefits. The problem is that much of the training material available is in English, not in French. The translation is therefore required. | - |

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| https://panorama.solutions/en/solution/resilient-livelihoods-flood-drought-protection-through-sustainable-use-natural-resources | | | |
| Mayesbrook river restoration project https://panorama.solutions/en/solution/mayesbrook-river-restoration-project | Restoration of Mayes brook Park in east London to create natural flood storage and generate multiple co-benefits. | Community engagement is key but linking them with existing institutions is also important.<br>Combining social and environmental regeneration goals.<br>It is important to be able to value ecosystem services. | - |
| Stormwater management and urban regeneration in Malmö https://panorama.solutions/en/solution/storm-water-management-and-urban-regeneration-malmo | Retrofit an area with Sustainable Urban Drainage Systems as part of a broader regeneration project to handle 70% of stormwater from roofs and sealed areas – thus reducing flood risk. | Clearly define the role and responsibility in a partnership (short and long-term) and clarify responsibilities.<br><br>Secure the financing before the project starts, including maintenance and monitoring activities.<br>Highlighting the benefits is important.<br>Stakeholders need a forum for dialogue. Residents involved in the design phase, reducing the potential for conflicts. | - |
| Wallasea Island Wild Coast Project – A landmark conservation and engineering scheme (UK) https://panorama.solutions/en/solution/wallasea-island-wild-coast-project-landmark-conservation-and-engineering-scheme | This is a habitat restoration project to offset coastal habitat loss and reducing flood risk. The aim was to raise 165ha of low-productivity agricultural land and create 235ha of coastal lagoon and grazing marsh habitat. | Consultation, early in and throughout the project is important, in part to explain the risks the systems would be facing under climate change.<br>Think outside the box to securing funding through innovative partnerships.<br>Strong relationship with landowners is essential.<br>Set up a technical advisory panel to identify technical and regulatory barriers and provide solutions to overcome them. | There was widespread support for the project thanks to a strong consultation process. |
| Nigg Bay Coastal Realignment https://panorama.solutions/en/solution/nigg-bay-coastal-realignment | Coastal realignment for intertidal habitat creation and coastal flood reduction, UK. | Consultation with relevant agencies.<br>Long term monitoring is essential. Resources are not always available for this though. | - |
| Green aeration corridors in Stuttgart City https://panorama.solutions/en/solution/green-aeration-corridors-stuttgart-city | Green belts and green divide in an urban environment to mitigate heat stress. | Generation of maps was important for planning and communication.<br>Green corridors and networks are more important for climate objectives than small isolated green spaces. | - |

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| | | Access to in-house technical competences and data facilitates the process tremendously.<br>Discussions with multiple stakeholders and scientific exchange.<br>Multiple partnerships were also important to develop joint products such as the 2008 Climate Atlas. | |
| Ecosystem-based Adaptation by small holders in Roslagen, Sweden https://panorama.solutions/en/solution/ecosystem-based-adaptation-small-holders-roslagen-sweden | Ecosystem-based measures are used by organic farmers to adaptively respond to climate variability and change to reduce crop damage and failure. | Build on local practices<br>Use natural indicators.<br>Essential to experiment and exchange information. Build on/revive traditional knowledge. | The EbA practices in Roslagen evolved from the grassroots level. |
| Flood Management and Ecological Improvement - The Creation of Lake Phoenix https://panorama.solutions/en/solution/flood-management-and-ecological-improvement-creation-lake-phoenix-0 | Large-scale restoration to return a stream and much of its catchment to a natural state, including the ecological hotspot Lake Phoenix, Germany. This now provides, among other things, flood protection. | Achieving multiple objectives requires compromises and therefore consultations and stakeholder engagement is essential.<br>Timing with important national and EU policy processes (e.g. for the latter the Water Framework Directive) played an important role.<br>Highlighting the multiple benefits scientifically is key, in particular for fundraising.<br>Feasibility studies required to convince decision-makers. | Funding secured from multiple partners, to make project partly self-supported. |
| Green-blue climate corridor Kamen - Disconnection of rainwater from sewage systems to prevent urban flooding https://panorama.solutions/en/solution/green-blue-climate-corridor-kamen-disconnection-rainwater-sewage-systems-prevent-urban | A green-blue corridor was developed in Kamen, Germany to improve the urban climate and restore the natural water supply in the area, thereby reducing flood risk. Properties were disconnected from the sewage system. | Engage the public to create a sense of ownership in the project.<br>Essential to conduct assessments of the cost-effectiveness of the measures and to communicate this clearly. Highlighting the benefits on well-being is also critical.<br>Ensure the approach develops into a balanced ecosystem. | Some residents were responsible for the implementation of individual adaptation measures on their own properties.<br>Residents accepted the implemented EbA measures. |

## ANNEX 1B NBS Best Practice Examples: Case studies from Natural Hazards- Nature-based Solutions database

The Natural Hazards – Nature-based Solutions platform contains database of projects, investments, guidance and studies related to the nature-based solutions to reduce the risks associated with natural hazards (https://naturebasedsolutions.org/). The platform was developed by the World Bank, the Global Facility for Disaster Reduction and Recovery (GFDRR), and Deltares. Although the database contains a large number of projects, evaluation report for all projects is not available, which limits the review of the projects from this database. Only a few important projects, which are relevant to OPERANDUM, are presented in the following matrix.

**Table 24** (1B): Lessons learned and acceptation of NBS projects (case studies from Natural Hazards- Nature-based Solutions database).

| NBS project | Short description of the NBS project | Lessons learned | Acceptance |
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| Water Management and Flood Prevention in France (https://www.naturalinfrastructureforbusiness.org/wp-content/uploads/2015/11/LafargeHolcim_NI4BizCaseStudy_WaterManagementFloodPrevention.pdf) | This project in Bellegarde in southern France is an example of stormwater management and flood prevention through targeted quarry rehabilitation and management programs that provide stormwater catchments and create beneficial wetland habitats. | Converting a quarry into water retention basins is a relatively simple solution for flood control, and this system has proven to be very effective in preventing flooding.<br>It shows that through working in partnership with local authorities and community stakeholders it is possible to develop a quarry restoration that can not only benefit the local community in many ways but also nature. | Accepted by the local community as they received numerous benefits from the project. |
| Hesketh Out Marsh Managed Realignment (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/651922/Case_Studies_46_to_65_Coasts_and_Estuaries.zip) | In the early 1980s, the intertidal salt marsh habitat of Hesketh Out Marsh was reclaimed from the Ribble Estuary for use as farmland. In 2008, the western part was reverted to intertidal saltmarsh when the RSPB, in partnership with the Environment Agency, breached the outer flood embankment of this western half. This breaching was possible by building a north–south cross-embankment separating the two parcels of land. Those works not only created 168ha of habitat – a nature reserve, owned and managed since by the RSPB – but also realigned the coastal margin for a more natural, robust and sustainable line of coastal flood defence. | It is possible to create saltmarsh by realignment simply by creating breaches and allowing tidal inundation to gradually erode creeks over time. However, this can be a very long process, as only the highest tides of the year will inundate the site, which may take many decades to attain habitat optimally. The process of habitat creation can be accelerated by the recreation of a sufficient creek network to feed tidal flows onto the site during the majority of the high tide cycles. This allowed the creation of a full saltmarsh vegetation community in 3–5 years following breaching on the Ribble Estuary. | Accepted by the community and stakeholders. The community now receives both flood mitigation and recreational benefits from the renewed natural habitat. |

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| Devon Beaver Project and River Otter Beaver Trial (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/651917/Case_Studies_1_to_23_Rivers_and_Floodplains.zip) | Detailed scientific studies into the impacts of beavers on hydrology and water quality were carried out. A group of beavers were introduced into the enclosed site of the river catchment. The beavers have: constructed 13 dams holding up to one million litres of additional water within ponds on the site, and influenced hydrology and water flow in the area by creating water storage, slowing down rainfall runoff and increasing base flow of the river. | Beavers are highly effective for managing and creating wetland habitats. They will often create new wetland habitats by damming watercourses in those areas where there is no deep water and their willow coppicing activities maintain open mosaic habitats.<br><br>Reintroduction of this species should be considered at a catchment scale rather than at a site scale, with the species often only moving into headwaters and suboptimal habitats as part of the colonisation of the wider catchment. | The results of the study were accepted by the scientific community, however other ecological impacts were not studied. |
| Urban River Restoration: a Sustainable Strategy for Storm-water management (http://climate-adapt.eea.europa.eu/metadata/case-studies/urban-river-restoration-a-sustainable-strategy-for-storm-water-management-in-lodz-poland) | In response to recent flooding events, Lodz carried out several activities within the EU SWITCH project, as 1) demonstration project of river restoration using natural processes, and 2) development of a new concept for the city planning, i.e. Blue-Green Network Concept. The developed strategy aims to: improve urban ecosystem health, reduce flood risk, and ameliorate the microclimate, thereby contributing to a better quality of life. | Main success factors can be summarised as follows:<br>- Participation in the SWITCH project was a major driving factor, not least due to the funding available through the project.<br>- Stakeholder involvement through the Learning Alliance was a strong driver of the initiative.<br>- A big part of the Learning Alliance success is due to the strong champions within the forum.<br>Limitation:<br>Discontinuation of funding after completion of the SWITCH project is a major limiting factor, which means replicating the demonstration project will be difficult. | The city authority has accepted the solution; however the funding for the project was limited. |
| Xining Flood and Watershed Mgmt (http://projects.worldbank.org/P101829/xining-flood-watershed-management?lang=en&tab=overview) | Xining Flood and Watershed Management project activities ranged from improving livelihood opportunities to enhancing flood management and environmental protection systems. Within an integrated framework, the project combined measures, including flood control works, wastewater collection, environmental sustainability, watershed rehabilitation, and livelihood improvement. | - Working with a large group of stakeholders has generated a shared vision for the watershed.<br>- The project resulted in environmental sensitization, including behavioural and mindset changes through education campaigns. | Acceptance to the greater community was achieved. The approach was based on key partnerships between Rural communities and local government to maximize project sustainability. The project also emboldened community conservation efforts while simultaneously strengthening the |

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| | | | community's resistance to environmental risk by improving urban environmental services. |
| Eco-engineered Coastal Defence integrated with Sustainable Aquatic Food Production (ECOBAS)( http://www.wur.nl/en/Expertise-Services/Research-Institutes/marine-research/show-marine/ECOBAS-Ecoengineered-coastal-defence-integrated-with-sustainable-aquatic-food-production.htm) | The objective of the ECOBAS project is to provide the coastal people of Bangladesh with an alternative approach for adaptation to coastal erosion and flooding. By using the concept of "eco-engineering", the natural resistance of shellfish reefs against hydrodynamic forces reduces human vulnerability to coastal erosion and flooding and delivers a source of aquatic food. | - The project showed a new technology for coastal shoreline protection by sediment trapping natural reef formations in the sea. | The project was at pilot scale. Further study is required to determine the acceptability. |
| Dunruchan Farm Peatland Restoration Project (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/651920/Case_Studies_31_to_45_Runoff.zip) | The scoping study for this project in the Allan Water Catchment used hydrological modelling that identified the Knaik sub-catchment as contributing on average 23% of the flood peak which occurs in the most downstream PVA in the catchment. Hillsides with fast flow pathways due to hill grips are one reason the Knaik sub-catchment has such an impact on the Allan Water flood peak. The project identified an area of the Knaik sub-catchment where extensive hill grips were present and work was possible. By using measures such as peat dams and wooden sediment traps, fast water conveyance was attenuated and the blanket bog habitat was restored. | The Dunruchan Farm Peatland Restoration Project restored 48.2ha of extensively drained upland blanket bog at just under 300m altitude by using approximately 790 peat dams, 10.4km (10,365m) ditch and gully reprofiling, 6 wooden sediment traps, one 10m bund, 30m worth of in-ditch bunds and 7 plastic dams.<br>Some built features can function temporarily, but may not last the test of time if constructed to an unsatisfactory specification for the particular site. The Dunruchan Farm Restoration Project suffered from this issue with the wooden sediment traps, but the project was able to correct it by asking the contractor to return to site. | The evaluation of acceptance was not done yet. |

## ANNEX 1C NBS Best Practice Examples: Case studies from Think-nature database

Think-nature is a multi-stakeholder communication platform that supports the understanding and promotion of Nature-based Solutions (NBS) (https://platform.think-nature.eu/home). This database includes several case studies on nature-based solutions. Evaluation of some of the case studies is presented in the following matrix.

**Table 25** (1C): Lessons learned and acceptation of NBS projects (case studies from Think-nature database).

| NBS project | Short description of the NBS project | - | Lessons learned | Acceptance |
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| Landscape-ecological planning in the urban and peri-urban area - study area Trnava, Slovakia (https://platform.think-nature.eu/nbs-case-study/17266) | Major actions:<br>Developing and testing usable methods for valuation selected ecosystem services at the local and regional level, and promote their incorporation into the spatial planning process and in the broader decision making process in Slovakia. | - | Simple valuation methods are more suitable for practical implementation.<br>- Comprehensive methods are more reliable<br>- Stakeholder involvement is a powerful tool, but it has several constraints.<br>- "Tiered" approach (national ES assessment - regional priorities - local planning process) could be useful for comprehensive planning. | The valuation methods are accepted by the local authority, however, these are based on local context and could be applicable to a similar type of landscapes (e.g. sub-urban areas with dominant agricultural use) in other places. |
| Urban hybrid dunes in Barcelona (https://platform.think-nature.eu/nbs-case-study/17274) | Major actions:<br>Constructing and maintaining semi-fixed dunes on heavily used urban beaches to optimize the flows of ecosystem services, protection against sea level rise as well as enhancing recreational use. | - | Assessment of ecosystem services of the beaches helped to develop a comprehensive understanding of the economic activity, administration complexity, and vulnerability to climate change.<br>- Social mapping and instruments for cultural ecosystem services valuation proved to be useful to improve communication between big administrations and citizens<br>- Systematic analysis of the beach management system has led to a simpler and cost-efficient strategy which integrates natural capital building and adaptation to climatic change. | The solutions developed by the project was accepted by the stakeholders. An integrated methodology was adopted involving complementary interaction systems (dune-beach, marram grass-dune, social use-beach and dune) to get a simpler way to manage such a complex environment. |
| Izta - Popo - Replenishing Groundwater through Reforestation in Mexico (https://platform.think-nature.eu/nbs-case-study/18030) | Major actions:<br>Natural infrastructure alternatives such as trees, pits and earthen banks were developed which would enable more than 1,300,000 cubic meters of additional water per year to be fed into the ground reserves in the Iztaccíhuatl-Popocatépetl National Park region. | - | It was important to use the experience of local people and ensure their ownership for the success of the project.<br>- Participation of stakeholders including the agency responsible for the Puebla State drinking water was key to the project's success. | The project was accepted by the stakeholders. The success of the Itza Popo project has prompted Volkswagen de México to initiate a similar new project involving 100 hectares of trees to be planted in Filao, Mexico. |

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| Park 500 Natural Treatment System (https://platform.think-nature.eu/nbs-case-study/18035) | Major actions:<br>The Park 500 Natural Treatment System (NTS) was constructed as a voluntary effort to provide a low-energy, low-maintenance alternative to reducing nitrogen and phosphorus in the wastewater coming from tobacco processing.<br>The project was initiated to reduce the environmental footprint of the tobacco production facility and help Philip Morris USA meet its environmental sustainability goals. | - The NTS reduces mass loading to the James River and creates a performance buffer for the existing plant discharge to ensure long-term compliance.<br>- High population growth of unwanted species could hamper the performance of the treatment system. So, detailed feasibility studies are key to success in executing a constructed wetland.<br>- Early engagement of key stakeholders was critical to success.<br>- Unavailability of land and inadequate support from government authorities could limit the success of the project. | Having a positive outcome, the project was accepted to the PM USA. The project acted as a catalyst in improving PM USA's overall environmental management system. |
| Riparian Forest Restoration and River Bank Protection, Evrotas River, Greece (https://platform.think-nature.eu/nbs-case-study/18366) | Actions:<br>A bank restoration system using large stones following the rivers curvatures to stabilize the bank and the riparian zone from future flood events was designed and constructed.<br>The selection of large stones was made for two reasons: they can alleviate the power of future floods as well as allowing space for fish to spawn. In addition, riparian forest of 200 poplar trees was planted to decrease nutrient loads due to uptake and enhanced denitrification. | - The riparian forest enhanced stabilization of the river bank<br>- Riparian forest was naturally extended to close the gap of riparian vegetation created by the flood.<br>- Riparian forest reduced nitrate-N pollution to the river by 70%. | The NBS solution was accepted as a low cost-high impact solution which can be easily be adapted to other rivers. |
| Ecuador: The Socio Bosque Program (https://platform.think-nature.eu/nbs-case-study/18372) | Major actions:<br>The Socio Bosque Program that began in Sept 2008 is an initiative of the Ministry of the Environment of Ecuador (MAE) that offers economic incentives to owners of land with native forests to guarantee its protection over the medium to long-term; to date, conservation agreements have been signed for 630,000 hectares. | - People are more committed to protect and nourish the land when they have the ownership<br>- Conservation actions must be coupled with income in order to generate activities for long-term sustainability. | The project was accepted by the people as they received financial incentives.<br>The model can be applied to other countries. |
| Medmerry, West Sussex coastal flooding (https://platform.think-nature.eu/nbs-case-study/18379) | Major actions:<br>A new inland flood defence was built along the existing coastline of Medmerry, West Sussex coast, ensuring the conservation of birds and other wildlife as well as protecting important Bronze Age settlements. | - Collaboration of a wide range of stakeholders was necessary to complete the project successfully.<br>- Engagement of local residents was critical to carrying out a successful project and created an environment of trust. | The stakeholders accepted the solution when they were involved in the whole planning and implementation process, although initially there was some resistance. |

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| | | | The solution can be applied to other coastal areas subject to erosion. |
| Basel, Switzerland: Green roofs: Combining mitigation and adaptation on measures (https://platform.think-nature.eu/nbs-case-study/18381) | Major actions:<br>Since 1995 the total number of green roofs resulted in 1711 extensive green roof projects and 218 intensive green roofs in the city of Basel. So, approximately 23% of Basel's flat roof area was green roof in 2006. | - Well adopted technology in the city<br>- Stakeholder engagement and leadership were the keys to success.<br>- A comprehensive suite of mechanisms, from incentives to statutory regulations, has ensured a wide uptake of green roofs in Basel. | It has been accepted to the community and house builders. |
| Green corridor in Passeig de Sant Joan, Barcelona (ENABLE project) (https://platform.think-nature.eu/nbs-case-study/18419) | Major actions:<br>Introduction of green infrastructure (green spaces), that promote health and wellbeing of residents as well as improve local climate and air quality.<br>The semi-permeable pavement and irrigation system was installed in most part of Passeig Sant Joan allows for water collection and mitigates run-off while also promoting sustainable water use. | - Re-prioritising more integrated NBS thinking within local institutions is as necessary as cultivating higher levels of socio-environmental awareness.<br>- Ecosystem services provided by NBS contributing to health, leisure, aesthetics or economic aspects, can be in conflict with ecological/sustainability priorities. | The urban community accepted the project. However, the cost of maintenance remains a major concern for long term viability. |
| Paris Oasis Schoolyards programme (https://platform.think-nature.eu/nbs-case-study/18474) | Major actions:<br>Reducing heating of school grounds by putting light-coloured, low carbon footprint substrate with a modular porosity on schoolyards grounds. Use of rainwater to cool down the ground surface.<br>Increasing trees, school gardens, green walls and roofs create shade to reduce temper with heat waves as well as to increase environmental awareness among children. | - Integrated vision in response to various urban vulnerabilities was generated<br>- Inclusive approach of residents, public institutions and the private sector was developed | A good example of integrating NSB in the urban environment. This programme can be transposed to cities. |
| Moss for green infrastructure (https://platform.think-nature.eu/nbs-case-study/18870) | Major Actions:<br>A moss-brick wall was built in Helsinki Jätkäsaari. Roof of a small bus stop was covered with moss to demonstrate the technique.<br>A set of four different sized moss roofs were built on a villa next to a city of Lohja.<br>Small storage building in Helsinki was constructed with a moss roof to see how moss roof can handle extreme sun exposure. | - Building a ultra-thin moss roof is a cost-effective way of building green roofs.<br>- Moss roofs can be applied to places that were previously unreachable, and the maintenance of moss roofs is carefree. | Pilot-scale demonstration of a moss roof was accepted by the stakeholders. Further upscaling would require initiatives from the city authorities. |

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| Newport Wetlands Nature Reserve (https://platform.think-nature.eu/nbs-case-study/19192) | Major actions:<br>- Multi-functional nature-based watershed management and ecosystem restoration<br>- 865.72 ha of the nature reserve was created which includes mudflats, saltmarsh, reed beds, and wet furrows to reduce pollution, enhance wetland biodiversity, a drainage system and sea defences. | - Creating new wetlands and reed beds can clean up a polluted area where wildlife can thrive. | - The newly created nature reserve area was accepted by the local community.<br>- Similar project can be taken in other areas. |
| Yanweizhou Wetland Park-A resilient landscape, Jinhua (https://platform.think-nature.eu/nbs-case-study/18018) | Major actions:<br>- Adaptive tactics to preserve and enhance the remnant habitats: Water resilient terrain and plantings were designed to adapt to the monsoon floods;<br>- Water resilient terrain and planting design: This is achieved through the meandering vegetated terraces, curvilinear paths, a serpentine bridge, circular bio-swales and planting beds, and curved benches.<br>- A resilient pedestrian bridge connecting city and nature: A resilient bridge and paths system were designed to adapt to the dynamic water currents and people flows. | - Remnant wetland habitats in urban areas can be regenerated with water resilient terrain and green infrastructures. | - The new wetland park has been accepted by the local community. Around 40000 visitors used the park each day.<br>- The design strategies applied in Jinhua can be applied in similar contexts for creating resilient landscapes. |
| Delft: Sand Engine (https://platform.think-nature.eu/nbs-case-study/17630) | Major actions:<br>The sand engine, the artificially created expanse of sand off the coast of Zuid-Holland was developed to protect the Dutch coastline from erosion by making use of naturally occurring maritime currents. The main objectives of the project are to establish nature-based solutions for coastal resilience, restoring ecosystems and their functions, developing climate change adaptation, and improving risk management and resilience. | - Before the trial began, the Sand Motor was expected to last for twenty years. It was thought that the sand would be spread along the Delfland coast during that time. That will probably take longer.<br>- At present, the Sand Motor is already supplying sand to a five-kilometre stretch of coast. In the first four years, almost a million cubic metres of sand was moved to the south and about 1.5 million cubic metres has been moved to the north. | The Sand Motor has become an international icon of innovation. In Jamaica as well as in Norfolk in the United Kingdom, there are plans for a sandy strategy like the Sand Motor.<br><br>Experts are already contemplating whether the same principle might be used in the Wadden Islands to protect them from constant sea |

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| | | - Dunes in the coastal area near the Sand Motor have grown less quickly than expected. However, this has not affected the level of protection afforded by the coast since the coast was already strong enough before the Sand Motor.<br>- The main reason the dunes are growing more slowly is that the sand has to cover a relatively large distance before reaching the dunes. | erosion and rising sea levels. That idea constitutes the basis for the SEAWAD research project (TU Delft). |
| Adaptation of Bratislava city to Climate Change (https://platform.think-nature.eu/nbs-case-study/19033) | Major actions:<br>Rainwater management scheme to reduce urban flooding. Majority of implemented projects/measures represent different forms of SUDs, green roofs or rain gardens. Government subsidy was provided to building owners for the installation of rainwater management systems. | - Involvement of specialists or experts from different fields is required to avoid future complications in the realisation phase and setbacks on the pathway. | The authority has allocated budget to encourage the households and private sectors to take part in sustainable urban drainage management and climate change adaptation. The scheme was supported by the stakeholders. |
| Embleton Road Rain Gardens (https://platform.think-nature.eu/nbs-case-study/19168) | Major actions:<br>Rain gardens are created on the street to manage storm runoff and local flooding on streets in Bristol city. | - Community engagement in the design and implementation of the project was key to success.<br>- Rain gardens should not be planted directly under trees as leaf build up can be a maintenance issue. Openings should be as wide as possible.<br>- An evaluation package should be created for these projects with regular monitoring to determine the impacts on water quality and flood risk. | Accepted by the road users and city authority. The model can be applied in streets suffering from road runoff and flooding or in need of traffic control measures. |

## ANNEX 1D NBS Best Practice Examples: Case studies from Oppla database

Oppla is the repository of the Nature-Based Solutions implemented within the European Union. This database provides a marketplace for sharing the latest knowledge on natural capital, ecosystem services and nature-based solutions (https://oppla.eu/about). This database includes 17 case studies on nature-based solutions. Evaluation of the case studies is presented in the following matrix.

**Table 26** (1D): Lessons learned and acceptation of NBS projects (case studies from Oppla database).

| NBS project | Short description of NBS project | Lessons learned | Acceptance |
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| Amsterdam - NBS for greening the city and increasing resilience (https://oppla.eu/node/18009) | As part of the 'Structural Vision: Amsterdam 2040', the 'Agenda Groen 2015-2018' (Green Agenda 2015-2018) was adopted, which included specific 'Nature-Based Solutions' such as improving the city parks, greening the city, creating green neighbourhoods and green corridors, and ensuring proper implementation of delta plan. | The project shows the potential opportunity of creating green jobs and engaging the local community in city planning and decision making.<br>Co-financing from the government authority and not-for-profit organizations can be a suitable approach for financing NBS projects.<br>The practical knowledge needed to implement nature-based solutions in cities is often not present.<br>The relationship between the city, with its integrated view, and the local community, with a single bright idea, is not always easy. | The NBS initiatives were accepted by the city of Amsterdam and the public, not-for-profit organisations, companies and authorities, which led to co-financing the project within total more than 55 million euro.<br>Amsterdam received the European Capital of Innovation award in 2016. |
| Bari - NBS for greening the urban space (https://oppla.eu/node/18000) | The NBS actions undertaken by Bari city authority, Italy include Operation Zero Degradation (Revitalising residual urban areas as green spaces), Shagree (Green shadows programme- increasing green roof buildings), and Lama Balice Nature Park (protected area management). | The 'Operation Zero Degradation' initiative under the Green Surge project showed evidence of economic benefits in terms of increasing economic activities (e.g. cafés and bars) in the proximity of green areas.<br><br>The 'Shagree' project was not implemented yet due to a lack of legal and administrative support.<br><br>The 'Lama Balice Nature Park' was preserved, which enhanced environmental quality and biodiversity, increased availability of green areas, and improved drainage.<br>Existing high building density in the city of Bari places physical limits on greening initiatives<br>It is challenging for the city authority to manage numerous fragmented green or open spaces. | Since the Green Surge project was not directly implemented by the city authority, they were not much interested in the project, although the other stakeholders including professional and local community showed high interest. The city authority is overloaded with day-to-day activities. It seems there is a lack of political commitment to the projects. |

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| Berlin - NBS for urban green connectivity and biodiversity (https://oppla.eu/node/18090) | The NBS projects of the city of Berlin include several initiatives such as BENE (urban greening), green Moabit, transforming vacant urban areas, school gardens, Mixed forests programme, Green Walks, and nomadic gardening. The projects aim to create connectivity across the city and a 'green belt' as a border boundary for urban growth and protection against urban sprawl. | Adequate policy and legal support are necessary for implementing NBS. Public policies need to be adjusted to support green infrastructures. The 'Bottom-up citizens' initiatives' taken in the NBS project in Berlin have helped to create important green infrastructure, influencing and transforming public policies.<br>Maintenance of green spaces remains a major challenge to the government due to limited funds and resources. Citizen's involvement through bottom-up initiative could minimize the funding limitations, as observed in some NBS in Berlin. | The NBS project is accepted by the government agencies as well as the local community. Some initiatives like Green walk was started by citizens, later adopted by the city administration. |
| Bilbao - NBS for dealing with extreme temperature and rainfall events (https://oppla.eu/node/18001) | Major projects include:<br>- Zorrotzaurre project (urban renewal to promote the sustainable restoration of a currently derelict site including flood prevention measures, a transport network, and restoration of the area's cultural heritage)<br>- Bilbao Greenbelt Expansion (to expand and connect the city's green areas) | Both projects have been successful in bringing climate-change mitigation and adaptation concerns into urban planning. They have also influenced local policy and the revision of the Master Plan, which was due for preliminary approval in 2018.<br>Bilbao's history of successfully managing severe crises with commitment and creativity has helped it to adopt innovative measures.<br>Economic constraints are the major factor that limits the adoption of NBS in Bilbao. | The city administration has an interest in NBS projects. The city's interest in NBS-related measures was already evident in its participation in the FP7 projects Econadapt and RAMSES and in the H2020 project RESIN. |
| Bristol - NBS for ensuring a sustainable future (https://oppla.eu/node/18002) | Major projects include<br>- Green infrastructure (GI) such as trees, green walls and roofs, to minimise and mitigate the urban heat island effect.<br>- Green areas for flood management (Sustainable Urban Drainage Systems (SUDS)). | Despite having the GI concepts in the policies and plans, financial constraints are becoming an issue.<br>Engaging local communities was key to success in implementing the NBS.<br>It is important to engage highly skilled experts working for urban green areas in the municipality and/or in connected research institutes. | Bristol city administration, businesses and local communities have shown greater interest in the planning and implementation of NBS projects.<br>Bristol became the European Green Capital in 2015. |
| Budapest - NBS for climate resilience and pollution control (https://oppla.eu/node/18003) | Major actions include<br>- 'Pocket parks' and urban gardens<br>- Renewing city parks<br>- Preserving forests on the outskirts and existing green areas | Effective cooperation among different municipalities and stakeholders has led to the successful implementation of the NBS project.<br>Limited financial capacity and technical knowledge of the municipalities often hindered the progress of NBS. | There is a strong commitment to the city authority to make the city 'green' through NBS projects. |
| Dresden - NBS for sustainable urban transition (https://oppla.eu/node/18010) | Major actions include<br>- Transforming former allotment gardens into community gardens<br>- Landscape plan to create a 'compact city within an ecological network' intended to | Bottom-up initiatives were recognised as a successful approach for implementing NBS. These have brought changes in the current local governance process. | The city authority and local community have accepted the project, which was evident through their participation. Having knowledge on NBS, the |

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| | enhance connectivity and green areas in the city | However, access to resources and funding is a serious limiting factor for the work of bottom-up initiatives, which rely on the voluntary work of members. | city participated in the German national initiative 'Zukunftsstadt' |
| Dublin - NBS for a more sustainable city by 2030 (https://oppla.eu/node/17999) | Major actions include:<br>- Sustainable urban drainage<br>- Green infrastructure (GI) (Green roofs and green walls) | During the implementation of the NBS projects, Dublin city mapped the potential open spaces, which resulted in a 53% increase in the number of officially known underused/vacant spaces and buildings. It was very helpful to make urban regeneration plans and meeting housing needs.<br>Long term maintenance of the GI and green areas was considered a major issue, which was dealt with subsequent development of policies and legislation. | Dublin City Council has a strong commitment towards promoting a green infrastructure strategy based on the Council's sustainability principles, both for biodiversity and ecosystem services. |
| Edinburgh - NBS enhancing health, wealth and sustainability (https://oppla.eu/node/18004) | Major actions include:<br>- Pollinator Pledge project (creating pollinator-friendly green spaces).<br>- Granton Community Gardeners | Community-led initiatives benefit when they receive a high level of support.<br>Involvement of too many different groups often creates tension in managing the project. | Community involvement and integration of the GI concepts in the city's plan shows acceptability of NBS. |
| Genk - NBS bridging green and industrial heritage (https://oppla.eu/node/18091) | Major actions include:<br>- Urban farming (69 gardens have been created on an old industrial terrain)<br>- Bee Plan (Bijenplan) (pollinators, creating flower meadows in their gardens and installing bee hotels and supporting beekeepers)<br>- Green Corridor (Stiemerbeek Valley)<br>- Heempark (miniature model of the agricultural landscape, become an educational nature and environment centre). | Small-scale nature-based solutions projects can grow significantly when managed well.<br>Replicating the projects is necessary to make the benefits visible.<br>Transition initiatives often struggle to reach citizens outside the local sustainability scene, especially those with foreign roots, young people and citizens who are not highly educated. | Nature-based solutions are an integral part of Genk's multi-annual strategic plan.<br><br>Local community, educators and research professionals accepted the NBS project by actively participating in those. |
| Linz - NBS as a motor for urban growth (https://oppla.eu/node/18011) | Major actions include:<br>- Landschaftspark Bindermichl-Spallerhof (landscaped park area of 8 ha over a highway tunnel.)<br>- solarCity (residential development in a rural area with high energy-efficiency standards) | Urban greening projects require management of conflicts of interests of different users without compromising the overall goal of sustainability. | There were complaints from the local community that the city authority did not have a rigorous policy for resolving conflicts between investment in new buildings and conservation of existing green spaces. |

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| | - Urban greening strategy | | The city authority did not show further interest in participating in other EU funded NBS projects. |
| London - NBS for a leading sustainable city (https://oppla.eu/node/18093) | Major actions include:<br>- Green roofs (London/Barking Riverside)<br>- Natural Water Retention Measures (NWRM) (River Quaggy)<br>- Brownfield restoration, Barking Riverside (landscape design including green walls and roofs, SUDs)<br>- Olympic Park (biosolar roofs - green roof with solar panels)<br>- Beetle Bump, University of East London campus (nature reserve constructed and monitored) | The River Quaggy project found that the NWRM costs were generally lower than those for more 'traditional' measures.<br>Getting NBS implemented takes longer than expected. Flexible planning and management system are required for NBD projects, as we cannot control things in practice when dealing with nature.<br>A barrier to the implementation of NBS can be a lack of knowledge about cost-effectiveness.<br>Regarding green walls and roofs, a number of barriers to implementation were identified: lack of common standards, fire hazard, maintenance, cost, structural issues, leakage and damage to waterproofing, lack of expertise and lack of policy. | London city has long been involved in implementing NBS. London Plan and local authorities have GI on their agenda, as London has a green roof policy. |
| Milan - NBS for urban regeneration (https://oppla.eu/node/18005) | Major actions include:<br>- Bosco Verticale (Vertical Forest) (a showcase of advanced engineering and technological development which uses nature-based solutions)<br>- Green Rays and Green Belts to connect the green areas using pedestrian/cycling green roads.<br>- Gorla Water Park, a multi-purpose green infrastructure (a series of built wetlands surrounded by a park). | Boeri's Vertical Forest proved to be a nature-based solution, which could be upscaled and replicated.<br>The Gorla water park is a virtuous example of a nature-based solution. The Gorla water park has been developed through a participatory process with public-private sponsorship. The Gorla example also shows how the EU's research and innovation funding strategy could be beneficial for the city's administration | The city of Milan has adopted the NBS in city planning agenda and involved local residents and companies for implementation and maintenance.<br><br>Vertical forest model is replicated in China.<br>Nanjing Vertical Forest Nanjing Green Towers will be the first vertical forest built in Asia. |
| Oradea - Improving quality of life with NBS (https://oppla.eu/node/18006) | Major actions include:<br>- Green area rehabilitation and development of green infrastructure.<br>- Lake creation<br>- Creation of outdoor leisure areas | Quality green areas enable people to have a better quality of life and to spend time outdoors.<br>A close partnership between the city administration and the private sector is crucial, as is the involvement of citizens, who can trigger further development of green spaces with private requests.<br>Administrative difficulties, long and bureaucratic public procurement processes, and limited financing, especially for the management and maintenance of green areas are the major limitations. | The city administration, especially from the mayor, has full support for NBS projects. |

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| Poznań - NBS for a friendly, mobile city (https://oppla.eu/node/18012) | Major actions include:<br>- Maintaining the green wedge system.<br>- Planting 18 000 trees on the roadside and using transitional green elements.<br>- Transforming car parks into green areas.<br>- Community gardens.<br>- Creating seasonal beaches. | Despite the high interest of the city authority and communities, it is often difficult to create green areas due to lack of space in the inner city, sometimes create conflict with other infrastructures.<br>More dialogue with the other responsible sectors and showcasing the multiple benefits of NBS while at the same time employing technical solutions to enable NBS can be beneficial. | The city authority and local community has accepted the NBS projects and are closely involved in developing green areas. |
| Rotterdam - NBS for building a waterproof city (https://oppla.eu/node/18094) | Major actions include:<br>- 'waterproof city' - robust and resilient with a mix of paving and vegetation.<br>- Increasing water storage capacity.<br>- Delta plan (multi-layered flood protection based on adaptive construction and design: e.g. 'flood-proof' buildings, 'flood-proof' public areas, floating communities and 'building with nature'.)<br>- Tidal park programme (several outer-dyke areas are being developed with alternatives to solid constructions to prevent flooding at high water levels). | Effective collaboration among the municipal services, other government departments such as the water boards, the citizens and private organisations, and utilities are essential to implement NBS projects. | Rotterdam city is one of the pioneer cities in the area of implementing NBS projects. Examples of NBS in Rotterdam city are followed by many cities around the world. Rotterdam is participating with other cities in the C40 Cities Climate Leadership Group. |

## ANNEX 1E NBS Best Practice Examples: Case studies from Climate Adapt database

The European Climate Adaptation Platform Climate-ADAPT is a partnership between the European Commission and the European Environment Agency (EEA). Part of the organisation's remit is to run a database of CCA-related documents, case studies, guidance, tools, etc. A search of this database brought up 250 documents with relevance to this study. A further scan of these revealed 30 case studies and other examples that can demonstrate best practice for nature-based solutions in disaster risk reduction. These are presented in the following matrix.

**Table 27** (1E): Lessons learned and acceptation of NBS projects (case studies from Climate-Adapt database).

| NBS Project | Short description of NbS project | Lessons learned | Acceptance |
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| Moor protection in the Allgäu region (Germany) through a stakeholder-based approach (2018) https://climate-adapt.eea.europa.eu/metadata/case-studies/moor-protection-in-the-allgau-region-germany-through-a-stakeholder-based-approach | '"Allgäuer Moorallianz" is an initiative to foster moor protection in the Allgäu region (Germany). It is a high wetland with a diversity of moor types. The conservation of these moor landscapes has a significant effect on reducing climate change impacts and maintain ecosystem services such as climate regulation. | Land purchase of bog area and working closely with farmers, supporting them to buy agricultural equipment, has been key to long term conservation.<br>The project has substantial funding, mostly from central government, to cover conservation activities plus funding for a rural development project under the "Ländliche Entwicklung" agricultural, tourism and regional economy funding regime.<br>Public awareness raising activities have also been important for the project's success as well as educating people on the moorland landscape and ecosystem services. | Nature conservation experts, activists, farmers, landowners and communal tourism office all had an important role in conservation. One of the main challenges has been working with so many stakeholders with different interests, especially as land ownership is very fragmented. |
| Sigma Plan II, Belgium https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/guide_multi_benefit_nature.pdf | The Sigma Plan II is a long-term strategy to manage flood protection and nature restoration of the Scheldt estuary in Belgium.<br>Major actions for flood protection:<br>- Creation of higher dykes<br>- Flood plains and wetland restoration<br>Nature restoration along the Scheldt river and its tributaries. | The plan used a stepwise strategy, with areas prone to flooding identified, then a land use plan developed for each project. | Scientists, economists, sociologists, landscape architects and ecologists contributed to each plan, as well as local government, nature associations and local residents with interests in land use. This was seen to improve the acceptance of the plans. |
| Benefits of Green Infrastructure Socio-economic Importance of Constructed Urban Wetlands, Nummela, Finland. | The Kilsoi watershed had experienced problems with erosion, flooding, drought, habitat degradation and low water quality.<br><br>Major actions: | Success factors:<br>- Monitoring has been important for demonstrating positive outcomes and convincing decision makers of the project's benefit. This has resulted in support for a second multipurpose wetland park in the same area.<br>- The project came about as a collaboration between a wide ranges of partners including local authorities. | Local population consulted using participatory methods with input from a consulting agency. As a result of this process, the municipality acquired land along the stream |

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| P. 105 in https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/guide_multi_benefit_nature.pdf | - New wetlands created along the heavily degraded stream corridor to restore lost stream corridor habitats.<br>- A large wetland park named the Nummela Gateway Wetland Park was established. | This has been important for key expertise such as landscape design and monitoring. | and allocated this as a core zone for water protection. |
| Nature-based measures against rock falls over forests in the Engadin Region, Switzerland (2018) https://climate-adapt.eea.europa.eu/metadata/case-studies/nature-based-measures- | Forests can provide effective protection against rock falls, landslides and avalanches. The Protect Bio method enables the evaluation of these ecosystem services. The method aims to evaluate if technical protective measures (i.e. engineered structures which are often expensive) need to be implemented in forests to provide protection against rock falls or if forests can naturally prevent damages caused by these events. The method was first used on the Fuorn Pass road in the Engadin region, Switzerland. | Success factors:<br>- For Fuorn Pass road near Zernez, results showed that no rock fall nets are needed on around half of the affected stretch of road. More expensive measures are now only needed in stretches of the road where the forest is thin.<br>- As a low-cost complementary measure, felled trees can be arranged crossways to the slope.<br>Limiting factor:<br>- The role of protection forest services against natural hazards such as avalanches, landslides and debris flows, are rather difficult to assess and quantify; data are not available in every location. | |
| Flood protection in the Upper Vistula river basin: grey and green measures implemented in the Sandomierz area (2018) https://climate-adapt.eea.europa.eu/metadata/case-studies/flood-protection-in-the-upper-vistula-river-basin-grey-and-green-measures-implemented-in-the-sandomierz-area/#solutions_anchor | Following intense flooding, new initiatives were launched to increase flood protection and the retention capacity of the river basin.<br>Major actions (grey and green):<br>- Naturalized reservoirs and restored wetlands are used<br>- Expansion reconstruction and modernization of river embankments<br>- Restoration of dike functionalities<br>- Reconstruction of water pump stations and water discharge channels. | Success factors<br>- The recent floods contributed to a sense of urgency for the implementation of the measures.<br>- The EU Water Framework and the Flood Directives also played an important role in initiating the integrated process aiming to reduce the flood risk and promoting green measures. | Stakeholders were involved via the informal Public Participation Committee of the Water Management Council in which 20 elected representatives from local government authorities, agriculture, fisheries, other economic sectors and ecological organizations, water users and water managers. They disseminated information about the project to other interested parties and ran two surveys and various public meetings. |
| Mainstreaming adaptation in water management for | Major actions:<br>- Establishment and restoration of riparian buffers | Success factor:<br>- The MWMP has been possible thanks to the determination of the municipal government of Isola | Citizens were involved in site surveys and in the identification of the most critical areas |

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| flood protection in Isola Vicentina (2017) https://climate-adapt.eea.europa.eu/metadata/case-studies/mainstreaming-adaptation-in-water-management-for-flood-protection-in-isola-vicentina/#solutions_anchor | - Rehabilitation and restoration of rivers<br>- Adaptation of flood management plans<br>- Improved water retention in agricultural areas<br>- Awareness campaigns for behavioural change | Vicentina, the scientific support of the IUAV University and the fieldwork carried out by municipal and technical consultants.<br>Limiting factor:<br>- A single municipality was in charge of the MWMP, without official coordination with surrounding municipalities. As a result, downstream municipalities will benefit from the risk reduction measures, whereas some critical issues generated outside (upstream) Isola Vicentina could not be solved by the plan. | (drawing upon past experience of flooding). Citizens were also surveyed through consultative public meetings.<br>Agreeing on responsibilities of each stakeholder group over the various drainage system components was very challenging (including farmers for agricultural practices and rural drainage; home-owners for cleaning of private ditches; water companies for urban storm-water management). |
| The Watermachine: a multifunctional area for flood protection and improved water quality - Kristalbad, Enschede (2017) https://climate-adapt.eea.europa.eu/metadata/case-studies/the-watermachine-multifunctional-area-for-flood-protection-and-improved-water-quality-kristalbad-enschede/#success_limitations_anchor | This is one of the last remaining green areas between these two cities, playing a role for ecosystem-based adaptation to cope with potential climate change-related impacts.<br><br>Based on the Swedish concept of "Watermachine", the seven public partners involved in the Kristalbad project are transforming Kristalbad into a multi-functional area. The Watermachine makes use of different elevation levels to create a water flow between different compartments of the area to naturally purify the water. Moreover, these compartments are able to store water, thus contributing to flooding protection. | Success factors:<br>- Policymakers from the local, regional and national governments were involved in developing and carrying the re-development project in a coordinated way from the beginning.<br>- As a co-benefit, the "Watermachine" stores water in an ecological way and can be used for agricultural purposes, providing a way to cope with drought.<br>- The area has also generated benefits for inhabitants and tourists, as they can use the area for walking, cycling and other recreational activities.<br>Limiting factor:<br>- Subsidy requests included very strict deadlines. This means that the process of the development of the plan had to speed up tremendously in order to be able to achieve funding. | The project has gained social support because of recreational co-benefits.<br>Citizens as such were not actively involved in the process but were informed and consulted on a regular basis. The citizens were represented by the so-called 'esthetical commission', composed of architects that provide advice to local policymakers on development plans. |
| Relocation as adaptation to flooding in the Eferdinger Becken, Austria (2017)<br><br>https://climate-adapt.eea.europa.eu/metad | The area of the Eferdinger Becken, Upper Austria, is a small area that lies on the Danube and is highly flood prone, including about 154 houses that flood regularly. | Success factor:<br>- A 250 million EUR budget for flood protection including resettlements and technical flood protection in the Eferdinger Becken was negotiated with the federal government and bindingly secured with a state contract in record time. This allowed offering 80% of | Although the first organised waves of relocation were received by the local population with high reservations and did not attract many volunteers for |

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| ata/case-studies/relocation-as-adaptation-to-flooding-in-the-eferdinger-becken-austria | Due to the importance of the retention space for the discharge and the difficult technical feasibility, passive flood protection was considered as more suitable. Homeowners needed to decide on relocation by the end of 2015. The federal and the regional governments compensate citizens 80% of the value of the house if they agree to move.<br><br>146 out of 154 highly affected property owners applied for the valuation of compensation and 80 out of those finally decided for resettlement. | house value compensations to the relocation volunteers.<br>- The local authorities also designated some limited special relocation areas and fixed land prices to avoid land price speculations.<br>- Each property owner can decide individually if she/he accepts the offer. This is in contrast to other reallocation action in Austria where the community had to decide commonly for or against the reallocation (e.g. Marchland).<br>Limiting factor:<br>- The non-movers were most likely older and less mobile people who are generally less resilient to cope with future flood events. | resettlement, interest increased after the 2013 flooding event.<br><br>The regional government developed a map of resettlement areas based on risk levels, and the level of difficulty to provide technical solutions and hazard response. The map was discussed and agreed with the mayors of the affected municipalities, representatives from the communities as well as with an advisory committee which represented all interested parties. |
| Giving rivers space – polders in Brandenburg, p. 27 in Risk Nexus<br>Central European floods 2013: a retrospective https://www.zurich.com/en/media/news-releases/2014/2014-0612-01 | In the state of Brandenburg (Austria) flood polders have been set up to restore flood plains near Lenzen. In this system, cropland is used to contain water. | The polders have successfully mitigated floods. | Initially, some farmers were sceptical that such a system would work. After the polders were used in flood events in recent years, confidence has increased.<br>Landowners affected now believe they can contribute to flood risk management and are no longer opposed to polders provided they receive adequate and fair compensation for the loss of arable land during floods. |
| Austria's experience, p.31 in Risk Nexus<br>Central European floods 2013: a retrospective https://www.zurich.com/en/media/news- | In Austria keeping retention areas vacant in order to allow them to flood is now generally regarded as the preferred option in efforts to keep risk low, even if this means flooding of agriculture and some built structures. This has proved effective, for example in flood retention areas around the town of Tulln. | Success factor:<br>- A great deal of effort went into determining clear lines of responsibility. Beyond this, training is carried out regularly for decision-makers at both the municipal and state levels. This proved very effective in 2013.<br>Limiting factor: | In some instances, incentives were provided to inhabitants living in high-risk zones to permanently resettle elsewhere. Those decisions were the result of a participatory process, which |

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| releases/2014/2014-0612-01 | | - Greater cooperation between states, as well as between countries bordering the Danube, is still needed. | allowed for appropriate incentives that seem to have been well accepted by those affected. |
| Lower Danube green corridor: floodplain restoration for flood protection (2014) https://climate-adapt.eea.europa.eu/metadata/case-studies/lower-danube-green-corridor-floodplain-restoration-for-flood-protection | In recent years severe floods occurred along the Lower Danube River. The restoration of floodplains is meant to provide room to retain and safely release flood waters. Restoring the natural resilience of the environment to climate events by decommissioning under-performing water infrastructure and thereby improving the natural capacity to retain and release peak floods, brings additional benefits both for nature and people. | Success factors:<br>- International agreements for better water and river management have been a powerful tool for change in the Danube River Basin.<br>- New opportunities for eco-tourism, fishing, and grazing and fibre production strengthen local economies, and the resulting higher quality habitat attracts a wider range of species, including endangered ones.<br>- In other cases, the need of the local communities to have access to enhance natural resources was the main driver.<br>- Financial resources have been important, but in the end, the political will in each country is believed to be the decisive factor to scale up the project.<br>- An independent organisation with know-how (WWF) took the lead and kept putting the effort in bringing the countries together, providing technical and financial support for meetings, encouraging governments to stay committed, etc.<br><br>Limiting factors<br>- Change of land ownership after the land restitution reforms in the Lower Danube Green Corridor countries make restoration projects challenging. | Land ownership was a key issue. In each restoration project, a few to a dozen landowners had to be convinced that a change in land use would be beneficial for them. For private landowners it was important to ensure them that they don't lose the property rights. The trigger to accept such change was the understanding of the benefits deriving from changing the unproductive arable land into wetlands (following two WWF-led pilot projects).<br><br>The implementation of the restoration projects would likely be accelerated if compensatory schemes for landowners are in place, however, this is not the case in any of the participating countries. |
| A transboundary depoldered area for flood protection and nature: Hedwige and Prosper Polders (2016) https://climate-adapt.eea.europa.eu/metadata/case-studies/a- | In this project, the outer defences of the Hertogin-Hedwige and the Prosper Polders – low lying areas of reclaimed land – will be removed, reopening these areas to the tides. The 'depoldering' process involves moving dike protection inland. Doing so will provide room for water during tidal surges, | Success factors:<br>- Economic analysis showed that a combination of projects, including the Hedwige-Prosper Polder project, would be more cost-effective in protecting urban areas and economic activities than building a large storm surge barrier.<br>Limiting factors: | The project encountered opposition from the Belgian owner of agricultural land in the Hedwige Polder and farmers and residents in the Netherlands. Their concerns included the loss of agricultural land plus |

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| transboundary-depoldered-area-for-flood-protection-and-nature-hedwige-and-prosper-polders | thereby reducing the risk of floods, and re-establishing an estuarine natural area. | - The estuarine natural areas envisioned will need to be maintained over time. Concerns have been expressed that the sedimentation rates in the project areas could be too high, resulting in areas not compatible with the natural or flood protection objectives of the project.<br>- Strong opposition in the Netherlands was a delaying factor. | resistance to deploring in general and a fear that more deploring projects might be undertaken. This opposition led postponement and the Dutch national government undertook an analysis of alternatives. This did not identify an acceptable alternative so in 2012 they decided to go ahead with the works at Hedwige polder. |
| Rehabilitation and restoration of rivers (2015) https://climate-adapt.eea.europa.eu/metadata/adaptation-options/rehabilitation-and-restoration-of-rivers/#success_factors | River restoration is done to mitigate the negative effects of the modifications, which is not only for ecological functioning of the river but usually other uses as well. Achieving river restoration implies that apart from the technical and ecological considerations, raising support and creating public awareness are just as essential to obtain results. An integrated approach is a prerequisite for success. | Success factors:<br>- Strong cooperation among public administrations and other stakeholders, raising support and creating public awareness.<br>- In general, it is intended to have positive effects on biodiversity.<br>Limiting factors:<br>- Implementation of river restoration measures can have a negative effect on navigation, and varying effects (+/-) on tourism, agriculture and drainage,<br>- It is not always feasible to implement because sometimes the river margins don't allow to restore the river. | The implementation of this adaptation option requires the involvement of various actors (river managers, farmers, inhabitants of villages, etc.) who should be involved to make the adoption of the adaptation option feasible. |
| Dune construction and strengthening (2015) https://climate-adapt.eea.europa.eu/metadata/adaptation-options/dune-construction-and-strengthening/#success_factors | Dune grass planting, thatching and fencing can all be used to prevent dune erosion - a natural phenomenon that can be worsened by human activities. These methods are complementary and are usually combined: grass planting usually requires fencing and thatching to succeed. | Success factors:<br>- If they are well managed, dunes can offer a high degree of protection against flooding and erosion.<br>- They also provide valuable habitats for animal and plant species.<br>- Dune thatching, fencing and grass planting are low-cost solutions to reduce dune erosion. They are not however likely to succeed if erosion is very severe. These methods are also labour intensive; they have a limited lifetime and require frequent maintenance.<br>Limiting factors: | Potential for conflicts of interest over land use: landowners may be eager to preserve sea views while safeguarding beach use is important in touristic places. To a lesser extent, fencing and thatching can also have a negative impact on the landscape. Another public concern is that sand can be deposited in nearby residential or commercial areas. |

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| | | - Construction of fences and thatching will limit access to the dune and the beach. They can alter the natural visual aspect of the dune, which may have a negative influence on tourists' flows and recreational activities.<br>- Land loss can be an issue for the construction of artificial dunes and can be controversial.<br>- Often dune construction and strengthening and the creation of sand drift dikes repress the natural functioning of dunes. | Dune construction, strengthening and rehabilitation projects can also provide an opportunity to raise awareness of local stakeholders and visitors. |
| Addressing coastal erosion in Marche region, Italy (2014) https://climate-adapt.eea.europa.eu/metadata/case-studies/addressing-coastal-erosion-in-marche-region-italy/#adapt_options_anchor | A series of actions were taken to address erosion in the section of coast between the municipalities of Sirolo and Numana, in the region of Le Marche (Italy): beach nourishment, cliff stabilisation, as well as the removal of a portion of an artificial reef.<br>Retreat from the coast and relocation of tourism installations and settlements had also been considered, however, funding has not been made available for these. | Success factors:<br>- Use of cost/benefit analysis (and EIA) to strengthen project planning;<br>- Strong public information, stakeholder consultation and cooperation with local communities.<br>Limiting factors:<br>- Beach nourishment will have to be repeated due to ongoing erosion (proposed works to re-establish river sediment transport could reduce future erosion);<br>- Budget uncertainties for follow-up work due to the economic crisis. | The regional administration of Le Marche provided information to local citizens via flyers and newsletters. Moreover, interviews were held with tourism operators in the two municipalities, along with meetings with key stakeholders including the fishing and tourism sectors. These helped to generate acceptability of the project. |
| Renaturing of small waters as a means of climate change adaptation. P. 21 in http://www.circle-era.eu/np4/%7B$clientServletPath%7D/?newsId=432&fileName=BOOK_150_dpi.pdf | The city of Arnsberg and nearby villages experienced heavy flooding in 2007. Following citizen concern that it could happen again, within two years of the event 2.7 kilometres of the streams were successfully renatured, arranged in a more natural and ecologically sound way.<br><br>As part of the renaturing measures, stream banks in and outside of the villages were enlarged and flattened. Water obstructing elements, such as stairs, close to the stream bed were removed. | Co-benefits of the measures included increased biological diversity through nature (re)-development, improvement of the city landscape and increased touristic value of the city of Arnsberg. | This quick operation was made possible by the fruitful cooperation between the municipality and local inhabitants and fuelled by the prevalent fear that such an extreme event might cause serious harm in future.<br>Several times citizens agreed to give up parts of their properties to allow the streams to expand again, in some cases houses being given up. Most citizens were willing to cooperate as the |

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| | | | flood adaptation measures led to a higher safety level. |
| Wetlands reduce flood risks in Egå Engsø, p. 45 in http://www.circle-era.eu/np4/%7B$clientServletPath%7D/?newsId=432&fileName=BOOK_150_dpi.pdf | Egaa Engsoe a lake surrounded by wet meadows which store water during heavy rainfall and reduce the risk of flooding. It is located in the densely populated and low-lying valley of River Egaa close to Aarhus, Denmark. In 2006 the old river dikes were removed and the drained and pumped area was flooded. | Success factors<br>- A dynamic flow model shows that the lake has reduced the flood risk of the densely populated areas in the lower part of the river valley.<br>- The lake also reduces nitrogen leaching from surrounding agricultural areas. | Initially, it was difficult to sell the idea because this was a new concept. But when the area first became flooded, people saw the benefit.<br>It is now one of the most popular recreational sites in the municipality. |
| Rain gardens to manage extreme rainfall events, p. 59 in http://www.circle-era.eu/np4/%7B$clientServletPath%7D/?newsId=432&fileName=BOOK_150_dpi.pdf | The Norwegian city of Trondheim is building rain gardens to reduce the water load on the sewers and retain water on the site where it falls as rain.<br><br>Rain gardens are constructed as shallow planted depressions and facilitate local management of stormwater through collection, retention and infiltration of water. | To test the effectiveness of the rain garden a model was created to simulate the hydrological performance of the Risvollan rain garden. The model contains real data that was measured since its instalment in 2010.<br>One potential downside is that a functioning rain garden requires a certain amount of maintenance, for example, weeding and irrigation. | Open stormwater systems can give the population more value for money as they create green and blue structures in the urban environment. |
| Freiston shore managed realignment, p. 73 in http://www.circle-era.eu/np4/%7B$clientServletPath%7D/?newsId=432&fileName=BOOK_150_dpi.pdf | One of the largest managed realignment sites in the United Kingdom is located at the Freiston shore on the north-western bank of The Wash bay and estuary. Managed realignment schemes along the United Kingdom's coastline provide a sustainable flood defence solution that incorporates a functioning ecosystem and compensates for habitat loss by traditional flood defence and other human-induced works. | The newly created salt marsh (on what had been reclaimed agricultural land) provides a natural habitat for birds and plants and serves as a sustainable sea defence. It also breaks the incoming waves and reduces their energy.<br>In addition, a bird reserve has been created for many different species. The area is now a valuable nursery habitat for juvenile fish. | The nationally significant species of birds and wildlife that can be seen at the site and adjacent lagoon has made Freiston popular with visitors, and the RSPB receives approximately 60.000 visitors to the site every year. The RSPB was also one of the partners (along with government agencies) who set up the project. |
| Strengthening weak link Noordwijk p. 79 in http://www.circle-era.eu/np4/%7B$clientServletPath%7D/?newsId=432&fileName=BOOK_150_dpi.pdf | At Noordwijk (Netherlands) a so-called dike-in-dune defence has been built. This will effectively protect Noordwijk and its assets during a storm. If it's an extreme storm, the waves will first attack and erode the dunes. When all sand in front of the | A wide dune or a high dike would both have negative consequences on the activities on the boulevard and recreational activities in the area that form the backbone of Noordwijk's economy. The hybrid dike-in-dune was the perfect compromise. This way the view over the sea was mostly maintained, the area kept its natural dune landscape. | |

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| | dike is eroded away, the dike at the core can withstand the rest of the storm. | | |
| Adaption Option: Retreat from high-risk areas (2015) https://climate-adapt.eea.europa.eu/metadata/adaptation-options/retreat-from-high-risk-areas | In southwestern France, a shoreline road in the municipalities of Sète et de Marseillan (Languedoc-Roussillon region) was moved inland as it was threatened by the erosion of the beach. This allowed the reconstruction of a larger beach and dune system, which together should provide greater protection against erosion.<br>Another approach is to provide compensation or support for private owners whose homes are threatened. An example is seen in the UK, where erosion is threatening cliff-top settlements in East Anglia and Norfolk counties on the eastern coast of England. In Happisburgh, Norfolk, UK authorities decided not to take action against cliff erosion. Instead, ten owners of cliff-top homes at risk received compensation to relocate inland. The project also relocated a caravan site and a parking lot and redeveloped access routes to the beach under the cliffs. | Success factors:<br>- In areas with low population densities, the costs of retreat (including compensation and infrastructure costs) could be significantly less than other grey or green measures to protect assets where they are.<br>- The retreat of settlements and infrastructure can be combined with the recreation of natural features, such as vegetation buffers, wetlands, dunes, that can provide landscape and biodiversity benefits as well as protection against erosion, debris flows and floods.<br>- Retreat policies are likely to be more successful and receive stronger public support if they are designed in a long-term perspective.<br>In the US, the California Coastal Act and its implementing rules call local governments to establish requirements that new buildings be located at a minimum distance from the shoreline. In a dynamic approach, these types of requirements could be linked to erosion rates or sea-level rise, thus steadily moving the no-construction zone further inland. | Retreat strategies can be controversial and may result in strong opposition, in particular from homeowners affected. In the Happisburgh (UK) example, some homeowners felt that compensation was not adequate. Some local opponents were unhappy with what they saw as a change in government policies to protect against erosion. |
| Adaptation Option: Beach and shoreface nourishment (2015) https://climate-adapt.eea.europa.eu/metadata/adaptation-options/beach-and-shoreface-nourishment | Beach nourishment is common practice in the Netherlands, Germany, Spain, France, Italy, the UK and Denmark. Several beach nourishment techniques can be used including sand being spread over the beach where erosion is occurring; sand being stockpiled on the backshore; shoreface nourishment; by using inland sources of sand; and by using offshored dredging for larger amounts of sand. | Success factors<br>- Beach nourishment is a flexible and fast coastal management option compared to hard construction, and relatively cheap. If conditions change, additional nourishment can be simply added.<br>- Beach nourishment can complement by grey measures such as seawalls or groynes and green measures such as dune reinforcement.<br>- Co-benefits including tourism and recreation.<br>Limiting factors:<br>- Beach nourishment potentially can negatively affect foreshore ecosystem with the burial of biota, the loss | |

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| | | of habitats in nearshore sandbars, or the disruption of bird and another animal nesting.<br>- Beach nourishment is usually an ongoing process, which leads to higher costs over time and repeated disturbance of the ecosystem.<br>- Finding a source with sufficient quantities and good-quality sand can be challenging. | |
| Adaptation Option: Restoration and management of coastal wetlands (2015) https://climate-adapt.eea.europa.eu/metadata/adaptation-options/restoration-and-management-of-coastal-wetlands | Coastal wetlands (or tidal marshes) are saltwater and brackish water wetlands located in coastal areas. They provide a natural defence against coastal flooding and storm surges by wave energy dissipation and erosion reduction, helping to stabilise shore sediments. In some locations (such as the Schedlt Estuary), coastal wetlands can be used to absorb storm surge waters, attenuating flooding. | Success factors:<br>- Managed realignment and wetland restoration reduces the need for hard coastal defences. Even in combination, these approaches can reduce the need to heighten and broaden dikes, leading to a positive impact on the landscape.<br>- A healthy wetland can also help to cope with sea level rise.<br>- Managed realignment recreates important intertidal habitats, potentially including those playing a valuable role (nursery, spawning or feeding area) for species of commercial interest.<br>- In addition to preserving biodiversity, these new areas can be used for recreation and ecotourism.<br>- The restoration and preservation of wetlands marshes reduce eutrophication and can help to maintain freshwater quality.<br>Limiting factors<br>The main difficulty in implementing managed realignment involves changing land use e.g. relocation of buildings and activities, possibly at high costs (including expropriation), or in the loss of land used for recreation and agriculture. Managed realignment should be carefully planned to minimise the costs of relocation of activities. However, significant realignment projects are carried out on agricultural land as it does not require relocation of infrastructure. | |
| Adaptation Option: Cliff stabilisation (2015) https://climate- | Coastal cliff stabilisation techniques are 'green' measures to reduce cliff erosion and its consequences – landslide, collapse, falling off | Littoral strip reloading success factors:<br>- Reloading sand cliffs limits erosion and has a stabilising effect for the foot of the cliff. | Revegetation has little impact on landscapes and is usually |

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| adapt.eea.europa.eu/metadata/adaptation-options/cliff-stabilisation | rocks. They are often combined with 'grey' cliff strengthening measures. Stabilisation techniques include littoral strip reloading in which sand or pebbles are placed at the foot of the cliff and re-vegetation. | - It does not impact the landscape.<br>Littoral strip reloading limiting factors:<br>- Good quality sand or pebbles matching the characteristics of the original is needed.<br>- Repeated reloading is usually required as it does not stop ongoing erosion.<br>Revegetation success factors:<br>- Revegetation is an effective technique to prevent movements on the slope as it encourages the accumulation of sediment and runoff water.<br>Revegetation limiting factors:<br>- Vegetation will only stabilise the upper layer of sediments.<br>- Revegetation usually can only be applied to small areas and the type of vegetation planted has to be chosen carefully depending on the soil or the rock surface.<br>- If not well managed, the growth of the roots can have the reverse effect of causing instability by causing rock fracturation.<br>- Revegetation alone will in most cases be only a short-term solution. | supported by those who use the area. |

# ANNEX2: Stakeholder mapping: full list of primary, secondary and tertiary OPERANDUM stakeholders

**Table 28** (2A): List of OPERANDUM primary stakeholders.

| Source | Value Chain Position | Geographical coverage | Stakeholder Name<br>Type of organization<br>Area of interest | Brief description of the stakeholder<br>Website |
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| OAL AUSTRIA | End-user<br>Policy maker | *Local* | **Municipal administrator (Ortsvorsteher)**<br>*Public Body/Policy maker*<br>*Governance* | The municipal administrator is the local contact point between residents and municipality |
| OAL AUSTRIA | End-user<br>Policy maker | *Local* | **Municipality Wattens**<br>*Public Body/Policy maker*<br>*Governance* | OAL Austria is located within the Municipality of Wattens<br>https://www.wattens.com/ |
| OAL AUSTRIA | End-user | *Local* | **Agrargemeinschaft**<br>*Association*<br>*Agriculture, fisheries, forestry* | Association of local farmers |
| OAL AUSTRIA | End-user | *Local* | **Skiing area Vögelsberg**<br>*Company*<br>*Tourism* | Smalll-scale skiing area with 1 lift and 0,5 km of slopes<br>http://voegelsberg.at/index.php/liftanlage/ |
| OAL GREECE | Investor/funder<br>Policy maker<br>Designer<br>Delivery&Maintenance<br>Monitoring<br>Influencer | *Local* | **Water Management Directorate Of Central Greece**<br>*Public Body/Policy maker*<br>*Governance* | Legislation, Licensing of Water Uses<br>http://www.apdthest.gov.gr/Intro/διεύθυνση-υδάτων-στερεάς-ελλάδας.aspx |
| OAL GREECE | End-user | *Local* | **Independent Civil Protection Directorate of Central Greece**<br>*Public Body/Policy maker*<br>*Governance* | Coordination, overseeing work for the prevention, preparedness, response and disaster recovery<br>https://pste.gov.gr/periferia/γενικές-διευθύνσεις/αυτοτελής-διεύθυνση-πολιτικής-προστ/ |
| OAL GREECE | End-user<br>Monitoring<br>Influencer | *Local* | **Department of Agricultural Economics & Veterinary**<br>*Public Body/Policy maker*<br>*Governance* | Ensuring the development and quality improvement of the production sectors in the region<br>https://pste.gov.gr/periferia/γενικές-διευθύνσεις/geniki-diefthinsi-periferiakis-agro/ |

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| OAL GREECE | End-user<br>Investor/funder<br>Delivery&Maintenance<br>Supplier<br>Monitoring | *Local* | **Agricultural Cooperative of Lamia**<br>Association<br>Agriculture&fisheries | Exploitation of the biggest percentage of the local production<br>https://agrifoodcentralgreece.gr/en/producer/agrotikos-syneterismos-lamias/ |
| OAL GREECE | End-user<br>Policy maker<br>Designer<br>Delivery&Maintenance<br>Supplier<br>Influencer | *Local* | **Technical Chamber of Greece, Eastern Stereas section**<br>*Association*<br>*Engineering* | Advising role for shaping environmental policy and interventions<br>http://www.teetas.gr/ |
| OAL GREECE | End-user<br>Policy maker | *Local* | **Public Health Directorate, Central Greece**<br>*Public Body/Policy maker*<br>*Society&culture* | Preservation and improvement for the health and well-being of the population<br>https://pste.gov.gr/periferia/γενικές-διευθύνσεις/geniki-diefthinsi-dimosias-igias-ke/ |
| OAL GREECE | End-user<br>Policy maker | *National* | **Ephorate of Antiquities of Phthiotida and Evrytania**<br>*Public Body/Policy maker*<br>*Governance* | Regulating Body concerning all public works with respect to Byzantine antiquities<br>https://www.culture.gr/en/ministry/SitePages/viewyphresia.aspx?iID=1675 |
| OAL FINLAND | Policy maker<br>Supplier | *Local* | **Pro Puruvesi Ry**<br>*Association*<br>*Environment* | Water protection activities<br>www.propuruvesi.fi |
| OAL FINLAND | End-user<br>Supplier<br>Monitoring | *Local* | **Puruveden kalastusalue (Puruvesi Fishing region)**<br>*Association*<br>*Agriculture, fisheries, forestry* | Water and fish management, starting 1.1.2019<br>http://www.puruvesi.info/ |
| OAL FINLAND | Supplier<br>Monitoring | *Local* | **ELY-keskus, Pohjois-Karjala (Centre for Economic Development, Transport and Environment, Northern Carelia)**<br>*Public Body/Policy maker*<br>*Governance* | Regional administration<br>http://www.ely-keskus.fi/web/ely/ely-pohjois-karjala |
| OAL FINLAND | Supplier<br>Monitoring | *Local* | **ELY -keskus Etelä-Savo (Centre for Economic Development, Transport and Environment, Southern Savolax)**<br>*Public Body/Policy maker*<br>*Governance* | Regional administration<br>http://www.ely-keskus.fi/web/ely/ely-etela-savo |

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| OAL FINLAND | Supplier<br>Monitoring | *National* | **Metsähallitus, Luontopalvelut, Savonlinna (Metsähallitus, nature services, Savonlinna)**<br>*Public Body/Policy maker*<br>*Agriculture, fisheries, forestry* | To manage state owned forests and protected areas; supply wood to the country's forest industry and create and maintain recreation services<br>http://www.metsa.fi/web/en |
| OAL FINLAND | Delivery&Maintenance<br>Supplier<br>Monitoring | *Local* | **Suomen Metsäkeskus/Savo (Finnish Forest Centre/ Savolax)**<br>*Public Body/Policy maker*<br>*Agriculture, fisheries, forestry* | Promoting forestry and related livelihoods; advising landowners on how to care for and benefit from their forests and the ecosystems therein; collecting and sharing data related to forests and enforcing forestry legislation<br>www.metsäkeskus.fi |
| OAL FINLAND | End-user<br>Supplier | *Local* | **Puruvesi -newspaper**<br>*Company*<br>*Media&Communication* | Dissemination, information delivery<br>www.puruvesi.net |
| OAL FINLAND | Delivery&Maintenance<br>Supplier<br>Monitoring | *National* | **Freshabit Core (LIFE project)**<br>*Research Organization*<br>*R&D* | Implementing and monitoring water protection activities in Puruvesi region, research, participation in modelling<br>http://www.propuruvesi.fi/FRESHABIT/index.php |
| OAL FINLAND | End-user<br>Supplier<br>Monitoring | *Local* | **MTK Etelä-Savo ja Savonlinna (Central Union of Agricultural Producers and Forest Owners/ Southern Savolax and Savonlinna**<br>*Association*<br>*Agriculture, fisheries, forestry* | Regional unit for agricultural producers and forest owners, aiming to promote their interests, extension<br>https://www.mtk.fi/liitot/etelasavo/fi_FI/etusivu/ |
| OAL FINLAND | Delivery&Maintenance | *Local* | **Local hunting clubs/Kumpurannan metsästysseura**<br>*Association*<br>*Society&culture* | associations for local hunting and game management<br>http://kumpurannanmetsastys.net/yhteystiedot/ |
| OAL FINLAND | End-user<br>Monitoring | *National* | **Vesistökunnostusverkosto (Water Restoration Network)**<br>*Research Organization*<br>*R&D* | research, monitoring and advisory<br>http://www.ymparisto.fi/vesistokunnostusverkosto |
| OAL FINLAND | Supplier | *Local* | **Metsänhoitoyhdistys Etelä-Savo (Forest Management Association, Southern Savolax)**<br>*Association*<br>*Agriculture, fisheries, forestry* | Association for forest management; Expertise in local forestry, connections to local forest owners<br>www.mhy.fi/etela-savo |
| OAL FINLAND | End-user<br>Supplier | *Local* | **Itä-Savo - newspaper**<br>*Company* | Media<br>https://ita-savo.fi/ |

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| | | | *Media and Communication* | |
| OAL FINLAND | Delivery&Maintenance<br>Supplier<br>Monitoring | *Local* | **Forest owners in the case study area**<br>*Company*<br>*Agriculture, fisheries, forestry* | forestry, recreation, participation in forest and water management activities |
| OAL UK | End-user<br>Designer<br>Delivery&Maintenance<br>Monitoring | *Local* | **Catterline Brae Action Group (CBAG)**<br>*Association*<br>*Society&culture* | Community group representing local residents affected by landslide/coastal erosion |
| OAL IRELAND | End-user<br>Investor/funder<br>Policy maker<br>Monitoring<br>Influencer | *National* | **Smart Docklands**<br>*Public Body/Policy maker*<br>*Governance* | branch of DCC dealing with tech companies<br>www.smartdocklands.ie |
| OAL IRELAND | End-user<br>Policy maker<br>Monitoring<br>Influencer | *National* | **Smart Dublin**<br>*Public Body/Policy maker*<br>*Governance* | association of local authorities<br>www.smartdublin.ie |
| OAL IRELAND | End-user<br>Investor/funder<br>Policy maker<br>Designer<br>Delivery&Maintenance<br>Supplier<br>Monitoring<br>Influencer | *National* | **Dublin City Council**<br>*Public Body/Policy maker*<br>*Governance* | Dublin city council<br>www.dcc.ie |
| OAL GERMANY | End-user<br>Investor/funder<br>Policy maker<br>Designer<br>Delivery&Maintenance<br>Monitoring<br>Influencer | *Local* | **Biosphere Reserve Administration 'Niedersächsische Elbtalaue'**<br>*Public Body/Policy maker*<br>*Environment* | The tasks to be performed by the biosphere reserve administration are derived mainly from the state law which brought about its inception as well as state and national nature conservation legislation. In the category 'C' zones of the reserve, the biosphere administration also fulfils the function of the local nature conservation authority. The areas of responsibility can be summed up as follows:<br>•development of sustainable forms of land usage<br>•protection of nature and genetic resources<br>•research on and observation of nature<br>•environmental education and public relations |

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| | | | | The administrative staff is answerable to the Lower Saxonian Ministry for the Environment, Energy and Climate Protection. http://www.river-elbe-biosphere.niedersachsen.de/startseite/ |
| OAL ITALY | End-user<br>Designer<br>Monitoring<br>Influencer | *Local* | **Regione Emilia-Romagna – Land Security Agency and Civil Protection Agency**<br>*Public Body/Policy maker*<br>*Governance* | Authority for land security<br>https://protezionecivile.regione.emilia-romagna.it/protezionecivile |
| OAL ITALY | End-user<br>Policy maker<br>Designer | *Local* | **Goro municipality**<br>*Public Body/Policy maker*<br>*Governance* | Local administration town of Goro<br>http://www.comune.goro.fe.it/goro/common/Main.do |
| OAL ITALY | Delivery&Maintenance Supplier | *Local* | **University of Bologna - Construction and Sustainability Office (AUTC)**<br>*Research Organization*<br>*R&D* | construction Service of the University of Bologna<br>https://www.unibo.it/it/ateneo/organizzazione/amministrazione-generale/10900 |
| OAL ITALY | End-user<br>Policy maker<br>Monitoring | *National* | **Inter-regional Agency of the Po River (AIPO)**<br>*Public Body/Policy maker*<br>*Governance* | Inter-regional agancy responsible for flood protection and flood damage reduction in the Po valley<br>https://www.agenziapo.it/ |
| OAL ITALY | End-user<br>Policy maker | *Local* | **Province of Modena**<br>*Public Body/Policy maker*<br>*Governance* | Provincial body in charge of public work at province level: roads, bridges, support to water works.<br>http://www.provincia.modena.it/ |
| OAL ITALY | End-user<br>Designer | *National* | **IRIS SAS- Environmental engineering**<br>*Company*<br>*Engineering* | Expert in NBS |
| OAL CHINA-SRW | Investor/funder<br>Policy maker<br>Designer<br>Delivery&Maintenance Supplier<br>Monitoring<br>Influencer | *Local* | **Minqin County Government**<br>*Public Body/Policy maker*<br>*Governance* | Makes the policies for land and water use |
| UNESCO | Influencer | Global | **UNESCO field office in Venice**<br>*Public Body/Policy maker*<br>*Italy* | The UNESCO field office in Venice, is the only UNESCO field office in the region with a specific mandate on programme development and implementation. Their task is to facilitate the advancement of the overall UNESCO programme through specialised as well as |

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| | | | | interdisciplinary actions in the field of culture and natural sciences, to foster sustainable development, dialogue, reconciliation, and cooperation, with special focus on South-East Europe and the Mediterranean basin. http://www.unesco.org/new/en/venice |
| UNESCO | Influencer | Global | **UNESCO field office in Jakarta** *Public Body/Policy maker* *Indonesia* | The UNESCO Office in Jakarta covers two dimensions: As a Cluster Office, it represents UNESCO in Brunei Darussalam, Indonesia, Malaysia, the Philippines, and Timor Leste in all UNESCO fields of competence: Education, Culture, Social and Human Sciences, Communication and Information and Natural Sciences. As a Regional Bureau for Science, it covers Asia and the Pacific Region, through its programmes in Freshwater, Oceans, Basic and Engineering Sciences, Earth Sciences, and Coastal zones and Small Islands. http://www.unesco.org/new/en/jakarta/ |
| UNESCO | Influencer | Global | **UNESCO field offices in Montevideo** *Public Body/Policy maker* *Uruguay* | it is UNESCO's Regional Bureau for Science in Latin America and the Caribbean. 2) it is the UNESCO Office for MERCOSUR (Argentina, Brazil, Paraguay and Uruguay) and Chile. 3) as the UNESCO Office in Montevideo, it assumes the functions of national office (representation, planning and execution of the programme) for Argentina, Paraguay and Uruguay. http://www.unesco.org/new/en/office-in-montevideo/home/ |
| UNESCO | Influencer | Global | **UNESCO field office in San Jose** *Public Body/Policy maker* *Costa Rica* | Official representators for five Member States: Costa Rica, El Salvador, Honduras, Nicaragua and Panama. Its mission is to promote sustainable development, democracy and peace at the regional level through the promotion of universal education, peace and culture. http://www.unesco.org/new/es/sanjose/ |
| UNESCO | Influencer | Globa — | **UNESCO field office in Almaty** *Public Body/Policy maker* | Cluster Office to Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan. http://en.unesco.kz/ |
| UNESCO | Influencer | Global | **UNESCO field office in Cairo** *Public Body/Policy maker* *Egypt* | Serves all Arab States in the area of Sciences. The main objective of UNESO Cairo Office (UCO), as a Regional Bureau for Science in Arab States, is to contribute to the scientific development of the Arab member states. As a cluster office for Egypt, Sudan and Libya, (UCO) also undertakes national activities in those countries in all themes of UNESCO. |

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| | | | | http://www.unesco.org/new/en/cairo |
| UNESCO | Influencer | Global | **UNESCO field office in Beijing**<br>*Public Body/Policy maker*<br>*China* | works to find and implement innovative solutions in social, cultural, environmental and economic dimensions of sustainable development, helping countries to achieve their national development priorities and commitments on Sustainable Development Goals and the Education Agenda 2030. UNESCO Beijing Cluster Office for he Democratic People's Republic of Korea, Japan, Mongolia, the People's Republic of China and the Republic of Korea<br>https://en.unesco.org/countries/field-offices/beijing-cluster-office |
| UNESCO | End-user<br>Influencer | National | **Italian National Commission for UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*Italy* | UNESCO National Commission in Italy, an OAL country<br>http://www.unesco.it |
| UNESCO | End-user<br>Influencer | National | **Permanent Delegation of Italy to UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*Italy* | UNESCO Permanent Delegation of Italy, an OAL country<br>https://delegazioneunesco.esteri.it/rappunesco/en/ |
| UNESCO | End-user<br>Influencer | National | **Finnish National Commission for UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*Finland* | UNESCO National Commission in Finland an OAL country |
| UNESCO | End-user<br>Influencer | National | **Permanent Delegation of Finland to UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*Finland* | UNESCO Permanent Delegation of Finland an OAL country<br>http://www.finlandunesco.org/public/default.aspx?nodeid=34694&contentlan=1&culture=fi-FI |
| UNESCO | End-user<br>Influencer | National | **German Commission for UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*Germany* | UNESCO National Commission in Germany an OAL country |
| UNESCO | End-user<br>Influencer | National | **Permanent Delegation of Germany to UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*Germany* | UNESCO Permanent Delegation of Germany an OAL country<br>www.unesco.diplo.de |
| UNESCO | End-user<br>Influencer | National | **Hellenic Commission for UNESCO (OAL country)**<br>*Public Body/Policy maker* | UNESCO National Commission in Greece, an OAL country<br>http://www.unesco-hellas.org |

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| | | | *Greece* | |
| UNESCO | End-user<br>Influencer | National | **Permanent Delegation of Greece to UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*Greece* | UNESCO Permanent Delegation of Greece, an OAL country |
| UNESCO | End-user<br>Influencer | National | **Austrian Commission for UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*Austria* | UNESCO National Commission in Austria, an OAL country<br>http://www.unesco.at |
| UNESCO | End-user<br>Influencer | National | **Permanent Delegation of Austria to UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*Austria* | UNESCO Permanent Delegation of Austria, an OAL country |
| UNESCO | End-user<br>Influencer | National | **Irish National Commission for UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*Ireland* | UNESCO National Commission in Ireland, an OAL country |
| UNESCO | End-user<br>Influencer | National | **Permanent Delegation of Ireland to UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*Ireland* | UNESCO Permanent Delegation of Ireland, an OAL country |
| UNESCO | End-user<br>Influencer | National | **United Kingdom National Commission for UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*United Kingdom* | UNESCO National Commission in UK, an OAL country |
| UNESCO | End-user<br>Influencer | National | **Permanent Delegation of the United Kingdom of Great Britain and Northern Ireland to UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*United Kingdom* | UNESCO Permanent Delegation of UK, an OAL country |
| UNESCO | End-user<br>Influencer | National | **Australian National Commission for UNESCO (OAL country**)<br>*Public Body/Policy maker*<br>*Australia* | UNESCO National Commission in Australia, an OAL country<br>http://www.dfat.gov.au/intorgs/unesco/ |

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| UNESCO | End-user<br>Influencer | National | **Permanent Delegation of Australia to UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*Australia* | UNESCO Permanent Delegation of Australia, an OAL country<br>http://www.france.embassy.gov.au/pari/unesco/html |
| UNESCO | End-user<br>Influencer | National | **National Commission of the People's Republic of China for UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*China* | UNESCO National Commission in China, an OAL country<br>http://www.unesco.org.cn/index.jsp |
| UNESCO | End-user<br>Influencer | National | **Permanent Delegation of the People's Republic of China to UNESCO (OAL country)**<br>*Public Body/Policy maker*<br>*China* | UNESCO Permanent Delegation of China, an OAL country |
| UNESCO | End-user<br>Designer<br>Monitoring<br>Influencer | Global | **UNESCO designated sites managers at OAL**<br>*Public Body/Policy maker* | |
| UNESCO | End-user<br>Designer<br>Monitoring | Global | **Flusslandschaft Elbe UNESCO Biosphere Reserve**<br>*Other*<br>*Germany* | UNESCO designated site as OAL (Elbe River, Germany)<br>http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/europe-north-america/germany/flusslandschaft-elbe/ |
| UNESCO | End-user<br>Designer<br>Monitoring | Globa — | **Po Delta UNESCO Biosphere Reserve**<br>*Other*<br>*Italy* | UNESCO designated site as OAL (Po Valley, Italy)<br>http://www.biosferadeltapo.org/delta-po-biosphere-reserve/ |
| UNESCO | End-user<br>Designer<br>Monitoring | Global | **Hong Kong New Territories UNESCO Geopark**<br>*Other*<br>*China* | UNESCO designated site as OAL (Hong Kong New territories, China)<br>http://www.geopark.gov.hk/en_index.htm |
| UNESCO | End-user<br>Designer<br>Monitoring | Global | **Dublin Bay UNESCO Biosphere Reserve**<br>*Other*<br>*Ireland* | UNESCO designated site as OAL (Dodder River, Ireland)<br>http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/europe-north-america/ireland/dublin-bay/ |
| UNESCO | Monitoring<br>Influencer | Global | **IUCN - International Union for Conservation of Nature**<br>*Public Body/Policy maker*<br>*environment, ecosystem services, policy* | The International Union for Conservation of Nature (IUCN) is a membership Union uniquely composed of both government and civil society organisations. It provides public, private and non-governmental organisations with the knowledge and tools that enable |

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| | | | | human progress, economic development and nature conservation to take place together.<br>http://web.unep.org/ |
| UNESCO | Monitoring | Global | **UNEP - United Nations Environment Programme**<br>*Public Body/Policy maker*<br>*Environment, Ecosystem Services, policy* | The United Nations Environment Programme (UN Environment) is the leading global environmental authority that sets the global environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system, and serves as an authoritative advocate for the global environment.<br>https://www.iucn.org/ |

Table 29 (2B): List of OPERANDUM secondary stakeholders.

| Source | Value Chain Position | Geographical coverage | Stakeholder Name<br>*Type of organization*<br>*Area of interest* | Brief description of the stakeholder<br>Website |
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| **OAL AUSTRIA** | Designer<br>Delivery & Maintenance<br>Supplier<br>Monitoring<br>Influencer | National | **Austrian Research Centre for Forests (BFW)**<br>*Research Organization*<br>*R&D* | The BFW is an Austrian federal, multidisciplinary research and education centre which holds the legal status of an institution under public law. The BFW consists of six specialist institutions, two forest training centres (Traunkirchen in Upper Austria and Ossiach in Carinthia), one library and documentation office and numerous internal service centres. multidisciplinary institution for forestry research targeting practioneers, politics and research<br>https://bfw.ac.at |
| **OAL AUSTRIA** | Policy maker<br>Designer<br>Supplier<br>Monitoring | National | **Austrian Service for Torrent and Avalanche Control (WLV)**<br>*Public Body/Policy maker*<br>*Governance* | Providing base data for monitoring, conception and implementation of protection measures following legal directives.<br>https://www.bmnt.gv.at/forst/wildbach-lawinenverbauung.html |
| **OAL AUSTRIA** | Policy maker<br>Monitoring | Local | **Federal State of Tyrol**<br>*Public Body/Policy maker*<br>*Governance* | The Department of Geoinformation provides geo-base data for monitoring<br>https://www.tirol.gv.at/en/ |

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| **OAL AUSTRIA** | Designer | National | **Technical Consultant Umweltbüro Schütz**<br>*Company*<br>*Engineering* | Technical consultant with experience in soil bioengineering<br>https://www.tb-schuetz.at/ |
| **OAL AUSTRIA** | Influencer | Local | **Tourism Association Region Hall-Wattens**<br>*Association*<br>*Tourism* | Tourism Association of the region Hall-Wattens.<br>https://www.wattens.com/tourismusverband-region-hall-wattens--278088-de.html |
| **OAL GREECE** | End-user<br>Delivery&Maintenance<br>Monitoring | Local | **The Management Body of Mt Oiti National Park**<br>*Public Body/Policy maker*<br>*Environment* | Management Body subject to the supervision of the Ministry of Environment, Energy and Climate Change<br>https://oiti.gr/en/home/ |
| **OAL GREECE** | End-user<br>Investor/funder<br>Delivery&Maintenance<br>Supplier | Local | **Municipality of Lamia**<br>*Public Body/Policy maker*<br>*Governance* | Municipality, Regional Government<br>http://www.lamia.gr/ |
| **OAL GREECE** | End-user<br>Delivery&Maintenance<br>Monitoring | Local | **Technological Educational Institute**<br>*Research Organization*<br>*R&D* | Local Academic and Research Institute<br>http://www.teiste.gr/ |
| **OAL GREECE** | End-user<br>Influencer | Local | **Hunting Association of Lamia**<br>*Association*<br>*Society&culture* | Local association<br>http://www.kslamias.gr/ |
| **OAL GREECE** | End-user<br>Delivery&Maintenance<br>Monitoring<br>Influencer | Local | **www.e-ecology.gr**<br>*Association*<br>*Media&Communication* | Website for ecology, environment, climbing and quality of life<br>http://www.e-ecology.gr/ |
| **OAL GREECE** | End-user<br>Influencer | Local | **Association of Primary Education Teachers**<br>*Association*<br>*Society&culture* | Local association<br>http://dipe.fth.sch.gr/v2/ |
| **OAL GREECE** | End-user<br>Delivery&Maintenance<br>Monitoring<br>Influencer | Local | **Cultural Associations of many local regions near Sperxeios River**<br>*Research Organization*<br>*Society&culture* | Cultural Assosiations aim at enhancing and highlighting the customs and beauty of the local area |
| **OAL GREECE** | Influencer | Local | **LAMIA REPORT portal**<br>*Company*<br>*Media&Communication* | The most commonly used portal for information in Central Greece<br>http://www.lamiareport.gr/ |

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| **OAL GREECE** | End-user<br>Investor/funder<br>Supplier | Local | **CHAMBER OF FTHIOTIDA**<br>*Association*<br>*Society&culture* | Local association of traders, industrialists, craftsmen, professionals<br>http://www.fthiotidoscc.gr/fthiotida/shared/index.jsp?context=101 |
| **OAL GREECE** | End-user<br>Delivery&Maintenance<br>Influencer | National | **Hellenic Ornithological Society**<br>*Association*<br>*Environment* | Protection of wild birds and their habitats and ensure a sustainable natural environment for birds and people<br>http://www.ornithologiki.gr/page_in.php?tID=2679 |
| **OAL GREECE** | Designer<br>Monitoring | National | **AGRICULTURAL UNIVERSITY OF ATHENS**<br>*Research Organization*<br>*R&D* | Univercity with long involvement in studies related to Sperxeios Basin<br>https://www2.aua.gr//en |
| **OAL GREECE** | Policy maker<br>Monitoring<br>Influencer | National | **National Center for Environment and Sustainable Development**<br>*Public Body/Policy maker*<br>*Environment* | Scientific contribution to the development, implementation and evaluation of policies, relating to the environment and sustainable development<br>http://ekpaa.ypeka.gr/ |
| **OAL GREECE** | Influencer | National | **Centre for Renewable Energy Sources and Saving (CRES)**<br>*Public Body/Policy maker*<br>*R&D* | Research and promotion of RES/RUE/ES applications, taking into consideration the principles of sustainable development.<br>http://www.cres.gr/cres/index_uk.html |
| **OAL GREECE** | End-user<br>Designer<br>Monitoring<br>Influencer | National | **WWF Greece**<br>*Association*<br>*Environment* | Biodiversity conservation and footprint (lifestyles and economy), impact of the economic crisis on environmental protection and policies.<br>http://www.wwf.gr/en/ |
| **OAL FINLAND** | End-user<br>Supplier<br>Monitoring | Local | **Useat Puruveden osakaskunnat**<br>*Association*<br>*Agriculture, fishery, forestry* | Management of fish resources and monitoring of fishing |
| **OAL FINLAND** | Policy maker | Local | **Savo-Karjalan vesiensuojeluyhdistys**<br>*Association*<br>*Environment* | Management and monitoring and maintenance of water resources |
| **OAL FINLAND** | Delivery&Maintenance<br>Monitoring | Local | **Saimaan vesiensuojeluyhdistys**<br>*Association*<br>*Environment* | Management and monitoring and maintenance of water resources |
| **OAL FINLAND** | Policy maker<br>Monitoring | Local | **Itä-Suomen luonnonsurojelupiiri**<br>*Association* | Nature conservation, incl. water related biotopes |

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| | | | *Environment* | |
| **OAL FINLAND** | End-user<br>Monitoring | Local | **Kerimäki association**<br>*Association*<br>*Society&culture* | local cultural association |
| **OAL FINLAND** | End-user<br>Policy maker<br>Monitoring | Local | **Kuonan kylät**<br>*Association*<br>*Society&culture* | village association |
| **OAL FINLAND** | End-user<br>Monitoring | Local | **Villala village**<br>*Public Body/Policy maker*<br>*Governance* | to maintain local viability |
| **OAL FINLAND** | End-user<br>Monitoring | Local | Puruveden kalaharrit<br>*Association*<br>*Agriculture, fishery, forestry* | fishermen association (hobby and professional) |
| **OAL FINLAND** | End-user | Local | **Town Kitee**<br>*Public Body/Policy maker*<br>*Governance* | Local administration, local policy making |
| **OAL FINLAND** | End-user<br>Supplier<br>Monitoring | Local | **Town Savonlinna**<br>*Public Body/Policy maker*<br>*Governance* | Local administration, local policy making |
| **OAL FINLAND** | Influencer | Local | **Suomen järvikalastus - ja vesimuseiosäätiö**<br>*Association*<br>*Society&Culture* | to maintain water related culture |
| **OAL FINLAND** | End-user | Local | **Kerimäki School**<br>*Public Body/Policy maker*<br>*Society&culture* | educational activities |
| **OAL FINLAND** | Influencer | Local | **Koti-Karjala**<br>*Company*<br>*Media&Communication* | dissemiantion, information deliveriy |
| **OAL FINLAND** | Influencer | Local | **Karjalainen**<br>*Company*<br>*Media&Communication* | dissemiantion, information deliveriy |
| **OAL FINLAND** | Influencer | Local | **Savonmaa -lehti**<br>*Company*<br>*Media&Communication* | dissemiantion, information deliveriy |

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| **OAL FINLAND** | Influencer | Local | **ItäSavo**<br>*Company*<br>*Media&Communication* | dissemiantion, information deliveriy |
| **OAL FINLAND** | Designer<br>Monitoring | National | **Suomen luonnonsuojelukeskus**<br>*Research Organization*<br>*R&D* | research, monitoring and advisory |
| **OAL FINLAND** | Designer<br>Supplier<br>Monitoring | Local | **Karelia ammattikorkeakoulut**<br>*Research Organization*<br>*R&D* | educational activities, research |
| **OAL FINLAND** | End-user<br>Policy maker<br>Delivery&Maintenance<br>Supplier<br>Influencer | Local | **UPM metsä Savonllinnan metsäpalvelutoimisto**<br>*Company*<br>*Agriculture, fisheries, forestry* | forest industry |
| **OAL FINLAND** | End-user<br>Policy maker<br>Supplier | Local | **Metsä Group/Metsäliitto Osuuskunta Mikkelin piiritoimisto**<br>*Association*<br>*Agriculture, fisheries, forestry* | forest industry, forest advisory |
| **OAL FINLAND** | End-user<br>Supplier<br>Influencer | Local | **Stora Enso**<br>*Company*<br>*Agriculture, fisheries, forestry* | forest industry |
| **OAL UK** | Investor/funder<br>Influencer | National | **Scottish Water**<br>*Company*<br>*Environment* | Water supply and drainage<br>https://www.scottishwater.co.uk/ |
| **OAL UK** | End-user<br>Investor/funder<br>Designer<br>Delivery&Maintenance<br>Monitoring | Local | **Aberdeenshire - Ports**<br>*Public Body/Policy maker*<br>*Governance* | Section of the Local Authority in charge of the ports<br>https://www.aberdeenshire.gov.uk/ |
| **OAL UK** | End-user<br>Investor/funder<br>Designer<br>Delivery&Maintenance<br>Monitoring | Local | **Aberdeenshire - Transport**<br>*Public Body/Policy maker*<br>*Governance* | Section of the Local Authority in charge of the transportation infrastructure<br>https://www.aberdeenshire.gov.uk/ |

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| **OAL UK** | End-user<br>Investor/funder<br>Designer<br>Delivery&Maintenance<br>Supplier<br>Monitoring | Local | **Aberdeenshire - Flooding**<br>*Public Body/Policy maker*<br>*Governance* | Section of the Local Authority in charge of the flooding policy<br>https://www.aberdeenshire.gov.uk/ |
| **OAL UK** | End-user<br>Investor/funder<br>Designer<br>Delivery&Maintenance<br>Monitoring | Local | **Aberdeenshire - Coastal**<br>*Public Body/Policy maker*<br>*Governance* | Section of the Local Authority in charge of the coastal infrastructure<br>https://www.aberdeenshire.gov.uk/ |
| **OAL UK** | End-user<br>Policy maker<br>Supplier<br>Monitoring<br>Influencer | National | **SEPA**<br>*Public Body/Policy maker*<br>*Governance* | Regulator of environmental matters<br>https://www.sepa.org.uk/ |
| **OAL UK** | Investor/funder<br>Supplier<br>Influencer | National | **Woodlands Trust**<br>*Association*<br>*Society & culture* | Charitable organisation providing the planting stock and nbs-related grants to communities<br>https://www.woodlandtrust.org.uk/ |
| **OAL UK** | Investor/funder<br>Supplier | Local | **Windfarm Community Fund**<br>*Association*<br>*Society&culture* | Charitable organisation providing windfarm-related grants to communities |
| **OAL UK** | End-user<br>Policy maker | Local | **Stonehaven and District Community Council**<br>*Association*<br>*Governance* | Community group representing local residents<br>https://www.facebook.com/stonehavenanddistrictcommunitycouncil/ |
| **OAL UK** | End-User | Local | **Diving Club**<br>*Association*<br>*Environment* | Users of the area |
| **OAL IRELAND** | Policy maker<br>Influencer | National | **Office of Public Works**<br>*Public Body/Policy maker*<br>*Governance* | state body responsible for flood risk<br>www.opw.ie |

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| **OAL IRELAND** | Policy maker<br>Influencer | National | **Met Eirean**<br>*Public Body/Policy maker*<br>*Governance* | state body responsible for meteo<br>www.met.ie |
| **OAL IRELAND** | Supplier | Global | **Softbank**<br>*Company*<br>*R&D* | multinational interested in supporting sensors deployment<br>www.softbank.com |
| **OAL GERMANY** | Policy maker<br>Designer<br>unclear<br>Influencer | Local | **Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz**<br>*Public Body/Policy maker*<br>*Governance* | NLWKN is a Land authority under the supervision of the Lower Saxony Ministry for the Environment and Climate Protection.NLWKN is a modern service provider – in every respect. NLWKN protects people from the results of floods, storm surges or hazardous radiation, and we provide industry, other public authorities and the general public with competent expert information on the overall situation in our rivers and nature as a whole.<br>https://www.nlwkn.niedersachsen.de/service/nlwkn_international/information_english/ |
| **OAL GERMANY** | Policy maker<br>Designer<br>Influencer | Local | **Niedersächsische Ministerium für Umwelt, Energie, Bauen und Klimaschutz**<br>*Public Body/Policy maker*<br>*Governance* | The Lower Saxony Ministry for the Environment, Energy, Construction and Climate Protection was established in July 1986. Since then, its "classic" tasks have been nature conservation, water protection and water management, waste and emission control, as well as the licensing, monitoring and management of nuclear facilities. Since 2001, the Ministry has also been responsible for energy policy and climate protection.<br>http://www.umwelt.niedersachsen.de/startseite/ |
| **OAL GERMANY** | End-user<br>Investor/funder<br>Designer<br>Supplier<br>Influencer | Local | **Regionaler Bauernverband**<br>*Association*<br>*Society&culture* | The people of Lower Saxony represent the interests of agricultural policy in rural areas. It is party-politically independent and finances itself through membership fees and service fees.<br>https://landvolk.net/ |
| **OAL GERMANY** | End-user<br>Investor/funder<br>Designer<br>Supplier<br>Influencer | Local | **Regionaler Wasserunterhaltungsverband**<br>*Association*<br>*Environment* | It is the task of the water management association to find acceptable solutions for all sides in the maintenance of watercourses. For the maintenance of water bodies, the associations with their cost-effective self-administration, experience and competence are the most important contacts in the area. The employees of the maintenance associations are experts in the field of water management. In addition to "classic" water |

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| | | | | maintenance, the list of tasks of the maintenance associations can also include tasks of other hydraulic engineering measures (e.g. dismantling), melioration or landscape conservation. https://www.wasserverbandstag.de/verbaende/unterhaltungsverbaende.html |
| **OAL GERMANY** | End-user<br>Monitoring<br>Supplier<br>Influencer | Local | **Landowners-managers**<br>*Company*<br>*Agriculture, fisheries, forestry* | Local farmers |
| **OAL ITALY** | End-user<br>Policy maker<br>Influencer | Local | **Management Board for Parks and Biodiversity - Po Delta**<br>Public Body/Policy maker<br>Governance | Natural park authority managing the Po delta area<br>http://www.parcodeltapo.it/pages/it/home.php |
| **OAL ITALY** | End-user<br>Policy maker<br>Influencer | Local | **Municipality of Comacchio - Territory and Economic Development Department**<br>Public Body/Policy maker<br>Governance | Local administration town of Comacchio<br>http://www.comune.comacchio.fe.it/ |
| **OAL ITALY** | End-user<br>Designer<br>Influencer | Local | **Archeology, natural and cultural heritage for the metropolitan city of Bologna (Modena, Reggio Emilia and Ferrara) Ferrara operative center**<br>Public Body/Policy maker<br>Governance | Authority for cultural and landscape heritage conservation policy<br>http://www.sbapbo.beniculturali.it/ |
| **OAL ITALY** | Policy maker | Local | **Police Department for biodiversity and parks protection - Punta Marina Regional Office**<br>Public Body/Policy maker<br>Governance | Authority for natural conservation policy<br>http://www.carabinieri.it/arma/oggi/organizzazione/organizzazione-per-la-tutela-forestale-ambientale-e-agroalimentare |
| **OAL ITALY** | End-user | Local | **Dieci Cento Mille Pensieri Srl**<br>Company<br>Tourism | Manager of the hotel next to the Goro lighthouse |
| **OAL ITALY** | End-user<br>Designer<br>Delivery&Maintenance | Global | **Gruppo Industriale Maccaferri**<br>Company<br>Engineering | Global company; highly-specialized professionals trained in designing and developing complex solutions in the civil engineering, geotechnical and environmental construction markets. Interests in innovative NBS |

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| | | | | https://www.maccaferri.it/ |
| **OAL ITALY** | End-user | Local | **Lighthouse management company**<br>Company<br>Society&culture | |
| **OAL CHINA-SRW** | Policy maker<br>Designer<br>Delivery&Maintenance<br>Supplier<br>Monitoring<br>Influencer | Local | **Water bureau**<br>Public Body/Policy maker<br>Governance | Water mamagement |
| **OAL CHINA-SRW** | Policy maker<br>Designer<br>Delivery&Maintenance<br>Supplier<br>Monitoring<br>Influencer | Local | **Forest bureau**<br>Public Body/Policy maker<br>Governance | Forest and grassland management |
| **OAL CHINA-SRW** | Policy maker<br>Designer<br>Delivery&Maintenance<br>Supplier<br>Monitoring<br>Influencer | Local | **Primary industry**<br>Public Body/Policy maker<br>Governance | Agriculture and husbandry management |
| **OAL CHINA-SRW** | Policy maker<br>Designer<br>Delivery&Maintenance<br>Supplier<br>Monitoring<br>Influencer | Local | **Environment bureau**<br>Public Body/Policy maker<br>Governance | Environment protection |
| **UNESCO** | Influencer | Global | UNESCO Chair in Water and Education for Sustainable Development (ID:561)<br>Research Organization<br>Hydrology, Sustainable Development | Hydrology, Sustainable Development<br>http://www.unl.edu.ar/ |

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| **UNESCO** | Influencer | Global | UNESCO Chair in South-South Cooperation on Science and Technology to Address Climate Change (ID:737)<br>Research Organization<br>Climate Change | Climate Change |
| **UNESCO** | Influencer | Global | UNESCO Chair in Environment and Development (ID: 962)<br>Research Organization<br>Environment, Sustainable Development | Environment, Sustainable Development<br>http://www.instec.cu/index_en.php |
| **UNESCO** | Influencer | Global | UNESCO Chair on Water, Women and Governance (ID:1044)<br>Research Organization<br>Hydrology | Hydrology<br>www.iglobal.edu.do |
| **UNESCO** | Influencer | Global | UNESCO Chair on World Heritage and Biosphere Reserve Observation and Education (ID:1161)<br>Research Organization<br>Environment, World Heritage, Biosphere Reserves | Environment, World Heritage, Biosphere Reserves<br>http://www.ph-heidelberg.de/ |
| **UNESCO** | Influencer | Global | UNESCO Chair on Solid Earth Physics and Geohazards Risk Reduction (ID:1113)<br>Research Organization<br>Earth sciences, DRR | Earth sciences, DRR<br>https://www.teicrete.gr/en |
| **UNESCO** | Influencer | Global | UNESCO Chair on Conservation and Ecotourism of Riparian and Deltaic Ecosystems (ID:1159)<br>Research Organization<br>Environment, Ecosystem Services | Environment, Ecosystem Services |

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| **UNESCO** | Influencer | Global | UNESCO Chair on Natural Hazards in the Geosphere, the Hydrosphere and the Atmosphere (ID:751)<br>Research Organization<br>Hydrology/Meteorology | Hydrology/Meteorology<br>http://www.noa.gr/indexen.html |
| **UNESCO** | Influencer | Global | UNESCO Chair in Climate Science and Policy (ID: 999)<br>Research Organization<br>Climate Change & Policy | Climate Change & Policy<br>http://www.teriuniversity.ac.in/ |
| **UNESCO** | Influencer | Global | UNESCO Chair on Natural Disasters Management in the Islamic Republic of Iran and Countries in the Region (ID:1075)<br>Research Organization<br>DRR | DRR |
| **UNESCO** | Influencer | Global | UNESCO Chair on the prevention and sustainable management of geo-hydrological hazards (ID:1135)<br>Research Organization<br>DRR, Geology, Hydrology | DRR, Geology, Hydrology<br>www.dst.unifi.it |
| **UNESCO** | Influencer | Global | UNESCO Chair on Intersectoral Safety for Disaster Risk Reduction and Resilience (ID:1270)<br>Research Organization<br>DRR | DRR |
| **UNESCO** | Influencer | Global | UNESCO Chair on Geoenvironmental Disaster Reduction (ID:1260)<br>Research Organization<br>DRR, Environment | DRR, Environment |
| **UNESCO** | Influencer | Global | UNITWIN-UNESCO/KU/ICL Chair on Landslide Risk Mitigation for Society and the Environment Cooperation Programme (ID:605)<br>Research Organization<br>DRR, Environment | DRR, Environment<br>http://iplhq.org/ |

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| **UNESCO** | Influencer | Global | UNESCO Chair on Water, Energy and Disaster Management for Sustainable Development (ID: 1256)<br>Research Organization<br>Hydrology, Energy, DRR, Sustainable Development | Hydrology, Energy, DRR, Sustainable Development<br>http://www.dpri.kyoto-u.ac.jp/en/ |
| **UNESCO** | Influencer | Global | UNESCO Chair on Hydrometeorological Risks (ID: 1173)<br>Research Organization<br>Hydrology/Meteorology Risk | Hydrology/Meteorology Risk<br>http://www.udlap.mx/inicio.aspx |
| **UNESCO** | Influencer | Global | UNESCO Chair on Water, Disaster Management and Climate Change (ID: 1183)<br>Research Organization<br>hydrology, DRR, Climate Change | hydrology, DRR, Climate Change<br>http://www.chula.ac.th/en/ |
| **UNESCO** | Influencer | Global | UNESCO Chair in the Development of a Sustainable Geo-environment (ID:835)<br>Research Organization<br>Geology, Environment, Sustainable Development | Geology, Environment, Sustainable Development |
| **UNESCO** | Influencer | Global | UNESCO Cat 2 Centre on DRR and CC & water:<br>Other<br>DRR, climate change, hydrology | DRR, climate change, hydrology |
| **UNESCO** | Monitoring<br>Influencer | Global | UNESCO Cat 2 Centre: International Centre for Water Hazard and Risk Management (ICHARM)<br>Other<br>hydrology, DRR | UNESCO Cat 2 Centre related to DRR, CCA & Water<br>http://www.icharm.pwri.go.jp/ |
| **UNESCO** | Monitoring<br>Influencer | Global | PEDRR network (all partners)<br>Public Body/Policy maker<br>DRR, Climate change, ecosystem services | As a global thematic platform of the International Strategy for Disaster Reduction (ISDR),PEDRR seeks to promote and scale-up implementation of ecosystem-based disaster risk reduction and ensure it is mainstreamed in development planning at global, national and local levels, in line with the Sendai Framework for Disaster Risk Reduction<br>http://pedrr.org/ |

**Table 30** (2C): Keywords selected for tertiary stakeholders mapping.

| Coarse level- keywords | Second level -keywords | |
|---|---|---|
| "disaster prevention" | "Climate change"+"disater risk reduction" | "co-creation"+"disaster risk reduction" |
| "Disaster resiliance" | "Eco-Disaster Risk Reduction" | "co-development"+"disaster risk reduction" |
| "Disaster risk management" | "Ecosystem-based" + "disaster risk reduction" | "costal erosion"+"risk management" |
| "Disaster risk reduction" | "sustainable innovation"+"Disaster risk reduction" | "drought"+"risk management" |
| "Ecosystem based adaptation" | "Climate Change"+"nature-based solution" | "flooding"+"risk management" |
| "ecosystem functions" | "Hydro-meteorological risk"+reduction | "increased nutrients"+"risk management" |
| "ecosystem services" | "Climate Change"+"disaster risk reduction" | "Landslide"+"risk management" |
| "Ecosystem-based mitigation" | "Nature conservation"+"Disaster risk reduction" | "salt intrusion"+"risk management" |
| "Environment Risk Management" | "Environment Risk"+ management | "sediment loading"+"risk management" |
| "Green Infrastructure" | "ecosystem services"+policy | "stakeholders perception" |
| "Hydro-meteorological hazards" | "Hydro-meteorological risk"+management | "storm surge"+"risk management" |
| "Hydro-Meteorological risk" | "Spatial planning" | Blue+"Nature based solution" |
| "landscape quality" | "Environmental planning" | green+"Nature based solution" |
| "Living labs" | "sustainable development"+"disaster risk reduction" | Hybrid+"Nature based solution" |
| "Natural infrastructure" | "Policy-science-society interface" | Partecipatory innovation |
| "Natural-Hazard risk" | "Disaster risk reduction"+"rural areas" | Participatory planning |
| "Nature Based Solution" | "Natural hazard risks"+ mitigation | sustainable development planning |
| "Open Air Laboratories" | | |
| "plant-soil interactions" | | |
| "eco-engineering" | | |
| Geohazard | | |
| NBS | | |

**Table 31** (2D): List of EU funded projects mapped.

| Acronym | Title | Funding scheme Call for proposal | Project funding | Status | N° partners | Coordinator | Country | Website |
|---|---|---|---|---|---|---|---|---|
| ANYWHERE | EnhANcing emergencY management and response to extreme WeatHER and climate Events | IA-Innovation action H2020-DRS-2015 | 11973367 € | Active | 35 | UNIVERSITAT POLITECNICA DE CATALUNYA | SPAIN | http://anywhere-h2020.eu/ |
| BETTER | Big-data Earth observation Technology and Tools Enhancing Research and development | RIA-Research and Innovation action H2020-EO-2017 | 1998540 € | Active | 8 | DEIMOS SPACE SOCIEDAD LIMITADA UNIPERSONAL | SPAIN | https://www.ec-better.eu/ |
| BINGO | Bringing INnovation to onGOing water management – A better future under climate change | RIA-Research and Innovation action H2020-WATER-2014-two-stage | 7822422 € | Active | 20 | LABORATORIO NACIONAL DE ENGENHARIA CIVIL | PORTUGAL | http://www.projectbingo.eu/ |
| BiodivERsA3 | Consolidating the European Research Area on biodiversity and ecosystem services | ERA-NET Cofund H2020-SC5-2014-one-stage | 11988018 € | Active | 33 | FONDATION FRANCAISE POUR LA RECHERCHE SUR LA BIODIVERSITE | FRANCE | http://www.biodiversa.org/ |
| BRIGAID | BRIdges the GAp for Innovations in Disaster resilience | IA-Innovation action H2020-DRS-2015 | 7739805 € | Active | 25 | TECHNISCHE UNIVERSITEIT DELFT | NETHERLANDS | https://brigaid.eu/ |

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|---|---|---|---|---|---|---|---|---|
| BUMILLA | Business Model Innovation in Living Labs | MC-IAPP Industry-Academia Partnerships and Pathways (IAPP) FP7-PEOPLE-2012-IAPP | 740139 € | Closed | 3 | INSERO AS | DENMARK | https://cordis.europa.eu/project/rcn/106681/en |
| CAPHAZ-NET | Social Capacity Building for Natural Hazards: Toward More Resilient Societies | CSA-CA Coordination (or networking) actions FP7-ENV-2008-1 | 910000 € | Closed | 8 | HELMHOLTZ-ZENTRUM FUER UMWELTFORSCHUNG GMBH - UFZ | GERMANY | https://cordis.europa.eu/project/rcn/91264/factsheet/en |
| CATALYST | Capacity Development for Hazard Risk Reduction and Adaptation | CSA-CA Coordination (or networking) actions FP7-ENV-2011 | 843931 € | Closed | 7 | FONDAZIONE ENI ENRICO MATTEI | ITALY | https://cordis.europa.eu/project/rcn/100136/factsheet/en |
| CHANGES | Changing Hydro-Meteorological Risks- As Analyzed by A New Generation of European Scientists | MC-ITN Networks for Initial Training (ITN) FP7-PEOPLE-2010-ITN | 3671703 € | Closed | 11 | UNIVERSITEIT TWENTE | NETHERLANDS | http://www.changes-itn.eu/ |
| CLARA | Climate forecast enabled knowledge services | IA- Innovation action H2020-SC5-2016-TwoStage | 3459075 € | Active | 11 | FONDAZIONE CENTRO EURO-MEDITERRANEOSUI CAMBIAMENTI CLIMATICI | ITALY | http://www.clara-project.eu/ |
| CLEVER Cities | CLEVER Cities - Co-designing Locally tailored | IA - Innovation action | 14214660 € | Active | 34 | FREIE UND HANSESTADT HAMBURG | GERMANY | http://cleverciti es.eu/ |

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|---|---|---|---|---|---|---|---|---|
| | Ecological solutions for Value added, socially inclusivE Regeneration in Cities | H2020-SCC-NBS-2stage-2017 | | | | | | |
| CLIPC | Climate Information Platform for Copernicus (CLIPC) | CP-FP-Small or medium-scale focused research project FP7-SPACE-2013-1 | 5985067 € | Closed | 23 | SCIENCE AND TECHNOLOGY FACILITIES COUNCIL | UNITED KINGDOM | http://www.clipc.eu/ |
| CLUVA | CLimate change and Urban Vulnerability in Africa | CP-FP-SICA - Small/medium-scale focused research project for specific cooperation actions dedicated to international cooperation partner countries(SICA) FP7-ENV-2010 | 3494580 € | Closed | 13 | AMRA - ANALISI E MONITORAGGIO DEL RISCHIO AMBIENTALE SCARL | ITALY | https://cordis.europa.eu/project/rcn/96934/factsheet/en |
| COEXIST | Interaction in coastal waters: A roadmap to sustainable integration of aquaculture and fisheries | CP-FP - Small or medium-scale focused research project FP7-KBBE-2009-3 | 2995500 € | Closed | 14 | HAVFORSKNINGSINSTITUTTET | NORWAY | https://cordis.europa.eu/project/rcn/94252/factsheet/en |

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|---|---|---|---|---|---|---|---|---|
| CONNECTING Nature | COproductioN with NaturE for City Transitioning, INnovation and Governance | IA-Innovation action H2020-SCC-NBS-2stage-2016 | 11394282 € | Active | 34 | THE PROVOST, FELLOWS, FOUNDATION SCHOLARS & THE OTHER MEMBERS OF BOARD OF THE COLLEGE OF THE HOLY & UNDIVIDED TRINITY OF QUEEN ELIZABETH NEAR DUBLIN | IRELAND | https://connectingnature.eu/ |
| CORFU | Collaborative research on flood resilience in urban areas | CP-FP-SICA - Small/medium-scale focused research project for specific cooperation actions dedicated to international cooperation partner countries(SICA) FP7-ENV-2009-1 | 3490000 € | Closed | 17 | THE UNIVERSITY OF EXETER | UNITED KINGDOM | http://www.corfu7.eu/ |
| Co-VAL | Understanding value co-creation in public services for transforming European public administrations | RIA-Research and Innovation action H2020-SC6-CULT-COOP-2017-one-stage | 4461508 € | Active | 13 | ATHENS TECHNOLOGY CENTER ANONYMI BIOMICHANIKI EMPORIKI KAI TECHNIKI ETAIREIA EFARMOGON YPSILIS TECHNOLOGIAS | GREECE | http://www.co-val.eu/ |
| CUIDAR | Cultures of Disaster Resilience among children and young people | CSA-Coordination & support action H2020-DRS-2014 | 2009653 € | Closed | 6 | LANCASTER UNIVERSITY | UNITED KINGDOM | https://cordis.europa.eu/project/rcn/194896/factsheet/en |

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|---|---|---|---|---|---|---|---|---|
| DROUGHT-R&SPI | Fostering European Drought Research and Science-Policy Interfacing | Small or medium-scale focused research project FP7-ENV-2011 | 3439950 € | Closed | 12 | WAGENINGEN UNIVERSITY | NETHERLANDS | http://www.eu-drought.org/ |
| EDUCEN | European Disasters in Urban centres: a Culture Expert Network (3C – Cities, Cultures, Catastrophes) | CSA - Coordination and support action H2020-DRS-2014 | 1644671 € | Closed | 10 | WAGENINGEN UNIVERSITY | NETHERLANDS | https://www.educenproject.eu/ |
| EKLIPSE | Establishing a European Knowledge and Learning Mechanism to Improve the Policy-Science-Society Interface on Biodiversity and Ecosystem Services | CSA - Coordination and support action H2020-SC5-2015-one-stage | 2997270 € | Active | 11 | NATURAL ENVIRONMENT RESEARCH COUNCIL | UNITED KINGDOM | http://www.eklipse-mechanism.eu/ |
| ENHANCE | Enhancing risk management partnerships for catastrophic natural disasters in Europe | CP - Collaborative project (generic) FP7-ENV-2012-two-stage | 5992084 € | Closed | 24 | STICHTING VU | NETHERLANDS | http://www.enhanceproject.eu/ |
| EnviCOP | Environmentally Friendly Coastal Protection in a | MC-IRSES - International research staff | 193200 € | Closed | 5 | UNIVERSITA DEGLI STUDI DELLA CAMPANIA LUIGI VANVITELLI | ITALY | http://www.envicop.eu/ |

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|---|---|---|---|---|---|---|---|---|
| | Changing Climate | exchange scheme (IRSES) FP7-PEOPLE-2011-IRSES | | | | | | |
| ERA4CS | European Research Area for Climate Services | ERA-NET Cofund H2020-SC5-2015-one-stage | 25000000 € | Active | 48 | AGENCE NATIONALE DE LA RECHERCHE | FRANCE | http://www.jpi-climate.eu/ERA4CS |
| ESMERALDA | Enhancing ecoSysteM sERvices mApping for poLicy and Decision mAking | CSA - Coordination and support action H2020-SC5-2014-one-stage | 3002166 € | Closed | 39 | GOTTFRIED WILHELM LEIBNIZ UNIVERSITAET HANNOVER | GERMANY | http://esmeralda-project.eu/ |
| ESPREssO | Enhancing Synergies for disaster PRevention in the EurOpean Union | CSA-Coordination & support action H2020-DRS-2015 | 2068021 € | Active | 7 | AMRA - ANALISI E MONITORAGGIO DEL RISCHIO AMBIENTALE SCARL | ITALY | http://www.espressoproject.eu/ |
| EU-MACS | European Market for Climate Services | RIA-Research and Innovation action H2020-SC5-2016-OneStageB | 1499621 € | Active | 9 | ILMATIETEEN LAITOS | FINLAND | http://eu-macs.eu/ |
| EVER-EST | European Virtual Environment for Research - Earth Science Themes | RIA-Research and Innovation action H2020-EINFRA-2015-1 | 6561627 € | Closed | 13 | EUROPEAN SPACE AGENCY | FRANCE | https://ever-est.eu/ |
| GEO | geohazards and geomechanics | MC-IRSES - International research staff exchange scheme (IRSES) | 438900 € | Closed | 7 | THE UNIVERSITY OF WARWICK | UNITED KINGDOM | https://cordis.europa.eu/project/rcn/102415/factsheet/en |

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| | | FP7-PEOPLE-2011-IRSES | | | | | | |
| GEO-RAMP | Geohazards: Risk Assessment, Mitigation and Prevention | MSCA-RISE - Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE) H2020-MSCA-RISE-2014 | 1804500 € | Active | 8 | UNIVERSITY OF NEWCASTLE UPON TYNE | UNITED KINGDOM | http://www.geohazard.ac.uk/ |
| GREEN-WIN | Green growth and win-win strategies for sustainable climate action | RIA - Research and Innovation action H2020-SC5-2014-two-stage | 3624762 € | Closed | 17 | GCF - GLOBAL CLIMATE FORUM EV | GERMANY | http://green-win-project.eu/ |
| GROW GREEN | Green Cities for Climate and Water Resilience, Sustainable Economic Growth, Healthy Citizens and Environments | IA-Innovation action H2020-SCC-NBS-2stage-2016 | 11224058 € | Active | 25 | MANCHESTER CITY COUNCIL | UNITED KINGDOM | http://growgreenproject.eu/about/ |
| HELM | Harmonised European Land Monitoring | CSA-CA - Coordination (or networking) actions FP7-SPACE-2010-1 | 1000000 € | Closed | 27 | UMWELTBUNDESAMT GESELLSCHAFT MIT BESCHRANKTER HAFTUNG (UBA GMBH) | AUSTRIA | https://cordis.europa.eu/project/rcn/97889/factsheet/en |
| HERCULES | towards geoHazards rEsilient | MSCA-RISE - Marie Skłodowska- | 2016000 € | Active | 12 | THE UNIVERSITY OF WARWICK | UNITED KINGDOM | https://cordis.europa.eu/projec |

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| | infRastruCtUre under changing cLimatES | Curie Research and Innovation Staff Exchange (RISE) H2020-MSCA-RISE-2017 | | | | | | t/rcn/216437/factsheet/en |
| IMPACT2C | Quantifying projected impacts under 2°C warming | CP-IP - Large-scale integrating project FP7-ENV-2011 | 6499999 € | Closed | 29 | HELMHOLTZ-ZENTRUM GEESTHACHT ZENTRUM FUR MATERIAL- UND KUSTENFORSCHUNG GMBH | GERMANY | https://impact2c.hzg.de/ |
| IMPREX | IMproving PRedictions and management of hydrological EXtremes | RIA-Research and Innovation action H2020-WATER-2014-two-stage | 7996848 € | Active | 23 | KONINKLIJK NEDERLANDS METEOROLOGISCH INSTITUUT-KNMI | NETHERLANDS | https://www.imprex.eu/ |
| IMPRINTS | IMproving Preparedness and RIsk maNagemenT for flash floods and debriS flow events | CP-FP - Small or medium-scale focused research project FP7-ENV-2008-1 | 3280000 € | Closed | 19 | UNIVERSITAT POLITECNICA DE CATALUNYA | SPAIN | http://www.crahi.upc.edu/imprints/ |
| IRMA | Integrated Risk Management for Africa | CP - Collaborative project (generic) FP7-ICT-2007-2 | 2481395 € | Closed | 17 | UNIVERSITE DU LUXEMBOURG | LUXEMBOURG | https://cordis.europa.eu/project/rcn/87828/factsheet/en |
| ISAC | Information Service on Agricultural Change | CP - Collaborative project (generic) FP7-SPACE-2010-1 | 1250757 € | Closed | 5 | VLAAMSE INSTELLING VOOR TECHNOLOGISCH ONDERZOEK N.V. | BELGIUM | http://www.gmes-isac.info/index.html |

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|---|---|---|---|---|---|---|---|---|
| iSCAPE | Improving the Smart Control of Air Pollution in Europe | RIA-Research and Innovation action H2020-SC5-2015-two-stage | 5850828 € | Active | 15 | UNIVERSITY COLLEGE DUBLIN, NATIONAL UNIVERSITY OF IRELAND, DUBLIN | IRELAND | https://www.iscapeproject.eu/ |
| KNEU | Developing a Knowledge Network for EUropean expertise on biodiversity and ecosystem services to inform policy making economic sectors | CSA-CA - Coordination (or networking) actions FP7-ENV-2010 | 998719 € | Closed | 19 | HELMHOLTZ-ZENTRUM FUER UMWELTFORSCHUNG GMBH - UFZ | GERMANY | http://www.vliz.be/projects/biodiversityknowledge/ |
| KNOW-4-DRR | Enabling knowledge for disaster risk reduction in integration to climate change adaptation | CSA-CA - Coordination (or networking) actions FP7-ENV-2013-one-stage | 992951 € | Closed | 11 | POLITECNICO DI MILANO | ITALY | http://www.know4drr.polimi.it/ |
| LANDSUPPORT | Development of Integrated Web-Based Land Decision Support System Aiming Towards the Implementation of Policies for Agriculture and Environment | RIA-Research and Innovation action H2020-RUR-2017-2 | 6999771 € | Active | 19 | UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II. | ITALY | https://www.landsupport.eu/ |

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| LIVERUR | Living Lab research concept in Rural Areas | RIA-Research and Innovation action H2020-RUR-2017-2 | 4107005 € | Active | 23 | FUNDACION UNIVERSITARIA SAN ANTONIO | SPAIN | https://liverur.eu/ |
| MICORE | Morphological Impacts and COastal Risks induced by Extreme storm events | CP-FP - Small or medium-scale focused research project FP7-ENV-2007-1 | 3499954 € | Closed | 16 | UNIVERSITA DEGLI STUDI DI FERRARA | ITALY | https://www.micore.eu/ |
| NAIAD | NAture Insurance value: Assessment and Demonstration | RIA-Research and Innovation action H2020-SC5-2016-OneStageB | 4994370 € | Active | 23 | CONFEDERACION HIDROGRAFICA DEL DUERO | SPAIN | http://naiad2020.eu/ |
| Nature4Cities | Nature Based Solutions for re-naturing cities: knowledge diffusion and decision support platform through new collaborative models | RIA-Research and Innovation action H2020-SCC-NBS-1stage-2016 | 7499981 € | Active | 28 | NOBATEK INEF 4 | FRANCE | https://www.nature4cities.eu/ |
| NATURVATION | Nature Based Urban Innovation | RIA-Research and Innovation action H2020-SCC-NBS-1stage-2016 | 7797877 € | Active | 14 | UNIVERSITY OF DURHAM | UNITED KINGDOM | https://naturvation.eu/ |

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| OpenNESS | Operationalisation of Natural Capital and Ecosystem Services | CP - Collaborative project (generic) FP7-ENV-2012-two-stage | 8 999 193 € | Closed | 37 | SUOMEN YMPARISTOKESKUS | FINLAND | http://www.openness-project.eu/ |
| OPERAs | Operational Potential of Ecosystem Research Applications | CP - Collaborative project (generic) FP7-ENV-2012-two-stage | 8997909 € | Closed | 29 | THE UNIVERSITY OF EDINBURGH | UNITED KINGDOM | http://www.operas-project.eu/ |
| PEARL | Preparing for Extreme And Rare events in coastaL regions | CP - Collaborative project (generic) FP7-ENV-2013-two-stage | 4998851 € | Closed | 26 | STICHTING IHE DELFT INSTITUTE FOR WATER EDUCATION | NETHERLANDS | http://www.pearl-fp7.eu/ |
| PHUSICOS | PHUSICOS: 'According to nature' - solutions to reduce risk in mountain landscapes | IA-Innovation action H2020-SC5-2017-TwoStage | 9 472 200 € | Active | 16 | STIFTELSEN NORGES GEOTEKNISKE INSTITUTT | Norway | https://phusicos.eu/ |
| PLACARD | PLAtform for Climate Adaptation and Risk reDuction | CSA-Coordination & support action H2020-DRS-2014 | 2852760 € | Active | 10 | FCIENCIAS.ID - ASSOCIACAO PARA A INVESTIGACAO E DESENVOLVIMENTO DE CIENCIAS | PORTUGAL | https://www.placard-network.eu/ |
| proGIreg | productive Green Infrastructure for post-industrial urban regeneration | IA-Innovation action H2020-SCC-NBS-2stage-2017 | 10432512 € | Active | 32 | RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE AACHEN | GERMANY | http://www.progireg.eu/ |

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| RAIN | Risk Analysis of Infrastructure Networks in response to extreme weather | CP-FP - Small or medium-scale focused research project FP7-SEC-2013-1 | 3493600 € | Closed | 16 | THE PROVOST, FELLOWS, FOUNDATION SCHOLARS & THE OTHER MEMBERS OF BOARD OF THE COLLEGE OF THE HOLY & UNDIVIDED TRINITY OF QUEEN ELIZABETH NEAR DUBLIN | IRELAND | http://rain-project.eu/ |
| REAL | Resilience in East African Landscapes: Identifying critical thresholds and sustainable trajectories – past, present and future | MC-ITN - Networks for Initial Training (ITN) FP7-PEOPLE-2013-ITN | 3968063 € | Closed | 7 | UPPSALA UNIVERSITET | SWEDEN | http://www.real-project.eu/ |
| RECONECT | RECONECT-Regenarating ECOsystems with Nature-based solutions for hydro-meteorological risk rEduCTion | IA-Innovation action H2020-SC5-2017-TwoStage | 13520689 € | Active | 34 | STICHTING IHE DELFT INSTITUTE FOR WATER EDUCATION | NETHERLANDS | http://www.reconect.eu/ |
| RENATURE | promoting Research Excellence in NAture-based soluTions for innovation, sUstainable economic | CSA-Coordination & support action H2020-WIDESPREAD-05-2017-Twinning | 995885 € | Active | 5 | MALTA COLLEGE OF ARTS SCIENCE AND TECHNOLOGY | MALTA | http://renature-project.eu/ |

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| | GRowth and human wEll-being in Malta | | | | | | | |
| ResiStand | Increasing disaster Resilience by establishing a sustainable process to support Standardisation of technologies and services | CSA-Coordination & support action H2020-DRS-2015 | 1962553 € | Closed | 15 | GEOWISE OY | FINLAND | http://www.resistand.eu/ |
| RISC-KIT | Resilience-Increasing Strategies for Coasts - toolKIT | CP - Collaborative project (generic) FP7-ENV-2013-two-stage | 5999692 € | Closed | 19 | STICHTING DELTARES | NETHERLANDS | http://www.risckit.eu/np4/home.html |
| ROCK | Regeneration and Optimisation of Cultural heritage in creative and Knowledge cities | IA-Innovation action H2020-SC5-2016-TwoStage | 9873585 € | Active | 32 | COMUNE DI BOLOGNA | ITALY | https://rockproject.eu/ |
| SAFELAND | Living with landslide risk in Europe: Assessment, effects of global change, and risk management strategies | CP-IP - Large-scale integrating project FP7-ENV-2008-1 | 6610000 € | Closed | 27 | STIFTELSEN NORGES GEOTEKNISKE INSTITUTT | NORWAY | https://cordis.europa.eu/project/rcn/91248/factsheet/en |
| SEOCA | GEO capacity building | CSA-SA - Support actions | 576516 € | Closed | 14 | TECHNISCHE UNIVERSITAT BERLIN | GERMANY | https://cordis.europa.eu/projec |

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| | initiative in Central Asia | FP7-ENV-2009-1 | | | | | | t/rcn/94001/factsheet/en |
| SINCERE | Spurring INnovations for Forest ECosystem SERvices in Europe | IA-Innovation action H2020-RUR-2017-1 | 3993250 € | Active | 23 | EUROPEAN FOREST INSTITUTE | FINLAND | https://sinceresforests.eu/ |
| THESEUS | Innovative coastal technologies for safer European coasts in a changing climate | CP-IP - Large-scale integrating project FP7-ENV-2009-1 | 6530000 € | Closed | 32 | ALMA MATER STUDIORUM - UNIVERSITA DI BOLOGNA | ITALY | http://www.vliz.be/projects/theseusproject/ |
| ThinkNature | Development of a multi-stakeholder dialogue platform and Think tank to promote innovation with Nature based solutions | CSA-Coordination & support action H2020-SC5-2016-OneStageB | 2974163 € | Active | 18 | POLYTECHNEIO KRITIS | GREECE | https://www.think-nature.eu/ |
| TRANS-URBAN-EU-CHINA | Transition towards urban sustainability through socially integrative cities in the EU and in China | RIA-Research and Innovation action H2020-SC6-ENG-GLOBALLY-2017 | 2499993 € | Active | 14 | LEIBNIZ-INSTITUT FUR OKOLOGISCHE RAUMENTWICKLUNG EV | GERMANY | http://transurbaneuchina.eu/ |
| UNALAB | Urban Nature Labs | IA-Innovation action | 12768931 € | Active | 28 | Teknologian tutkimuskeskus VTT Oy | FINLAND | https://www.unalab.eu/ |

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| | | H2020-SCC-NBS-2stage-2016 | | | | | | |
| URBAN GreenUP | New Strategy for Re-Naturing Cities through Nature-Based Solutions | IA - Innovation action H2020-SCC-NBS-2stage-2016 | 13970642 € | Active | 26 | FUNDACION CARTIF | SPAIN | https://www.urbangreenup.eu/ |
| URBiNAT | URBiNAT - Healthy corridors as drivers of social housing neighbourhoods for the co-creation of social, environmental and marketable NBS | IA-Innovation action H2020-SCC-NBS-2stage-2017 | 13019300 € | Active | 28 | CENTRO DE ESTUDOS SOCIAIS | PORTUGAL | https://urbinat.eu/ |

**Table 32** (2E): List of OPERANDUM tertiary stakeholders.

| INNOVATORS | | | | | | | |
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| **ID** | **Source** | **#Projects** | **Geographical coverage** | **Value Chain Position** | **Stakeholder Name**<br>*Type*<br>*Area of Interest*<br>*Country* | **Brief description of the stakeholder** | **Website Contacts** |
| **1** | EU Project | 12 | GLOBAL | designer<br>monitoring | **CONSIGLIO NAZIONALE DELLE RICERCHE**<br>*Research Organization*<br>*R&D*<br>*ITALY* | Research and development centre for innovative solutions in multidisciplinary fields | https://www.cnr.it/en/homepage<br>protocollo-ammcen@pec.cnr.it |
| **2** | EU Project | 9 | GLOBAL | designer<br>monitoring | **CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS**<br>*Research Organization*<br>*R&D*<br>*FRANCE* | Research and development centre for innovative solutions in multidisciplinary fields | http://www.cnrs.fr/en/cnrs |
| **3** | EU Project | 9 | GLOBAL | designer<br>monitoring | **HELMHOLTZ-Centre for Environmental research-UFZ**<br>*Research Organization*<br>*R&D*<br>*GERMANY* | Research institute specialised in ecosystems, water resources and environment, chemicals in the environment, environmental engineering and biotechnology | http://www.ufz.de/<br>49 341 / 235-0 |
| **4** | EU Project | 9 | GLOBAL | designer<br>monitoring | **JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION**<br>*Research Organization*<br>*R&D*<br>*BELGIUM* | Supports EU policies with independent scientific evidence throughout the policy cycle. It has specialized laboratories and research facilities for every interesting field for the EU | https://ec.europa.eu/jrc/en |

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| 5 | EU Project | 7 | GLOBAL | designer monitoring | **BRGM - Geoscience for a sustainable earth**<br>*Research Organization*<br>*R&D*<br>*FRANCE* | French government geological survey which aim is the management of resources, and surface and sub-surface risks. | www.brgm.fr<br>+33 (0)2 38 64 34 34 |
| 6 | EU Project | 7 | GLOBAL | designer monitoring | **ETH Zürich**<br>*Research Organization*<br>*R&D*<br>*Switzerland* | The Department of Earth Sciences (D-ERDW) is a teaching and research entity of the Federal Institute of Technology (ETH Zurich). | https://www.ethz.ch/en.html<br>https://www.erdw.ethz.ch/en/<br>Department of Environmental Systems Science Climate Policy Group:<br>ANNA SCOLOBIG E-mail anna.scolobig@usys.ethz.ch |
| 7 | EU Project | 7 | GLOBAL | designer monitoring | **NERC-NATURAL ENVIRONMENT RESEARCH COUNCIL**<br>*Research Organization*<br>*R&D*<br>*UK* | The Natural Environment Research Council is the UK's largest funder of independent environmental science, training and innovation, delivered through universities and research centres. | https://nerc.ukri.org/<br>jodie.mitchell@nerc.ukri.org<br>carla.yorukoglu@nerc.ukri.org |
| 8 | EU Project | 7 | GLOBAL | designer monitoring | **Dutch techcentre for life science**<br>*Research Organization*<br>*R&D*<br>*Netherlands* | Research institutes specialised in the field of Food and Food Production, Living environment, Health, lifestyle and livelihood. Not only studies climate change, but also studies the causes and develops new technologies to address the consequences of climate change with reference to impacts on water, soil, agriculture, forests and urban territory. | https://www.wur.nl/en.htm<br>info@dtls.nl |
| 9 | EU Project | 7 | GLOBAL | designer monitoring | **SYKE- Finnish Environment institute**<br>*Research Organization*<br>*R&D*<br>*Finland* | Research and development of innovative solutions on the main environmental problems such as climate change and the adequacy of natural resources. The research covers many fields such as sea, water, urbanization, fauna and forest environment | http://www.syke.fi/<br>Tel. +358 295 251 072<br>syke_ajankohtaiset@ymparisto.fi |

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| **10** | EU Project | 6 | GLOBAL | designer monitoring | **IIASA-International Institute for Applied Systems Analysis** *Research Organization R&D Austria* | ASA research ultimately aims to produce, practice, and prototype novel systems-analytical approaches, methods and tools, which enable solving problems such as climate. Offers research and development of innovative solutions in air quality and greenhouses gases. Examines environmental and socio-economic risks and strategic options across multiple spatial and temporal scales to provide an analytical basis for improving the management and governance of natural disasters, addressing climate change and facilitating technological and ecological transitions to sustainability. | http://www.iiasa.ac.at/ (+43 2236) 807 0 - info@iiasa.ac.at |
| **11** | EU Project | 6 | GLOBAL | designer monitoring | **UNIVERSITAT POLITECNICA DE CATALUNYA** *Research Organization R&D SPAIN* | The university is active in research and has multidisciplinary research centers including the Applied Research Center in Hydrometeorology (CRAHI) specialized in environmental and climate | https://www.upc.edu José A. Jiménez jose.jimenez@upc.edu |
| **12** | EU Project | 5 | GLOBAL | designer monitoring | **DELTARES** *Research Organization R&D Netherlands* | Stichting Deltares is the Dutch institute for applied research and development on issues related to living and working in delta areas. The mission of Deltares is to develop, acquire, apply and disseminate integral, multidisciplinary knowledge and knowledge products related to living and working in delta (coastal, estuarine, and riverine) areas, on an internationally leading level | https://www.deltares.nl info@deltares.nl |
| **13** | EU Project | 5 | GLOBAL | designer monitoring | **UNIVERSITY OF CAMBRIDGE** *Research Organization R&D UK* | The Department of Geography: The Department of Geography today is a flourishing and expanding academic community committed to high standards of research. The questions we ask, the philosophies and methodologies we draw upon, embrace the natural and social sciences as well as the humanities. | https://www.cam.ac.uk/ https://www.geog.cam.ac.uk/research/projects/conservationstrategies/ enquiries@geog.cam.ac.uk |
| **14** | EU Project | 5 | GLOBAL | designer monitoring funder | **UNIVERSITY OF OXFORD** *Research Organization R&D UK* | Academic and Research Institute Environmental Change Institute was established in 1991 'to organize and promote interdisciplinary research on the nature, causes and impact of environmental change and to contribute to the development of management strategies for coping with future environmental change'. | http://www.ox.ac.uk/ https://www.eci.ox.ac.uk/about/ Phone: +44 (0) 1865 275848 Email: enquiries@eci.ox.ac.uk |

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| **15** | EU Project | 5 | GLOBAL | designer monitoring | **UNIVERSITAT AUTONOMA DE BARCELONA** *Research Organization R&D Spain* | Academic and Research Institute he UAB has seen recognition for its efforts in promoting quality in teaching, in attracting international talent and in obtaining a growing impact in research, together with a progressive improvement in its classifications in the most prestigious and influential international rankings. | https://www.uab.cat/web/research-1345666325304.html H2020 project management Environment and Energy Efficiency Veronica Colombo: veronica.colombo@uab.cat Telephone: +34 935868630 |
| **16** | EU Project | 5 | GLOBAL | designer monitoring | **UNIVERSITE DE NICE SOPHIA ANTIPOLIS** *Research Organization R&D FRANCE* | Center of training and transdisciplinary research around collaborative technological platforms, between research laboratories and companies, it focuses on 4 major themes: Smart buildings and energy, water cycle, risk and environment, and smart sustainable mobility (IMREDD CENTER). | http://imredd.fr/ Hervé le Guyader, herve.le_guyader@upmc.fr |
| **17** | EU Project | 5 | GLOBAL | designer monitoring | **WAGENINGEN UNIVERSITY** *Research Organization R&D Netherlands* | The university presents several specialized research institutes including those in the field of Food and Food Production, Living environment, Health, lifestyle and livelihood. Wageningen University & Research not only studies climate change, but also studies the causes and develops new technologies to address the consequences of climate change with reference to impacts on water, soil, agriculture, forests and urban territory. | https://www.wur.nl/ info.cdi@wur.nl |
| **18** | EU Project | 4 | GLOBAL | designer monitoring | **Spanish National Research Council (CSIC)** *Research Organization R&D Spain* | The Spanish National Research Council (CSIC) is the largest public institution dedicated to research in Spain and the third largest in Europe. Belonging to the Spanish Ministry of Science, Innovation and Universities through the Secretary of State for Universities, Research, Development and Innovation, its main objective is to develop and promote research that will help bring about scientific and technological progress, and it is prepared to collaborate with Spanish and foreign entities in order to achieve this aim. | http://www.csic.es/ |
| **19** | EU Project | 4 | GLOBAL | designer monitoring | **CETAQUA - CENTRO TECNOLOGICO DEL AGUA** *Research Organization* | Analyze the use of renewable energy and seek energy self-sufficiency in wastewater treatment plants, develop new techniques to monitor and improve the quality of drinking water, purified or natural water bodies (rivers, lakes, aquifers and sea ), develops models and | http://www.cetaqua.com info@cetaqua.com |

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| | | | | | *R&D*<br>*Spain* | technologies for water purification in order to improve energy yield, develops water treatment regimes defining viable methodologies for their purification at surface and underground levels | |
| **20** | EU Project | 4 | GLOBAL | monitoring<br>influencer<br>policy maker | **ECOLOGIC INSTITUT**<br>*Research Organization*<br>*Society&Culture*<br>*Germany* | Ecologic Institute is an independent, academic think tank for environmental research and policy analysis. Since our founding in 1995, Ecologic Institute has been dedicated to improving environmental policy, sustainable development and policy practice. Through findings and ideas Ecologic Institute helps to mainstream environmental issues into other policy areas. | https://www.ecologic.eu/<br>berlin@ecologic.eu |
| **21** | EU Project | 4 | GLOBAL | designer<br>monitoring | **Swiss Federal institute for Forest, Snow and Landscape Research WSL**<br>*Research Organization*<br>*R&D*<br>*Switzerland* | WSL explores the dynamics of the terrestrial environment, and the use and protection of natural habitats and cultural landscapes. WSL monitors forests, landscapes, biodiversity, natural hazards, and snow and ice. WSL develops sustainable solutions for socially relevant issues - together with its partners from science and society | https://www.wsl.ch/en.html<br>Tel.: +41 44-739 21 11 wslinfo@wsl.ch+41 44 739 22 01 |
| **22** | EU Project | 4 | GLOBAL | influencer | **Foundation for Research on Biodiversity**<br>*Research Organization*<br>*R&D*<br>*France* | The Foundation for Research on Biodiversity is a platform between the different scientific actors and the actors of society on biodiversity. The ultimate goal of these actions is to better understand and communicate the functioning of biodiversity in the context of a rapprochement between science, society and politics. | http://www.fondationbiodiversite.fr/en/<br>secretariat@fondationbiodiversite.fr<br>Tél. : +33 (0)1 80 05 89 10 |
| **23** | EU Project | 4 | GLOBAL | designer<br>monitoring | **FUNDACAO DA FACULDADE DE CIENCIAS DA UNIVERSIDADE DE LISBOA FP**<br>*Research Organization*<br>*R&D*<br>*Portugal* | Academic and Research Institute. Research is organised in R&D multi-departmental units, with different names: centres, laboratories and institutes. These units join researchers from different Faculty departments and also include many researchers (about 30%) from other Portuguese and international universities. | https://ciencias.ulisboa.pt/en/fcul-foundation<br>info@ciencias.ulisboa.pt |
| **24** | EU Project | 4 | NATIONAL | designer<br>delivery&maintenance<br>monitoring<br>policy maker | **Italian Institute for Environmental Protection and Research, ISPRA**<br>*Research Organization*<br>*R&D* | ISPRA performs, with the inherent financial resources, equipment and personnel, the duties of: Italian Environment Protection and Technical Services Agency National Institute for Wildlife Central Institute for Scientific and Technological Research applied to the Sea. The Institute acts under the vigilance and policy guidance of | http://www.isprambiente.gov.it/en?set_language=en<br>Phone (+39) 0650071<br>criterimetodologici@isprambiente.it |

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| | | | | | *Italy* | the Italian Ministry for the Environment and the Protection of Land and Sea (Ministero dell'Ambiente e della Tutela del Territorio e del Mare). | |
| **25** | EU Project | 4 | GLOBAL | designer monitoring | **KOBENHAVNS UNIVERSITET - Copenhagen Center for Disaster Research (COPE)** *Research Organization R&D Denmark* | Copenhagen Center for Disaster Research (COPE) is a transdisciplinary research center founded by Copenhagen Business School and University of Copenhagen. COPE's aim is to facilitate multidisciplinary disaster research by (1) supporting and promoting collaborative studies, (2) sharing results from this research and (3) circulating the results of these projects, thus advancing knowledge in the field. | https://research.ku.dk/ https://cope.ku.dk/ Kristian CEDERVALL LAUTA (project EspreSSo) E-mail: klau@jur.ku.dk Phone: +45 35324381 |
| **26** | EU Project | 4 | GLOBAL | designer monitoring | **Royal Netherlands Meteorological Institute (KNMI)** *Research Organization R&D Netherlands* | KNMI provides meteorological and seismological products and services that support various governmental organizations in their activities. In particular, it is focused on the research and development of urban space planning, in providing information and methodologies on risky meteorological situations, in providing scenarios on energy production and storage and information on climate change. | http://www.knmi.nl info@weeronline.nl. |
| **27** | EU Project | 4 | GLOBAL | designer monitoring | **UNIVERSITY of SALZBURG DEPARTMENT OF GEOINFORMATICS - Z_GIS** *Research Organization R&D Germany* | The Interfaculty Department of Geoinformatics (Z_GIS) is an established interdisciplinary centre of competence at Paris London University of Salzburg (PLUS). PLUS provides valuable experience and expertise in the field of spatial analysis, which feeds directly into the project. This includes the application of innovative methods for spatial decision support and policy implementation relating to DRR and CCA, which have been applied in various case studies. | www.zgis.at E-Mail: zgis@sbg.ac.at phone: +43 (0)662 8044 – 7502 |
| **28** | EU Project | 4 | GLOBAL | designer monitoring | **POLITECNICO DI MILANO** *Research Organization R&D Italy* | Presents interdisciplinary research centers and also specialize in issues related to climate change. In particular, it is focused on Physical Sciences and Engineering, Life Sciences, Social Sciences and Humanities | http://www.polimi.it |
| **29** | EU Project | 4 | GLOBAL | designer monitoring | **IHE Delft Institute for Water Education** *Research Organization R&D Netherlands* | Institute for Water Education is the largest international water education facility in the world and is based in Delft, the Netherlands. Its mission is to contribute to the education and training of water professionals and build capacity to organisations active in the fields of water and environment. The specialization research of coastal engineering and port development focuses on the modelling of coastal processes, for the forecast of short-term coastal risks, for the | https://www.un-ihe.org/ Dano Roelvink, d.roelvink@unesco-ihe.org |

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| | | | | | | evaluation of long-term morphodynamic changes in tidal basins, estuaries and open shores and in the assessment of the impacts of climate change on the coasts. | |
| **30** | EU Project | 4 | GLOBAL | designer monitoring | **Vrije University Amsterdam** *Research Organization R&D Netherlands* | Local Academic and Research Institute. Research in interdisciplinary fields | https://www.vu.nl/nl/index.asp pers@vu.nl |
| **31** | EU Project | 4 | GLOBAL | designer monitoring | **SEI-Stockholm Environment Institute** *Research Organization R&D Sweden* | Research institute focusing on environment and development issues at local, national, regional and global policy levels. | http://www.sei-international.org/ |
| **32** | EU Project | 4 | GLOBAL | designer monitoring | **TECHNISCHE UNIVERSITAT HAMBURG** *Research Organization R&D Germany* | Area of expertise: green technologies, life science technologies, aviation and maritime systems | https://www.tuhh.de praesident@tuhh.de |
| **33** | EU Project | 4 | GLOBAL | designer monitoring | **THE PROVOST, FELLOWS, FOUNDATION SCHOLARS & THE OTHER MEMBERS OF BOARD OF THE COLLEGE OF THE HOLY & UNDIVIDED TRINITY OF QUEEN ELIZABETH NEAR DUBLIN** *Research Organization R&D Ireland* | Whether through the generation of new ideas that change our perception and understanding of the world around us, or our response to real societal needs, or the challenge of developing novel technologies, Trinity seeks to create an environment of inquiry and creativity that enables researchers and scholars fulfil their potential and maximise the impact of their endeavours. | http://www.tcd.ie/ dean.of.research@tcd.ie |
| **34** | EU Project | 4 | GLOBAL | designer monitoring | **THE UNIVERSITY OF EXETER** *Research Organization R&D UK* | Research in interdisciplinary fields with particular focus on the research of animal behaviour in nature, on the influence of climate change in Antarctica. It also has a research centre on aquatic resources in which it aims to improve the understanding of how chemicals entering the environment affect aquatic organisms, monitor the current and future global impact of ocean acidification and climate changes; evaluate the | https://www.exeter.ac.uk/ Dr Stephen Simpson, S.Simpson@exeter.ac.uk |

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| | | | | | | impact of anthropogenic noise pollution on aquatic ecosystems; work for sustainable aquaculture; | |
| **35** | EU Project | 4 | GLOBAL | designer monitoring | **THE UNIVERSITY OF READING** *Research Organization R&D UK* | Research at the University of Reading aims to solve some of the biggest problems facing people today, based on five themes: environment, food, health, heritage and creativity and prosperity and resilience. Working across continents and disciplines, our researchers explore ways to tackle climate change, improve human health, provide food security and understand human culture. | http://www.reading.ac.uk/ |
| **36** | EU Project | 4 | GLOBAL | designer monitoring | **THE UNIVERSITY OF WARWICK** *Research Organization R&D UK* | Local Academic and Research Institute. Research in interdisciplinary fields | https://warwick.ac.uk/#Research Tel: +44 (0)24 7652 3523 Dr Xueyu Geng Rper. Project HERCULES Xueyu.Geng@warwick.ac.uk |
| **37** | EU Project | 4 | GLOBAL | designer monitoring | **UNIVERSITAT POLITECNICA DE VALENCIA** *Research Organization R&D SPAIN* | Local Academic and Research Institute. Research in interdisciplinary fields | https://www.upv.es/ Elisa Peñalvo López (Grow Green) Dr. Joaquín Andreu (IMPREX) |
| **38** | DESKTOP | | GLOBAL | designer delivery&maintenance monitoring | **CEREGE - Centre Européen de Recherche et d'Enseignement des Géosciences de l'Environnement** *Research Organization Environment FRANCE* | CEREGE is a joint interdisciplinary research centre focusing in: Climate (climate forcing, carbon cycle, sea level, ice sheets, glacier dynamics, water cycle, paleohydrology, acidification, biodiversity, vegetation), Sustainable Environment, Earth and Planets (earth surface processes, tectonic, climate, geodynamics, hydrology, geomorphology, geochronometry, palaeoenvironments, paleomagnetism, archeomagnetism), Ressources, Réservoirs and Hydrosystems. | https://www.cerege.fr Anne Alexandre (Director of research/Senior scientist,CNRS,CEREGE) email: alexandre@cerege.fr |

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| **39** | DESKTOP | | GLOBAL | designer<br>delivery&maintenance<br>monitoring | **UNIVERSITETI POLIS**<br>*Research Organization*<br>*R&D*<br>*ALBANIA* | The university has printed coral reefs in 3D to prevent flooding and the erosion of the Albanian coasts. Using a large-scale robotic arm the so-called Reef Ball protection elements are 3D printed in stone-like material (mixture of sand, cement and water as a binder) in layered similar configurations. The use of this technology would allow the printing of large-scale protective coral reefs to be used in different coastal areas in Albania with the risk of erosion. Innovation is not a fixed structure, but has mobile components. (https://climateinnovationwindow.eu/innovations/3d-printing-coastal-protection-reefs). | http://www.universitetipolis.edu.al/<br>Prof. Dr. Luljeta Bozo (GeoEnvironment area)<br>E-mail: lulibozo@gmail.com; luljeta_bozo@universitetipolis.edu.al |
| **40** | DESKTOP | | GLOBAL | influencer<br>policy maker | **BEYOND - centre of excellence for EO based monitorinf of natural disasters**<br>*Research Organization*<br>*Environment*<br>*Greece* | The BEYOND Center of Excellence develops research and provides disaster management services addressing priorities and needs in South Eastern Europe, Mediterranean, N. Africa, Middle East and the Balkans. The Center's creation supported by the competitive framework of EU FP7-REGPOT-2012-2013-1 and costed 2,3 MEuros. It generated unique excellence and EO research infrastructure for the region. | http://beyond-eocenter.eu/index.php<br>P: +30 210 34 90 086<br>E: christia@noa.gr |
| **41** | OAL | | GLOBAL | designer<br>monitoring | **University of Oulu**<br>*Research Organization*<br>*R&D*<br>*FINLAND* | Local Academic and Research Institute. Research in interdisciplinary fields | https://www.oulu.fi/university/node/38259<br>university.of.oulu(at)oulu.fi<br>Tel. +358 294 48 0000 |
| **42** | OAL | | GLOBAL | designer<br>monitoring | **Finnish Environment Institute**<br>*Research Organization*<br>*R&D*<br>*FINLAND* | SYKE is a multidisciplinary research and expert institute. Our most important task is to solve society's most burning questions that have an impact on the environment. | https://www.syke.fi/en-US<br>Communications and media services<br>Tel. +358 295 251 072<br>syke_ajankohtaiset@ymparisto.fi |
| **43** | OAL | | GLOBAL | designer<br>monitoring | **University of Eastern Finland - Faculty of science and forestry**<br>*Research Organization*<br>*R&D*<br>*FINLAND* | The Faculty of Science and Forestry is one of the four faculties at the University of Eastern Finland. They operate on two campuses, in Joensuu and in Kuopio. The mission of the Faculty of Science and Forestry is to provide education and conduct research in natural sciences and forestry which are of a high academic standard and have a strong impact on society. | http://www.uef.fi/en/uef/lumet<br>jukka.jurvelin@uef.fi<br>elina.oksanen@uef.fi |

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| **44** | OAL | | GLOBAL | designer monitoring | **University of Jyväskylä**<br>*Research Organization*<br>*R&D*<br>*FINLAND* | Among the others, University's research profile is based on following core fields: Learning, teaching and the learning and growth environments that support development Basic natural phenomena and mathematical thinking | https://www.jyu.fi/en/research/<br>+358 (0)14 260 1211 |
| **INVESTORS** | | | | | | | |
| **ID** | **Source** | **#Projects** | **Geographical coverage** | **Value Chain Position** | **Stakeholder Name**<br>*Type*<br>*Area of Interest*<br>*Country* | **Brief description of the stakeholder** | **Website Contacts** |
| **45** | EU Project | 5 | NATIONAL | designer delivery&maintenance supplier | **HYDROMETEOROLOGICAL INNOVATIVE SOLUTIONS**<br>*Company*<br>*Environment*<br>*SPAIN* | Offers innovative solutions in hydrometeorology. Products that minimize the effects of time on activities. Among the services it offers advanced hydrometerological processing systems, hydrometerological information systems for water resources management, metrological information systems for airport management | http://www.hyds.es/<br>info@hyds.es |
| **46** | EU Project | 3 | GLOBAL | designer delivery&maintenance monitoring | **ACCIONA CONSTRUCCION SA**<br>*Company*<br>*Engineering*<br>*Worldwide* | Its Specialised Business Units: Bridges, roads and special structures; Railways and Tunnels; Ports and Hydraulic Works and Concessions, support a comprehensive offering covering the entire value chain of the Construction business | www.acciona-construccion.com/es/<br>Magdalena Rózanska<br>Project Manager<br>magdalena.rozanska@acciona.com |
| **47** | EU Project | 4 | NATIONAL | designer delivery& maintenance supplier | **HKV- LIJN IN WATER BV**<br>*Company*<br>*Engineering*<br>*Netherlands* | With universities, authorities and businesses we develop, test and implement innovations, new approaches and services related to flood risk and water resource management. | http://www.hkv.nl<br>info@hkv.nl |
| **48** | EU Project | 3 | NATIONAL | influencer | **I-CATALIST SL**<br>*Company*<br>*Environment*<br>*SPAIN* | Is a company specialised in socio-ecological knowledge brokerage and natural resources management. expertise in policy evaluation and management, risk assessment, sociotechnical systems and socio-ecological transitions, ecosystem services, GIS & remote sensing, e- | https://www.icatalist.eu/ |

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| | | | | | | government and data transparency. Our background joins environmental sciences and geography. | Phone: (+34) 918 311 696<br>info@icatalist.eu |
| **49** | EU Project | 3 | GLOBAL | designer<br>monitoring | **FUTUREWATER SL**<br>*Company*<br>*Environment*<br>*Spain*<br>*Netherlands* | FutureWater is a research and consulting organization that works all over the world to combine scientific research with practical solutions for water management. FutureWater works globally, nationally and locally with partners for projects related to water for food, irrigation, excess water, water scarcity, climate change and river basin management. | http://www.futurewater.eu<br>info@futurewater.nl<br>Dr. Peter Droogers - Senior Hydrologist and Climate Change Expert<br>Email: p.droogers@futurewater.nl<br>Tel: +31 (0)317 460 050 |
| **50** | EU Project | 2 | NATIONAL | designer<br>influencer | **GREEN4CITIES GMBH**<br>*Company*<br>*Environment*<br>*Austria* | The design, submission and implementation of research and development projects on Urban Green Infrastructure. Green4Cities offers a variety of consulting and coaching services on Green Infrastructure. | http://www.green4cities.com/<br>office@green4cities.com<br>Doris Schnepf -CEO<br>Telephone(s) +43 676 670 0215<br>E-mail doris.schnepf@green4cities.com |
| **51** | EU Project | 2 | NATIONAL | designer<br>monitoring | **HYDROLOGIC RESEARCH BV**<br>*Company*<br>*Environment*<br>*Netherlands* | Hydrologic is a team of hydrologists and ICT experts who are seeking sustainable, innovative environmental solutions to urgent water problems. They aim at providing water stakeholders with reliable information, simulation models, in-depth water knowledge and tools for solving water problems. Their clients include environmental agencies, ministries, water boards, provinces, municipalities and the European Commission. They focus on high-quality services, on ensuring reliable and consistent information, on simulation models, and tools, and in-depth water knowledge to support our decision-making. They provide tools that run as web-based hydro-informatics solutions on portals and mobile phone applications with customisable dashboards, | http://www.hydrologic.com/<br>T: +31 33 4753535<br>info@hydrologic.com |

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| | | | | | | GIS-based viewers and graphical presentations of key information for strategic and operational water management. | |
| **52** | EU Project | 2 | GLOBAL | designer delivery&maintenance supplier | **INTERNATIONAL WATER ASSOCIATION** *Company Engineering Belgium* | International engineering and consultancy company in the field of natural waters: development of innovative services and solutions in a number of sectors contributing to the progression of water management worldwide. research and projects focused on solutions for water and wastewater management | http://www.iwa-network.org water@iwahq.org |
| **53** | EU Project | 2 | NATIONAL | influencer | **SOCIEDADE PORTUGUESA DE INOVACAO - CONSULTADORIA EMPRESARIAL E FOMENTO DA INOVACAO S.A.** *Company Engineering PORTUGAL* | Sociedade Portuguesa de Inovação (SPI) is a private consulting company. SPI has become a leading promoter of linkages between national and international public and private organizations/companies/S&T institutes. | www.spieurope.eu João Medina Manager joaomedina@spi.pt |
| **54** | EU Project | 2 | NATIONAL | designer monitoring | **TERRADUE SRL** *Company Engineering ITALY* | Terradue's mission is to innovate services in Earth Science, tailored for data-intensive applications; remove barriers and automate Cloud data storage, data analysis algorithms and massive computing power | https://www.terradue.com/ PEDRO PEREIRA GONÇALVES Founder, CTO |
| **55** | EU Project | 2 | GLOBAL | designer delivery&maintenance, supplier | **RAMBOLL** *Company Engineering GLOBAL* | Ramboll is a leading engineering, design and consultancy company founded in Denmark in 1945. he company employs more than 15,000 experts globally and has especially strong representation in the Nordics, UK, North America, Continental Europe, Middle East and Asia-Pacific. | https://ramboll.com/ T: +45 5161 1000 info@ramboll.com |

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| **56** | EU Project | 2 | GLOBAL | designer deliveri&maintenance supplier | **Atos IT Solutions and Services Iberia**<br>*Company*<br>*Engineering*<br>*WORLDWIDE* | With its cutting-edge technologies and industry knowledge, Atos supports the digital transformation of its clients across all business sectors. | https://atos.net/en-gb/united-kingdom<br>Freephone: 0800 783 3040 |
| **57** | EU Project | 2 | NATIONAL | monitoring influencer | **ESSRG Kft.**<br>*Company*<br>*Society&Culture*<br>*HUNGARY* | Research and development enterprise working on the boundaries of environmental and social sciences with a transdisciplinary approach. ESSRG takes seriously the social responsibility of the academic sphere and embarks on various community engagement activities by involving diverse actors as co-researchers. It also implies that scientifically trained researchers and local people work together as knowledgeable actors in a self-reflective and creative way with an equal standing throughout the research process. | https://www.essrg.hu/en/<br>info@essrg.hu |
| **58** | EU Project | 2 | LOCAL | designer | **Fabis Consulting**<br>*Company*<br>*Society&Culture*<br>*UK* | Designing strategies & building capacities for a sustainable environment. Our expertise covers such topics as the sustainable management of environmental resources at the landscape scale. The work we have undertaken has dealt with the assessment of ecosystem services, and the development of tools and methods for sustainability appraisal, strategic planning and environmental valuation. Our aim has been to support the development of evidence-based policy and management by providing access to the best and most up-to-date science that is needed to design strategies for sustainability. | https://www.fabisconsulting.com/<br>marion.potschin@fabisconsulting.com |
| **59** | EU Project | 2 | GLOBAL | designer deliveri&maintenance supplier | **INTERNATIONAL MARINE AND DREDGING CONSULTANTS**<br>*Company*<br>*Engineering*<br>*BELGIUM* | IMDC is an international engineering and consultancy company in the field of natural waters: precipitation, groundwater, rivers, estuaries, coastal areas, ports and marine waters. It employs over 80 specialists and is based in Antwerp, Belgium. | https://imdc.be/en<br>32 3 270 92 95<br>info@imdc.be |
| **60** | EU Project | 2 | GLOBAL | designer | **ITASCA CONSULTANTS**<br>*Company*<br>*Engineering*<br>*WORLDWIDE* | Itasca is a global, employee-owned, engineering consulting and software firm, working primarily with the geomechanics, hydrogeological and microseismics communities. | https://www.itascacg.com/<br>info@itascacg.com |

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| **61** | EU Project | 2 | NATIONAL | monitoring influencer | **URBASOFIA SRL**<br>*Company*<br>*Society&Culture*<br>*ROMANIA* | Urbasofia is a laboratory for urban development, policy design and territorial cohesion focused on developing more integrated, participatory and smart-oriented solutions to pressing urban problems. | http://urbasofia.eu/en/home/<br>office@urbasofia.eu |
| **62** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier monitoring | **IRIDRA**<br>*Company*<br>*Engineering*<br>*ITALY* | It plays activities related to the analysis, planning, DESIGNER and assistance in implementing interventions for the sustainable management of water resources. In particular, IRIDRA is recognized as a leading company in the fields of nature-based solutions (green-based solutions) and green infrastructures (green infrastructure), such as phytodepuration, sustainable urban drainage, ecosystem services, cycle management adaptation of water to climate change. | http://www.iridra.eu<br>Riccardo Bresciani (engineer-DESIGNER and management of water treatment systems)<br>email:bresciani@iridra.com |
| **63** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier | **JACOBS ENGINEERING GROUP**<br>*Company*<br>*Engineering*<br>*USA* | Provides engineering DESIGNER, construction management, project construction, operations, maintenance, development and rehabilitation of critical water resources systems, water / wastewater transport systems and flood defence projects. | http://www.jacobs.com<br>Lorrie Crum (Relations with the global media)<br>Email:<br>Lorrie.Crum@jacobs.com |
| **64** | DESKTOP | | NATIONAL | designer delivery&maintenance supplier monitoring | **FLOW-ING SRL**<br>*Company*<br>*Engineering*<br>*ITALY* | It deals with environmental engineering DESIGNER specializing in the study, development and realization of new technologies for the mitigation of hydrogeological risks, avalanche risk mitigation interventions, interventions of mountain basins and open water courses, maritime engineering interventions. It carries out specialist studies and fact-finding surveys, environmental numerical modelling, analysis and processing of environmental data, preparation of civil protection plans and develops and implements forecasting software for environmental risks | http://www.flow-ing.com<br>Francesco Ferro (Technical Director)<br>email:f.ferro@flow-ing.com |
| **65** | DESKTOP | | GLOBAL | designer supplier | **NATUREM Solutions**<br>*Company*<br>*Engineering*<br>*BELGIUM* | The company develops nature-based solutions and Eco-technologies in rural and urban areas for the treatment, reclamation and management of water, air, soil and waste, renewable energy, production and valorisation of biomass, eco-buildings, the fight against climate change and sustainable agriculture. | https://www.naturem-solutions.com<br>info@www.naturem-solutions.com<br>Tel:+32 478329494 |

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| **66** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier monitoring | **CTI ENGINEERING INTERNATIONAL CO.LTD** *Company Engineering JAPAN* | Engineering consultancy services operating in all engineering sectors. In particular, it is specialized in planning, designing and implementing solutions for river improvement and flood control. The company manages several projects for infrastructure development and socio-environmental improvement, such as monitoring the water quality of the major waterways and flood risk management. | https://www.ctii.co.jp Masakazu Maeda (General Manager of Business Promotion & Planning Division) email:eigyokikaku@ctii.co.jp |
| **67** | DESKTOP | | GLOBAL | design delivery&maintenance supplier monitoring | **SUEZ ENVIRONMENT** *Company Engineering FRANCE* | The company is specialized in water management. It has developed its own technology, Influx ®, which concerns a continuous meteorological surveillance system to help cities anticipate rainy periods. SUEZ adapts rainwater storage capacity in real time to prevent overflow, which is a source of pollution and flooding. Once rainwater has been collected, it is treated and can be reused for collective purposes, such as parks and irrigated gardens. | https://www.suez.com Catherine des Arcis (Press Responsible) Tel:+33 1 58 81 54 23 email:catherine.desarcis@suez.com |
| **68** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier monitoring | **PHYTOREM** *Company Engineering FRANCE* | Company is specialized in water purification and soil remediation by plants. Designs and builds eco-friendly wastewater treatment plants, operating both in urban and rural areas. It is owner of Bamboo-Sanitation technology (http://bambooforlife.fr) that allows purifying the water with zero co2 emissions. Company will participate in a project to reduce pollution of the Seine ahead of the 2024 Olympic Games | http://www.phytorem.com Frédéric Panfili (Scientific manager) email: fredericpanfili@phytorem.com |
| **69** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier monitoring | **BIOMANDA** *Company Environment FRANCE* | Biomanda is a company specializing in bioinformatics: pathogen detection, characterization of microbiota, microbial source tracking, the impact of pollutant on the microbial environment, and analysis of biological data | http://biomanda.eu Dr. Julien Gardès (CEO and Biology and Bioinformatics Expert) email: julien.gardes@biomanda.com, jgardes@gmail.com |
| **70** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier monitoring | **BURGEAP - Bureau d'études en Environnement et Sites et Sols Pollués** *Company Environment FRANCE* | BURGEAP aims for technical excellence in environmental preservation, sustainable local and urban development, environmentally responsible businesses, and for the energy transition. Hydrogeology, Geothermal Energy, Groundwater, Soil Remediation, Hydraulics, Polluted Soils, Environmental Engineering, Waste, Asbestos Removal, Deployment, and Energy. | https://www.burgeap.fr/ Michele Cyna (Executive Director) email:linkedin.com/in/michele-cyna-426a9613, |

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| **71** | DESKTOP | | NATIONAL | designer delivery&maintenance supplier | **AGROSYLVA** *Company Environment FRANCE* | Agrosylva is a French residuals management consulting and implementation company, specialized in Sludge treatment, Ponds cleaning, Biosolids valorisation. Areas of intervention: Protection of the water resource, collective / non-collective sanitation, organic waste management, drainage of basins saturated with mud or sediment, organic waste treatment, recovery of organic waste, and prevention of natural disasters (revegetation of ski slopes/ prevention of landslides, maintenance of fuel cuts/ fire prevention and watercourse cleaning/ flood prevention. | http://agrosylva.eu Joël Pouget (Founder) email: j.pouget@agrosylva.eu |
| **72** | DESKTOP | | GLOBAL | designer delivery&maintenance policy maker | **BIOTOPE - Biotope Environnement SA** *Company Engineering FRANCE* | BIOTOPE is the leading French company for biodiversity and ecosystem service assessment, nature conservation planning, and natural history communication and publishing. Specialized in Habitat management, Habitat restoration, Stakeholder engagement, Natural history publishing, Biodiversity Action Plans, Critical Habitats, Biodiversity Management Plans, Biodiversity policies, Mitigation hierarchy and offsets, and Mapping & GIS. | https://www.biotope.fr/en/ Nathalie Boyer (Partnerships Manager) phone: +33 04 67 18 61 69, +33 06 79 71 22 55 email: nboyer@biotope.fr |
| **73** | DESKTOP | | GLOBAL | designer delivery&maintenance monitoring policy maker | **BRGM - Bureau de Recherches Géologiques et Minières** *Company Environment FRANCE* | BRGM is France's reference public institution for Earth Science applications in the management of surface and subsurface resources and risks, specialized in: geology, mineral resources, geothermal energy, geological storage of $CO_2$, risks, post-mining, water, polluted sites and soils, waste, metrology and laboratories, information systems. | https://www.brgm.eu/ Jean-Claude Guillaneau (International Director) email: jc.guillaneau@brgm.fr. Tel: +33 02 38 64 37 93 |
| **74** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier monitoring | **F-REG - Flow Regulation Systems** *Company Engineering FRANCE* | F-REG is a company working on the autonomous hydrodynamic valve, managing sanitation networks in urban areas. Main functions: controlling floods and reducing rain pollution by mobilizing the available volume of networks to regulate the flow in rainy weather by freeing up land holdings, avoiding clogging of storm and retention basins to allow long-term operation of the sanitation system by minimizing maintenance. | https://f-reg.fr/ Emmanuel Curinier (General Manager) email: e.curinier@f-reg.fr tel: +33 06 61 41 26 04 |

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| **75** | DESKTOP | | GLOBAL | designer<br>delivery&maintenance<br>supplier<br>monitoring | **IMAGEAU**<br>*Company*<br>*Engineering*<br>*FRANCE* | Imageau is a company working on the protection of groundwater resources by means of an accurate cutting-edge monitoring technology developed in the Montpellier Geosciences Lab, focusing in: coastal aquifers management, assessment of the aquifer, and support. Their products: Subsurface (underground) Monitoring Device, Reservoir (shallow water) Monitoring Device, Specific Resource Monitoring, and Real-Time Management of Environmental Data | https://www.imageau.eu/<br>Olivier Depraz (General Director)<br>tél : +33 4 67 20 41 31 / +33 6 45 62 69 17<br>email : olivier.depraz@imageau.eu |
| **76** | DESKTOP | | GLOBAL | designer<br>delivery&maintenance<br>supplier<br>monitoring | **Mascara Renewable Water**<br>*Company*<br>*Environment*<br>*FRANCE* | Mascara Renewable Water is a company specializing in innovative water treatment solutions with the use of renewable energy to produce affordable drinking water for everyone. Their first development phase resulted in the industrialization of OSMOSUN®, the world's first product range of seawater desalination based on sunshine power only | https://mascara-nt.fr/<br>Marc Vergnet (Co-founder and CEO)<br>email: m.vergnet@mascara-nt.fr<br>tel: +33 0237343075, +33 0623895364 |
| **77** | DESKTOP | | GLOBAL | designer<br>delivery&maintenance<br>monitoring | **Egis Group**<br>*Company*<br>*Engineering*<br>*FRANCE* | Egis Group is a French engineering group involved in the areas of infrastructure and transport systems, planning, water and environment. Egis is also involved in the business of setting up projects and operations for roads and airports. In environmental sector, Egis works are focused in environmental engineering, industrial environment, biodiversity and ecological engineering, waves, acoustics, and vibrations, air, waste, and contaminated sites and soils. While in the water sector, its works are focused in drinking water, water management, flood hazard, dikes and dams, waste and industrial water. | http://www.egis-group.com<br>Régis DUMAY (CEO Major Structures, Water Environment Energy)<br>email: regis.dumay@egis.fr |
| **78** | DESKTOP | | GLOBAL | designer<br>delivery&maintenance<br>supplier<br>monitoring | **CSD ENGINEERS**<br>*Company*<br>*Engineering*<br>*SWITZERLAND* | CSD Engineers, biologists and other experts plan, observe, develop and renew the environment. Provide services in spatial planning and construction management (e.g. ecological quality analyses, living environment inventories, environmental / soil monitoring, risk analyses). They also coordinate and carry out renaturations (reforestation, ponds for amphibians, renaturations of streams and rivers, etc.). For protection against natural hazards, CSD engineers draw up regional hazard maps. | https://www.csd.ch/en<br>Martina Schmucki Schubiger (Head of department Environment)<br>Tel: +41 71 229 00 97<br>Email: m.schmucki@csd.ch |

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| **79** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier monitoring | **EBP SCHWEIZ AG** *Company Engineering SWITZERLAND* | They offer a broad range of consulting, planning, design, construction, communication and IT services with the goal of preserving the earth and securing the well-being of future generations. Among the sectors in which they operate, there are also Climate Change, Environmental and Hydric Resources sectors. | https://www.ebp.ch/en Denise Fussen (Expert in Climate Change) Email: denise.fussen@ebp.ch |
| **80** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier monitoring | **HOLINGER** *Company Engineering SWITZERLAND* | They implement cost-effective and ecologically forward-looking solutions based around resource-saving processes and techniques and deliver progressive solutions for social challenges relating to water, construction, infrastructure, resources, natural risks, the environment and energy. | https://www.holinger.com Martin Anderson (Member of the Branch Management) Tel: +41 61 926 23 31 Email: martin.anderson@holinger.com |
| **81** | DESKTOP | | GLOBAL | designer delivery&maintenance influencer | **THE NATURE CONSERVANCY** *Company Engineering USA* | Non-profit, charitable association that helps to tackle Climate Change, protect Land and Water, provide Food and Water Sustainability and build Healthy Cities. | https://www.nature.org/en-us/ Marianne Kleiberg (European Managing Director) Ref. contact - Lee Hornung: Email: lee.hornung@tnc.org |
| **82** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier monitoring | **ACCLIMATISE - BUILDING CLIMATE RESILIENCE** *Company Engineering UK* | Specialist advisory and analytics company providing world-class expertise in climate change adaptation and risk management. | http://www.acclimatise.uk.com/ Will Bugler (Senior Communications Consultant) Email: w.bugler@acclimatise.uk.com Tel: +44 (0) 7726665908 |

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| **83** | DESKTOP | | LOCAL | designer delivery&maintenance monitoring | **COASTAL ENVIRONMENTS INC.** *Company Environment USA* | Small business that provides environmental services in the area of Biological Assessments; Environmental Permitting; Environmental Restoration; Geology and Geomorphology; Hydrologic Modelling; Sustainable Development; Threatened & Endangered Species Surveys; Wetland Delineations. Coordination of a project from the planning and design stages through research and analysis to final implementation and monitoring. Efficient and cost-effective project completion throughout the Gulf Coast and Mississippi Alluvial Valley. | https://www.coastalenv.com/ MARK H. GAGLIANO (PRESIDENT, RESTORATION SCIENTIST) Email: MGAGLIANO@COASTALENV.COM Tel: (225) 383-7455 EXT. 111 |
| **84** | DESKTOP | | GLOBAL | delivery&maintenance supplier monitoring | **SIRIUS TECHNOLOGIES AG** *Company Environment SWITZERLAND* | Software development company. Product and services offerings include hosted software and support in the key areas of corporate responsibility (CR), sustainability and Health, Safety & Environment (HSE). | https://www.sirius.ch/en/ General Contact E-mail: info@sirius.ch Tel.: +41 61 3757575 / Fax: +41 61 3757570 |
| **85** | DESKTOP | | NATIONAL | delivery&maintenance supplier | **PINE ENVIRONMENTAL SERVICES INC.** *Company Environment USA* | Provider of rental equipment in the nation for Environmental Monitoring Equipment, Sampling and Safety Supplies, Non-Destructive Testing and Visual Inspection Instruments, as well as Continuous Emissions Monitoring (CEMS) Equipment and EPA Protocol Gases. | http://www.pine-environmental.com/ Brian Bendis (Director) Email: bbendis@pine-environmental.com Tel: 813-620-1001 |
| **86** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier monitoring | **ENTA TREATMENT SYSTEMS ENGINEERING CONTRACTING LTD** *Company Engineering TURKEY* | Service network is in the field of environmental technology, design, manufacturing, installation, consulting, operating and complete turnkey water / wastewater treatment plants. Is also active in the areas of Waste Water Treatment Plant's Equipments, Package Treatment Units, Manufacturing Domestic and Industrial Waste Water Treatment Plant's Equipments. | http://enta.com.tr/en/ Mehmet YÜCEYURT (General Manager) Email: mehmet@enta.com.tr |
| **87** | DESKTOP | | GLOBAL | delivery&maintenance supplier monitoring | **ENVEA** *Company Environment FRANCE* | Manufacturing air pollution, emission and process monitoring systems, with full turnkey capabilities (gas analysers, dust monitors, solids and flue gas flow meters...) completed by environmental DAHS, processing & reporting software. Preservation of the natural environment and providing public and private organizations with the necessary tools to | http://envea.global/en/ Malek Hattar (General Manager) Email: m.hattar@envea.global |

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| | | | | | | assess, measure and thus reduce the impact of human activities on eco-systems. | |
| **88** | DESKTOP | | GLOBAL | supplier | **LAKES ENVIRONMENTAL**<br>*Company*<br>*Engineering*<br>*CANADA* | Supplies robust and easy-to-use air dispersion modelling software, training, and services to consulting companies, industries, governmental agencies and academia. | https://www.weblakes.com/index.html<br>Jesse L. Thé (President)<br>Email: jesse.the@weblakes.com |
| **89** | DESKTOP | | GLOBAL | designer<br>delivery&maintenance<br>influencer | **GIRAFFE INNOVATION LTD**<br>*Company*<br>*Environment*<br>*UK* | Delivery of a wide range of sustainability-driven projects to the UK and global organisations; engage clients, implement change and change their culture; eco-design consultancy. Giraffe also provides senior management support and coaching to a wide range of organisations including advice on the legal compliance obligations and business benefits of EU Environmental Legislation. | http://giraffeinnovation.com/<br>Rob Holdway (Director of Environmental Management Consultants ) Email: r.holdway@giraffeinnovation.com<br>Tel: + 44 (0)1273 422099 |
| **90** | DESKTOP | | GLOBAL | designer<br>delivery&maintenance<br>monitoring | **ECOSYSTEMS LTD**<br>*Company*<br>*Environment*<br>*HONG KONG* | Provides ecological consulting services in the East and South-East Asian region in the following fields: Protection area management; Ecological baseline survey; Conservation project development and implementation; Ecological impact assessment and monitoring; Ecological restoration and conservation; Ecotourism planning. | http://www.ecosystems-ltd.com/ecosystems_eng/frame1.htm<br>Tom Dahmer (Wildlife Biologist and Director)<br>Email: tdahmer@pacific.net.hk. |

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| **91** | DESKTOP | | NATIONAL | designer delivery&maintenance supplier monitoring | **FORESIGHT ENGINEERING GROUP INC.** *Company Engineering USA* | It is a civil engineering, surveying, and ecological firm serving clients from both the public and private-sector with a variety of engineering, surveying, and environmental services: ecological services, wetland delineations, water resource permitting and wetland and stream restoration plans. | http://www.foresightengr.com/ Robert Provost (President) Secretary contact - Steven N. Roessner Email: snr@foresightengr.com |
| **92** | DESKTOP | | NATIONAL | designer delivery&maintenance supplier monitoring | **ECOLOGY BY DESIGN** *Company Environment UK* | Ecology consultancy that provides a full range of ecological services from preliminary ecological appraisals through to impact assessments, licence applications, mitigation and monitoring. | https://www.ecologybydesign.co.uk/ Ben Gardner (Managing Director) Email: ben@ecologybydesign.co.uk Tel: +44 01865893346 |
| **93** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier monitoring | **S.I.A. - SOCIETA' ITALIANA PER L'AMBIENTE** *Company Environment ITALY* | Environmental consultancy in the following areas: Feasibility studies and cost / benefit analysis extended to environmental components; Drafting of studies of Strategic Environmental Assessment (SEA), environmental planning; Drafting of studies of Environmental Impact Assessment (EIA) for infrastructure projects; Environmental resources management; Economic-financial analyses for investment projects; Design of impact mitigation measures; Landscape renaturation and redevelopment; Environmental risk assessment; Environmental monitoring; Environmental modelling; Remediation of polluted sites; Acoustics and vibrations; Air quality and pollution of urban areas; Environmental geology. | http://www.laienvconsulting.com/?lang=en Giuseppe Marfoli (President) Email: Giuseppe.marfoli@siaenv.com Tel: +39 06 521.555.4 Mobile: 335 5919186 |
| **94** | DESKTOP | | GLOBAL | delivery&maintenance supplier monitoring | **SIMBIENTE - ENVIRONMENTAL ENGINEERING AND MANAGEMENT LTD.** *Company Environment PORTUGAL* | Technological company focused on research, development, innovation and services in Environmental Engineering areas: Water resources management; Management of resources, uses and risks of the territory; Waste management; Environmental and sustainability assessment; Conservation and improvement of ecosystems. | https://www.simbiente.com Sergio Costa (Manager and Executive Director) Email: sergio.costa@simbiente.com |

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| **95** | DESKTOP | | GLOBAL | delivery&maintenance supplier monitoring | **TRACE2O**<br>*Company*<br>*Engineering*<br>*UK* | Trace2o is a global manufacturer and supplier of vanguard technologies and tools in the field of environmental monitoring. | https://www.trace2o.com<br>Jill Moran (Marketing Assistant)<br>email:jill.moran@trace2o.com |
| **96** | DESKTOP | | GLOBAL | designer delivery&maintenance | **DILLON CONSULTING LIMITED**<br>*Company*<br>*Environment*<br>*CANADA* | Dillion provides environmental consulting and planning. Their environmental services include, contaminant management, site and facility audits, remediation and rehabilitation, hydrogeology, air quality, solid and hazardous waste, terrestrial and aquatic habits, wetlands, watersheds and ecosystems, water resources, environmental policy and assessments, water supply, waste water and training. | http://www.dillon.ca/<br>Don McKinnon (Environmental Planning Manager)<br>email:dpmckinnon@dillon.ca |
| **97** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier monitoring | **RIBEKA GMBH**<br>*Company*<br>*Engineering*<br>*GERMANY* | Ribeka develops and supplies user-friendly software systems and solutions for water management, water and environmental resources, groundwater monitoring systems (such as multi-parameter data loggers that can be managed via the Internet), for the acquisition of mobile data and GIS supported analysis. The company also designs water management plans. | https://www.ribeka.com/<br>Erich Berger (water resources management)<br>email:berger@rebeka.com |
| **98** | DESKTOP | | NATIONAL | delivery&maintenance monitoring | **ARBEAUSOLUTIONS**<br>*Company*<br>*Environment*<br>*FRANCE* | ARBEAUSOLutions is a company specialized in the diagnosis and management of the risk of consulting on the vegetation of hydraulic structures and river banks. Between its main skills include: Study of the fluvial context and vegetation / bank / dam interaction (stabilization / remobilization of alluvial materials / erosion / destructuring); Analysis of the risks induced by the trees present on structures / hydraulic benches; Environmental and ecological monitoring during the construction phase. | http://www.arbeausolutions.fr<br>Caroline ZANETTI (Founder and President)<br>Tel: 06 82 18 55 43<br>E-mail: c.zanetti@arbeausolutions.fr |
| **99** | DESKTOP | | GLOBAL | designer delivery&maintenance supplier monitoring | **Altereo**<br>*Company*<br>*Engineering*<br>*FRANCE* | Altereo (before: G2C Environnement) is an engineering company focusing on: water and environmental engineering (studies & master plans, advanced asset management, water utility performance), Consulting for Public Utility Management (organisation & management of public services, public service delegation), Sustainable Development of Cities & Territories (urban planning and projects, smart territories, | http://altereo.fr/en/<br>Mr Christian Laplaud (Chairman)<br>tel: +(33) 4 42 54 00 68<br>fax: +(33) 4 42 54 06 78<br>email: c.laplaud@g2c.fr |

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| | | | | | | circular economy), and GIS/ Geographic Intelligence Solutions (water & territories, customised business applications). | |
| **100** | DESKTOP | | NATIONAL | designer<br>delivery&maintenance<br>supplier<br>monitoring | **Wetland Engineering**<br>*Company*<br>*Environment*<br>*UK* | Wetland Engineering is all about improving the quality of wetlands, rivers and streams: Treatment wetlands, Natural flood management, Habitat creation, Sustainable drainage (SuDS), Environmental chemistry, Mine-water treatment. | http://wetlandengineering.co.uk/<br>tel: 01706 817922<br>email:geoff.sweaney@wetlandengineering.co.uk |
| **101** | DESKTOP | | NATIONAL | designer<br>delivery&maintenance<br>supplier<br>monitoring | **EVANS RIVERS AND COASTAL**<br>*Company*<br>*Engineering*<br>*UK* | It is a chartered environmental consultancy specialising in: Flood risk assessments; Surface water management plans and sustainable drainage schemes (SUDS) using Microdrainage; Flood flow calculation; In-house 1-Dimensional and 2-Dimensional river/coastal breach/surface water modelling and mapping; In-house flood hazard modelling and mapping assessment; Flood mitigation and river engineering; Flood response / evacuation plans / business continuity plan; Coastal retreat, management and adaptation strategies(CEVA); Pollution prevention strategies. | https://www.evansriversandcoastal.co.uk/<br>Rupert Evans (Managing Director)<br>Email: rupert.evans@evansriversandcoastal.co.uk<br>Tel: 07896 328 220<br>Tel: 01603 304 077 |
| **102** | DESKTOP | | GLOBAL | designer<br>delivery&maintenance<br>supplier<br>monitoring | **HYQUEST SOLUTIONS PTY LTD**<br>*Company*<br>*Engineering*<br>*AUSTRALIA* | HyQuest Solutions offers a range of environmental monitoring, data acquisition and reporting solutions for water, air and energy applications. It is specialized in the field of hydrography and hydrology, but has developed also instruments (hardware and software) for meteorology and design services. | https://www.hyquestsolutions.com/<br>Phil White (General Manager)<br>Phone: +64 7 857 0811<br>E-Mail: phil.white@hyquestsolutions.co.nz |
| **103** | DESKTOP | | NATIONAL | designer<br>delivery&maintenance<br>supplier<br>monitoring | **ECOSYSTEM SERVICES**<br>*Company*<br>*Environment*<br>*USA* | Ecosystem Services is a natural resource consulting firm specializing in ecological restoration, mitigation banking, water resources planning and engineering, and environmental permitting. | https://ecosystemservices.us<br>Jackson Simmons (Business Administrator)<br>Email: jackson(at)ecosystemservices.us<br>Tel: 540.320.7785 |

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| **104** | DESKTOP | | NATIONAL | designer delivery&maintenance supplier monitoring | **ECOSALIX** *Company Engineering PORTUGAL* | Consulting, Technical Support and Natural Engineering Projects; Construction Monitoring and Inspection; Natural Engineering Training Actions; Product Supply associated mainly with erosion control, soil and slope stability, and landscaping. | http://ecosalix.pt/ Aldo Freitas (General Manager) Email: aldo.freitas@ecosalix.pt Tel: (+351) 249 095 379 |
| **105** | DESKTOP | | NATIONAL | designer delivery&maintenance monitoring | **CARDINAL STRATEGIES** *Company Environment USA* | Specialized in the application of the latest technologies on water resources projects related to the analysis and management of alluvial soils, management of water basins, transport of runoffs, geomorphic assessments, restoration of flows and design of erosion and sediment control. Areas of expertise: Water Resources, Watershed Modelling, Natural Channel Design, Hydraulic Studies, Stormwater Pollution Prevention Plan, Stormwater Management Plan, Stormwater Compliance, Drainage issues, Floodplain studies, Stormwater inspections, stream restoration, downstream assessment. | https://www.cardinalstrategies.com Jerry Sanders (Construction Services Manager) email:jerry.sanders@cardinalstrategies.com |
| **106** | DESKTOP | | NATIONAL | delivery&maintenance monitoring | **814 Solutions, LLC** *Company Environment USA* | It provides site-specific solutions about reclamation, revegetation, and erosion control. It offers soil analysis, site compliance assessment, environmental consulting. | http://www.814solutions.com Kevin Langham (Chief Operation Officer-Scheduling, Estimating, Project Specific Requests) Mobile: 505-450-1989; Email: Kevin@814Solutions.com |
| **107** | DESKTOP | | NATIONAL | designer delivery&maintenance monitoring | **EAM - ENVIRONMENT ASSESSMENT & MANAGEMENT** *Company Environment TUNISIA* | EAM provides the following services: Environmental and Social Impact Assessment; Environmental and Social Baseline Survey; Oil spill Response Plan; Environmental Due Diligence ; Contaminated Site Management ; Health Risk Assessment ; Oil Spill Modelling; Air Dispersion Modelling; Modelling of pollutants dispersion in aquatic environment; Industrial Risk Analysis; Consulting and Training. | http://www.eamtunisia.com/index.htm Tahar Khouaja (General Manager) Tel.: [+216] 71 947 797 E-mail: tahar.khouaja@eamtunisia.com |

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| **108** | DESKTOP | | GLOBAL | designer delivery&maintenance monitoring | **ALDAR CONSULTING ENGINEERS** *Company Environment EGYPT* | Consultancy firm in potable water, sanitation, water resources and environmental management. The experience extends to design, supervise and offer consultancy services in the various fields of potable water and wastewater networks and treatment plants; the firm is also specialized in preparing Environmental and Social Impact Assessment studies for international donors. | http://www.aldar-ce.com/ Mahmoud A. Azeem (Managing Director) Email: mazeem@intouch.com |
| **109** | DESKTOP | | GLOBAL | delivery&maintenance monitoring | **WETLANDS CONSULTING SERVICES PTY LTD** *Company Environment SOUTH AFRICA* | Specialised service in wetland and river consulting, comprising Environmental Impact Assessments (EIA's). In addition to the above Wetland Consulting Services has expanded its field of expertise in aquatic ecology (accredited SASS5 and Diatom analysis), biodiversity assessments, soils (including soil surveys), ecological assessments and land use management. | http://www.wetcs.co.za/ Dieter Kassier (Head Office Professional Staff) Email: dieterk@wetcs.co.za |
| **110** | DESKTOP | | NATIONAL | monitoring | **WAESS- World Agricultural Economic and Environmental services** Company *Agriculture, fisheries, forestry USA* | World Agricultural Economic and Environmental Services (WAEES) is a 21st Century consulting firm specializing in providing rigorous analytic support for private and public sector decision makers operating in production agriculture, upstream and downstream agribusinesses, trade, and related environmental areas. | https://waees-llc.com/ John Kruse jkruse@waees-llc.com Patrick O'Brien ecs.obrien4@comcast.net |
| **111** | OAL | | LOCAL | end-user | **Kerimäen kalatalo** *Company Agriculture, fisheries, forestry FINLAND* | Fishing, fish processing and marketing | http://www.kerimaenkalatalo.fi/ 044 973 4188 |
| **112** | OAL | | LOCAL | end-user | **Hotel Herttua** *Company Tourism FINLAND* | local services | - +358 15 769900 |
| **113** | OAL | | LOCAL | end-user | **Ruokkeen Lomakylä** *Company Tourism FINLAND* | local services | https://www.ruokkeenlomakyla.fi/eng/ info@ruokkeenlomakyla.fi |

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| **114** | OAL | | LOCAL | end-user | **Hotelli Punkaharju**<br>*Company*<br>*Tourism*<br>*FINLAND* | local services | http://hotellipunkaharju.fi/it/<br>welcome@hotellipunkaharju.fi |
| **115** | OAL | | LOCAL | monitoring influencer end-user | **Punkaharjun Metsäpalvelu Oy LKv**<br>*Company*<br>*Environment*<br>*FINLAND* | forest management and advisory | https://www.metsat.fi/fi/<br>info@metsat.fi<br>358504646500 |
| **116** | OAL | | LOCAL | monitoring influencer end-user | **Vesistö- ja luontokunnostus Janne Raassina**<br>*Company*<br>*Environment*<br>*FINLAND* | forest management and advisory | 041 4598339 |
| **117** | OAL | | LOCAL | monitoring influencer end-user | **Otso Metsäpalvelut**<br>*Company*<br>*Environment*<br>*FINLAND* | forest management and advisory | https://www.otso.fi/<br>asiakaspalvelu@otso.fi |
| **POLICY MAKERS AND ASSOCIATIONS** | | | | | | | |
| **ID** | **Source** | **#Projects** | **Geographical coverage** | **Value Chain Position** | **Stakeholder Name**<br>*Type*<br>*Area of Interest*<br>*Country* | **Brief description of the stakeholder** | **Website Contacts** |
| **117** | EU Project | 5 | GLOBAL | influencer funder | **ICLEI - Local Governments for Sustainability**<br>*Association*<br>*Society&Culture*<br>*Germany* | ICLEI – Local Governments for Sustainability is the world's leading network of local and regional governments committed to sustainable development. It promotes, offers advice and provides sustainable solutions in the field of biodiversity, adaptation to climate change, urban resilience, renewable energy, infrastructures and eco-sustainable buildings | http://iclei-europe.org/<br>iclei-europe@iclei.org |

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| **118** | EU Project | 5 | NATIONAL | monitoring<br>influencer<br>end user | **SMHI- Swedish Meteorological and Hydrological Institute**<br>*Public Body/Policy maker*<br>*Environment*<br>*Sweden* | SMHI, the Swedish Meteorological and Hydrological Institute, is an expert agency under the Ministry of the Environment and Energy. It offers a service of meteorology, hydrology, oceanography and climate sciences. | http://www.smhi.se<br>info@skogen.se |
| **119** | EU Project | 5 | NATIONAL | designer<br>monitoring<br>influencer | **UMWELTBUNDESAMT Environment Agency Austria (UBA GMBH)**<br>*Public Body/Policy maker*<br>*Environment*<br>*Austria* | The Umweltbundesamt is the expert authority of the federal government for environmental protection and thus responsible for writing the State-of-the-Environment Report. | http://www.umweltbundesamt.at/en/<br>office@umweltbundesamt.at |
| **120** | EU Project | 4 | GLOBAL | monitoring | **MET OFFICE**<br>*Public Body/Policy maker*<br>*Environment*<br>*UK* | The Met Office provides a wide range of weather forecasts and warnings and targeted research on climate change by providing sustainable strategies, technologies and models | http://www.metoffice.gov.uk<br>enquiries@metoffice.gov.uk |
| **121** | DESKTOP | | GLOBAL | designer<br>influencer<br>investor/funder<br>policy maker | **PRIMA-Partnership for Research and Innovation in the Mediterranean Area**<br>*Public Body/Policy maker*<br>*R&D*<br>*SPAIN* | Partnerships between EU Member States, associated countries of Horizon 2020 and Mediterranean partner countries on an equal basis, which aims to promote, build and finance research and innovation capacity and develop common knowledge and innovative solutions for agri-food systems and supply and integrated management of water in the Mediterranean basin (arid and semi-arid areas), in order to make these systems more resistant to climate change and environmentally sustainable | http://prima-med.org<br>Marco Orlando (waters management)<br>Email:marco.orlando@prima-med.org<br><br>Tel: +34 93 401 08 40 |
| **122** | DESKTOP | | GLOBAL | designer<br>influencer<br>policy maker | **ECOSHAPE**<br>*Association*<br>*R&D*<br>*NETHERLANDS* | Foundation composed of engineering companies, research institutes, governments and NGOs working together on projects for the development and design of innovative and sustainable engineering solutions in the field of water resources, in particular on thematic such as defences against floods based on nature and ecosystem restoration. | https://www.ecoshape.org<br>Huib J De Vriend (Director Stichting)<br>email:huib.de.vriend@ecoshape.nl |
| **123** | DESKTOP | | GLOBAL | influencer<br>investor/funder | **BIODIVERSA**<br>*Association*<br>*Environment*<br>*FRANCE* | BiodivERsA is a network of national and regional funding organisations promoting pan-European research on biodiversity and ecosystem services, and offering innovative opportunities for the conservation and sustainable management of biodiversity. | https://www.biodiversa.org<br>Xavier Leroux (Project coordinatoor)<br>email:<br>xavierleroux@hotmail. |

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| **124** | DESKTOP | | GLOBAL | influencer<br>policy maker | **IIED- International Institute for Environment and Development**<br>*Public Body/Policy maker*<br>*R&D*<br>*UK* | Policy and action research organization which promotes sustainable development to improve livelihoods and protect the environments on which these livelihoods are built. It shares knowledge to define development policies and practices for climate resilience, fair global governance and the adaptation of the community to climate change. | https://www.iied.org<br>Illari Aragon (Researcher on Climate Change)<br>email:illari.aragon@iied.org |
| **125** | DESKTOP | | GLOBAL | influencer<br>policy maker | **IEEP- Institute for European Environmental Policy**<br>*Association*<br>*Environment*<br>*UK, BELGIUM* | The Institute for European Environmental Policy<br>is a sustainability think tank. Working with stakeholders across EU institutions, international bodies, academia, civil society and industry, our team of policy professionals composed of economists, scientists and lawyers produce evidence-based research and policy insight | https://ieep.eu<br>Anna Lorant (Senior Policy Analyst-climate change, environmental economics, Agricultural policy, adaptation)<br>Email:alorant@ieep.eu<br>Phone: +32 (0)2 738 7482 |
| **126** | DESKTOP | | GLOBAL | influencer<br>policy maker | **IUCN-International Union for Conservation of Nature**<br>Public Body/Policy maker<br>Governance<br>SWITZERLAND | It is a membership Union uniquely composed of both government and civil society organisations. It provides public, private and non-governmental organisations with the knowledge and tools that enable human progress, economic development and nature conservation. IUCN assesses the impacts of climate change on species and ecosystems. Through its work on ecosystem-based mitigation, adaptation and disaster risk reduction, it also highlights the important role of nature-based solutions to climate change. It also works to ensure that climate policy and action are gender-responsive, socially inclusive and take into account to the needs of the most vulnerable. | http://www.iucn.org<br>Jane Smart (Global Director Biodiversity conservation Group)<br>email:jane.smart@iucn.org.<br>Tel:41 22 999 0219 |

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| **127** | DESKTOP | | GLOBAL | influencer | **RESILIENCE NOW**<br>*Association*<br>*Society&culture*<br>*FRANCE* | International NGO whose mission is to support vulnerable communities to improve their resilience in a context of natural resources depletion and climate change. It makes a participatory evaluation of the socio-environmental resilience of the community and ability to improve the sustainable management of natural resources, evaluation of the social and environmental impacts of projects and makes participatory elaboration of a resilience improvement plan | http://resilience.ngo<br>Florence Gibert (Executive director)<br>email:flogib@gmail.com<br>Tel:+33 2 43 55 11 89 |
| **128** | DESKTOP | | GLOBAL | influencer<br>policy maker | **UN ENVIRONMENT**<br>*Public Body/Policy maker*<br>*Governance*<br>*SWITZERLAND* | The main global environmental authority that defines the global environmental agenda, promotes the consistent implementation of the environmental dimension of sustainable development within the United Nations system and acts as an authoritative defender of the global environment | https://www.unenvironment.org<br>Matt Billot (regional coordinator of Europe)<br>email:matthew.billot@unep.org |
| **129** | DESKTOP | | GLOBAL | influencer<br>policy maker | **FEDERAL AGENCY FOR NATURE CONSERVATION**<br>*Public Body/Policy maker*<br>*Environment*<br>*GERMANY* | is the German government's scientific authority with responsibility for national and international nature conservation. The Agency maintains a constant dialogue with policy makers, companies, the scientific community, educators and the media, constantly adapting nature conservation tools to climate changes. | https://www.bfn.de<br>Gisela Stolpe (Head of the International Academy for Nature Conservation)<br>Phone: +49(0)38301-86-113<br>email:gisela.stolpe@Bfn.de |
| **130** | DESKTOP | | GLOBAL | influencer | **IWRA- International Water Resources Association**<br>*Association*<br>*Environment*<br>*USA* | A non-profit, non-governmental and educational organization with the aim of improving and expanding understanding of water-related problems, advancing water resources and promoting related environmental research internationally | https://www.iwra.org<br>Callum Clench (Executive Director)<br>email:c.clench@iwra.org<br>Tel: +33-1-41-201661 |
| **131** | DESKTOP | | GLOBAL | designer<br>delivery&maintenance supplier<br>monitoring<br>influencer | **GREEN POP**<br>*Association*<br>*Environment*<br>*SOUTH AFRICA* | Non-profit organization which deals with the planting of trees through nature-based reforestation projects and aims to promote and spread awareness of environmental problems above all through the involvement of people through green festivals and workshops throughout southern Africa. | https://greenpop.org<br>Zoë Gauld-Angelucci (Head of Programmes)<br>email: zoe@greenpop.org |

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| **132** | DESKTOP | | NATIONAL | monitoring<br>influencer<br>investor/funder<br>policy maker | **FUNDACAO GRUPO BOTICARIO**<br>*Association*<br>*Environment*<br>*BRASIL* | The organization aims to spread awareness of environmental issues also related to climate change and aims to promote (including at government level) and undertake nature conservation actions through surveys, observations and analysis tools. The organization finances environmental conservation projects throughout Brazil. | http://www.fundacaogrupoboticario.org.br<br>Juliana Baladelli Ribeiro (Coordinator Nature-Based Solution area)<br>email: ribeiroj@fundacaogrupoboticario.org.br |
| **133** | DESKTOP | | LOCAL | policy maker | **ICPR-International Commission for the Protection of the Rheine**<br>*Public Body/Policy maker*<br>*Governance*<br>*GERMANY* | Focal points for the work of sustainable development of the Rhine, its areas and the good state of all waters in the watershed. | https://www.iksr.org<br>Martine Rohn-Brossard (Chair)<br>Mail: sekretariat@iksr.de<br>Tel: 0049- (0) 261-94252-0 |
| **134** | DESKTOP | | GLOBAL | influencer<br>investor/funder | **GFDRR-Global Facility for Disaster Reduction and Recovery**<br>*Association*<br>*Environment*<br>*USA* | It is a global partnership that helps developing countries better understand and reduce their vulnerability to natural hazards and climate change. GFDRR is a grant-funding mechanism, managed by the World Bank, that supports disaster risk management projects worldwide | https://www.gfdrr.org<br>Sajid Anwar (Disaster Risk Management Specialist)<br>email:sanwar@worldbank.org |
| **135** | DESKTOP | | GLOBAL | influencer<br>investor/funder<br>policy maker | **ESP- Ecosystem Services Partnership**<br>*Association*<br>*Environment*<br>*NETHERLANDS* | The organization represents a partnership of institutional members, universities, researchers and companies, with the aim of promoting best practices mainly in the field of biodiversity, ecosystem services (in particular for their restoration) and reduction of environmental disaster risks | https://www.es-partnership.org<br>Peter van Bodegom (Chair of Biodiversity and Ecosystem services team)<br>email:p.m.van.bodegom@cml.leidenuniv.nl |
| **136** | DESKTOP | | GLOBAL | influencer<br>policy maker | **TEEB- The Economics of Ecosystems & Biodiversity**<br>*Public Body/Policy maker*<br>*Environment*<br>*SWITZERLAND* | Its main objective is to integrate the values of biodiversity and ecosystem services into decision-making at all levels. It aims to achieve this goal by following a structured assessment approach that helps decision makers recognize the wide range of benefits offered by ecosystems and biodiversity, to demonstrate their values in economic terms and to suggest how to capture these values in decisions. The main | http://www.teebweb.org<br>Salman HUSSAIN (TEEB Coordinator and Head of Ecosystem Services Economics |

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| | | | | | | areas of interest concern the ecosystems and biodiversity of the oceans and coasts, water treatment and wetlands. | Unit) email:Salman.Hussain @unep.org |
| **137** | DESKTOP | | GLOBAL | influencer policy maker | **BIOECON- Biodiversity and Economics for Conservation** *Association Environment NETHERLANDS* | An interdisciplinary network of the European community composed of economists, lawyers, university/ research institutes scientists, political organizations that work to promote the conservation of biodiversity and to design and implement economic incentives on this topic connected to climate change. It is focused on all issues where biodiversity is converted into its economic, legal and institutional aspects. | http://www.bioecon-network.org<br><br>Martin Quaas (Scientists in Leipzig) E-mail: martin.quaas@idiv.de |
| **138** | DESKTOP | | GLOBAL | influencer policy maker | **MED WET- The Mediterranean Wetlands initiative** *Public Body/Policy maker Environment FRANCE* | A regional intergovernmental network that involves key players, committed to promoting and supporting multi-stakeholder policies and actions on the ground for the conservation, restoration and sustainable use of Mediterranean wetlands. MedWet encourages and supports governments to adopt policies and implement actions on the ground in favor of the conservation and sustainable use of Mediterranean wetlands. | https://medwet.org SPYROS KOUVELIS (Project Manager) Tel: + 30 210 8089270 Email: kouvelis@medwet.org |
| **139** | DESKTOP | | GLOBAL | influencer | **BIO 4 CLIMATE** *Association Environment USA* | The association will promote educational, political and awareness actions for the issue related to climate change and the restoration of biodiversity in ecosystems around the world. In particular, it is aimed at restoring the soil, the ecosystems of forests, wetlands, coasts and oceans, together with the associated cycles of carbon, water and nutrients, to break down excess atmospheric greenhouse gases, cool the biosphere and reverse the global warming. | https://bio4climate.org/ Adam D. Sacks (Executive Director) email:adam.sacks@bio4climate.org |
| **140** | DESKTOP | | LOCAL | influencer | **ARASIM** *Association Environment INDIA* | Non-Governmental Organization that promotes the sustainability of forests, marine ecosystems and wildlife conservation through awareness campaigns. | http://www.arasmin.org Phone :+91-9437038275 / +91-9437469112 Fax :+91-6847-260109 arasmin@gmail.com |

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| **141** | DESKTOP | | GLOBAL | influencer<br>policy maker | **FWP- French Water Partnership**<br>*Association*<br>*Environment*<br>*FRANCE* | Non-profit association that promotes actions at all levels to mitigate climate impacts in the water field. In particular, the association is committed to promoting the operational implementation of international commitments in the water and climate sector, strengthening international commitments and promoting its implementation in national policies, including knowledge problems and nature-based solutions in policies and strategies at all levels, to promote adequate funding. | https://www.partenariat-francais-eau.fr<br>Clara Minjoulat-Rey (Communication Manager)<br>email:clara.minjoulat-rey@partenariat-francais-eau.fr<br>Tel:33141201978 |
| **142** | DESKTOP | | GLOBAL | influencer | **EIA - Environmental Investigations Agency**<br>*Association*<br>*Environment*<br>*UK* | EIA investigates and campaigns against environmental crime and abuse with focus on wildlife (elephants, tigers, and pangolins), forests (timber, palm oil), ocean (plastic pollution, vaquita and totoaba, whales, dolphins, and porpoises), climate (energy efficiency, EU F-Gas regulation, the Montreal Protocol, cooling technologies). | https://eia-international.org/<br>Jennifer Lonsdale (Founder Director and Oceans Campaigner)<br>email: jenniferlonsdale@eia-international.org |
| **143** | DESKTOP | | GLOBAL | delivery&maintenance<br>influencer<br>policy maker | **IFGR - Initiatives for the Future of Great Rivers**<br>*Association*<br>*Environment*<br>*FRANCE* | IFGR brings together actors who give a voice to rivers. Gathering river managers, the representatives of institutions (basin organisations, national supervisory bodies) and experts (climatologist, anthropologist, economist, historian), IFGR offers an original, international and multidisciplinary forum open to stakeholders and oriented towards action in favour of tomorrow's rivers. Its works are organised around three themes: governance, human and ecosystem health, and the the link between rivers and oceans | http://www.initiativesfleuves.org/<br>Bertrand Porquet (General Secretary)<br>bertrand.porquet@iagf-ifgr.org<br>+33 (0)4 72 00 18 25 |
| **144** | DESKTOP | | GLOBAL | delivery&maintenance<br>monitoring<br>investor/funder<br>policy maker | **AFD - Agence Francaise de Developpement**<br>*Public Body/Policy maker*<br>*Governance*<br>*FRANCE* | AFD is France's inclusive public development bank. In keeping with the United Nations Sustainable Development Goals, AFD works in: energy, healthcare, biodiversity, water, digital technology, professional training. | https://www.afd.fr/<br>Christine Poursat (Senior Operations Lead - Financial Inclusion)<br>email: poursatc@afd.fr |

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| | | | | | | | tel: +33 (1) 5344 3087<br>fax: +33 (1) 5344 3733 |
| **145** | DESKTOP | | GLOBAL | influencer<br>policy maker | **THE FLOW PARTNERSHIP**<br>*Association*<br>*Environment*<br>*UK* | Works with partners to rejuvenate landscapes and counter the increasing threat of floods, droughts, soil erosion, and habitat loss at their source. Provides a crucial link between communities, government, business, scientists and landowners, empowering local communities to build Natural Catchment Measures (NCM). | https://www.theflowpartnership.org<br>MINNI JAIN (Director of Operations)<br>Tel: 0044-7910201155<br>Email: minni@earthlinksall.com |
| **146** | DESKTOP | | GLOBAL | designer<br>delivery&maintenance<br>monitoring<br>influencer<br>policy maker | **GLOBAL WATER PARTNERSHIP**<br>*Association*<br>*Governance*<br>*SWEDEN* | Their mission is to advance governance and management of water resources for sustainable and equitable development. They are a large, diverse, inclusive, multi-stakeholder partnership that supports communities and countries to improve the way they manage water. | https://www.gwp.org/en/<br>François Brikké (Senior Network Specialist, European Region)<br>Email: francois.brikke@gwp.org |
| **147** | DESKTOP | | LOCAL | supplier<br>influencer | **ENVIRONMENTAL CONCERN INC.**<br>*Association*<br>*Environment*<br>*USA* | Promotes public understanding and stewardship of wetlands with the goal of improving water quality and enhancing nature's habitat, through wetland outreach and education, native species horticulture, and the restoration, construction and enhancement of wetlands. Currently, EC cultivates approximately 120 wetland plant species that are native to the Northeast US and has the ability to propagate over 200 species. | http://www.wetland.org/index.htm<br>Taylor Gordon (Wetland Program Coordinator)<br>Tel: (410) 745-9620 x226<br>Email: tgordon@wetland.org |
| **148** | DESKTOP | | GLOBAL | influencer<br>policy<br>maker | **EUROPEAN ENVIRONMENTAL BUREAU - EEB**<br>*Association*<br>*Environment* | Their aim is to ensure the EU secures a healthy environment and rich biodiversity. It currently consists of over 150 member organisations in more than 30 countries (virtually all EU Member States plus some accession and neighbouring countries). It focuses on influencing EU | https://eeb.org/<br>Stefan Scheuer (Policy Director)<br>Tel: +32 2 2891304<br>Email: |

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| | | | | | *BELGIUM* | policymaking and implementation and assessment of its agreed policies. | Stefan.scheuer@eeb.org |
| **149** | DESKTOP | | GLOBAL | influencer<br>policy maker | **CLIMATE-KIC**<br>*Association*<br>*Environment*<br>*UK* | Climate-KIC is one of three Knowledge and Innovation Communities (KICs) created in 2010 by the European Institute of Innovation and Technology (EIT). Its aim is to accelerate and stimulate innovation in climate change mitigation and adaptation, by integrating a network of European partners from the private, public and academic sectors. Climate-KIC drives innovation in climate change through creative partnerships between business, academia and public entities. | https://www.climate-kic.org<br>Kirsten Dunlop (CEO)<br>email:kirsten.dunlop@climate-kic.org |
| **150** | DESKTOP | | GLOBAL | delivery&maintenance<br>influencer | **CI - Conservation International**<br>*Association*<br>*Environment*<br>*USA* | Conservation International (CI) works to ensure a healthy and productive environment from remote villages to the offices: Safeguarding Fresh Water, Freshwater Strategy, Developing Responsible Land Use, Food security, and Cultural Services. | https://www.conservation.org/<br>Herbert Lust (Vice President, CI Europe)<br>email: hlust@conservation.org<br><br>Chaussée de Charleroi 112<br>1060 Bruxelles – Belgium<br>email: infoeurope@conservation.org |
| **151** | DESKTOP | | NATIONAL | delivery&maintenance<br>monitoring<br>influencer<br>policy maker | **Agence de l'Eau Rhineuse**<br>*Public Body/Policy maker*<br>*Environment*<br>*FRANCE* | Agende de l'eau Rhini-Meuse is a public establishment of the Ministry in charge of sustainable development, with the mission of reducing water pollution and to protect Rhine basin's water and aquatic source in terms of: pollution, health, nature and spatial planning, scarcity, solidarity, and governance. | http://www.eau-rhin-meuse.fr/<br>Nicolas Forray (Chairman of the Board of Directors)<br>email: nicolas.forray@developpement-durable.gouv.fr |

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| **152** | DESKTOP | | GLOBAL | policy maker influencer | **UNISRD - United Nation Office for Disaster Risk Reduction**<br>*Public Body/Policy maker*<br>*Governance*<br>*Worldwide* | UNISDR's mandate has been defined by a number of United Nations General Assembly Resolutions, the most notable of which is "to serve as the focal point in the United Nations system for the coordination of disaster reduction and to ensure synergies among the disaster reduction activities of the United Nations system and regional organizations and activities in socio-economic and humanitarian fields" | https://www.unisdr.org/ |
| **153** | DESKTOP | | GLOBAL | policy maker influencer | **OECD - Organisation for Economic Co-operation and Development Trade and Agriculture Directorate**<br>*Association*<br>*Agriculture&fisheries*<br>*Worldwide* | The Trade and Agriculture Directorate is one of twelve substantive departments of the Organisation for Economic Co-operation and Development (OECD) and provides policy analysis and advice to help governments develop trade, agriculture, and fisheries policies that contribute to more inclusive and sustainable growth | http://www.oecd.org/agriculture/about/<br>tad.contact@oecd.org. |
| **154** | DESKTOP | | GLOBAL | policy maker influencer | **FAO- Food and Agriculture Organization of the United Nations**<br>*Association*<br>*Agriculture, fisheries, forestry*<br>*Worldwide* | FAO's work in land and water is relevant to several dimensions of sustainable development, such as the governance and management of food production systems; the provision of essential ecosystem services; food security; human health; biodiversity conservation; and the mitigation of, and adaptation to, climate change. | http://www.fao.org/land-water/home/en/<br>Amani Alfarra, Land and Water Officer, FAO<br>land-water@fao.org |
| **155** | DESKTOP | | NATIONAL | funder influencer | **Bangladesh Tropical Forest Conservation Foundation**<br>*Association*<br>*Environment*<br>*Bangladesh* | The mission of AF is to facilitate the conservation, protection, restoration and sustainable use of tropical forests in Bangladesh, which provide a wide range of benefits to mankind, by providing financial grants or other support to qualified organizations or entities. | http://arannayk.org/<br>info@arannayk.org |
| **156** | OAL | | GLOBAL | monitoring influencer | **future earth**<br>*Association*<br>*Environment*<br>*Worldwide* | Future Earth is a global platform for international scientific collaboration, providing the knowledge required for societies in the world to face risks posed by global environmental change and to seize opportunities in a transition to global sustainability. | http://www.futureearth.org/<br>contact@futureearth.org |

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| **157** | OAL | | GLOBAL | monitoring influencer | **The Intergovernmental Panel on Climate Change (IPCC)** *Association Environment SWITZERLAND* | The objective of the IPCC is to provide governments at all levels with scientific information that they can use to develop climate policies. IPCC reports are also a key input into international climate change negotiations. | https://www.ipcc.ch/ Phone: +41 22 730 8208/54/84 Fax: +41 22 730 8025/13 Email: ipcc-sec@wmo.int |
| **158** | OAL | | GLOBAL | monitoring influencer | **The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)** *Association Environment GERMANY* | IPBES is an independent intergovernmental body, established by member States in 2012. It provides policymakers with objective scientific assessments about the state of knowledge regarding the planet's biodiversity, ecosystems and the benefits they provide to people, as well as the tools and methods to protect and sustainably use these vital natural assets. | https://www.ipbes.net/about Email: secretariat@ipbes.net Tel: +49 228 815 0570 |
| **159** | OAL | | GLOBAL | monitoring influencer | **Mountain Research Initiative (MRI)** *Association Environment SWITZERLAND* | The Mountain Research Initiative is a non-profit organization that promotes global change research in mountain regions across borders and disciplines through connection, communication, and collaboration – with a view to supporting pathways towards sustainable mountain development. | http://www.mountainresearchinitiative.org/en/ 41 31 631 51 41 mri@mountainresearchinitiative.org |
| **160** | OAL | | NATIONAL | monitoring influencer | **Austrian Research Association on Geomorphology and Environmental Change** *Association Environment AUSTRIA* | Is a platform for geomorphologists connecting researchers, policy makers, educational institutions and companies. | http://www.geomorph.at/ oliver.sass(at)uni-graz.at |
| **161** | OAL | | GLOBAL | monitoring influencer | **ESA Geohazard TEP** *Association Environment* | The satellite EO and geohazards community is growing in size and importance, with the advent of large new initiatives and projects of global interest. The geohazard platform or GEP offers this expanding community a unique set of tools to forge new applications in direct collaboration with large numbers of actors. In particular, the community will benefit from a cloud-based workspace, allowing advanced EO data exploitation activities and offering access to a broad range of shared processing tools. Each partner brings their tools and | https://geohazards-tep.eu/ |

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| | | | | | | processing chains but also has access in the same workspace to large data sets and shared processing tools. The vision for the Platform was inspired by the Scientific & Technical Memorandum of the International Forum on Satellite EO for Geohazards. | |
| **162** | OAL | | GLOBAL | influencer | **Permanent Secretariat of the Alpine Convention (CIPRA)**<br>*Association*<br>*Environment*<br>*AUSTRIA* | The Alpine Convention is an agreement within the law of nations for the overall protection and the sustainable development of the Alps. It was set up upon the initiative and after long preliminary work by CIPRA. The general framework convention, which in the meantime has been ratified by all the contracting parties, is applied by means of the so-called Protocols of Implementation. The protocols of implementation are envisaged for twelve sectors, and protocols already exist for eight sectors. | http://www.alpconv.org/en/convention/default.aspx<br>Tel.: 0043-512-588589-0<br>Email:info@alpconv.org |
| **163** | OAL | | GLOBAL | influencer | **Euromontana**<br>*Association*<br>*Environment*<br>*FRANCE* | Euromontana is the European multisectoral association for co-operation and development of mountain territories. It embraces regional and national mountain organisations throughout greater Europe, including regional development agencies, local authorities, agriculture organisations, environmental agencies, forestry organisations and research institutes. | https://www.euromontana.org/en/<br>By phone : 00 32 2 280 42 83<br>By email : info@euromontana.org |
| **164** | OAL | | NATIONAL | influencer | **Environmental Agency Austria**<br>*Public Body/Policy maker*<br>*Governance*<br>*AUSTRIA* | With more than 30 years of experience, we are a top provider of environmental consultancy services. Our range of services includes performing evaluations, setting standards and developing methods and recommendations. We provide the basics for decision-making as well as sustainable solutions. Based on our broad expertise we offer sustainable solutions and services in many areas. | http://www.umweltbundesamt.at/en<br>office@umweltbundesamt.at |
| **165** | OAL | | LOCAL | designer<br>policy maker<br>influencer | **Tyrolean Environmental Ombudsman**<br>*Public Body/Policy maker*<br>*Governance*<br>*AUSTRIA* | The Tyrolean Environmental Ombudsman lends a voice in official proceedings to those who cannot speak for themselves: the flora and fauna, and habitats that are rare or worthy of protection. This is done in order to ensure the prudent use of our natural resources and landscape. In addition to involvement in official proceedings, the Tyrolean Environmental Ombudsman uses a variety of platforms to draw attention to the Tyrol's natural assets and the need for their careful management, including nature projects, courses and forward-looking guidelines – all in accordance with the motto "For our natural environment and quality of life". | http://www.tiroler-umweltanwaltschaft.gv.at/en/<br>Telefon: +43/512/508-3492<br>landesumweltanwalt@tirol.gv.at |

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| **166** | OAL | | NATIONAL | influencer | **YLE Joensuu**<br>*Public Body/Policy maker*<br>*Media&communication*<br>*FINLAND* | TV and radio , dissemination, information delivery | https://yle.fi/uutiset/18-202747 |
| **167** | OAL | | NATIONAL | influencer | **YLE Mikkeli**<br>*Public Body/Policy maker*<br>*Media&communication*<br>*FINLAND* | TV and radio | https://yle.fi/uutiset/18-187460 |
| **168** | OAL | | LOCAL | end-user | **Pääkanta Foundation**<br>*Association*<br>*Society&culture*<br>*FINLAND* | to maintain local archive and Pääkanta recreation area | - |
| **169** | OAL | | LOCAL | influencer | **Kerimäen yrittäjät**<br>*Association*<br>*Society&culture*<br>*FINLAND* | promotion of local entrepreneurship | https://www.yrittajat.fi/en/about-suomen-yrittajat-526258<br>toimisto@yrittajat.fi |
| **170** | OAL | | LOCAL | influencer | **Punkaharjun yrittäjät**<br>*Association*<br>*Society&culture*<br>*FINLAND* | promotion of local entrepreneurship | https://www.yrittajat.fi/etela-savon-yrittajat/punkaharjun-yrittajat/a/punkaharjun-yrittajat-311548<br>toimisto@yrittajat.fi |
| **171** | OAL | | GLOBAL | policy maker<br>influencer<br>funder/investor | **Department of Hydrology and Meteorology (Nepal)**<br>*Public Body/Policy maker*<br>*Environment*<br>*NEPAL* | The Department of Hydrology and Meteorology (DHM) is an organization under the Ministry of Energy, Water Resources and Irrigation, Government of Nepal. | https://www.dhm.gov.np/ |

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| **172** | OAL | | GLOBAL | policy makers<br>influencers | **ICIMOD**<br>*Public Body/Policy maker*<br>*Environment*<br>*NEPAL* | The International Centre for Integrated Mountain Development (ICIMOD) is a regional intergovernmental learning and knowledge sharing centre serving the eight regional member countries of the Hindu Kush Himalaya – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Overall, they are working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream, now and for the future. | www.icimod.org<br>info@icimod.org |
| **173** | OAL | | GLOBAL | policy makers<br>investors/funders | **Department of Environment (Nepal)**<br>*Public Body/Policy maker*<br>*Environment*<br>*NEPAL* | Promotion of environmental friendly activities through awareness and implementation as well as enforcement to the concerned agencies has become widely realized interventions. Environmental degradation and global warming have become widespread concerns and Nepal is no exception. | https://doenv.gov.np/<br>E-mail : info@doenv.gov.np |
| **174** | OAL | | GLOBAL | influencers<br>delivery&mainenance supplier | **ADAPT Nepal**<br>*Association*<br>*Society&culture*<br>*NEPAL* | ADAPT-Nepal is a non-profit making company initiated with an aim to improve the capacity of the communities, particularly the poor, by developing tools and methods in determining climate change, its impacts and vulnerabilities as well as possible adaptation and mitigation options in order to reduce the risks associated with climate change. This is achieved by establishing institutions active in the climate change sector, promoting cooperation with relevant stakeholders to undertake climate change projects, advocating for policy and regulatory reforms and undertaking targeted research studies. | http://www.adaptnepal.org.np/home.php?id=1<br>Tel : + 977-1-5011022, 5011066, Email: info@adaptnepal.org.np |
| **175** | OAL | | GLOBAL | designer<br>delivery&maintenance supplier<br>monitoring influencer | **Finnish Red Cross in Nepal**<br>*Association*<br>*Environment*<br>*NEPAL* | The aim of the FRC is to improve the ability of the communities to respond to disasters and to alleviate their impacts within those communities. | https://www.redcross.fi/node/3093 |

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| **176** | OAL | | GLOBAL | designer delivery&maintenance supplier monitoring influencer | **National Centre for Hydro-Meteorological Forecasting (NCHMF)** *Public Body/Policy maker Environment VIETNAM* | National Centre for Hydro-Meteorological Forecasting (NCHMF) is a governmental organization belonging Vietnam Meteorological Hydrological Administration (VMHA) with authority to issue forecasting/warning information for weather, climate, hydrology, water resource, marine weather (i.e. hydro-meterology) and provide hydro-meterology services. | http://www.nchmf.gov.vn/web/en-US/105/92/Default.aspx vtttkttv@monre.gov.vn |
| **177** | OAL | | GLOBAL | policy makers investors/funders | **The Ministry Of Natural Resources and the Environment of Viet Nam (MONRE).** *Public Body/Policy maker Environment VIETNAM* | The Ministry of Natural Resources and Environment (MONRE) is a government ministry in Vietnam responsible for: land, water resources; mineral resources, geology; environment; hydrometeorology; climate change; surveying and mapping; management of the islands and the sea. | monre.gov.vn portal@monre.gov.vn, tel: (0243) 7956868 - Fax : (0243) 8359221 |
| **178** | OAL | | GLOBAL | policy makers investors/funders | **Department of Meteorology, Hydrology and Climate change - IMHEN (Vietnam)** *Public Body/Policy maker Environment VIETNAM* | Department of Meteorology, Hydrology and Climate change -IMHEN (Vietnam) is a governmental research institute under the Ministry of Natural Resources and Environment (MONRE). Functioning in scientific research and technological development of meteorology, climatology, climate channge, agricultural meteorology, hydrology, water resources, marine hydrometeorology and environment. | http://www.imh.ac.vn/?lang=vn khoahoc@imh.ac.vn |
| **179** | OAL | | GLOBAL | policy makers investors/funders | **Vietnam Environment Administration (VEA)** *Public Body/Policy maker Environment VIETNAM* | Environmental administration in Vietnam. | http://vea.gov.vn/en/Pages/trangchu.aspx Email: admin@vea.gov.vn |
| **180** | OAL | | GLOBAL | policy makers investors/funders | **The Department of Meteorology and Hydrology (DHM) Myanmar** *Public Body/Policy maker Environment BIRMANIA* | Hydrology/Meteorology | https://www.moezala.gov.mm/ |

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| **181** | OAL | | GLOBAL | policy makers investors/funders | **Ministry for Foreign Affairs of Finland**<br>*Public Body/Policy maker*<br>*Society&culture*<br>*FINLAND* | The Minister for Foreign Affairs handles the Finnish Government's foreign policy and relations and is in charge of the Ministry for Foreign Affairs. The Minister for Foreign Trade and Development is also associated with this ministry. | https://um.fi/ministry |
| **PATENT OWNERS** | | | | | | | |
| **ID** | **Source** | **Geographical coverage** | **Value Chain Position** | **Stakeholder Name**<br>*Type*<br>*Area of Interest*<br>*Country* | **Brief description of the stakeholder** | | **Website**<br>**Contacts** |
| **182** | PATENT | GLOBAL | designer<br>supplier | **THIRD INSTITUTE OCEANOGRAPHY STATE OCEANIC ADMINISTRATION**<br>*Research Organization*<br>*R&D*<br>*CHINA* | Research and development on various issues related to climate change and its effects. The institute has patented a mixed mangrove seeding method to efficiently capture carbon dioxide<br>PATENT NAME: Mixed planting method for improving carbon fixation capability of mangrove forest vegetation<br>PATENT DOCUMENT ID: CNA/CN106613735 | | Contact Inventors of Patent: Bin Chen (Marine biology and ecology) Email: chenbin@tio.org.cn<br>Guangcheng Chen (Research Associate in Marine biology and ecology) Email: gc.chen@tio.org.cn |
| **183** | PATENT | National | designer<br>influencer | **INSURANCE BUREAU OF CANADA**<br>*Company*<br>*Environment*<br>*CANADA* | The IBC promotes environmental risk assessments and educational initiatives to help Canadian residents adapt to climate change. The company has also patented a system and a method to prevent and predict flooding due to climate change.<br>PATENT NAME: System and method for predicting and preventing flooding<br>PATENT DOCUMENT ID: USA1/US20130110399 | | http://www.ibc.ca<br>Vanessa Barrasa (Media Relations Manager) Tel: 416-362-2031 ext. 4312 Email: vbarrasa@ibc.ca |

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| **184** | PATENT | National | designer supplier | **CLIMATE RESTORATION TECHNOLOGIES inc.** *Company Environment USA* | CRT aims to restore a sustainable Earth. Multi-disciplinary scientific team's mission is to create breakthrough technologies that can restore climate, revitalize oceans, stabilize polar ice, preserve coastlines, minimize flood, and relieve drought while enabling clean energy development and ultra-clean transportation fuels. it has also patented a technology to restore the climate and improve soil moisture retention through the use of algae in bioreactors, mitigating the problem of drought.<br>PATENT NAME: Amplified Relief From Drought and Famine- A Spin-Off Technology From Fossil-Fueled Climate Restoration<br>PATENT DOCUMENT ID: USA1/US20150225271 | http://www.climaterestore.com<br>Robert C. Fry (Chief Scientific Officer) as reference person email of reference:info@climaterestore.com Tel: (402) 680-3799 |
| **185** | PATENT | National | designer delivery&maintenance supplier | **CHINESE ACADEMY FOR ENVIRONMENTAL PLANNING (CAEP)** *Public Body/Policy maker Environment CHINA* | CAEP offers technical support and services such as environmental planning, environmental policy and consultation on the management of the selection of environmental projects for the Chinese government and businesses. It has patented a simulation method for monitoring, managing and protecting water quality in marine environments.<br>PATENT NAME: Water-quality simulation method based on control-unit water-environment-quality target management<br>PATENT DOCUMENT ID: CNA/CN108287950 | http://www.caep.org.cn<br>Yu Lei (Atmospheric Environmental Planning) E-mail: leiyu@caep.org.cn |
| **186** | PATENT | National | designer delivery&maintenance supplier | **CHINA INSTITUTE OF WATER RESOURCES & HYDROPOWER RESEARCH** *Research Organization* | The IWHR has continuously provided the government with technological support for important decisions on flood management, rational allocation of water resources, environmental protection, safe drinking water, environmentally friendly hydroelectric projects. One of his patents concerns a method about storage of floods in river basins through ecological sponges use. | http://www.iwhr.com<br>Emily Wang (Division of International Cooperation): Tel: +86-10-6878- 1650<br>Email: wangyw@iwhr.com / Email: dic@iwhr.com |

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| | | | | *R&D*<br>*CHINA* | PATENT NAME: Method for evaluation of surface runoff storage capacity of river basin green infrastructure<br>PATENT DOCUMENT ID: WOA1/2018103510 | |
| **187** | PATENT | GLOBAL | designer<br>supplier | **IMGEOSPATIAL**<br>*Company*<br>*Engineering*<br>*UK* | The company develops applications for remote sensing and mapping of floods. It also has patented a method and mapping system for flood risk.<br>PATENT NAME: Flood risk mapping and warning system and method<br>PATENT DOCUMENT ID: WOA1/2016198873 | https://www.imgeospatial.com/<br>Alexis Hannah Smith (CEO)<br>Email: hello@imgeospatial.com Tel: +44 7858 246609 |
| **188** | PATENT | National | designer<br>supplier | **RENSSELAER POLYTECHNIC INSTITUTE**<br>*Research Organization*<br>*R&D*<br>*USA* | The university provide research and development in experimental, analytical and environmental geochemistry, petrology of terrestrial systems, environmental informatics, geophysics, geobiotechnology and paleoclimate. It has also patented a biomechanical structure to favor the restoration of the coasts.<br>PATENT NAME: Method and apparatus for coastline remediation, energy generation, and vegetation support<br>PATENT DOCUMENT ID: WOA2/201275065 | http://cee.rpi.edu/node/193<br>Kimberly Boyce (Administrative Coordinator of Civil and Environmental Engineering)<br>Email: boycek@rpi.edu |
| **189** | PATENT | National | designer<br>delivery&maintenance | **HULUNBEIR FOREST RESEARCH INSTITUTE**<br>Research Organization<br>*R&D*<br>*CHINA* | The institute has patented a method of mixed planting of shrubs and plants that improves the problem of desertification of grasslands in the region caused by wind erosion.<br>PATENT NAME: Method for controlling grassland wind erosion desertification<br>PATENT DOCUMENT ID: CNA/CN104145671 | http://english.forestry.gov.cn/<br>Tel: +86-10-62889267 E-mail: englishwebsite@forestry.gov.cn |
| **190** | PATENT | GLOBAL | designer<br>supplier | **ECONCRETE TECH LTD**<br>*Company*<br>*Engineering*<br>*ISRAEL* | The company provides high-performance concrete solutions that improve the biological and ecological value of coastal and marine environments, in particular by allowing an efficient carbon sequestration process thanks to greater floral activity (seaweed / kelps). The company has patented a solution of matrix concrete blocks to | https://econcretetech.com<br>Shimrit Perkol-Finkel (Co-founder and CEO) Email: Shimrit@econcretetech.com |

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| | | | | | promote flora and fauna in marine and coastal environments.<br>PATENT NAME: Methods and matrices for promoting fauna and flora growth<br>PATENT DOCUMENT ID: EPB1/2956001 | |
| **191** | PATENT | GLOBAL | designer<br>delivery&maintenance | **BIOMATRIX WATER SOLUTIONS**<br>*Company*<br>*Engineering*<br>*UK* | The company develops ecological technologies and engineering solutions in the water sector, with a particular focus on the treatment of urban and rural waters. In particular, it designs floating ecosystems to promote biodiversity<br>PATENT NAME: Floating ecosystem<br>PATENT DOCUMENT ID: WOA2/201725711 | http://www.biomatrixwater.com<br>Michael Shaw (Director)<br>Email: michaelshaw@biomatrixwater.com |
| **192** | PATENT | National | designer<br>delivery&maintenance<br>supplier | **METEOWISE WEATHER RISK MANAGEMENT**<br>*Company*<br>*Engineering*<br>*CHINA* | The company provides complete solutions for meteorological risk, including meteorological risk analysis and assessments, weather forecasts and insurance on weather indices for sectors such as agriculture, insurance, transport, energy and tourism. The mesoscale flake weather forecasting system was developed using the optimized WRF mode and artificial intelligence.<br>PATENT NAME: Meteorology risk evaluation method and analysis and early-warning platform based on grid meteorology data<br>PATENT DOCUMENT ID: CNA/CN107679167 | https://meteowise.com/<br>sunnyhu@meteowise.com / wangjx@meteowise.com (general info:Tel: 0755-26656933 / Email: info@meteowise.com) |
| **193** | PATENT | National | designer<br>supplier | **HANGZHOU KEEPSOFT TECHNOLOGY**<br>*Company*<br>*Engineering*<br>*CHINA* | It provides information technology consulting, software development, system integration, and other technology support services for water conservation, as well as disaster prevention and mitigation sectors. It has also patented a water prevention and disaster prevention risk management system based on the HIMS model.<br>PATENT NAME: Mass prediction and disaster prevention water conservancy risk management system based on the HIMS model<br>PATENT DOCUMENT ID: CNU/CN203102355U | http://www.keepsoft.net/<br>Tel: 0571-86690911 |

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| **194** | PATENT | GLOBAL | designer<br>supplier<br>influencer | **SWISS REINSURANCE CO LTD**<br>*Company Environment*<br>*SWITZERLAND* | The company operates as a wholesale provider of reinsurance and, through the Swiss Re Foundation, provides also financial grants for emergency measures following major disasters and promote disasters resilience regarding climate change. The company also has patented a method and a system for automatic recognition and mapping of flood risks.<br>PATENT NAME: Method and system for automated location-dependent recognition of flood risks<br>PATENT DOCUMENT ID: EPB1/1761906 | https://www.swissre.com<br>Martin Weymann (Head of Sustainability, Emerging and Political Risk Management) Tel: +41 43 285 9555 Email: Martin_Weymann@swissre.com |

OPERANDUM

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