the LENSES project

LEarning and action alliances for NexuS EnvironmentS in an uncertain future

LENSES

WP5

D5.1 Report on the review of existing frameworks

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Project partners

Project coordinator

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Report on the review of existing frameworks

Introduction

The Horizon 2020 Expert Group report on 'Nature-Based Solutions and Re-Naturing Cities' (EC, 2015) was one of the precursors to the development of the R&I agenda on Nature-Based Solutions (NBS). The Expert Group identified research and innovation actions that highlight the multi-functional role of NBS and their potential ability to fulfill multiple social, economic and environmental goals. In addition, the Expert Group stressed the need to develop a scientifically sound R&I programme articulated around multi-stakeholder engagement, and the development of a scientific and business evidence base for NBS. In the following years, the EC R&I agenda made provision for more widespread adoption of NBS across Europe through the development of innovative business and investment models, as well as legal and institutional frameworks to ensure the long-term financing of NBS (Faivre et al., 2017). As a result, the need for robust methods, frameworks and indicators that allow the quantification and the multiple levels of interaction associated with NBS, from co-design to implementation became necessary.

The objective of Task 5.1 was to undertake a critical review of existing frameworks for evaluating options for adaptation/building a resilient Water-Ecosystem-Food Nexus for rural areas. The aim of the review was to identify commonalities and gaps in existing frameworks in relation to addressing the WEF Nexus, as well as their applicability at different spatial scales. Following the review of the framework landscape a draft WEF-Nexus-appropriate framework for evaluating options for increasing resilience was developed. Feedback from the pilots (pilot leaders and stakeholders) on the applicability of the framework was also used to revise the framework in order to support NBS selection to optimize the WEF Nexus at the basin scale. The framework will then be used for the development of the NBS Nexus tool in task 5.3.

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Critical review of existing evaluation frameworks

The EC defines NBS as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience; such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions." NBS have been used extensively to improve the ecosystem services provided by landscapes and have been used to address global societal challenges, which are directly connected to the Sustainable Development Goals (SDGs) (Faivre et al., 2017). Figure 1 presents examples from EU on how NBS address the SDGs. One of the critical aspects for the successful adaptation of NBS as a mainstream solution to address global challenges is the development of a rigorous NBS evaluation framework. An evaluation framework by definition should include the challenge or goal to be solved, to have a list of specific targets as well as Key Performance Indicators (KPIs) that need to be monitored that will be used to evaluate the performance of the NBS.

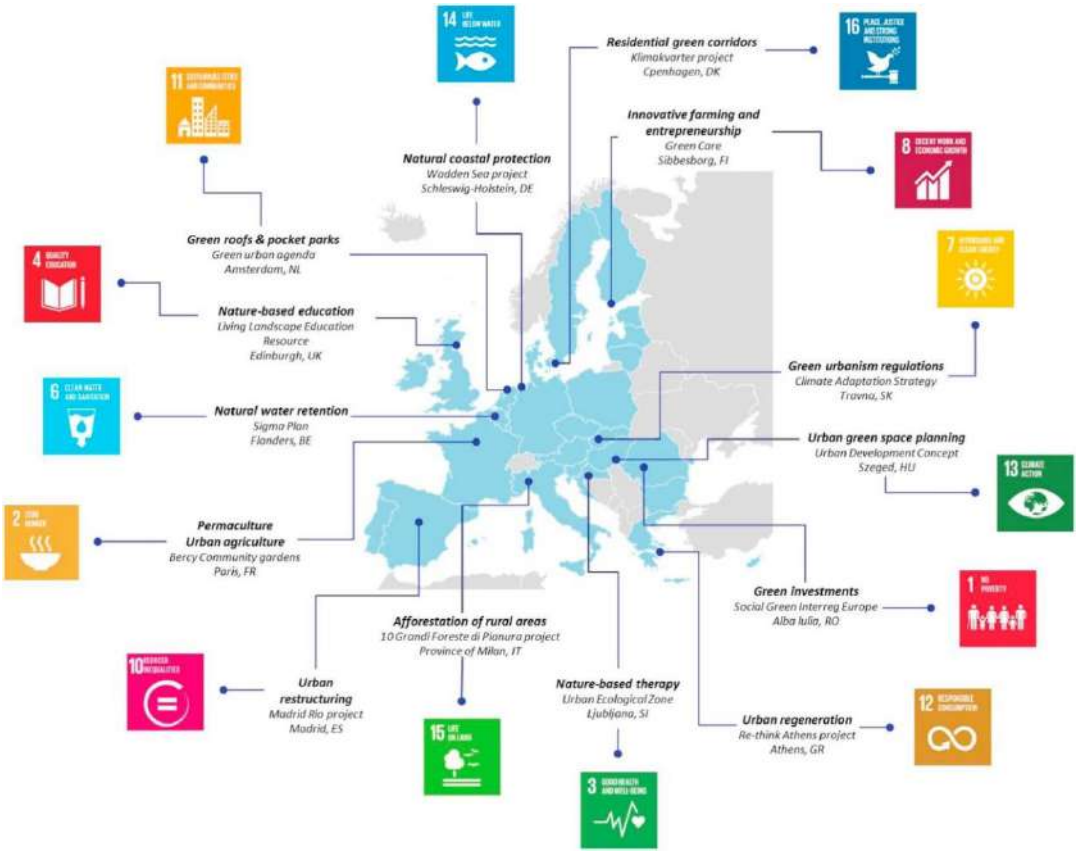

Figure 1 How NBS address the SDGs. Examples from the EU (Faivre et al., 2017)

To this extend, we have identified 3 evaluation frameworks that will be critically reviewed for their applicability to assess the WEF Nexus. These are

- Sustainable Development Goals,

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- The EKLIPSE Impact Evaluation Framework, and
- The EU NBS handbook for practitioners.

Sustainable Development Goals

The 2030 Agenda for Sustainable Development is an action plan, adopted by all United Nations Member States in 2015 and is comprised of 17 SDGs (Figure 2), tackling global challenges and putting pressure on the society, the economy, and the environment. NBS contribute to the following UN SDGs.

Specifically, the SDGs related to WEF NEXUS are SDG2 (No Hunger), SDG 3 (Good Health), SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption), SDG 13 (Climate Action), SDG 14 (Life Below Water), SDG 15 (Life on Land) (Figure 2). Table 1 presents the Targets and indicators under each of the above SDGs that are related to NEXUS.

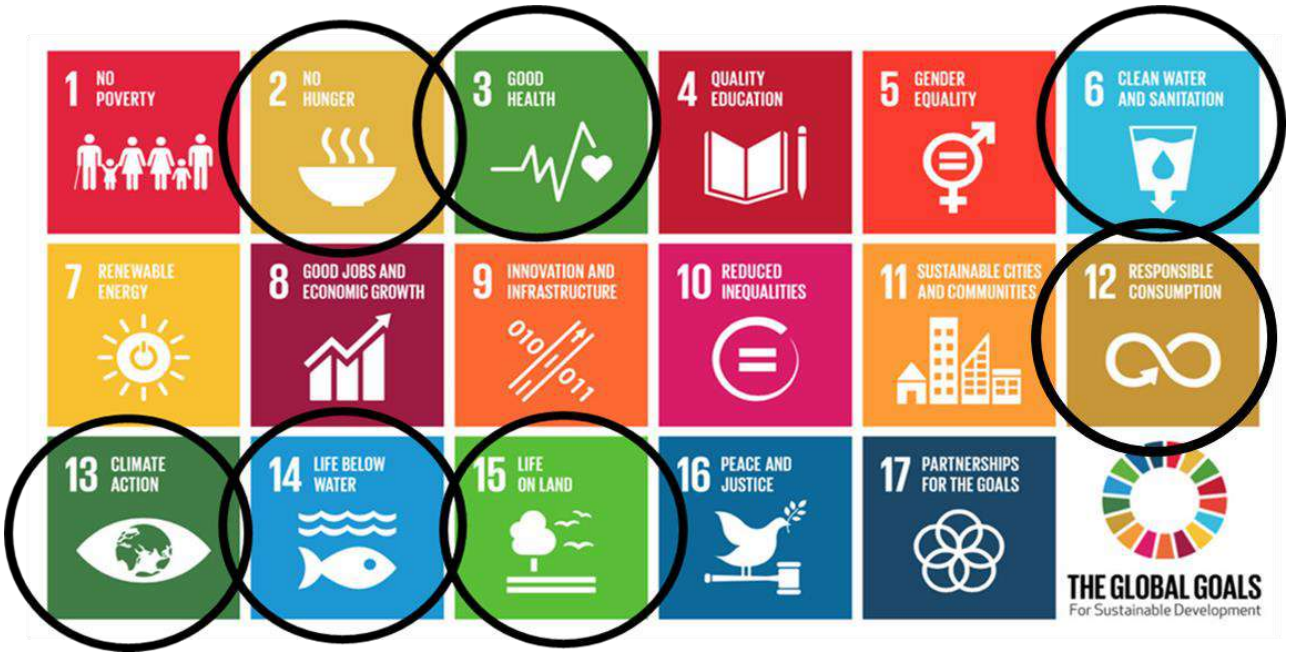

Figure 2 Presentation of SDGs (https://sustainabledevelopment.un.org/sdgs). Black circle depicts those related to NEXUS.

Table 1 SDGs' targets and indicators related to WEF NEXUS.

SDG 2 Zero hunger. End hunger, achieve security and improved nutrition and promote sustainable agriculture
Target 2.3. By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment
Indicator 2.3.1 Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size *Indicator 2.3.2 Average income of small-scale food producers, by sex and indigenous status*
Target 2.4. By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality
Indicator 2.4.1 Proportion of agricultural area under productive and sustainable agriculture
Target 2.a. Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries
Indicator 2.a.1 The agriculture orientation index for government expenditures *Indicator 2.a.2 Total official flows (official development assistance plus other official flows) to the agriculture sector*
SDG 3 Good health and well-being. Ensure health lives and promote well-being for all at all ages.
Target 3.9. By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.
Indicator 3.9.1 Mortality rate attributed to household and ambient air pollution *Indicator 3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)* *Indicator 3.9.3 Mortality rate attributed to unintentional poisoning*

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SDG 6 Clean water and sanitation. Ensure availability and sustainable management of water and sanitation for all.

Target 6.1. By 2030, achieve universal and equitable access to safe and affordable drinking water for all
Indicator 6.1.1 Proportion of population using safely managed drinking water services
Target 6.3. By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
Indicator 6.3.1 Proportion of wastewater safely treated *Indicator 6.3.2 Proportion of bodies of water with good ambient water quality*
Target 6.4. By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
Indicator 6.4.1 Change in water-use efficiency over time *Indicator 6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources*
Target 6.5. By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
Indicator 6.5.1 Degree of integrated water resources management implementation (0-100) *Indicator 6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation*
Target 6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
Indicator 6.6.1 Change in the extent of water-related ecosystems over time
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
Indicator 6.a.1. Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan

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Target 6.b Support and strengthen the participation of local communities in improving water and sanitation management
Indicator 6.b.1 Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management
SDG 12 Responsible Consumption and Production. Ensure sustainable consumption and production patterns
Target 12.2 By 2030, achieve the sustainable management and efficient use of natural resources
Indicator 12.2.1 Material footprint, material footprint per capita, and material footprint per GDP *Indicator 12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP*
Target 12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment
Indicator 12.4.1 Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement *Indicator 12.4.2 Hazardous waste generated per capita and proportion of hazardous waste treated, by type of treatment*
Target 12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
Indicator 12.5.1 National recycling rate, tons of material recycled
Target 12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature
Indicator 12.8.1 Extent to which (i) global citizenship education and (ii) education for sustainable development (including climate change education) are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
SDG 13: Climate Action. Take urgent action to combat climate change and its impacts
Target 13.2. Integrate climate change measures into national policies, strategies and planning

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Indicator 13.2.1 Number of countries that have communicated the establishment or operationalization of an integrated policy/strategy/plan which increases their ability to adapt to the adverse impacts of climate change, and foster climate resilience and low greenhouse gas emissions development in a manner that does not threaten food production (including a national adaptation plan, nationally determined contribution, national communication, biennial update report or other)
Target 13.3. Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
Indicator 13.3.1 Number of countries that have integrated mitigation, adaptation, impact reduction and early warning into primary, secondary and tertiary curricula *Indicator 13.3.2 Number of countries that have communicated the strengthening of institutional, systemic and individual capacity-building to implement adaptation, mitigation and technology transfer, and development actions*
Target 13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
Indicator 13.a.1 Mobilized amount of United States dollars per year starting in 2020 accountable towards the $100 billion commitment
Target 13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities
Indicator 13.b.1 Number of least developed countries and small island developing States that are receiving specialized support, and amount of support, including finance, technology and capacity-building, for mechanisms for raising capacities for effective climate change-related planning and management, including focusing on women, youth and local and marginalized communities
SDG 14 Life below water. Conserve and sustainably use the oceans, sea and marine resources for sustainable development
Target 14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution
Indicator 14.1.1 Index of coastal eutrophication and floating plastic debris density

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Target 14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
Indicator 14.2.1 Proportion of national exclusive economic zones managed using ecosystem-based approaches
Target 14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels
Indicator 14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations
Target 14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information
Indicator 14.5.1 Coverage of protected areas in relation to marine areas
Target 14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of The Future We Want
Indicator 14.c.1 Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nation Convention on the Law of the Sea, for the conservation and sustainable use of the oceans and their resources
SDG 15 Life on land. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainable manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
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
Indicator 15.1.1 Forest area as a proportion of total land area *Indicator 15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type*
Target 15.2. By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally

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Indicator 15.2.1 Progress towards sustainable forest management
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
Indicator 15.3.1 Proportion of land that is degraded over total land area
Target 15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development
Indicator 15.4.1 Coverage by protected areas of important sites for mountain biodiversity
Indicator 15.4.2 Mountain Green Cover Index *Target 15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species*
Indicator 15.5.1 Red List Index
Target 15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products
Indicator 15.7.1 Proportion of traded wildlife that was poached or illicitly trafficked
Target 15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species
Indicator 15.8.1 Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species
Target 15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts
Indicator 15.9.1 Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011-2020
Target 15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems
Indicator 15.a.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems

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Target 15.b Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation

Indicator 15.b.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems

EKLIPSE impact evaluation framework

The European Commission in 2015 requested from the EKLIPSE project (http://www.eklipse-mechanism.eu/) to help in building an evidence and knowledge base on the benefits and challenges of applying NBS. In response to the request, the EKLIPSE Expert Working Group on Nature-based Solutions to Promote Climate Resilience in Urban Areas (EWG) devised the following objectives: 1) To develop an impact evaluation framework with a list of criteria for assessing the performance of NBS in dealing with challenges related to climate resilience in urban areas; 2) To prepare an application guide for measuring how NBS projects fare against the identified indicators in delivering multiple environmental, economic and societal benefits; 3) To make recommendations to improve the assessment of the effectiveness of NBS projects, including the identification of knowledge gaps according to the criteria presented in the impact evaluation framework.

EKLIPSE developed a first version of an impact-evaluation framework with a list of criteria for assessing the performance of NBS in dealing with societal challenges in order to conduct a comparison of different NBS (Raymond et al., 2017a; 2017b) and develop an assessment framework that can be used by demonstration projects in the design, development, implementation, and assessment of NBS in urban areas.

The EWG selected 10 challenges from the expert report on NBS supported by DG Research and Innovation (EC, 2016) and a review of NBS frameworks (Kabisch et al., 2016):

1) Climate mitigation and adaptation;

2) Water management;

3) Coastal resilience;

4) Green space management (including enhancing/conserving urban biodiversity);

5) Air/ambient quality;

6) Urban regeneration;

7) Participatory planning and governance;

8) Social justice and social cohesion;

9) Public health and well-being;

10) Potential for new economic opportunities and green jobs

For each challenge area, a small number of representative examples of indicators were presented that were considered to be important for assessing key impacts of specific NBS actions, as well as a range of methods for assessing each indicator. All challenges consider impacts at the mesoscale (regional, metropolitan, urban)

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and microscale (neighbourhood/street, building). This framework did not provide a single answer for the assessment of NBS impacts. Rather, it recognised the potential for NBS impacts to vary across social and ecological contexts, and across temporal and geographical scales. The identified indicators were exemplary, and researchers and practitioners interested in NBS projects in cities were invited to enrich the impact assessment framework with additional operational and context-specific metrics and methods for valuation and assessment.

EU Handbook for practitioners

After the implementation of the EKLIPSE framework, the European Commission Directorate General Research and Innovation (DG RTD) requested the EU-funded NBS projects and collaborating institutions to work together for the development of an impact evaluation framework under the European Taskforce for NBS Impact Assessment. The DG RTDs' objectives were to:

- serving as a reference for relevant EU policies and activities;
- orient urban practitioners in developing robust impact evaluation frameworks for NBS at different scales;
- expand upon the pioneering work of the EKLIPSE framework by providing a comprehensive set of indicators and methodologies; and
- build the European evidence base regarding NBS impacts.

The result of the collaboration on this Taskforce was the development of the *EU Handbook for practitioners* (Dimitru and Wendling, 2021).

The *EU Handbook for practitioners* provided a protocol for selection of key indicators of NBS impact and methods for their assessment, which can be applied to monitor reference parameters. The handbook adopted the EKLIPSE Working Group impact evaluation framework approach with key challenge-based indicators (Raymond et al., 2017). Building on the EKLIPSE framework, which was primarily designed for urban areas, the EU Handbook for practitioners extended the original EKLIPSE challenge areas to address additional challenges and scales of NBS application.

The 12 societal challenge areas of the Handbook were the following:

1) Climate Resilience;

2) Water Management;

3) Natural and Climate Hazards;

4) Green Space Management;

5) Biodiversity;

6) Air Quality;

7) Place Regeneration;

8) Knowledge and Social Capacity Building for Sustainable Urban Transformation;

9) Participatory Planning and Governance;

10) Social Justice and Social Cohesion;

11) Health and Well-being;

12) New Economic Opportunities and Green Jobs.

The indicators developed reflect the state of the art in current scientific research on impacts of NBS and valid and standardized methods of assessment, as well as the state of play in urban implementation of evaluation frameworks. Annex 1 presents the recommended and additional indicators per challenge area, their class and applicability to the three types of NBS.

Designing the LENSES NBS framework

NBS classification scheme

The first step in developing the LENSES NBS Framework that can be used to address WEF Nexus issues is to identify an NBS classification scheme and the respective list of NBS that apply to the WEF Nexus. We adapted the classification scheme developed by the ThinkNature project (Somarakis et al., 2019) which was a result of a synthesis conducted from a literature review and stakeholder consultation/discussion on the ThinkNature platform (https://platform.think-nature.eu/). Each NBS type (Figure 3) can be classified into four distinct approaches that all together identify the uniqueness and usefulness of the NBS. The four approaches are:

- **Approach 1 (A1)** - It is based on the NBS typology developed by Eggermont et al. (2015) considering the level and the type of engineering or management applied to biodiversity and ecosystems along with the number of ecosystem services delivered and the stakeholder groups involved.
- **Approach 2 (A2)** – It is based on NBS approach classification (ecosystem-based approaches, community-based approaches, ecological engineering approaches, etc).
- **Approach 3 (A3)** - The NBS challenge that it is expected to solve. The NBS challenges used for the LENSES NBS framework were the 12 societal challenge areas resulted from the EU Handbook for practitioners (Dimitru and Wendling, 2021).
- **Approach 4 (A4)** - The ecosystem services it is delivering (EC, 2015).

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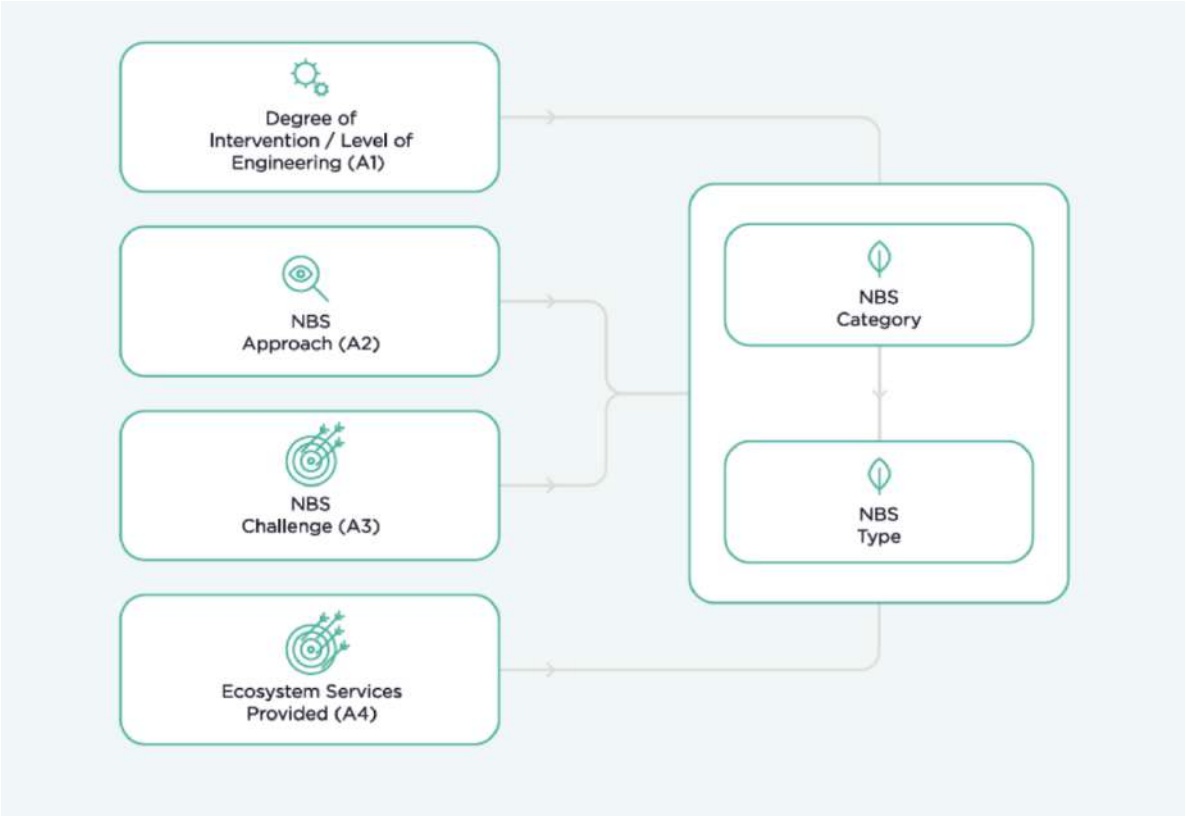

Figure 3 NBS classification scheme (Somarakis et al., 2019).

Approach 1 (A1)

NBS can be broadly grouped based upon their primary objective or function and by the level of ecosystem intervention. The following NBS typology (Figure 4) proposed by Eggermont et al. (2015) has been widely adopted:

Type 1 –no or minimal intervention in ecosystems - The objective of the action is to maintain or boost the effects of certain ecosystem services in already existing natural or weakly managed ecosystems. This type of NBS promotes better use of natural/protected ecosystems, implying the delivery of multiple ecosystem services to multiple stakeholder groups.

Type 2 –NBS for sustainability and multi-functionality of managed ecosystems - Effective management towards the sustainability and multifunctionality of ecosystems and landscapes so as to support selected ecosystem services. This type of NBS implies an increased provision of fewer ecosystem services to fewer stakeholders groups.

Type 3 – Design and management of new ecosystems - A more transformational "intrusive" approach that is often connected to the creation of new ecosystems. Restoration of degraded ecosystems falls under this type. This type of NBS includes the design and management of new ecosystems, seeking to maximise the delivery of key ecosystem services for key stakeholder groups.

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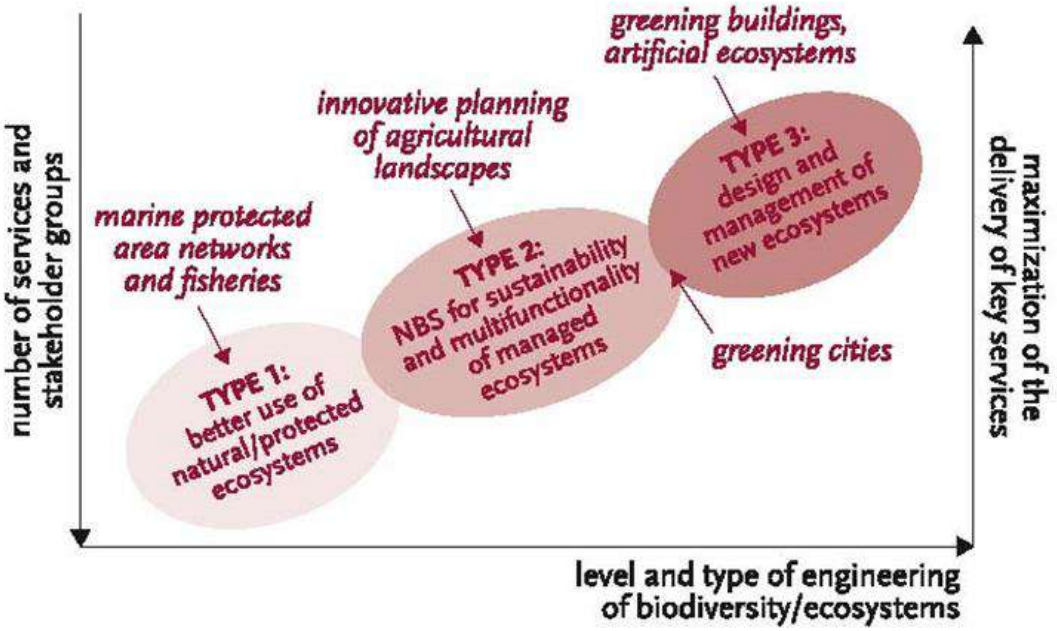

Figure 4 Classification according to degree of intervention/level and type of engineering (Eggermont et al., 2015.)

After reviewing the typology of Eggermont et al. (2015), the H2020 ThinkNature project identified a variety of NBS categories and classified according to the degree of intervention/level and type of engineering (Somarakis et al., 2019), as follows (here we list only the NBS categories related to the WEF Nexus):

Type 1 – Better use of protected/ natural ecosystems - No or minimal intervention in ecosystems, with the objectives of maintaining or improving the delivery of a range of ES both inside and outside of these preserved ecosystems

- Protection and conservation strategies in terrestrial (e.g. Natura2000), marine (e.g. MPA), and coastal areas (e.g. mangroves) ecosystems
- Monitoring

Type 2– NBS for sustainability and multifunctionality of managed ecosystems - Definition and implementation of management approaches that develop sustainable and multifunctional ecosystems and landscapes (extensively or intensively managed), which improves the delivery of selected ES compared to what would be obtained with a more conventional intervention

- Agricultural landscape management
- Coastal landscape management
- Extensive urban green space management

Type 3 – Design and management of new ecosystems – Managing ecosystems in very intrusive ways or even creating new ecosystems (e.g., artificial ecosystems with new assemblages of organisms for green roofs and walls to mitigate city warming and clean polluted air).

- Intensive urban green space management

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- Urban planning strategies
- Urban water management
- Ecological restoration of degraded terrestrial ecosystems
- Restoration and creation of semi-natural water bodies and hydrographic networks
- Ecological restoration of degraded coastal and marine ecosystems

Type 1 include protection and conservation strategies, urban planning strategies, and (environmental) monitoring strategies. Due to their nature, Type 1 NBS fall largely within the domain of governance, with implementation of Type 1 NBS strategies potentially limited or driven by a range of biophysical, social and institutional factors. Type 2 NBS are comprised of various sustainable management practices. Type 3 NBS are newly-created ecosystems, and therefore are the most "visible" solutions. Examples of Types 1-3 were presented by Cohen-Shacham et al. (2016), Eggermont et al. (2015), EC (2015) and Somarakis et al. (2019).

Approach 2 (A2)

The NBS approach list used for the LENSES NBS WEF Nexus Evaluation Framework was adopted from Thinknature classification scheme (Somarakis et al., 2019). The list is the following:

- **Climate adaptation approaches.** Benefits to people from increased social ability to respond to change, provided by the capacity of ecosystems to moderate and adapt to climate change and variability (Lavorel et al., 2015).
- **Community based adaptation.** Community-based adaptation draws on participatory approaches and methods developed in both disaster risk reduction and community development work, as well as sectoral-specific approaches
- **Ecosystem based adaptation.** The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change (CBD, 2009).
- **Ecosystem based management.** Integrated, science-based approach to the management of natural resources that aims to sustain the health, resilience and diversity of ecosystems while allowing for sustainable use by humans of the goods and services they provide (Kappel et al., 2006).
- **Ecosystem based mitigation.** Enhance the benefits for, and avoid negative impacts on biodiversity from reducing emissions, taking into account the need to ensure the full and effective participation of indigenous and local communities in relevant policy-making and implementation processes, where appropriate. Enhance the conservation, sustainable use and restoration of marine and coastal habitats that are vulnerable to the effects of climate change or which contribute to climate-change mitigation (CBD, 2010).
- **Ecosystem based disaster risk reduction.** The sustainable management, conservation and restoration of ecosystems to provide services that reduce disaster risk by mitigating hazards and by increasing livelihood resilience (Pedrr 2010)
- **Ecological engineering.** The design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both (Mitsch, 2012)
- **Ecological restoration.** The attempt to repair or otherwise enhance the structure and function of an ecosystem that has been impacted by disturbance or environmental change (Suding, 2011).
- **Infrastructure related approaches**

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- **Natural resources management.** Generic approaches to natural resources management.
- **Sustainable agriculture/agro-forestry/aquaculture.** Agroecological approaches for sustainable agriculture and forestry.

Approach 3 (A3)

The NBS challenges used for the LENSES NBS framework were the 12 societal challenge areas resulted from the EU Handbook for practitioners (Dimitru and Wendling, 2021). The description of these challenges was adapted for rural areas and landscapes only, and thus references to urban areas were excluded.

Climate Resilience: NBS are capable of providing resilience to the impacts of climate change through the provision of ecosystem services, and by enhancing social awareness and actions to combat climate change. The co-benefits delivered by NBS support climate change mitigation and adaptation efforts, contributing to the liveability of cities and ecosystems.

Water Management: NBS provide an excellent opportunity to address a diversity of issues associated with anthropogenic impacts on the water cycle. These include poor water quality, water availability for extraction, groundwater and surface water levels, recharging of aquifers, stormwater management, water treatment, wetland habitat management, soil water management, and ecological quality.

Natural and Climate Hazards: Risk is a combination of hazard and (negative) consequences. NBS employed for disaster risk reduction are expected to reduce risk level (i.e., influence risk components corresponding to hazard or vulnerability). At the same time, NBS deliver further social, human, and environmental co-benefits.

Green Space Management: Green space management refers to the planning, establishment and maintenance of green and blue infrastructure. Green and blue infrastructure (abbreviated as urban green infrastructure, UGI) are a type of NBS that refers specifically to the strategically managed network of natural and semi-natural ecosystems. UGI provides a range of ecological and socio-economic benefits (Raymond et al., 2017) and, if correctly managed, contributes to solutions for numerous challenges such as air and noise pollution, heat waves, flooding and concerns regarding public well-being (Maes et al., 2019). NBS support the wider deployment of green and blue infrastructure (EC, 2019a; EC, 2019b), thus supporting the EU Green Infrastructure Strategy (EC, 2013) and the EU Biodiversity Strategy for 2030 (EC, 2020).

Biodiversity Enhancement: Biodiversity loss and ecosystem collapse are among the greatest threats society faces in the near term. There are five primary direct drivers of biodiversity loss: changes in land and sea use, overexploitation, climate change, pollution, and invasive alien species. The link between climate change and biodiversity loss involves a feedback loop whereby climate change accelerates loss of natural capital, which is in turn a key driver of climate change. NBS support the EU Biodiversity Strategy for 2030 (EC, 2020) through the purposeful establishment of protected areas and restoration of degraded ecosystems.

Air Quality: NBS based on the creation, enhancement, or restoration of ecosystems in human-dominated environments play a relevant role in removing air pollutants and carbon dioxide, reducing the air temperature (which slows down the creation of secondary pollutants) and increasing oxygen concentration, contributing to a beneficial atmospheric composition for human life.

Place Regeneration: NBS hold the potential to contribute to the aim of ensuring successful achievement of sustainable place regeneration by way of enhancing the green space and people-nature connection, as well as using fewer environmental resources, enhancing place resilience to natural disasters, fostering collective

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participation and social cohesion, and improving individual wellbeing (Korkmaz and Balaban, 2020; Roberts and Sykes, 2000; Xiang et al., 2017).

Knowledge and Social Capacity Building for Sustainable Rural Transformation: Sustainable rural transformation delineates sustainable rural structures and environments, as well as radical social, economic, cultural, organizational, governmental, and physical change processes (Ernst et al., 2016; McCormick et al., 2013). Knowledge and social capacity building through educational initiatives can contribute to the complex enterprise of amassing resources for sustainable urban places. This challenge area is a new addition to the original ten challenges described in the EKLIPSE Expert Working Group impact evaluation framework (Raymond et al., 2017)

Participatory Planning and Governance: NBS demand approaches to planning and governance frameworks that support accessibility to green spaces, while maintaining their quality for ecosystem services provision. Rural environmental transformation is a highly complex undertaking that requires open collaborative governance and robust capacities for participatory planning. NBS already implemented and functional across Europe have contributed a wealth of knowledge in the area of participatory planning and governance, indicating, for instance, that successful outcomes call for openness to learning and experimenting along other urban actors so as to co-create and co-maintain nature-based solutions while shaping institutional spaces in cities that allow for this co-creation, social innovation and collaboration to continue (Frantzeskaki, 2019). Significantly, open collaborative governance and participatory planning invested in nature-based solution strategies bring forward opportunities for social transformation and increased social inclusiveness in cities (Wendling et al., 2018).

Social Justice and Social Cohesion: NBS have been linked to the notion of environmental justice across studies that explore the role of supporting urban processes involving equal access to neighbourhood green space in fostering social cohesion (e.g., bridging and bonding social capital) towards the cultural integration of typically-excluded social groups, like elderly, immigrants, persons with disabilities, etc. (i.e., recognition-based justice) (Ibes, 2015; Kweon et al., 1998; Raymond et al., 2017; Raymond et al., 2016; van Den Berg et al., 2017). Recently, Gentin et al. (2019) analysed the premises for a nature-based integration of immigrants in Europe and urged on researchers to set aside descriptions and analyses of immigrants' perceptions or use of nature and turn their focus towards exploring and developing nature-based solutions for the purposes of social integration.

Health and Wellbeing: Critical social and environmental determinants of health, including clean air, safe drinking water, sufficient food and secure shelter, are impacted by climate change44. More than half of the world's population lives in urban areas (towns and cities), and this number is projected to increase to two in three people by 205045. Climate change and other environmental issues affect all categories of population, however it is most threatening in urban areas where the majority of the population live. This means that the consequences of climate change, poor air quality and other current concerns are often very obvious and disruptive to urban living, and can affect services such as sanitation leading to public health issues.

New Economic Opportunities and Green Jobs: Key criteria of NBS are their cost-effectiveness, and their capacity to simultaneously provide environmental, social and economic benefits in support of resilience building. The adoption and implementation of NBS has the potential to create new economic opportunities and jobs in the green sector by enabling low-carbon, resource-efficient and socially inclusive economic growth. Within this paradigm, economic growth is driven by public and private investment in activities, infrastructure and assets that support reduced emissions of carbon and pollutants, and increased energy and resource efficiency whilst enhancing biodiversity and the provision of ecosystem services

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Approach 4 (A4)

Ecosystem Services are commonly defined as benefits people obtain from ecosystems. The Millennium Ecosystem Assessment (MEA, 2005), a four-year United Nations assessment of the condition and trends of the world's ecosystems, categorizes ecosystem services as:

- Provisioning services – food, water, materials and energy, which are directly used by people;
- Regulating services – those that cover the way ecosystems regulate other environmental media or processes;
- Cultural services – those related to the cultural or spiritual needs of people.
- Supporting services – ecosystem processes and functions that underpin other three types of services.

Table 2 presents a list of major ecosystem services used in terms of this classification.

Table 2 List of ecosystem services

Provisioning services	***Regulation and maintenance***	***Cultural***
Food, crops, wild foods and spices (F)	Carbon sequestration & climate regulation (CS&R)	Recreation (R)
Water (W)	Water purification (WP)	Intellectual and aesthetic appreciation (I)
Pharmaceuticals, biochem. & industry. Products (P)	Air quality regulation (AQ)	Spiritual and symbolic appreciation (S)
Energy (E)	Erosion prevention (EP)	
	Flood protection (FP)	
	Maintaining populations & habitats (MP&H)	
	Pest and disease control (P&DC)	
	Crop pollination (CP)	
	Nutrient dispersal & cycling (N)	

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Seed dispersal (SD) Soil formation & composition (SFC)

Identify NBS related to NEXUS

For the design of the LENSES NBS WEF NEXUS Evaluation Framework, the following list of NBS type (under each NBS category) was selected. Table 3 presents the final selection of NBS used in the LENSES WEF NEXUS Evaluation Framework.

Table 3 List of NBS related to WEF NEXUS.

Type 1 – Better use of protected/natural ecosystems

Protection and conservation strategies in terrestrial (e.g. Natura2000), marine (e.g. MPA), and coastal areas (e.g. mangroves) ecosystems
Limit or prevent specific uses and practices
Ensure continuity with ecological network (protection from fragmentation)
Protect forests from clearing and degradation from logging, fire, and unsustainable levels of non-timber resource extraction
Maintain and enhance natural wetlands
Protect remaining intertidal muds, saltmarshes and mangrove communities, seagrass beds, and vegetated dunes from further degradation, fragmentation, and loss.
Natural Protected Area network structure
Mangrove forests protected area MPA network structure
Monitoring
Assessment of NBS benefits
Ecosystem services valuation methods
Regular monitoring of bio-indicators

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Type 2 – NBS for sustainability and multifunctionality of managed ecosystems

Agricultural landscape management
Agro-ecological practices
Use grazing management and animal impact as farm and ecosystem development tools
Change crop rotations
Soil improvement and conservation measures
Increase soil water holding capacity and infiltration rates
Agro-ecological network structure
Mulching
Incorporating manure, compost, biosolids, or incorporating crop residues to enhance carbon storage
Produce and integrate biochar into agricultural soils
Enrichment planting in degraded and regenerating forests
Forest patches
Hedge and planted fence
Flower strips
Use soil conservation measures - Cover crops
Use soil conservation measures - Wind breaks
Use soil conservation measures - Deep-rooted plants and minimum or conservation tillage
Promote agroforestry
Coastal landscape management
Encourage development of early successional sand dune habitats (dry dunes and wet slacks) where carbon sequestration rates are high.

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Enhance or facilitate habitat expansion, including the facilitated range expansion of mangroves, as warming conditions and changes in storm occurrence permit.
Integrated coastal zone management

Type 3 – Design and management of new ecosystems

Ecological restoration of degraded terrestrial ecosystems
Quarry restoration
Phytoremediation
Systems for erosion control
Soil and slope revegetation
Strong slope revegetation
Replace hard engineered river stabilisation with softer alternatives (e.g. willow-based)
Plant trees/ hedges/perennial grass strips to intercept surface run-off
Use of pre-existing vegetation
Restoration and creation of semi-natural water bodies and hydrographic networks
Restore wetlands in areas of groundwater recharge
Reconnect rivers with floodplains to enhance natural water storage
Re-vegetation of riverbanks
Re-meander rivers (where they have been artificially straightened) to help reduce speed and height of flood peaks
Restore grassland/low input arable in drinking water catchments
Use engineered reedbeds/wetlands for tertiary treatment of effluent
Target ponds/wetland creation to trap sediment/pollution runoff in farmed landscape
Constructed wetlands and built structures for water management

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Rivers or streams, including remeandering, re-opening Blue corridors Floodplain restoration and management
Ecological restoration of degraded coastal and marine ecosystems
Create new intertidal habitat through afforestation, or planting of saltmarsh or seagrass at appropriate elevations in the tidal frame Restore micro-topography, creek networks, sediment inputs, and nutrient exchange in abandoned aquaculture ponds. Re-establish and restore previous intertidal habitat by de-poldering or coastal realignment Ecological restoration of degraded coastal and marine ecosystems Coastal sand engine Dune replenishment

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NEXUS NBS categorization

The Tables 4-10 present the NBS categorization used in the LENSES WEF-Nexus Evaluation Framework. Each NBS was categorized according to NBS Approaches, NBS challenges and Ecosystem Services provided.

Table 4 Categorization of NBS belong to Type 1- Protection and conservation strategies in terrestrial, marine and coastal areas ecosystems.

NEXUS related NBS	NBS APPROACH (A2)											NBS CHALLENGE (A3)											ECOSYSTEM SERVICES (A4)		
	Climate adaptation approaches	Community based adaptation	Ecosystem based adaptation	Ecosystem based management	Ecosystem based mitigation	Ecosystem based disaster risk reduction	Ecological engineering	Ecological restoration	Infrastructure related approaches	Natural resources management	Sustainable agriculture/agro-forestry/aquaculture	Climate resilience	Water management	Natural and Climate Hazards	Green space management	Biodiversity enhancement	Air quality	Place regeneration	Knowledge & Social Capacity Building for Sustainable Urban Transformation	Participatory planning and governance	Social justice and social cohesion	Health and well-being	New economic opportunities and green jobs	PROVISIONING SERVICES	REGULATION & MAINTENANCE	CULTURAL
Type 1 – Better use of protected/natural ecosystems																										
Protection and conservation strategies in terrestrial, marine and coastal areas ecosystems																										
Limit or prevent specific land uses and practices				x						x		x	x		x		x	x			x	x		(W)	(AQ), (EP), (FP), (CS&R)	(R), (I), (S)
Ensure of continuity of ecological networks (protection from fragmentation)		x	x	x	x	x														x		x			(MP&H)	(R), (I), (S)
Protect forests from clearing and degradation from logging, fire, and unsustainable levels of non-timber resource extraction	x	x		x	x	x		x	x	x	x	x		x						x	x	x	x	(F)	(EP), (FP), (MP&H), (CS&R)	(R), (I), (S)
Maintain and enhance natural wetlands	x	x	x	x	x			x				x	x	x		x				x			x	(W), (F)	(WP), (FP), (MP&H)	(R), (I), (S)
Protect remaining intertidal muds, saltmarshes and mangrove communities, seagrass beds, and vegetated dunes from further degradation, fragmentation, and loss.	x				x	x		x						x		x								(F)	(FP), (MP&H)	(R), (I), (S)
Natural Protected Area network structure			x	x	x	x		x	x				x	x		x						x				(R), (I), (S)
Mangrove forests protected area MPA network structure	x		x	x	x	x					x	x		x		x	x			x		x		(F)	(FP), (MP&H), (AQ), (CS&R)	(R), (I), (S)

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Table 5 Categorization of NBS belong to Type 1- Monitoring.

NEXUS related NBS	NBS APPROACH (A2)											NBS CHALLENGE (A3)												ECOSYSTEM SERVICES (A4)		
	Climate adaptation approaches	Community based adaptation	Ecosystem based adaptation	Ecosystem based management	Ecosystem based mitigation	Ecosystem based disaster risk reduction	Ecological engineering	Ecological restoration	Infrastructure related approaches	Natural resources management	Sustainable agriculture/agro-forestry/aquaculture	Climate resilience	Water management	Natural and Climate Hazards	Green space management	Biodiversity enhancement	Air quality	Place regeneration	Knowledge & Social Capacity Building for Sustainable Urban Transformation	Participatory planning and governance	Social justice and social cohesion	Health and well-being	New economic opportunities and green jobs	PROVISIONING SERVICES	REGULATION & MAINTENANCE	CULTURAL
Type 1 – Better use of protected/natural ecosystems																										
Monitoring																										
Assessment of NBS benefits				x					x	x										x	x		x			(S)
Ecosystem services valuation methods				x					x	x										x	x		x			(S)
Regular monitoring of bio-indicators				x					x	x										x	x		x			(S)

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Table 6 a Categorization of NBS belong to Type 2- Agricultural landscape management.

NEXUS related NBS	NBS APPROACH (A2)											NBS CHALLENGE (A3)											ECOSYSTEM SERVICES (A4)		
	Climate adaptation approaches	Community based adaptation	Ecosystem based adaptation	Ecosystem based management	Ecosystem based mitigation	Ecosystem based disaster risk reduction	Ecological engineering	Ecological restoration	Infrastructure related approaches	Natural resources management	Sustainable agriculture/agro-forestry/aquaculture	Climate resilience	Water management	Natural and Climate Hazards	Green space management	Biodiversity enhancement	Air quality	Place regeneration	Knowledge & Social Capacity Building for Sustainable Urban Transformation	Participatory planning and governance	Social justice and social cohesion	Health and well-being	New economic opportunities and green jobs	PROVISIONING SERVICES	REGULATION & MAINTENANCE	CULTURAL
Type 2 – NBS for sustainability and multifunctionality of managed ecosystems																										
Agricultural landscape management																										
Agro-ecological practices	x			x		x		x			x	x	x			x	x			x	x		x	(W), (F)	(AQ), (WP), (FP), (CS&R), (N), (SFC), (P), (SD)	(R), (I)
Use grazing management and animal impact as farm and ecosystem development tools			x	x	x						x									x	x		x	(F)	(MP&H), (SFC)	
Change crop rotations				x							x	x				x				x			x	(W) , (F)	SD), (SFC), (P), (CP)	
Soil improvement and conservation measures	x			x		x					x	x				x				x	x		x	(W) , (F)	(EP), (CS&R), (SFC), (N), (P)	(R)
Increase soil water holding capacity and infiltration rates	x	x	x	x		x		x			x	x	x							x	x		x	(W)	(FP), (EP), (CS&R)	
Agro-ecological network structure	x			x		x		x			x	x				x	x			x	x		x	(W), (F)	(AQ), (WP), (FP), (CS&R), (N), (SFC), (P), (SD)	(R), (I)
Mulching	x		x	x		x		x			x	x				x							x	(W), (F)	(CS&R), (N), (SFC), (P), (SD)	(R)

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Table 6b.Categorization of NBS belong to Type 2- Agricultural landscape management.

NEXUS related NBS	NBS APPROACH (A2)											NBS CHALLENGE (A3)											ECOSYSTEM SERVICES (A4)		
	Climate adaptation approaches	Community based adaptation	Ecosystem based adaptation	Ecosystem based management	Ecosystem based mitigation	Ecosystem based disaster risk reduction	Ecological engineering	Ecological restoration	Infrastructure related approaches	Natural resources management	Sustainable agriculture/agro-forestry/aquaculture	Climate resilience	Water management	Natural and Climate Hazards	Green space management	Biodiversity enhancement	Air quality	Place regeneration	Knowledge & Social Capacity Building for Sustainable Urban Transformation	Participatory planning and governance	Social justice and social cohesion	Health and well-being	New economic opportunities and green jobs	PROVISIONING SERVICES	REGULATION & MAINTENANCE	CULTURAL
Type 2 – NBS for sustainability and multifunctionality of managed ecosystems																										
Agricultural landscape management																										
Incorporating manure, compost, biosolids, or incorporating crop residues to enhance carbon storage	x		x	x		x		x			x	x				x							x	(W), (F)	(CS&R), (N), (SFC), (P), (SD)	(R)
Produce and integrate biochar into agricultural soils	x		x	x		x		x			x	x				x							x	(W), (F)	(CS&R), (N), (SFC), (P), (SD)	(R)
Enrichment planting in degraded and regenerating forests	x		x	x	x	x		x			x	x	x	x		x	x	x		x	x	x		(W)	(MP&H), (CS&R), (EP), (FP), (CP)	(R), (I)
Forest patches	x			x	x						x	x				x								(W)	(MP&H), (CS&R), (EP), (FP), (CP)	(R), (I)
Hedge and planted fence				x							x					x	x							(W), (F)	(MP&H), (CS&R), (N), (P&DC)	(R), (I)
Flower strips				x							x					x	x							(W), (F)	(MP&H), (CS&R), (N), (P&DC)	(R), (I)
Use soil conservation measures - cover crops	x			x		x		x			x	x		x		x	x							(W), (F)	(MP&H), (CS&R) (EP), (CP), (SFC),	(R), (I)
Use soil conservation measures - wind breaks	x				x	x					x	x		x		x	x							(F)	(EP), (MP&H), (CP), (P), (AQ)	(R), (I)
Use soil conservation measures - Deep-rooted plants and minimum or conservation tillage	x		x	x	x	x			x		x	x		x		x	x							(W), (F)	(MP&H), (CS&R), (EP), (FP), (SFC), (AQ)	(R), (I)
Promote agroforestry	x			x		x		x			x	x	x	x		x	x			x	x	x		(W), (F)	(MP&H), (CS&R), (N), (SD), (P), (AQ), (SFC)	(R), (I)

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Table 7 Categorization of NBS belong to Type 2- Coastal landscape management.

NEXUS related NBS	NBS APPROACH (A2)											NBS CHALLENGE (A3)												ECOSYSTEM SERVICES (A4)		
	Climate adaptation approaches	Community based adaptation	Ecosystem based adaptation	Ecosystem based management	Ecosystem based mitigation	Ecosystem based disaster risk reduction	Ecological engineering	Ecological restoration	Infrastructure related approaches	Natural resources management	Sustainable agriculture/agro-forestry/aquaculture	Climate resilience	Water management	Natural and Climate Hazards	Green space management	Biodiversity enhancement	Air quality	Place regeneration	Knowledge & Social Capacity Building for Sustainable Urban Transformation	Participatory planning and governance	Social justice and social cohesion	Health and well-being	New economic opportunities and green jobs	PROVISIONING SERVICES	REGULATION & MAINTENANCE	CULTURAL
Type 2 – NBS for sustainability and multifunctionality of managed ecosystems																										
Coastal landscape management																										
Encourage development of early successional sand dune habitats (dry dunes and wet slacks) where carbon sequestration rates are high.			x	x	x	x		x						x		x				x		x		(F)	(CS&R),(MP&H)	(R), (I)
Enhance or facilitate habitat expansion, including the facilitated range expansion of mangroves, as warming conditions and changes in storm occurrence permit.	x		x	x	x	x		x				x		x		x				x		x		(W), (F)	(EP), (FP), (MP&H)	(R), (I)
Integrated coastal zone management	x			x		x		x				x	x	x						x	x	x	x	(W), (F)	(AQ), (WP), (FP), (CS&R)	(R), (I)

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Table 8 Categorization of NBS belong to Type 3- Ecological restoration of degraded terrestrial ecosystems.

NEXUS related NBS	NBS APPROACH (A2)											NBS CHALLENGE (A3)											ECOSYSTEM SERVICES (A4)		
	Climate adaptation approaches	Community based adaptation	Ecosystem based adaptation	Ecosystem based management	Ecosystem based mitigation	Ecosystem based disaster risk reduction	Ecological engineering	Ecological restoration	Infrastructure related approaches	Natural resources management	Sustainable agriculture/agro-forestry/aquaculture	Climate resilience	Water management	Natural and Climate Hazards	Green space management	Biodiversity enhancement	Air quality	Place regeneration	Knowledge & Social Capacity Building for Sustainable Urban Transformation	Participatory planning and governance	Social justice and social cohesion	Health and well-being	New economic opportunities and green jobs	PROVISIONING SERVICES	REGULATION & MAINTENANCE	CULTURAL
Type 3 – Design and management of new ecosystems																										
Ecological restoration of degraded terrestrial ecosystems																										
Quarry restoration			x	x	x	x	x	x								x		x		x	x	x	x	(W), (F)	(EP), (SFC), (MP&H)	(R), (I)
Phytoremediation			x	x	x	x	x	x								x	x	x			x	x	x	(W), (F)	(WP),(MP&H), (FP), (EP), (N), (SFC)	(R), (I)
Systems for erosion control	x					x	x	x				x		x		x						x	x	(W), (F)	(CS&R), (EP), (FP), (MP&H), (SFC), (P)	(R), (I)
Soil and slope revegetation	x					x	x	x				x		x		x	x	x					x	(W), (F)	(CS&R), (EP), (FP), (MP&H), (CP),(SFC), (P), (N)	(R), (I)
Strong slope revegetation	x					x	x	x				x		x		x	x						x	(W), (F)	(CS&R), (EP), (FP), (MP&H), (CP),(SFC), (P), (N)	(R), (I)
Replace hard engineered river stabilisation with softer alternatives (e.g. willow-based)	x					x	x	x				x		x		x	x	x				x	x	(W), (F)	(CS&R), (EP), (FP), (MP&H), (CP),(SFC), (P), (N)	(R), (I)
Plant trees/ hedges/perennial grass strips to intercept surface run-off	x					x	x	x				x	x	x		x	x	x				x	x	(W), (F)	(CS&R), (EP), (FP), (MP&H), (CP),(SFC), (P), (N)	(R), (I)
Use of pre-existing vegetation	x					x		x				x				x	x	x				x	x	(W), (F)	(CS&R), (EP), (FP), (MP&H), (CP),(SFC), (P), (N), (SD)	(R), (I)

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Table 9 Categorization of NBS belong to Type 3- Restoration and creation of semi-natural water bodies and hydrographic networks.

NEXUS related NBS	NBS APPROACH (A2)											NBS CHALLENGE (A3)											ECOSYSTEM SERVICES (A4)		
	Climate adaptation approaches	Community based adaptation	Ecosystem based adaptation	Ecosystem based management	Ecosystem based mitigation	Ecosystem based disaster risk reduction	Ecological engineering	Ecological restoration	Infrastructure related approaches	Natural resources management	Sustainable agriculture/agro-forestry/aquaculture	Climate resilience	Water management	Natural and Climate Hazards	Green space management	Biodiversity enhancement	Air quality	Place regeneration	Knowledge & Social Capacity Building for Sustainable Urban Transformation	Participatory planning and governance	Social justice and social cohesion	Health and well-being	New economic opportunities and green jobs	PROVISIONING SERVICES	REGULATION & MAINTENANCE	CULTURAL
Type 3 – Design and management of new ecosystems																										
Restoration and creation of semi-natural water bodies and hydrographic networks																										
Restore wetlands in areas of groundwater recharge	x		x	x	x	x	x	x		x		x	x	x		x		x				x		(W), (F)	(CS&R), (EP), (FP), (MP&H),(SFC), (P), (N), (SD)	(R), (I)
Reconnect rivers with floodplains to enhance natural water storage	x		x	x	x	x	x	x		x		x	x	x						x		x		(W), (F)	(EP), (FP), (MP&H)	(R), (I)
Re-vegetation of riverbanks	x		x	x	x	x	x	x		x		x	x	x		x	x	x		x		x		(W), (F)	(CS&R), (EP), (FP), (MP&H),(SFC), (N), (SD), (AQ)	(R), (I)
Re-meander rivers (where they have been artificially straightened) to help reduce speed and height of flood peaks	x		x	x	x	x	x	x		x		x	x	x				x		x		x		(W), (F)	(CS&R), (EP), (FP), (MP&H)	(R), (I)
Restore grassland/low input arable in drinking water catchments	x		x	x	x	x	x	x		x		x	x	x		x		x				x		(W), (F)	(CS&R), (WP), (EP), (FP), (MP&H),(SFC), (N), (SD), (P&DC)	(R), (I)
Use engineered reedbeds/wetlands for tertiary treatment of effluent	x		x	x	x	x	x	x		x		x	x	x								x		(W), (F)	(CS&R), (WP), (MP&H), (N), (SD)	(R), (I)
Target ponds/wetland creation to trap sediment/pollution runoff in farmed landscape	x		x	x	x	x	x	x		x		x	x	x								x		(W), (F)	(CS&R), (WP), (MP&H), (N), (SD), (P&DC)	(R), (I)
Constructed wetlands and built structures for water management	x		x	x	x	x	x	x		x		x	x	x		x		x				x		(W), (F)	(CS&R), (WP), (MP&H), (N), (SD), (P&DC), (EP), FP)	(R), (I)
Rivers or streams, including remeandering, re-opening Blue corridors	x		x	x	x	x	x	x		x		x	x	x				x				x		(W), (F)	(EP), FP)	(R), (I)
Floodplain restoration and management	x		x	x	x	x	x	x		x		x	x	x				x		x		x		(W), (F)	(EP), FP), (MP&H)	(R), (I)

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Table 10 Categorization of NBS belong to Type 3- Ecological restoration on degraded coastal and marine ecosystems.

NEXUS related NBS	NBS APPROACH (A2)											NBS CHALLENGE (A3)												ECOSYSTEM SERVICES (A4)		
	Climate adaptation approaches	Community based adaptation	Ecosystem based adaptation	Ecosystem based management	Ecosystem based mitigation	Ecosystem based disaster risk reduction	Ecological engineering	Ecological restoration	Infrastructure related approaches	Natural resources management	Sustainable agriculture/agro-forestry/aquaculture	Climate resilience	Water management	Natural and Climate Hazards	Green space management	Biodiversity enhancement	Air quality	Place regeneration	Knowledge & Social Capacity Building for Sustainable Urban Transformation	Participatory planning and governance	Social justice and social cohesion	Health and well-being	New economic opportunities and green jobs	PROVISIONING SERVICES	REGULATION & MAINTENANCE	CULTURAL
Type 3 – Design and management of new ecosystems																										
Ecological restoration of degraded coastal and marine ecosystems																										
Create new intertidal habitat through afforestation, or planting of saltmarsh or seagrass at appropriate elevations in the tidal frame	x	x	x	x	x	x		x			x	x	x	x		x	x	x		x				**(F), (W)**	**(CS&R), (EP), (FP), (MP&H), (N)**	**(R), (I)**
Restore micro-topography, creek networks, sediment inputs, and nutrient exchange in abandoned aquaculture ponds.	x	x	x	x	x			x				x	x			x		x		x		x		**(F), (W)**	**(CS&R), (EP), (FP), (MP&H), (N)**	**(R), (I)**
Re-establish and restore previous intertidal habitat by de-poldering or coastal realignment	x	x	x	x	x			x				x		x		x		x						**(F), (W)**	**(CS&R), (EP), (FP), (WP), (MP&H), (N)**	**(R), (I)**
Ecological restoration of degraded coastal and marine ecosystems	x	x	x	x	x	x		x				x	x	x		x	x	x		x	x	x	x	**(F), (W)**	**(CS&R), (WP), (EP), (AQ), (FP), (MP&H), (N), (P&DC), (SFC), (P)**	**(R), (I)**
Coastal sand engine	x	x	x	x	x	x		x				x		x		x		x						**(F), (W)**	**(CS&R), (EP), (FP), (MP&H), (SFC)**	**(R), (I)**
Dune replenishment	x	x	x	x	x	x		x				x		x		x		x						**(F), (W)**	**(CS&R), (EP), (FP), (MP&H), (SFC)**	**(R), (I)**

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Final remarks

The aim of the present deliverable 5.1 was to give a detailed overview on the various available evaluation frameworks, to identify commonalities and gaps in frameworks, and to develop a WEF Nexus-appropriate framework for evaluating options for increasing resilience. Figure 5 presents the conceptual design of the LENSES evaluation framework.

In this framework, the NBS practitioner must follow the steps:

- Develop a vision for the landscape in consultation with the local stakeholders.
- Identify the challenges the area/basin under consideration is facing regarding the Water-Ecosystem-Food Nexus. These challenges can be viewed at this stage separately for each component of the Nexus.
- Identify the desired ecosystem services to obtain from the landscape as well the approaches to use to improve. These selections should be consistent with the vision identified in step 1.
- Use tables 4-10 and select a primary list of appropriate NBS that address the desired ecosystem services and the vision for the landscape.
- Identify related KPIs for each NBS selected.
- Evaluate the list of potentially applicable NBS that contribute to more than one component of the WEF Nexus.
- Conduct stakeholder consultation (focus groups) on the selected WEF optimized NBSs
- Revise list and follow the same steps until the NBS list that optimize the WEF Nexus is finalized.

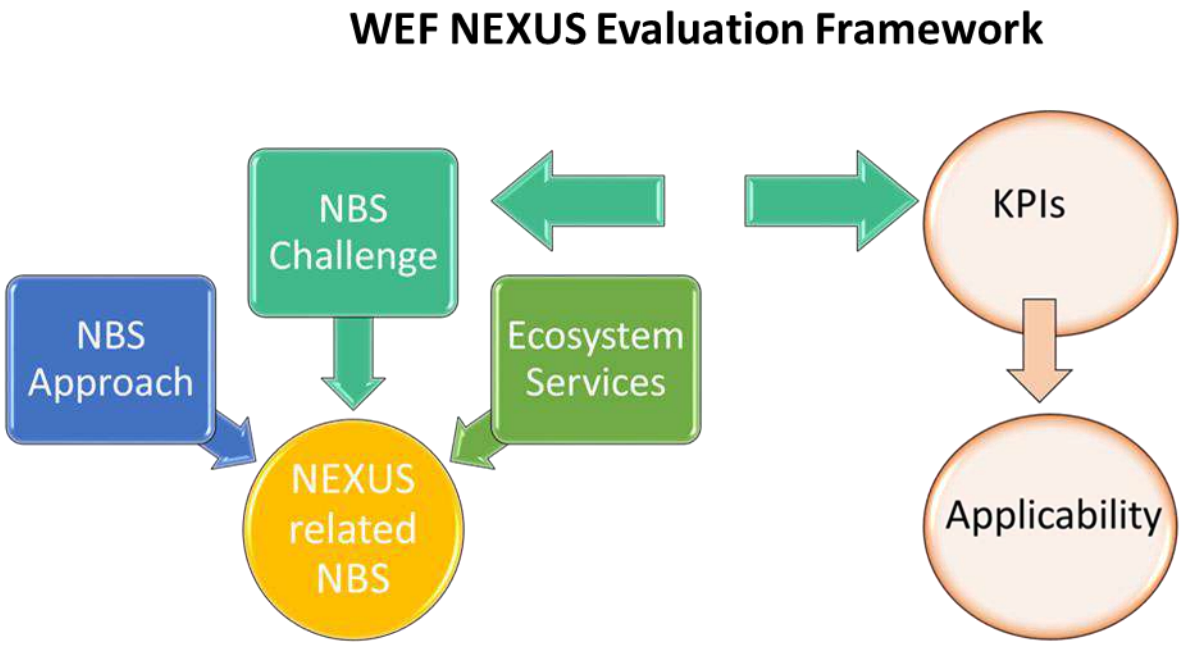

Figure 5 Design of WEF NEXUS evaluation framework

The LENSES WEF Nexus Evaluation framework presented in this deliverable will be used for the development of the NBS WEF Nexus Tool as part of Task 5.3.

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Annex 1 "Key performance indicators"

*structural (S), process focused (P) or outcome-based (O) indicators

	Units	Class	Applicability to NBS		
			Type 1	Type 2	Type 3
1 RECOMMENDED INDICATORS OF CLIMATE RESILIENCE					
1.1 Carbon removed or stored in vegetation and soil	kg/ha/y	O	x	x	x
1.2 Avoided greenhouse gas emissions from reduced building energy consumption	t CO2e/y	O		x	x
1.3 TXx, Monthly mean value of daily maximum temperature	°C	O	x		x
1.4 TNn, Monthly mean value of daily minimum temperature	°C	O	x		x
1.5 Heatwave Incidence	No./y	O	x		x
2 ADDITIONAL INDICATORS OF CLIMATE RESILIENCE					
2.1. Carbon storage and sequestration in vegetation					
2.1.1 Carbon storage and sequestration in vegetation per unit area per unit time	kg/ha/y	O	x	x	x
2.1.2 Carbon storage and sequestration in vegetation – annual determination	kg/ha/y	O	x	x	x
2.1.3 Total Leaf Area	m2	O	x	x	x
2.1.4 Carbon Storage Score	kg/day	O	x	x	x
2.1.5 Measured soil carbon content	ton/ha	O	x	x	x
2.1.6 Modelled carbon content of the upper soil layer	ton/ha	O	x	x	x
2.1.7 Soil carbon decomposition rate	% p.a.	O	x	x	x
2.2 Energy use savings due to green infrastructure implementation	kWh/y	O		x	x
2.3 Estimated carbon emissions reduction from building energy saving - cooling	t CO2e/y	O			x
2.4 Energy and CO2 emissions savings from reduced volume of water entering sewers	t CO2e/y	O	x	x	x
2.5 Soil Temperature	°C	O	x	x	x
2.6 Total surface area of wetlands	ha	O	x	x	x
2.7 Surface area of restored and/or created wetlands	ha	O	x	x	x
2.8 Aboveground tree biomass	t/ha	O	x	x	x
2.9 Human Comfort					
2.9.1 Universal Thermal Climate Index (UTCI)	°C	O	x		x
2.9.2 Thermal Comfort Score (TCS)	unitless	O	x		x

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2.9.3 Physiological equivalent temperature (PET)	°C	O	x		x
2.9.4 Predicted Mean Vote-Predicted Percentage Dissatisfied (PMV-PPD)	unitless	O	x		x
2.10 Urban Heat Island Effect					
2.10.1. Urban Heat Island (UHI) incidence	°C	O	x		x
2.10.2. Number of combined tropical nights and hot days	No	O	x		x
2.10.3 Thermal Storage Score	J	O	x		x
2.10.4 Thermal Load Score	°C	O	x		x
2.11 Estimated reduction in peak summer temperature	°C	O	x		x
2.12 Maximum surface cooling	°C	O	x		x
2.13 Mean or peak daytime temperature					
2.13.1 Mean or peak daytime temperature - Direct temperature measurement	°C	O	x		x
2.13.2 Mean or peak daytime temperature - Temperature modelling	°C	O	x		x
2.14 Daily Temperature Range (DTR)	°C	O	x		x
2.15 Cooling of ambient air					
2.15.1 Air cooling	°C	O	x		x
2.15.2 Air temperature reduction	°C	O	x		x
2.16 Tree shade for local heat reduction	m2	O	x	x	x
2.17 Rate of evapotranspiration	mm/day	O	x	x	x
2.18 Land surface temperature	°C	O	x	x	x
2.19 Surface reflectance - Albedo	unitless	O	x		x
2.20 Estimated carbon emissions from vehicle traffic	tC/y	O	x		x
3 RECOMMENDED INDICATORS OF WATER MANAGEMENT					
3.13 Surface runoff in relation to precipitation quantity	mm/%	O	x	x	x
3.14 Water Quality – general urban	various	O	x	x	x
3.15 Total Suspended Solids (TSS) content	mg/L	O	x	x	x
3.16 Nitrogen and phosphorus concentration or load	%	O	x	x	x
3.17 Metal concentration or load	%	O	x	x	x
3.18 Total faecal coliform bacteria	No	O	x	x	x
4 ADDITIONAL INDICATORS OF WATER MANAGEMENT					
4.13 Measured infiltration rate and capacity	% or mm/h and mm/d	O	x	x	x
4.14 Calculated infiltration rate and capacity	% or mm/h and mm/d	O	x	x	x

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4.15 Evapotranspiration rate	mm/m2 day	O	x	x	x
4.16 Peak flow variation	%	O	x	x	x
4.17 Flood peak reduction and delay	% and h	O	x	x	x
4.18 Height of flood peak and time to flood peak measurement	m3/s and h	O	x	x	x
4.19 Flood excess volume (FEV)	m3	O	x	x	x
4.20 Rainfall interception rate of NBS	mm/h	O	x	x	x
4.21 Runoff rate for different rainfall events	m3/s	O	x	x	x
4.22 Run-Off Score	unitless	O	x	x	x
4.23 Rainfall storage capacity of NBS	mm/%	O	x	x	x
4.24 Quantitative status of groundwater	Good or Poor	O	x	x	x
4.25 Depth to groundwater	m	O	x	x	x
4.26 Groundwater chemical status	Good or Poor	O	x	x	x
4.27 Trend in piezometric levels (TPL)	m3/y	O	x	x	x
4.28 Groundwater exploitation index (GEI)	%	O	x	x	x
4.29 Aquifer surface ratio with excessive nitrate	%	O	x	x	x
4.30 Aquifer surface ratio with excessive arsenic	%	O	x	x	x
4.31 Water availability for irrigation purposes	m3/y	O	x	x	x
4.32 Water Exploitation Index	%	O	x	x	x
4.33 Water dependency for food production	m3	O	x	x	x
4.34 Calculated drinking water provision	m3/ha/y	O	x	x	x
4.35 Net surface water availability	m3/y	O	x	x	x
4.36 Volume of water removed from water treatment system	m3/y	O	x	x	x
4.37 Volume of water slowed down entering sewer system	m3/s	O	x	x	x
4.38 Total surface area of wetlands within a defined area	ha	O	x	x	x
4.39 Total surface area of restored and/or created wetlands	ha	O		x	x
4.40 Soil water saturation	%	O	x	x	x
4.41 Soil water retention capacity	m3/m3	O	x	x	x
4.42 Stemflow rate	mm/h	O	x	x	x
4.43 Percolation rate under different rainfall events	mm/d	O	x	x	x
4.44 Dissolved oxygen (DO) content of NBS effluents	mg/L	O	x	x	x
4.45 Eutrophication	unitless	O	x	x	x
4.46 pH of NBS effluents	unitless	O	x	x	x
4.47 Electrical conductivity of NBS effluents	µS/cm	O	x	x	x

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4.48 Water Framework Directive: Physico-chemical quality of surface waters	High, Good, Moderate, Poor, Bad	O	x	x	x
4.49 Total pollutant discharge to local waterbodies	unitless	O	x	x	x
4.50 Water Quality: basic physical parameters	various	O	x	x	x
4.51 Total polycyclic hydrocarbon (PAH) content of NBS effluents	ng/L	O	x	x	x
4.52 Total organic carbon (TOC) content of NBS effluents	mg/L C	O	x	x	x
4.53 General ecological status of surface waters	High, Good, Moderate, Poor, Bad	O	x	x	x
4.54 Ecological potential for heavily modified or artificial water bodies	Maximum, Good, Moderate, Poor, Bad	O	x	x	x
4.55 Biological quality of surface waters	High, Good, Moderate, Poor, Bad	O	x	x	x
4.56 Total number and species richness of aquatic macroinvertebrates	unitless	O	x	x	x
4.57 Morphological Quality Index (MQI)	unitless	O	x	x	x
4.58 Hydromorphological quality of surface waters	High, Good, Moderate, Poor, Bad	O	x	x	x
4.59 Fluvial Functionality Index	unitless	O	x	x	x
5 RECOMMENDED INDICATORS OF NATURAL AND CLIMATE HAZARDS					
5.13 Disaster Resilience	unitless	S	x	x	x
5.14 Disaster-risk informed development	unitless	S	x		
5.15 Mean annual direct and indirect losses due to natural and climate hazards	€	O	x	x	x
5.16 Risk to critical urban infrastructure	%	O	x	x	x
5.17 Mean number of people adversely affected by natural disasters each year	unitless	O	x	x	x
5.18 Multi-hazard early warning	unitless	S	x		
6 ADDITIONAL INDICATORS OF NATURAL AND CLIMATE HAZARDS					
6.13 Potential areas exposed to risks					

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6.13.1 Urban/residential areas	ha	O	x	x	x
6.13.2 Productive areas	ha	O	x	x	x
6.14 Natural areas, sites of community importance and special protection areas	ha	O	x		
6.15 Potential population exposed to risks					
6.15.1 Inhabitants	No/ha	O	x	x	x
6.15.2 Area and population exposed to flooding	ha and No/ha	O	x	x	x
6.15.3 Other people (workers, tourists, homeless)	No/ha	O	x	x	x
6.15.4 Elderly, children, disabled	No/ha	O	x	x	x
6.16 Population Vulnerable to Risks	No/ha	O	x	x	x
6.17 Potential buildings exposed to risks					
6.17.1 Housing	No	O	x	x	x
6.17.2 Agricultural and industrial buildings	No	O	x	x	x
6.17.3 Strategic Buildings (Hospitals, schools, etc.)	No	O	x	x	x
6.18 Potential infrastructures exposed to risks					
6.18.1 Roads	m/km2	O	x	x	x
6.18.2 Railways	m/km2	O	x	x	x
6.18.3 Lifelines	m/km2	O	x	x	x
6.19 Potential infrastructures vulnerable to risks					
6.19.1 Buildings	No/km2	O	x	x	x
6.19.2 Transportation infrastructures and lifelines	m/km2	O	x	x	x
6.20 Insurance against catastrophic events	%	P	x		
6.21 Flood hazard	unitless	O	x	x	x
6.22 Flooded area	ha	O	x	x	x
6.23 Height of flood peak and time to flood peak	m3/s and h	O	x	x	x
6.24 Peak flow rate	m3/s and h	O	x	x	x
6.25 Peak flood volume	m3	O	x	x	x
6.26 Flood excess volume	m3	O	x	x	x
6.27 Moisture index	unitless	O	x	x	x
6.28 Flammability index	unitless	O	x	x	x
6.29 Soil Type	unitless	S		x	
6.30 Soil strength	kPa	S		x	
6.31 Soil temperature	°C	O	x	x	x
6.32 Level of Groundwater Table	m below ground surface	O	x	x	x
6.33 Shallow landslide risk – slope stability factor of safety	unitless	O	x	x	x
6.34 Landslide safety factor	unitless	O	x	x	x
6.35 Landslide risk – History of instability on site	unitless	S	x		

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6.36 Occurred landslide area	%	S	x		
6.37 Landslide risk – Digital elevation/terrain modelling	%	O	x	x	x
6.38 Soil mass movement	kg/ha	O	x	x	x
6.39 Velocity of occurred landslide	m/s	O	x		
6.40 Erosion risk	m3/year	O	x	x	x
6.41 Total Predicted Soil Loss	t/ha/y	O	x	x	x
6.42 Days with temperature >90th percentile (TX90p)	%	O	x	x	x
6.43 Warm spell duration index	unitless	O	x	x	x
6.44 Heatwave incidence	No./y	O	x	x	x
6.45 Human comfort: Universal thermal climate index	°C	O	x	x	x
6.46 Human comfort: Physiological equivalent temperature	°C	O	x	x	x
6.47 Mean or peak daytime temperature – Predicted Mean Vote-Predicted Percentage Dissatisfied	unitless	O	x	x	x
6.48 Urban Heat Island (UHI) incidence	°C	O	x	x	x
6.49 Effective drought index	unitless	O	x	x	x
6.50 Standardized Precipitation Index	unitless	S	x		
6.51 Quantitative status of groundwater	Good or Poor	O	x	x	x
6.52 Trend in piezometric levels (TPL)	m3/y	O	x	x	x
6.53 Groundwater exploitation index	%	O	x	x	x
6.54 Calculated drinking water provision	m3/ha/y	O	x	x	x
6.55 Water Exploitation Index	%	O	x	x	x
6.56 Net surface water availability	m3/y	O	x	x	x
6.57 Water availability for irrigation purposes	m3/y	O	x	x	x
6.58 Avalanche Risk: Snow cover map	unitless	S	x		
7 RECOMMENDED INDICATORS OF GREEN SPACE MANAGEMENT					
7.1 Green space accessibility	%	O	x		x
7.2 Total green space within a defined area: Share of green urban areas	Number (0-1)	O	x		x
7.3 Soil organic matter	%	O	x	x	x
7.3.1 Soil Organic Matter Index	Number (0-1)	O	x	x	x
8 ADDITIONAL INDICATORS OF GREEN SPACE MANAGEMENT					
8.1 Ecosystem service provision	N/A; Descriptive	O	x	x	x

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8.2 Annual trend in vegetation cover in urban green infrastructure	%	O			x
8.3 Edge density	m/ha	O	x		x
8.3.1 Public green space distribution	ha per capita	O	x		x
8.5 Distribution of blue space	%	O	x		x
8.6 Effective green infrastructure in the urban-rural interface	%	S	x		
8.7 Hot spot in peri-urban green infrastructure	%	S	x		x
8.8 Biotope Area Factor	%	O	x	x	x
8.9 Total vegetation cover	%	O	x	x	x
8.9.1 Woody vegetation cover	%	O	x	x	x
8.9.2 Non-woody vegetation cover	%	O	x	x	x
8.9.3 Total Leaf Area	m2	O	x	x	x
8.10 Diversity of green space	unitless	O	x	x	x
8.11 Stages of forest stand development -Number of class diameter	No. of individuals	O	x	x	x
8.12 Tree regeneration	number	O	x	x	x
8.13 Canopy gaps	dychotomic (Yes/No)	O	x	x	x
8.14 Tree biomass stock change	t/ha/y	O	x	x	x
8.15 Soil carbon content					
8.15.1 Measured soil carbon content	t/ha/y	O	x	x	x
8.15.2 Modelled carbon content of the upper soil layer	t/ha/y	O	x	x	x
8.15.3 Soil carbon to nitrogen ratio	unitless	O	x	x	x
8.15.4 Soil carbon decomposition rate	%	O	x	x	x
8.16 Soil matric potential	kPa	O	x	x	x
8.17 Soil temperature	°C	O	x	x	x
8.18 Soil water holding capacity	mm/cm depth	O	x	x	x
8.19 Plant-available water	mm/cm depth	O	x	x	x
8.19.2 Soil water available for plant uptake (SAW metric)	mm/cm depth	O	x	x	x
8.20 Vegetation Wilting Point	%	O		x	
8.21 Degree of soil saturation	%	O	x	x	x
8.22 Stemflow funnelling ratio	unitless	O	x	x	x
8.23 Soil Erodibility	mm3/ha	O	x	x	x
8.24 Total Predicted Soil Loss	t/ha/y	O	x	x	x
8.25 Soil Ecotoxicological Factor	Number (0-1)	O	x	x	x
8.26 Soil structure	unitless	S		x	
8.27 Soil chemical fertility/ cation exchange capacity	meq/100 g	O		x	
8.28 Flammability Index	unitless	O		x	
8.29 Community garden area	m2 per capita	O		x	x

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8.30 Food production in urban allotments and NBS	t/ha/y	O		x	x
8.31 Recreational opportunities provided by green infrastructure	Interactions/week	O	x	x	x
8.31.1 ESTIMAP nature-based recreation model	%	O	x	x	x
8.31.2 Number of visitors in new recreational areas	No.	O	x	x	x
8.31.3 Purpose of visits to recreational areas	unitless	O	x	x	x
8.31.4 Frequency of use of green and blue spaces	h/week	O	x	x	x
8.31.5 Activities allowed in recreational areas	No.	S	x		
8.32 Visual access to green space	Number (0-4)	O	x		x
8.32.1 Viewshed	km2	O	x		x
8.33 Satisfaction with green and blue spaces	Number (1-5)	O	x	x	x
8.34 Betweenness centrality	unitless	O	x		x
8.35 Proportion of road network dedicated to pedestrians and/or bicyclists	%	S	x		
8.35.1 New pedestrian cycling and horse paths	km	O	x		x
8.35.2 Sustainable transportation modes allowed	Number	S	x		
8.36 New links between urban centres and NBS	Number	S	x		
8.37 Walkability	Number	O	x	x	x
8.38 Land composition	% use class A, N, D, M	O	x		x
8.39 Land use change and green space configuration	various	O	x		x
8.40 Soil sealing	%	O	x		x
8.41 Ambient pollen concentration	Number	O	x	x	x
9 RECOMMENDED INDICATORS OF BIODIVERSITY ENHANCEMENT					
9.1 Structural and functional connectivity of urban green and blue spaces					
9.1.1 Structural connectivity of green space	various	O	x		x
9.1.2 Functional connectivity of urban green and blue spaces	various	O	x	x	x
9.2 Number of native species	Number	O	x	x	x
9.3 Number of non-native species introduced	Number	O	x	x	x
9.3.1 Number of invasive alien species	Number	O	x	x	x
9.4 Species diversity within defined area	Number	O	x	x	x
9.5 Number of species within defined area	Number	O	x	x	x
10 ADDITIONAL INDICATORS OF BIODIVERSITY ENHANCEMENT					

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10.1 Proportion of natural areas within a defined urban zone	%	O	x		x
10.2 Area of habitats restored	ha	O	x	x	x
10.3 Shannon Diversity Index of habitats	Number (unitless)	O	x	x	x
10.3.1 Abundance of ecotones/Shannon diversity	unitless	O	x	x	x
10.4 Length of ecotones	km	O	x	x	x
10.5 Publicly accessible green space connectivity	%	O	x	x	x
10.6 Ecological integrity	%	O	x	x	x
10.7 Proportion of protected areas	%	O	x		
10.7.1 Sites of community importance and special protection areas	ha	O	x		
10.7.2 Article17 habitat richness	No./grid	O	x	x	x
10.8 Number of veteran trees per unit area	No./ha	O	x	x	x
10.9 Quantity of dead wood per unit area	m3/ha	O	x	x	x
10.10 Forest habitat fragmentation – Effective Mesh Density	1/ha	O	x	x	x
10.11 Extent of habitat for native pollinator species	ha	O	x	x	x
10.12 Polluted soils	ha	O		x	x
10.13 Soil food web stability	unitless	O	x	x	x
10.14 Modelled C and N cycling in soil	t/ha/y	O	x	x	x
10.15 Equivalent used soil	m3	O			x
10.16 Number of conservation priority species	No.	O	x	x	x
10.17 Article17 species richness	No./grid	O	x	x	x
10.18 Number of native bird species within a defied urban area	No./ha	O	x	x	x
10.19 Species diversity – general	No.	O	x	x	x
10.19.1City Biodiversity Index	%	O	x	x	x
10.20 Bird species richness	No./grid	O	x	x	x
10.21 Animal species potentially at risk	No./ha	O	x	x	x
10.22 Typical vegetation species cover	%	O	x	x	x
10.23 Pollinator species presence	No./ha or %	O	x	x	x
10.24 Biodiversity Conservation	various	O	x	x	x
10.25 Metagenomic mapping	unitless	O	x	x	x
10.25.1Abundance of functional groups	Number (unitless)	O	x	x	x
10.25.2 Diversity of functional groups (plants)	Number (unitless)	O	x	x	x
10.25.3 Diversity of functional groups (animals)	Number (unitless)	O	x	x	x
11 RECOMMENDED INDICATORS OF AIR QUALITY					

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11.1 Number of days during which air quality parameters exceed threshold values	No. of days	O	x	x	x
11.2 Proportion of population exposed to ambient air pollution	%	O	x	x	x
11.3 European Air Quality Index	Good, Fair, Moderate, Poor, Very Poor, Extremely Poor	O	x	x	x
12 ADDITIONAL INDICATORS OF AIR QUALITY					
12.1 Removal of atmospheric pollutants by vegetation	kg/ha/y	O	x	x	x
12.2 Total particulate matter removed by NBS vegetation	kg/ha/y	O	x	x	x
12.3 Modelled O3, SO2, NO2 and Co capture/removal by vegetation	kg/ha/y	O	x	x	x
12.3.1 Total Leaf Area	m2	O	x	x	x
12.4 NOX and PM in gaseous releases	PM- µg/m3 NOx - ppb	O			x
12.5 Ambient pollen concentration	Number	O	x	x	x
12.6 Trends in NOx and SOx emissions	µg/m3	O	x	x	x
12.7 Concentration of particulate matter (PM10 and PM2.5), NO2 and O3 in ambient air	µg/m3	O	x	x	x
12.8 Concentration of particulate matter at respiration height along roads	µg/m3	O	x	x	x
12.9 Mean level of exposure to ambient air pollution	µg/m3	O	x	x	x
12.10 Morbidity, Mortality and Years of Life Lost due to poor air quality	No./y, No./y and y	O	x	x	x
12.11 Avoided costs for air pollution control measures	€	O	x	x	x
13 RECOMMENDED INDICATORS OF PLACE REGENERATION					
13.1 Derelict land reclaimed for NBS	ha	O			x
13.2 Quantity of blue-green space as ratio to built form	Number (0-1)	O	x		x
13.3 Perceived quality of urban green, blue and blue-green spaces	various	O	x		x
13.4 Place attachment: Place identity or "Sense of Place"		O	x	x	x
13.5 Recreational value of public green space	various	O	x	x	x
13.6 NBS incorporated in building design / incorporation of environmental design in buildings	Number (0-5)	P			x

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13.7 Cultural heritage protection	Number (0-5)	P	x		
14 ADDITIONAL INDICATORS OF PLACE REGENERATION					
14.1 Share of Green Urban Areas	%	O	x		x
14.2 Land composition	% use class A, N, D, M	O	x	x	x
14.3 Land take index	%	O			x
14.4 Area devoted to roads	Number (0-1)	O	x		x
14.5 Traditional knowledge and uses reclamation	Yes/No	O	x	x	x
14.6 Traditional events organised in NBS areas	No.	O	x		x
14.7 Social active associations	No.	S	x	x	x
14.8 Retail and commercial activity in proximity to green space	%	O	x		x
14.9 Number of new businesses created and gross value added to local economy	No. of businesses and €	O	x		x
14.10 Social return on investment	€/€	O			x
14.11 Population mobility	%	O	x	x	x
14.12 Population growth	%	O	x	x	x
14.13 Proportion of elderly residents	%	O	x	x	x
14.14 Areal sprawl	m2/m2	O	x		
14.15 Access to public amenities	various	O	x		x
14.16 Average distance of natural resources from urban centres/train station/public transport	km	O	x		x
14.17 Natural and cultural site availability	km2	O	x		x
14.18 Historical and cultural meaning	unitless	O	x	x	x
14.19 Cultural value of blue-green spaces	various	O	x		x
14.20 Opportunities for tourism	No./year	O	x		x
14.21 Building structure – Urban form	Dimensionless (0-140)	P	x		x
14.22 Material used coherence	Yes/No	P			x
14.23 Techniques used coherence	Yes/No	P			x
14.24 Design for sense of place	Number (0-5)	P	x		x
14.25 Viewshed	km2	O	x		x
14.26 Scenic sites and landmarks created	No.	O	x		x
14.27 Scenic paths created	km	O	x		x
15 RECOMMENDED INDICATORS OF KNOWLEDGE AND SOCIAL CAPACITY BUILDING FOR SUSTAINABLE URBAN TRANSFORMATION					
15.1 Citizen involvement in environmental education activities	No. of people	O	x	x	x
15.2 Social learning regarding ecosystems and their functions	Qualitative data (dimensionless)	O	x	x	x
15.3 Pro-environmental identity		O	x	x	x

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15.4 Pro-environmental behaviour	Number (0-168)	O	x	x	x
16 ADDITIONAL INDICATORS OF KNOWLEDGE AND SOCIAL CAPACITY BUILDING FOR SUSTAINABLE URBAN TRANSFORMATION					
16.1 Children involved in environmental educational activities	No./y	O	x	x	x
16.2 Engagement with NBS sites/projects	Qualitative data (dimensionless)	P	x	x	x
16.3 Mindfulness	Number (0-3)	O	x	x	x
16.4 Proportion of schoolchildren involved in gardening	%	O			x
16.5 Citizens' awareness regarding urban nature and ecosystem services	Number (0-5)	O	x	x	x
16.6 Green intelligence awareness	No. activities; No. attendees; No. Publications	O	x	x	x
16.7 Positive environmental attitudes motivated by contact with NBS		S, O			
16.8 Urban farming educational and/or participatory activities	Qualitative data (dimensionless)	O		x	x
17 RECOMMENDED INDICATORS OF PARTICIPATORY PLANNING AND GOVERNANCE					
17.1 Openness of participatory processes	Number (1-5)	P	x	x	x
17.1.1 Openness of participatory processes: proportion of citizens involved	%	P	x	x	x
17.2 Sense of empowerment: perceived control and influence over decision-making		O	x	x	x
17.3 Adoption of new forms of participatory governance: Public-private partnerships activated	No.	O	x	x	x
17.4 Policy learning for mainstreaming NBS: Number of new policies instituted	No.	S	x	x	x
17.5 Trust in decision-making procedure and decision-makers	Number (1-5)	O	x	x	x
18 ADDITIONAL INDICATORS OF PARTICIPATORY PLANNING AND GOVERNANCE					
18.1 Community involvement in planning	Number (0-5)	P	x	x	x
18.1.1 Citizen involvement in co-creation/co-design of NBS	No.	P			x
18.1.2 Stakeholder involvement in co-creation/co-design of NBS	No.	P			x
18.2 Community involvement in implementation	Number (0-5)	P		x	x
18.3 Involvement of citizens from traditionally under-represented groups	Number (0-5)	P	x	x	x
18.4 Active engagement of citizens in decision-making	%	P	x	x	x

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18.5 Consciousness of citizenship	Number (0-5)	O	x	x	x
18.6 Number of governance innovations adopted	Number (0-5)	S	x	x	x
18.7 Adoption of new forms of NBS (co-)financing	Number (0-5)	O	x	x	x
18.8 Development of a climate resilience strategy (extent)	Number (0-7)	O	x	x	x
18.9 Alignment of climate resilience strategy with UNISDR-defined elements	Number (0-5) across 117 categories	O	x	x	x
18.10 Adaptation of local plans and regulations to include NBS	Number (0-5)	O	x	x	x
18.11 Perceived ease of governance of NBS	Number (0-5)	O	x	x	x
18.12 Diversity of stakeholders involved	%	P	x	x	x
18.13 Transparency of co-production	Number (1-5)	P	x	x	x
18.14 Activation of public-private collaboration	No.	O	x	x	x
18.15 Reflexivity: identified learning outcomes	No.	P	x	x	x
18.16 Facilitation skills for co-production	Number (1-5)	P	x	x	x
18.17 Procedural fairness	Number (1-5)	P	x	x	x
18.18 Strategic alignment	Number (1-5)	P	x	x	x
18.19 Reflexivity: time for reflection	No.	P	x	x	x
19 RECOMMENDED INDICATORS OF SOCIAL JUSTICE AND SOCIAL COHESION					
19.1 Bridging and bonding – quality of interactions within and between social groups					
19.1.1 Bridging		O	x	x	x
19.1.2 Bonding		O	x	x	x
19.2 Inclusion of different social groups in NBS projects	Number (0-5)	P	x	x	x
19.3 Trust within the community		O	x	x	x
19.4 Solidarity among neighbours		O	x	x	x
19.5 Tolerance and respect		O	x	x	x
19.6 Availability and equitable distribution of blue-green space	map	O	x	x	x
20 ADDITIONAL INDICATORS OF SOCIAL JUSTICE AND SOCIAL COHESION					
20.1 Linking social capital		O	x	x	x
20.2 Perceived social interaction	Number (0-5) across 4 categories	O	x	x	x
20.3 Quantity and quality of social interaction	Frequency	O	x	x	x
20.4 Perceived social support					
20.4.1 Perception of socially supportive network	Number (0-5) across 5 categories	O	x	x	x
20.4.2 Perceived social support	Number (0-4)	O	x	x	x

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20.5 Perceived social cohesion	Number (0-4)	O	x	x	x
20.6 Perceived ownership of space and sense of belonging to the community	Number (0-5) across 2 categories	O	x	x	x
20.7 Proportion of community who volunteer	Number (0-5)	O		x	x
20.8 Proportion of target group reached by an NBS project	%	O	x	x	x
20.9 Perceived personal safety	Number (0-5)	O	x	x	x
20.10 Perceived safety of neighbourhood		O	x	x	x
20.11 Number of violent incidents, nuisances and crimes per 100 000 population	Np. Per 100 000	O	x	x	x
20.12 Realised safety		O	x	x	x
20.13 Area easily accessible for people with disabilities	km2	O	x	x	x
20.14 Change in properties incomes	%	O	x	x	x
21 RECOMMENDED INDICATORS OF HEALTH AND WELLBEING					
21.1 Level of outdoor physical activity		O	x		x
21.2 Level of chronic stress (Perceived stress)	Number (0-4)	O	x	x	x
21.3 General wellbeing and happiness	Number (0-7)	O	x	x	x
21.4 Self-reported mental health and wellbeing	Number (1-6)	O	x	x	x
21.5 Cardiovascular diseases (prevalence, incidence)	% , % per year	O	x		x
21.5 Morbidity, mortality due to cardiovascular disease	No./y	O	x		x
21.6 Quality of Life	Number (1-5)	O	x	x	x
22 ADDITIONAL INDICATORS OF HEALTH AND WELL-BEING					
22.1 Self-reported physical activity	Minutes per week	O	x		x
22.2 Observed physical activity level within NBS	% over 3 levels of physical activity (sedentary, walking, or vigorous)	O	x		x
22.3 Encouraging a healthy lifestyle	Number (1-5)	O	x		x
22.4 Incidence of obesity	% per year	O	x		x
22.5 Heat-related discomfort: Universal Thermal Climate Index (UTCI)	oC	O	x		x
22.6 Hospital admissions due to high temperature during extreme heat events	No. per 100 000	O	x		x
22.7 Heat-related mortality	No. per 1 000 000 per year	O	x		x
22.8 Exposure to noise pollution	%	O	x		x

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22.9 Perceived chronic loneliness	Number (1-3) across 3 categories	O	x	x	x
22.10 Somatisation	Low, Moderately high, Very high	O	x	x	x
22.11 Mindfulness	Number (0-4) across 12 categories	O	x	x	x
22.12 Visual access to green space	Number (0-4)	O	x		x
22.12 Time spent viewing green space from residence each day	Number (0-3)	O	x		x
22.13 Perceived restorativeness of public green space/ NBS	Number (0-10) across 4 categories	O	x	x	x
22.14 Perceived social support	Number (0-4)	O	x	x	x
22.15 Connectedness to nature	Number (1-5) across 14 categories	O	x	x	x
22.16 Prevalence of attention deficit/ hyperactivity disorder (ADHD)	%	O	x		x
22.17 Exploratory behaviour in children		O	x		x
22.18 Self-reported anxiety	Mild, Moderate, Severe	O	x	x	x
22.19 Prevalence, incidence, morbidity and mortality of respiratory diseases	%, %per year, No./y, No./y	O	x	x	x
22.20 Morbidity, Mortality and Years of Life Lost due to poor air quality	No./y, No./y, No. of years	O	x	x	x
22.21 Prevalence and incidence of autoimmune diseases	%, % per year	O	x	x	x
22.22 Prevalence, incidence and morbidity of chronic stress	%, % per year and No./y	O	x	x	x
23 RECOMMENDED INDICATORS OF NEW ECONOMIC OPPORTUNITIES AND GREEN JOBS					
23.1 Valuation of NBS					
23.1.1 Value of NBS calculated using GI-Val	€	O	x	x	x
23.1.2 Economic Value of Urban Nature Index	€	O	x	x	x
23.2 Mean land and/or property value in proximity to green space	€	O	x		x
23.2.1 Change in mean house prices/ rental markets	€	O	x		x
23.2.2 Average land productivity and profitability	€/ha	O	x	x	x
23.2.3 Property betterment and visual amenity enhancement	€/m2	O	x		x

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23.3 Direct economic activity: Number of new jobs created	€/year	O	x	x	x
23.4 Direct economic activity: Retail and commercial activity in proximity to green space	%	O	x		x
23.5 Direct economic activity: Gross value added to local economy from new business creation	%/year	O	x	x	x
23.6 Recreational monetary value	€/year	O	x		x
23.7 Overall economic, social and health wellbeing	Human Development Index	O	x	x	x
24 ADDITIONAL INDICATORS OF NEW ECONOMIC OPPORTUNITIES AND GREEN JOBS					
24.1 New businesses established in proximity to NBS	No./year	O	x		x
24.2 Value of rates paid by businesses in proximity to NBS	€/year	O	x		x
24.3 New customers to businesses in proximity to NBS	Mean No./day per quarter	O	x		x
24.4 Local economy GDP in proximity to NBS	€/year	O	x		x
24.5 Initial costs of NBS implementation	€	O	x	x	x
24.6 Maintenance costs of NBS	€/year	O	x	x	x
24.7 Replacement costs of NBS	€	O	x	x	x
24.8 Avoided costs due to NBS implementation	€	O	x	x	x
24.9 Payback period for NBS	year	O	x	x	x
24.10 Reduced/avoided damage costs from hydro meteorological risk reduction	€/year	O	x	x	x
24.11 Social Return on Investment (SROI)	€/€	O	x	x	x
24.12 Income generated via application of green administrative policies within Living Lab district	€/year	O	x	x	x
24.13 Subsidies applied for private NBS measures	€/year	O	x	x	x
24.14 Private finance attracted to the NBS site	€/year	O	x	x	x
24.15 Increase in tourism	Mean no. visitors/day per year	O	x		x
24.16 New activities in the tourism sector	Number (1-5)	O	x		x
24.17 Gross profit from nature-based tourism	€/year per km2	O	x		x
24.18 Number of new jobs in green sector	%	O	x	x	x
24.19 Jobs created in NBS construction and maintenance	Number (1-5)	O	x	x	x
24.20 New employment in the tourism sector	Number (1-5)	O	x		x
24.21 Turnover in the green sector	%	O	x	x	x
24.22 Employment in agriculture	No./ha	O	x	x	x
24.23 Rural Productivity Index	€/ha	O	x	x	x
24.24 Economic value of productive activities vulnerable to risks	€/km2	O	x	x	x
24.25 Innovation impact	No. Innovations	O	x	x	x

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24.26 Income/Disposable income per capita	€/year per person	O	x	x	x
24.27 Upskilling and related earnings increase	Increase in employment earnings per person per year	O	x	x	x
24.28 Population mobility	% in 1 y % in 2 y % in 5 y	O	x		x
24.29 Avoided cost of run-off treatment	€/y	O	x	x	x
24.30 Correction Cost of Groundwater Quality	€/m3	O	x	x	x
24.31 Dissuasive cost of water abstraction	€/m3	O	x	x	x
24.32 Average water productivity	€/m3	O	x	x	x
24.33 New areas made available for traditional productive uses	km2	O	x	x	x
24.34 Value of food produced in NBS	€/y	O		x	x
24.35 Renewable energy produced in NBS	kWh/y	O			x

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