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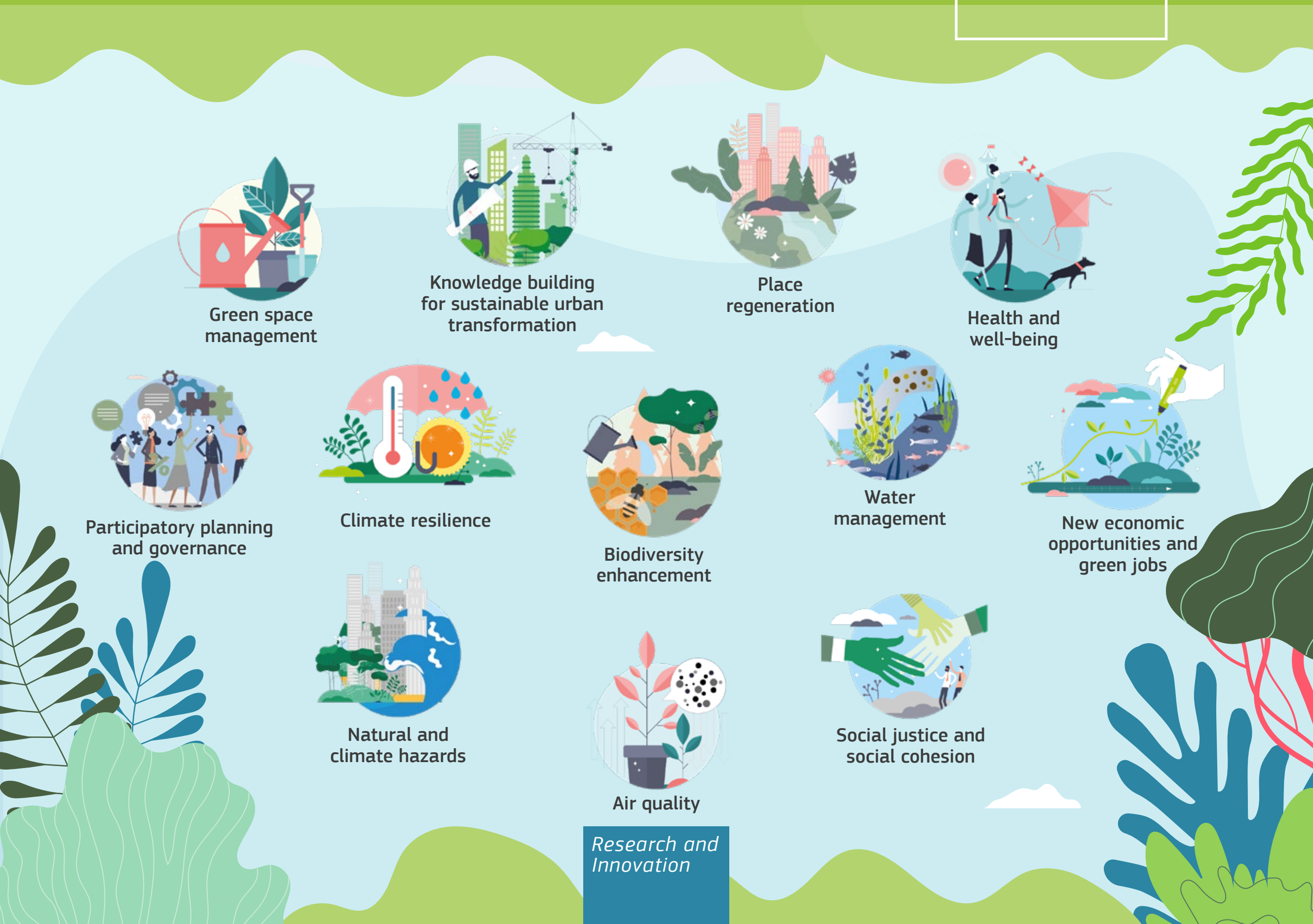
EVALUATING THE IMPACT OF NATURE-BASED SOLUTIONS

A Handbook for Practitioners

Independent Expert Report



Research and Innovation

Evaluating the Impact of Nature-based Solutions: A Handbook for Practitioners

European Commission
Directorate-General for Research and Innovation
Directorate C — Healthy Planet
Unit C3 — Climate and Planetary Boundaries

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A Handbook for Practitioners

Adina Dumitru and Laura Wendling, Eds.

2021

Directorate-General for Research and Innovation
Healthy Planet - Climate and Planetary Boundaries

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Summary

***What** is this chapter about?*

Selecting appropriate indicators of NBS performance and impact can be challenging, and is context-dependent. In this chapter, we present case studies from a variety of NBS demonstrations across Europe and Asia that illustrate the application of the NBS indicators and methods presented in Chapter 4 and thoroughly described in *Evaluating the Impact of Nature-Based Solutions: Appendix of Methods*. Each case study presents a brief NBS description, reasons for the selection of specific indicators for that particular NBS and a brief overview of the ways the indicators are applied and/or monitored. The case studies describe the stakeholders involved in co-design and co-monitoring of NBS and discuss the barriers and lessons learned during or after the process. Each case study provides key references for further reading.

The case studies in this chapter focus on the selection of recommended indicators for NBS performance and impact, which are generally of primary importance when creating NBS monitoring and evaluation plans. The case studies further demonstrate how and why additional indicators can be selected to reflect particular objectives of projects and local challenges.

***How** can I use this chapter in my work with NBS?*

The examples of indicator application illustrate the practice of selecting the appropriate indicators from the pool of indicators presented in Chapter 4. This information will aid in understanding *why* and *how* to select indicators for evaluating NBS performance and impact.

Information from the case studies presented in Chapter 5 can be used to support planning, indicator selection, execution and monitoring of NBS.

***When** should I use this knowledge in my work with NBS?*

We recommend consulting the case studies during the early stages of NBS planning and deployment, and well before selecting indicators and establishing NBS monitoring.

***How** does this chapter link with the other parts of the handbook?*

Chapter 5 complements the presentation of NBS indicators (Chapter 4 and Appendix of Methods) by presenting explicit examples tied to concrete NBS actions. This chapter assists in making a selection of the indicators listed under Chapter 4. It provides insights into NBS monitoring approaches described in Chapters 2, 3 and 6, and alludes to data generation techniques discussed in Chapter 7.

5.1 Introduction to holistic NBS impact assessment using the framework of recommended indicators

A series of concrete examples of the application of Recommended indicators are provided here to illustrate the type of narrative it is possible to develop from the gathered evidence. Specific messages regarding NBS outcomes can be tailored for different stakeholders, e.g., citizens, investors, policy-makers, etc. The Recommended indicators illustrated in the following examples reflect the multi-functionality of NBS and highlight synergies between outcomes in different societal challenge areas.

For the sake of demonstrating the importance of each individual indicator, the case studies presented herein describe only the basis for the selection of one, or in some cases several, either Recommended or Additional indicators (Chapter 4). This approach was adopted to highlight the importance of the Recommended indicators as the primary indicators to be addressed when creating NBS monitoring and evaluation plans, and to emphasise the value of selecting unique and complementing Additional indicators based on projects' objectives and the local challenges NBS aim to address. The case studies were selected per projects' suggestions given their relative advancement in NBS and their monitoring strategy implementation. It should be noted that although the case studies present indicators associated with a specific impact (e.g., water quality or air quality), the NBS exhibit a much greater number of impacts and co-benefits (e.g., on biodiversity, health and well-being), which must be considered when designing a monitoring strategy.

It is important to note that selected indicators of NBS impact should capture not only the range of different NBS co-benefits, but should also shed light on trade-offs for different social groups and between different challenge areas. For example, issues of gentrification, social justice and similar should be carefully considered in order to gain an understanding of both benefits and trade-offs, and to identify potential issues in order to develop effective mitigation strategies.

This Chapter is presented as a series of case studies related to the selection of Recommended indicators and Additional indicators. Table 6-1 lists the Recommended and Additional indicators illustrated in the case studies.

Table 5-1. Case studies illustrating the selection of Recommended and Additional indicators.

Challenge	Recommended indicator case study	Additional indicator case study
Climate Resilience	Carbon storage	Urban Heat Island incidence
Water Management	Water quality: total suspended solids (TSS) content; Nitrogen and phosphorus concentration or load	–
Natural and Climate Hazards	–	Flood risk
Green Space Management	Green space accessibility	Walkability; Annual trend in vegetation cover; Nature-based recreation; Land composition
Biodiversity Enhancement	Green infrastructure connectivity	Number of conservation priority species
Air Quality	PM_{10} and $PM_{2.5}$ concentrations	Trends in NO_x and SO_x emissions
Knowledge and Social Capacity Building for Sustainable Urban Transformation	–	Connectedness to nature
Social Justice and Social Cohesion	–	Perceived social support
Health and Wellbeing	Level of outdoor physical activity (min/week); Level of chronic stress ("Perceived stress"); Self-reported general wellbeing	Prevalence, incidence, morbidity of chronic stress; Perceived chronic loneliness

5.1.1 *Recommended indicators case study from Tampere, Finland*

NBS Name and Location	Vuores stormwater management system **(incl. retention pond, biofilter, alluvial meadows)** **Tampere (Finland)**
Brief description of NBS	The Vuores district is a new district in the City of Tampere (Finland), featuring an extensive stormwater management system (in Virolainen- and Tervaslampi Parks) comprising of several NBS, including the retention pond, biofilter, and alluvial meadows. The Vuores catchment drains to the Lake Koipijärvi, so preservation of the lake water quality was the main driver for creating a comprehensive urban runoff management (quality and quantity) system. Virolainen Park: – Biofilter (with sand as a filtering media): Treatment of urban runoff and runoff from a dog park Tervaslampi Park: – Retention pond: Treatment (retention and sedimentation) of urban runoff from new housing area – Alluvial meadows: Space for retention of the urban runoff at times of heavy rainfall Useful links: https://unalab.eu/en/our-cities/city-tampere www.tampere.fi/unalab (in Finnish)
Indicators of relevance	**3.2 Water quality: total suspended solids (TSS) content** **3.3 Nitrogen and phosphorus concentration or load**
Explanation for selection of Indicators in this case	Due to the densification and urbanisation of the newly built areas, stormwater quality management was the main priority for the City of Tampere to prevent the water quality deterioration of the local waterbodies. TSS content and nutrient (N and P) concentrations comprise the critical water quality constituents determining the urban runoff quality entering the surface waterbodies and their possible adverse effects on the aquatic environment (e.g., eutrophication). The NBS addressing water quality further aid in delivering a variety of co-benefits, including water quantity management, enhancement of local biodiversity, and contributing to increased local environmental awareness.
Description of Indicator Application	Multiple NBS across the Vuores district are equipped with the online water quality sensors continuously measuring a variety of water quality parameters. Each sensor is capable of measuring the basic water quality parameters, including nitrate-nitrogen (NO_3-N) concentrations. Subsequently, the sensors calculate total phosphorus concentration based on the turbidity measurements, and total nitrogen concentration based on the nitrate-nitrogen measurements. Manual sampling for TSS content is performed at regular time intervals.

Stakeholders involved	City representatives, citizens, NGOs, public and private sector actors (incl. research organisations), and representatives from universities
Barriers encountered and lessons learned	Barriers to 'physical' NBS implementation in Tampere included the biofilter space requirements in Virolainen Park. Some residents found the alluvial meadows and wetland vegetation (Figure 5-1) lacking the aesthetics. However, this was overcome through awareness raising with the information signs and during the co-creation workshops. The stakeholder engagement proved to be successful after a series of co-creation workshops that resulted in the change of plans for the Vuores area development, additionally considering local biodiversity, health and water management aspects (Särkilahti 2019).
Case study authors	Maria Dubovik[1] (maria.dubovik@vtt.fi), Ville Rinta-Hiiro[1], Maarit Särkilahti[2], Salla Leppänen[2] *[1]VTT Technical Research Centre of Finland, Espoo, Finland* *[2]City of Tampere, Finland*
References	Särkilahti, M., 'Co-creating nature based solutions in EU project demonstration city Tampere', *Rakennustekniikka*, 2019. Available from: https://www.ril.fi/fi/rakennustekniikka/teemat/co-creating-nature-based-solutions-in-eu-project-demonstration-city-tampere.html

Figure 5-1. Nature-based solutions in Vuores Central Park (© City of Tampere).

5.1.2 *Recommended indicators case study from Valladolid, Spain*

NBS name and location	Urban carbon sink **Valladolid Demo Site.** **The Urban Carbon Sink is located in the eastern part of the municipality of Valladolid, in the neighbourhood known as Los Santos-Pilarica (Sector 50, "Los Santos 2").**
Brief description of NBS	The Urban Carbon Sink (UCS; Figure 5-2) is conceived as an urban forest in which species have been selected mainly for their ability to fix carbon. Therefore it is a nature-based solution for the over-accumulation of carbon dioxide in cities' atmosphere. The design of the UCS is embedded into another projected NBS, the Floodable Park. It will consist in the installation of urban woodland (initially planned planting 1,500 trees in a 40,000 m^2 surface) with appropriate species adapted to temporary flood condition and with high capacity of carbon sequestration (*Fraxinus* spp., *Betula* spp., *Salix* spp., *Populus* spp., etc.). Trees of this forest will be allocated in specific arboreal series. This area will be a new urban carbon sink and will form a new urban ecosystem to preserve the biodiversity. Likewise, this woodland will provide biomass to energy use with social and economic purposes. Expected impacts: The UCS will be located close to industrial and traffic areas, which act as a source of carbon dioxide emissions due to combustion processes. This NBS is proposed to compensate the emissions of this greenhouse gas, capturing it in the form of biomass. In order to achieve this effect, it is necessary to include specific criteria for taxon selection composition and typology of them during designing stage of UCS. Likewise, it will be essential to take into account to establish a management plan (pruning, spacing, etc.). Multicriteria species assessment is required, focused on C fixation capacity, in addition with other aspects, such as native vegetation, easy management, aesthetics, health, ecological coherence and integrity criteria. Impacts derived from UCS implementation must be evaluated on medium-long term, since to C fixation capacity of the species is highly related to the maturity grade of the taxa.

Figure 5-2. Urban Carbon Sink conceptual design (URBAN GreenUP project)

Indicators of relevance	**1.1 Total carbon removed or stored in vegetation and soil per unit area per unit time** Temperature decrease Heatwave risk Green space distribution (m^2/capita) Green space distribution (km cycle lane/capita) **7.1 Green space accessibility** Green areas sustainability Elderly people life quality **9.1 Green infrastructure connectivity** Pollinator species increase
Explanation for selection of Indicators	This NBS will improve the accessibility to green space value in the area for the surrounded population, with 40.000 m^2 of new available green space. Other indicators that are related with this NBS are those related with Carbon storage, as it is the main purpose of this NBS.
Description of Indicator Application	In this case, the main indicator for impact assessment is 01.01 and 01.02 and additionally the other ones. This indicator will need an spatial and statistical analysis, following the following algorithm (Figure 5-3):

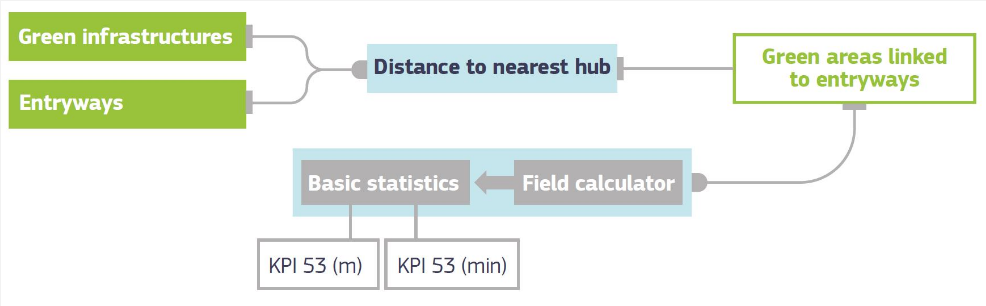

Figure 5-3. Suggested algorithm for the QGIS process as defined in Deliverable D2.4: Monitoring Program to Valladolid from the URBAN GreenUP Project.

In this case, "Green infrastructures" is referred to the arriving point and "entryways" to departure point.

Stakeholders involved	Different municipality areas (at least urbanism, environment and heritage), car park property, construction and gardening companies, River Duero Basin (it is located in the Esgueva River bank).
Barriers encountered and lessons learned	Main barriers are located in the availability of data required for this Indicator.
Case study authors	Raúl Sánchez[1], Jose Fermoso[1], Francisco Verdugo[1], Raquel Marijuan[1], Silvia Gómez, María González[1], José María Sanz[1], Esther San José[1] *[1]CARTIF Foundation. P.T. Boecillo, 205, 47151, Boecillo, Valladolid, Spain*

5.1.3 Recommended indicators case study from Guildford, UK

NBS name and location	Roadside green infrastructure **Guildford, UK**

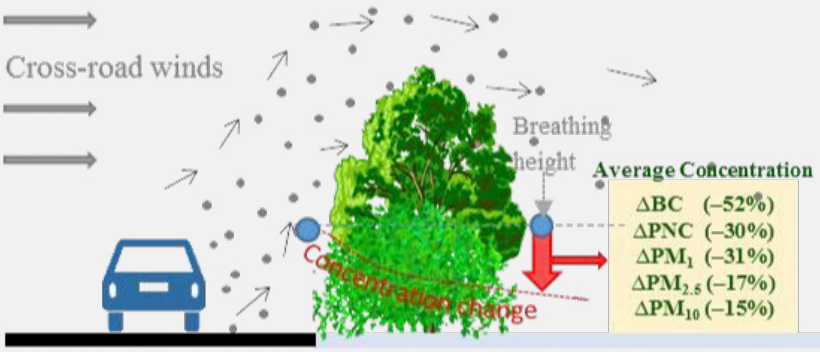

Figure 5-4. Roadside green infrastructure.

Brief description of NBS	**Roadside Green Infrastructure** (Figure 5-4) includes trees, hedges, individual shrubs, green walls, and green roofs. The focus of the iSCAPE pilot in Guildford (UK) was air pollution abatement and in specific on particulate matter (PM), which is composed of particles such as black carbon (BC). The pilot focused on near-road environments, where vegetation can act as a barrier between traffic emissions and pedestrians (figure below), by collecting pollutants and/or redirecting the flow of polluted air (Abhijith et al., 2017; Kumar et al., 2019; Riondato et al., 2020; Tiwari et al., 2019). This study performed as part of iSCAPE (GA nº 689954) pioneered the adoption of this kind of nature based solution as a passive control system for roadside pollution in urban street canyon and open road settings. The pilot assessed through monitoring and modelling different combinations of trees, hedges and individual shrubs to assess their performances in urban street canyon and open road settings in terms of abatement of road traffic particulate matter (PM). Project results show that green barriers can produce a reduction of concentration of Black Carbon up to 52%, PM_1 up to 31%, $PM_{2.5}$ up to 17%, PM_{10} up to 15%. A series of design parameters were also created for both urban street canyon and open road settings to help planners in the effective deployment of this kind of air pollution abatement intervention (Kumar et al., 2019):

Considerations for urban street canyon green infrastructure	
Design parameter	**Considerations**
Location	If the prime objective is to reduce exposure for pedestrians or cyclists, hedges should be planted close to the road, between the

	road and footpath/bike path. Green walls can be constructed on the pillars of flyovers, retaining walls and other boundary walls.
Selection of vegetation	In deep street canyons, no forms of vegetation except green walls are recommended. In mid-depth street canyons (Table 4), shrubs or hedges and green walls can be planted, but trees are not recommended. Large, dense trees should be avoided in all street canyons, but smaller or lighter-crowned trees may be planted in shallow street canyons.
Spacing	Continuous hedges (with no gaps or spacing) provide a better reduction in exposure for pedestrians and cyclists. If trees are to be planted (shallow canyons only), they should be spaced generously apart from one another.
Height	For hedges, a height of around 2m is recommended.
Thickness	For hedges, a thickness of 1.5m or more is recommended.
Density	In street canyons, a higher density for hedges and lower density for trees is recommended.

Considerations for open road green infrastructure	
Design parameter	**Considerations**
Location	Hedgerows should be planted between the road and walkways or dwellings and in front of trees (if present); this configuration offers the maximum reduction of exposure.
Spacing	Barriers with no gaps provide better downwind exposure reduction.
Height	Where possible, it is recommended that the combined hedge-tree barrier or green wall has a height of 5m or more. Vegetation barriers with greater height result in increased pedestrian-side pollutant reductions. A minimum height of 1.5m is recommended.
Thickness	The vegetation should be as thick as possible; thicker vegetation barriers offer greater exposure reduction. If possible, a thickness of more than 5m is recommended.
Density	High-density vegetation barriers are generally better for reducing exposure levels downwind.

Indicators of relevance	Monetary values: value of air pollution reduction; total monetary value of urban forests including air quality, run-off mitigation, energy savings, and increase in property values. **11.1 Air quality parameters (Particulate Matter)†** Concentration of particulate matter (PM2.5 and PM10) at respiration height along roadways and streets. *†Contributes to evaluating indicators 12.7/12.8*
Explanation for selection of Indicators	In future, if this NBS is widely installed it can be used recommended indicators for Air Quality challenges (Figure 5-5). Recommended indicators have a scale of measurement from district to region and they have not sensibility enough to study the impact of this NBS. Therefore, in the meantime it is needed additional indicators to assess the impact on air pollutants emission reduction with indicators such as the ones mentioned before.

Description of Indicator Application	In this case, the main indicators for impact assessment is 6.11 and 6.13. 6.11 implies the installation of sensors for continuous monitoring of PM on the two sides of the deployed green barrier NBS. It is also recommended to complement the monitoring campaign with modelling to account for the impact of local climate.
Stakeholders involved	A wide range of stakeholders including local authorities, academia and local community which were involved in co-design and co-monitoring activities.
Barriers encountered and lessons learned	The main challenge was the initial engagement of the stakeholders for the co-design and co-monitoring activities part of the Living Lab framework embraced by iSCAPE. The development of a solid strategy resulted in a very high engagement of the stakeholders in this pilot, which allowed to produce the adequate bottom-up support to push the findings from the pilot into policy within the lifetime of the project. The findings were endorsed and operationalised as policy by the Mayor of London (https://www.london.gov.uk/sites/default/files/green_infrastruture_air_pollution_may_19.pdf). The pilot clearly demonstrated the advantages of involving a wide range of stakeholders in the various stages of the design, development and monitoring of NBS. It also clearly demonstrated the effectiveness, if appropriately deployed, of common elements of green infrastructure as passive control systems for air pollution.
Case study authors	Francesco Pilla[1], Prashant Kumar[2] *[1]Spatial Dynamics Lab, University College Dublin, Ireland* *[2]Global Centre for Clean Air Research, University of Surrey, UK*
References	Abhijith, K.V., Kumar, P., Gallagher, J., McNabola, A., Baldauf, R., Pilla, F., Broderick, B., Di Sabatino, S. and Pulvirenti, B., 'Air pollution abatement performances of green infrastructure in open road and built-up street canyon environments–A review', *Atmospheric Environment*, Vol. 162, 2017, pp. 71-86. Kumar, P., Abhijith, K.V. and Barwise, Y., *Implementing green infrastructure for air pollution abatement: General recommendations for management and plant species selection*, 2019. Riondato, E., Pilla, F., Basu, A.S. and Basu, B., 'Investigating the effect of trees on urban quality in Dublin by combining air monitoring with i-Tree Eco model', *Sustainable Cities and Society*, Vol. 61, 2020, p. 102356. Tiwari, A., Kumar, P., Baldauf, R., Zhang, K.M., Pilla, F., Di Sabatino, S., Brattich, E. and Pulvirenti, B., 'Considerations for evaluating green infrastructure impacts in microscale and macroscale air pollution dispersion models', *Science of The Total Environment*, Vol. 672, 2019, pp. 410-426.

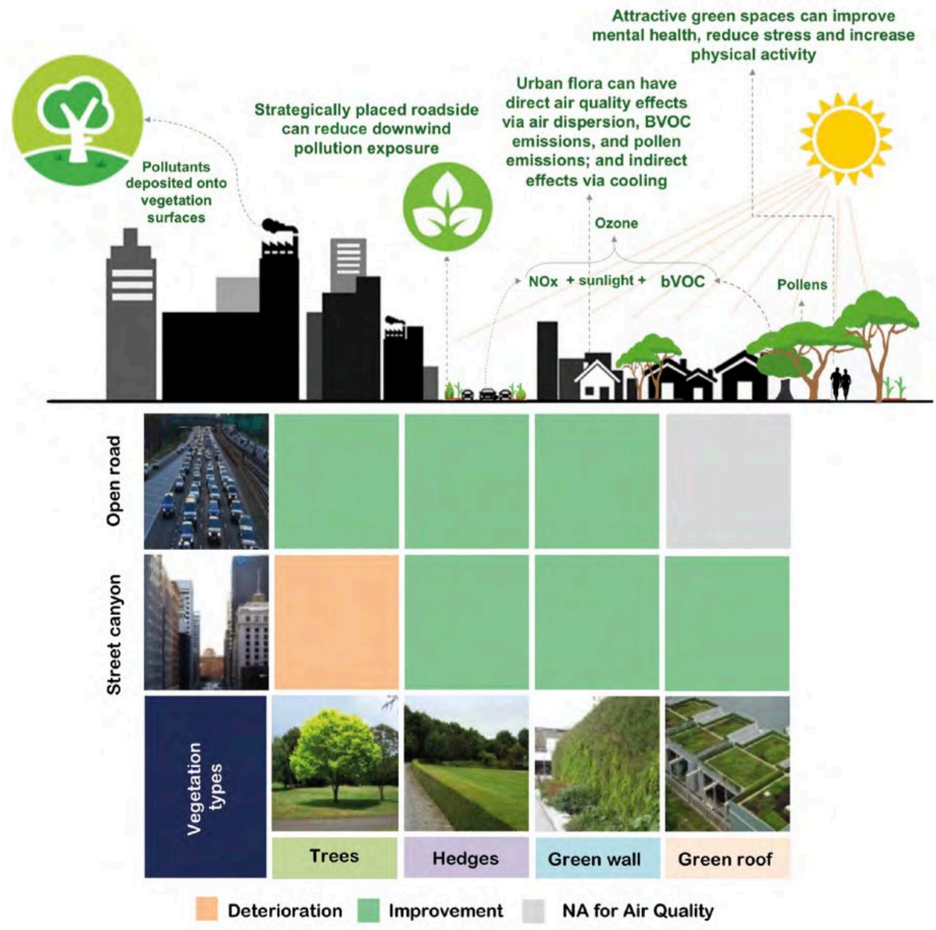

Figure 5-5. An overview of the relationship between air quality and green infrastructure with a matrix offering local-scale implementation impacts (adapted from Abhijith et al. 2017 and Kumar et al. 2019).

5.1.4 Recommended indicators case study from Genk, Belgium

NBS name and location	Schansbroek Park (Genk, Belgium)
Brief description of NBS	Schansbroek Park lies near the source zone of the Stiemerbeek River and near the coal mine of Waterschei. The park is an example of NBS for brownfield regeneration (Figure 5-6), as the area was surrounded by mining activities that were severely affected natural water management contributing to pollution and flooding for local residents (Connecting Nature, 2020). The topography of the area was altered by mining operations and to

	protect local residences, rainfall and groundwater has had to be pumped into the Stiemerbeek River. This severe hydrological impact caused water shortage for natural wetland areas negatively impacting their biodiversity. Regarding its attractiveness, although the area has a 16th century defensive structure 'De Schans', the surroundings were unattractive and there was a lack of recreational infrastructure for visitors, residents and workers (Green4Grey, 2020). In view of the state of the area, the Flemish Land Agency (VLM) together with the city of Genk began a participatory redesign, where the suggestions made by local citizens (i.e., allotments, children's play areas, cycling / hiking trails, picnic and meeting areas) were included in the new plan (Hölscher et al., 2019). In addition, the redesign involved measures to recreate a 'wet ecotope' by restoring a natural dam and ponds, and transforming an artificial reservoir from the former mine (Connecting Nature, 2020). The environmental benefits were powerful, since the biodiversity and natural conservation of the area were optimized, reducing flooding and improving water quality. Furthermore, the fact of regulating the floods provided thermal comfort zones. The benefits were not only in the environmental dimension but also in public governance and wellbeing. The new park enhanced the aesthetics of the area, with new spaces to exercise and meet up. Thus, it became an attractive space for residents and workers of the neighbouring Thorpark that allowed citizens to reconnect with nature, improving physical and mental wellbeing. The fact of having conducted participatory planning contributed to promoting social cohesion and environmental stewardship (Connecting Nature, 2020).
Indicators of relevance	**21.1 Level of outdoor physical activity (min/week)** **21.2 Level of chronic stress ("Perceived stress")** **21.4 Self-reported general wellbeing** Frequency of social activities in outdoor spaces
Description of Indicator Application	The indicators selected to assess the health and wellbeing dimension in Schansbroek Park form a coherent framework that allows analysing the NBS effects on citizens. Starting with the level of outdoor physical activity, defined as self-reported participation in organized or unorganized sport or exercise, outdoors, at least once a week (Schipperijn et al., 2013), is a fundamental indicator to discover if the new redesign of Schansbroek Park, with its cycling and hiking routes, improves the healthy habits of users. Knowing the weekly physical activity levels allow a broad vision of the health and well-being of the area, since numerous studies in various countries have shown that access to, and use of, urban green space contributes to increased physical activity, wellbeing, higher rates of recreational walking and reduced sedentary time (Almanza et al., 2012; Braubach et al., 2017; Lachowycz and Jones, 2014; Sallis et al., 2016; Schipperijn et al., 2013; Sugiyama et al., 2014).

	Complementarily, the indicator of frequency of social activities in outdoor spaces, follows the same line, since during the participatory design process of the new area of Schansbroek, neighbours and workers suggested including places that allow social interaction. This interaction is now possible in the park and represents a great advance in terms of health and well-being assessment, as green spaces contribute to social cohesion, fostering social interactions and engagement, promoting a sense of community (Jennings and Bamkole, 2019; Prezza et al., 2001). Chronic stress and self-reported wellbeing complete the vision on the potential impacts of Schansbroek Park can produce in terms of well-being, specifically mental health. A growing body of empirical evidence documents the relationship between connection and contact with green spaces and a greater subjective well-being (Frumkin et al., 2017; Howell et al., 2011; Howell and Passmore, 2013; Larson et al., 2016; MacKerron and Maurato, 2013; Pritchard et al., 2020; Wendelboe-Nelson et al., 2019; Zhang et al., 2014). Contact with natural urban environments can provide psychological relaxation and stress alleviation, enhancing immune function, stimulating social cohesion, supporting physical activity, and reducing exposure to air pollutants, noise and excessive heat (Braubach et al., 2017; Hartig et al., 2014). In addition, other indicators were implemented in the field of Health and Wellbeing, corresponding to indicators: Perceived restorativeness of NBS and Incidence of obesity among adults, of the taskforce.
Description of Additional Indicator Application	Methodology and data analysis require high expertise in psycho-social research but quantitative data collection requires no expertise. During the Connecting Nature project, the data gathering is conducted after the NBS implementation, but it allows making comparisons between different areas of the city or population groups (i.e., users versus no users). Indicator application was as follows: *Level of outdoor physical activity (min/week)* ☒ *Quantitative P*: Scale/Scale inventory/Questionnaire (survey procedure, paper-and-pencil administration, computer-based administration) ○ T: *International Physical Activity Questionnaire (IPAQ)* (International Physical Activity Questionnaires, n.d.). IPAQ (both long - 27 items, and short form - 7 items) assesses physical activity undertaken across a comprehensive set of domains including: • leisure time physical activity • domestic and gardening (yard) activities • work-related physical activity • transport-related physical activity *Frequency of social activities in outdoor spaces* ☒ *Quantitative P*: Scale/Scale inventory/Questionnaire (survey procedure, paper-and-pencil administration, computer-based administration)

- T: Ad hoc question adapted from Bloesma et al. (2018): How often do you intentionally go to a green environment (not your own garden or Schansbroek Park) for social activities (meeting family or friends, chatting with neighbours, having a picnic, playing board games)?

Level of chronic stress ("Perceived stress")

☒ *Quantitative P*: Scale/Scale inventory/Questionnaire (survey procedure, paper-and-pencil administration, computer-based administration)
  - T: *Perceived Stress Scale* (Cohen et al. 1983), a self-report measure intended to capture the degree to which persons perceive situations in their life as excessively stressful relative to their ability to cope. Within Connecting Nature, the PSS-10 version was used because it was established as the most recommended form of PSS (as cited in Taylor, 2015, p. 90).

Self-reported general wellbeing

☒ *Quantitative P*: Scale/Scale inventory/Questionnaire (survey procedure, paper-and-pencil administration, computer-based administration)
  - T: *Satisfaction with Life Scale* (Diener et al., 1985), a 7-point scale comprising 5 items that measure individual's general satisfaction with own life as a cognitive-judgmental process (i.e., based on a comparison with a standard that individual had set for him/herself).

Perceived restorativeness of NBS

☒ *Quantitative P*: Scale/Scale inventory/Questionnaire (survey procedure, paper-and-pencil administration, computer-based administration)
  - T: *Perceived Restorativeness Scale* (the short, PRS - 11) (Pasini et al., 2014), a shorter, parallel version of the Perceived Restorativeness Scale (PRS – 26) (Hartig et al., 1997), developed to address original psychometric limitations; PRS is based on the Attention Restoration Theory (ART; Kaplan, 1995) and its short version measures an individual's perception of 4 restorative factors assumed to be present to a greater or lesser extent in the environment, namely physical and/or psychological "being-away" from demands on directed attention, "fascination" a type of attention assumed to be effortless and without capacity limitations, the "coherence" and "scope" perceived in an environment. Participant's judgments are made on a 0 to 10-point scale.

Incidence of obesity among adults

☒ *Quantitative P*: Scale/Scale inventory/Questionnaire (survey procedure, paper-and-pencil administration, computer-based administration)
  - T: *Measurements of Body mass index (BMI)*. A ratio of weight to height that is calculated by the following formula: BMI = weight (kg) ÷ height (m)^2. For adults,

	BMIs in the range of 18.5 to 24.9 are considered to be healthy – and associated with the lowest risk of mortality and morbidity. Overweight is defined as a BMI of 25.0 to 29.9; obesity is defined as a BMI of at least 30, with 3 sub-categories (Class I, Class II, and Class III) that are associated with increasing risk of cardiovascular disease, type 2 diabetes, and all-cause mortality (Bhrem and D'Alessio, 2014).
Stakeholders involved	Connecting Nature; Stad Genk; Green4Grey; the Flemish government
Barriers encountered and lessons learned	Genk was formerly seen as a Grey City (dominated by hard infrastructure), with certain areas of the city disconnected. This made community participation or sense of ownership more difficult (van de Sijpe et al., 2019). In this sense, community opinion regarding the site already used was a barrier, local residents unofficially used the space and there was a lack of interest in draining their private gardens. However, the biggest barrier was the cost of the original design. This plan sought to divert pumped water back to a pond in the nature reserve to raise the water levels in order to meet ecological goals, but it became cost-prohibitive, and mono-functional, so the plan had to change. The lessons learned encompass this change in the redesign of the area, since less expensive measures were taken but that met the same objectives, in addition to enhancing the ecological and social value of the area (van de Sijpe et al., 2019). Active horizontal cooperation between several departments was needed, as well as workshops with the residents of the neighbourhood to explain the project and encourage them to participate in its co-design. Schansbroek was the first area to be redeveloped in the Stiemervallei context, so the lessons learned in terms of project management, stakeholder engagement and citizen communication will be of great use to scale up in other areas of the city.
Case study author	Adina Dumitru[1] (adina.dumitru@udc.es), David Tomé-Lourido[1], Peter Vos[2], Katrien van de Sijpe[2] *[1]University of A Coruña, Spain* *[2]City of Genk, Belgium*
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Figure 5-6. **Schansbroek Park (© Green4Grey).**

5.2 Case studies illustrating the 'story of an indicator' for some of the additional indicators

The case studies in this section are designed to illustrate the selection and use of Additional indicators from each of the 12 Challenge areas to examine a specific aspect of a given NBS. Each case study details the need for use of an Additional indicator and describes its application and the obtained results (or anticipated results).

It should be noted that NBS exhibit multiple co-benefits, identification of which is of outmost importance for evaluating the wider NBS impact. Case studies for selection of Additional indicators presented herein illustrate the selection of the unique indicators. They merely serve as examples of versatility of the NBS impact assessment approach, which can be tailored to local needs and challenges.

5.2.1 Climate Resilience – Urban Heat Island incidence

NBS name and location	Green façade **Valladolid Demo Site** **Shopping Centre El Corte Inglés,** **Calle Constitución, 2. 47001 Valladolid (Spain)**
Brief description of NBS	**Green Facade** is a constructive system that allows planting on a vertical façade. This NBS is built with a substructure and a waterproof panel. The substructure is affixed to the façade. The plants grow in a growing medium that is affixed to the panels. The water of the irrigation system nourishes the plants. This green wall was built in collaboration with a private company (*El Corte Inglés*), and has benefits for every part involved in the project: the mall, renewing the image of the facade and attracting new customers, and the city, improving the air quality, climate regulation, pollination and adding aesthetic values to a grey area in the city centre of Valladolid. This vertical garden covers an area of 350 m^2 and has more than 14,000 plants (Figure 5-7, Figure 5-8).
Additional Indicators of relevance	1.5 Heatwave incidence **1.13 Urban Heat Island (UHI) incidence** 1.15 Mean or peak daytime temperature - 1.15.1 Direct measurement. **6.9 Trends in emissions of NO_X and SO_X** 6.10 Monetary values: value of air pollution reduction; total monetary value of urban forests including air quality, run-off mitigation, energy savings, and increase in property values. 6.11 Air quality parameters. NO_X and PM.
Explanation for selection of	In future, if this NBS is widely installed it can be used recommended indicators for climate change and Air Quality

Additional Indicators	challenge. Recommended indicators have a scale of measurement from district to region and they have not sensibility enough to study the impact of this NBS. Therefore, in the meantime it is needed additional indicators to assess the impact on air pollutants emission reduction with indicators such as the ones mentioned before.
Description of Additional Indicator Application	In this case, the main indicator for impact assessment is 1.5 and 1.15 (1.15.1) and additionally the other ones. 1.15 implies the installation of several equipment for continuous monitoring of temperature and humidity in the green façade location and reference areas.
Stakeholders involved	Different municipality areas (at least urbanism, environment and heritage), shopping centre company (*El Corte Inglés*), construction companies.
Barriers encountered and lessons learned	Regarding the NBS implementation, the main barriers were administrative and economic. The green façade was installed in a commercial private building in a relevant area of the city. URBAN GreenUP joined the efforts of the *El Corte Inglés* technical team, different areas of the Valladolid city council and the technical experts of the Project leaded by SingularGreen. After more than 1 year of discussions, it was decided to separate into two interventions: A structure to support the NBS and the vertical garden itself. The structure was attached to the existing wall and it was designed and constructed by *El Corte Inglés*. Then, Green Facade was manage with local and EU funds.
Case study authors	Jordi Serramia[1], Hugo Riquelme[1], Patricia Briega[1], Alicia Villazán[2], Isabel Sánchez[2], Elena Sánchez[2], Juan Carlos Sánchez[3], Raúl Sánchez[4], Jose Fermoso[4], Raquel Marijuan[4], Silvia Gómez[4], María González[4], José María Sanz[4], Esther San José[4] *[1]SingularGreen S.L. C/ Francisco Carratalá Cernuda, 34 Bajo, 03010, Alicante, Spain* *[2]VALLADOLID City Council. Plaza Mayor 1, 47001, Valladolid, Spain* *[3]Tierra Ingeniería S.L. C/ Copenhague, 6, 28230, Las Rozas, Spain* *[4]CARTIF Foundation. P.T. Boecillo, 205, 47151, Boecillo, Valladolid, Spain*

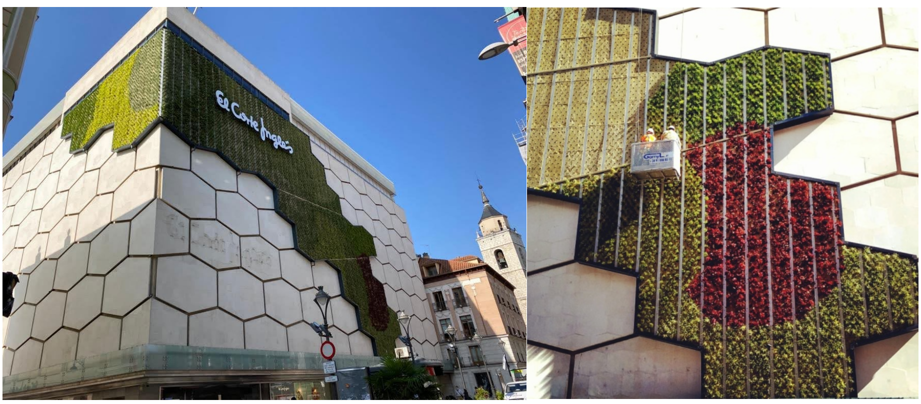
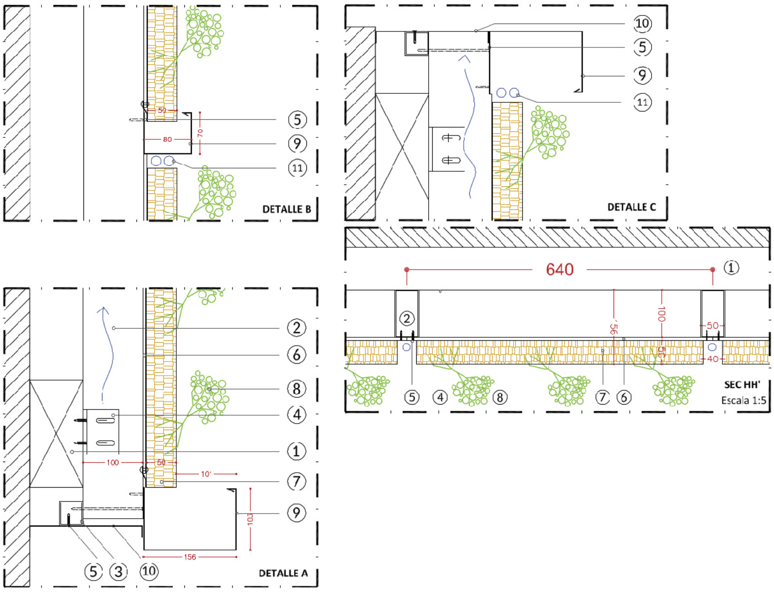


Figure 5-7. The green façade at El Corte Inglés, Valladolid.



LEGEND

1- Support structure planned for vertical garden anchoring
2- Vertical garden substructure. Aluminum upright 100x50.2mm
3- Square section aluminum profile for anchoring the garden finishing perimeter sheet
4- Galvanized steel anchor bracket with dimensions 60x60x100.2mm
5- Zinced steel self-tapping screw
6- 5mm thick foamed PVC panel screwed to uprights
7- Substrate made of rock wool panels of 80kg / m3. 50mm
8- Vegetation selected by SingularGreen S.L.
9- 1.5 thick aluminium gutter, lacquered. Color to be chosen by the Facultative Direction
10- Lacquered aluminium sheet for vertical garden perimeter finishing 190x20mm. Self-tapping anchored to aluminium profile. Color to be chosen by the Facultative Direction
11- Irrigation pipe SG-R16, self-compensating drippers 1.6l / h every 20 cm

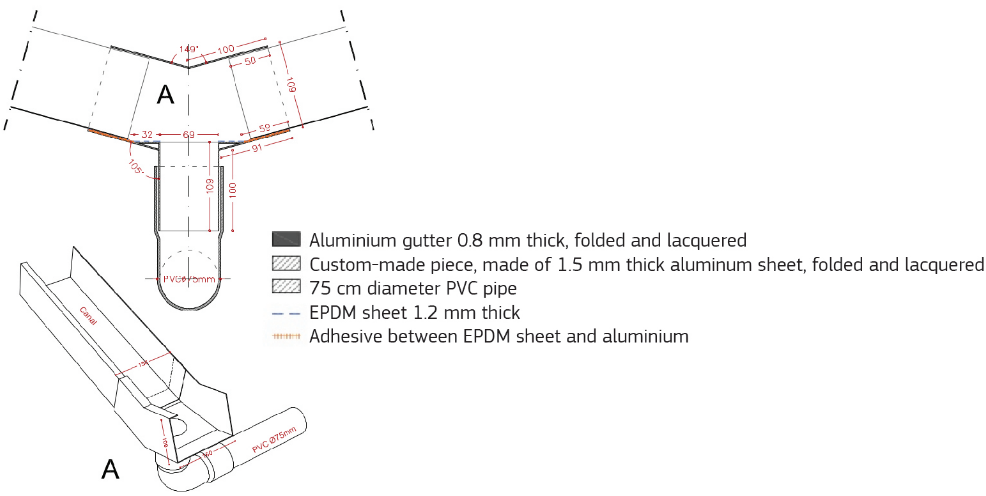


Figure 5-8. URBAN GreenUP Project: Green Façade construction details (© SingularGreen).

5.2.2 *Natural and Climate Hazards – Flood risk*

NBS Name and Location	Green barrier **Gudbrandsdalen Valley, Norway**
Brief description of NBS	A receded green flood barrier located at Jorekstad in Lillehammer municipality (Figure 5-9) is proposed to reduce the risk of floods due to snow melting and extreme rainfall. The NBS consists of removing the existing flood protection along a section of the riverbank, and building a new flood barrier, using only natural and local materials, further upland of the riverbanks. This will provide space for the river during periods of flooding and improve the capacity for upstream flood levels, as well as contribute positively to the flood plain ecosystem. For more information see: https://phusicos.eu/case_study/valley-of-gudbrandsdalen-norway/
Additional Indicators of relevance	**Risk reduction:** 6.13.1 Urban /Residential Areas 6.13.2 Productive Areas (Agriculture, Grazing, Industries) 6.15.1 Inhabitants 6.15.3 Other People (Workers, Tourists, Homeless) 6.15.4 Elderly, children, disabled 6.16.1 Population 6.17.1 Housing 6.17.2 Agricultural and Industrial Buildings 6.18.1 Roads 6.18.2 Transportation Infrastructures and Lifelines 6.18.3 Lifelines (Water main, Sewerage, Pipeline, etc.) 6.19.1 Buildings 6.22 Flooded Area 6.24 Peak Flow 24.24 Economic Value of the Productive Activities Vulnerable to Risk (i.e. Economic Value of the Fields, Workers No.) **Technical and feasibility aspects:** 14.22 Material used coherence 24.5 Initial costs 24.6 Maintenance costs 24.7 Replacement costs 24.8 Avoided costs 24.9 Payback Period **Environment and ecosystem:** 4.48 Physical parameters 4.48 Chemical Pollution Parameters 4.23 Water Storage Capacity Enhancement 6.41 Total Predicted Soil Loss (RUSLE) 10.22 Typical Vegetation Species Cover 10.3.1 Abundance of Ecotones/Shannon Diversity

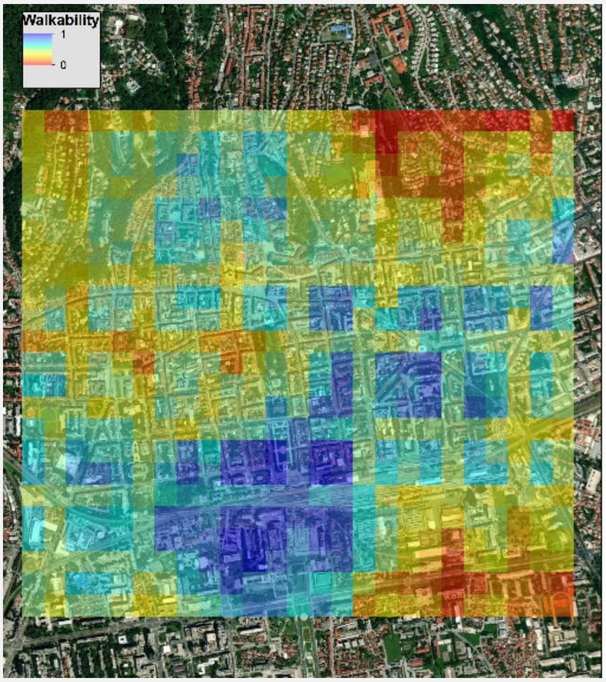
	10.25.1 Diversity of Functional Groups (Plant Functional Diversity) 10.25.2 Diversity of Functional Groups (Animal Functional Diversity) 10.7.1 Sites of Community Importance (SCI) And Special Protection Areas (SPA) **Society:** 8.31.2 Number of Visitors in New Recreational Areas Different Activities Allowed in New Recreational Areas 8.35.1 New Pedestrian, Cycling and Horse Paths 23.2 Rate of Increase in Properties Incomes 18.1.1 Citizen Involved 18.1.2 Stakeholders Involved 17.3 Public-Private Partnership Activated 17.4 Policies Set Up to Promote NBS 14.7 Social Active Associations 14.17 Natural and Cultural Sites, Made Available 14.25 Viewshed 14.26 Scenic Sites and Landmark Created **Local economy:** 24.18 Jobs Created in The Nature-Based Sector 24.19 Jobs Created in The Nature-Based Solution Construction and Maintenance 24.17 Gross Profit from Nature-Based Tourism 24.15 Touristic Activeness Enhancing 24.33 New Areas Made Available for Traditional Activities (Agriculture, Livestock, Fishing, ...)
Explanation for selection of Additional Indicators	The indicators tailored to this case study encompass a total of 47 indicators. The indicators are aggregated to provide information about the NBS with respect to five ambits: 1) Risk reduction, 2) Technical and feasibility aspects, 3) Environment and ecosystem, 4) Effects on the society, and 5) Effects on local economy. These five ambits form the basis of the NBS assessment framework developed in the PHUSICOS project (www.phusicos.eu).
Description of Additional Indicator Application	Quantitative, risk-related indicators include Peak Flow volume, Flooded Area – calculated through hydraulic modelling – and Exposed residential and productive areas, obtained by GIS mapping. Ecosystem indicators are aimed to assess both the effects on water quality, such as the Change in physical and chemical water parameters, and water quantity, such as the Total predicted soil loss (RUSLE), or enhanced Water storage capacity. Indicators for assessing the improved value of the forested floodplain include Typical vegetation species cover, and Diversity in plant and animal functional groups. Societal-related indicators include the Number of visitors in the new recreational areas and New pedestrian/cycling paths, whilst the Number of jobs created in the nature-based sector is one of the economy-related indicators.

Stakeholders involved	Innlandet County Administration, Lillehammer municipality, Private land owners, Local farmers' association, Norges Naturvernforbund (Friends of the Earth Norway, an environmental and nature protection NGO)
Barriers encountered and lessons learned	**<u>Barriers encountered:</u>** The tendering process for procurement of goods and services is often not straightforward, there are complaints from bidders who were not selected, etc. Local politics and bureaucracy; revision of land use plans, local elections, etc. Land owners resisting use of their land, for various reasons, e.g. ○ Loss of agricultural land ○ General scepticism to NBS, or lack of knowledge ○ Economic reasons; want land compensation, lose extra income from gravel out-take **<u>Lessons learned:</u>** • Plan well ahead. Getting plans through to practical implementation takes more time than one possibly could think of. • Bring stakeholders into the process as early as possible, if possible from scratch; co-creation and co-design of the measures establishes 'ownership' and increases enthusiasm. • Use their local knowledge wherever possible and show appreciation. • Identify potentially 'problematic' stakeholders and plan strategies to handle these. • If at all possible, choose public land for your NBSs. • Identify individuals who can be good ambassadors for the project and work closely with them. • Procurement can be time consuming. Be as detailed as possible in the tender documents. Complaints will lead to serious delays.
Case study author	Vittoria Capobianco (vittoria.capobianco@ngi.no) *Norwegian Geotechnical Institute, Norway*
Reference	https://phusicos.eu/case_study/valley-of-gudbrandsdalen-norway

Figure 5-9. Aerial photo of the area with the location of the existing flood barrier and the new flood barrier (top); visualization of the area with the potential multiple actions that can be supported by the flood barrier (by Agence Ter, bottom).

5.2.3 *Green Space Management – Walkability*

NBS Name and Location	Living Lab districts **Turin (Italy), Zagreb (Croatia),Dortmund (Germany), Ningbo (China)**
Brief description of NBS	During the proGIreg project, this indicator will be calculated for the Living (LL) district and for the entire city area in each Front-Runner City (FRC).
Additional Indicators of relevance	8.37 Walkability
Explanation for selection of Additional Indicators	The Walkability index express the likelihood that a particular area may be covered by walking. It provides additional information on the urban structure of a city and, in turn, individual districts. Additionally, it can be of useful in assess the effects of Land use changes (pre/post intervention)
Description of Additional Indicator Application	The Walkability index is a GIS derived raster image, function of connectivity, accessibility and perceived pleasantness with values ranging from 0 to 1 where 1 indicates the most walkable area (e.g., a park with pedestrian lanes well connected to city hot spots like residential and working areas) and 0 indicates the least walkable area (e.g., a major urban road) (Figure 5-10). The calculation of the Walkability index requires the following data: ○ Pop Density map ○ Road Network ○ Public Transit (including stops and routes) ○ Land Use and zoning: residential, commercial and office, industrial, institutional (e.g., schools, libraries, kindergartens), green/park area, and water and wetland ○ Digital elevation model

	 **Figure 5-10.** Example of walkability index (city of Zagreb – preliminary results by Vincenzo Giannico, University of Bari).
Stakeholders involved	Civil local authorities for data collection during baseline have been involved
Barriers encountered and lessons learned	The walkability index is a derived metric that requires a large number of input data. This characteristic leads to two major issues: (1) data availability and (2) data harmonization across the civil local authorities involved. To date, only two of the four FRCs (i.e., Zagreb and Dortmund) sent us the requested data. Additionally, of the received data, only the files received by the city of Zagreb were actually usable as the rest of the files were not compliant with the model request and thus were not useful. However, the problem was discussed with the local authorities of Dortmund, and they assured that the data will be provided in the correct data type within a short period of time. The city of Turin, similarly, is committed to provide the data as soon as possible. Another issue concerns the harmonization of data across cities. Given the nature of the input data involved in the calculation of the Walkability index, it has been found to be difficult to obtain data acquired in the same year across cities. For example, the Land Use map provided by city of Zagreb is from 2012 while the city of Dortmund provided a Land Use map generated in the first decade of the 2000s. Land Use maps, in particular, are usually developed on a multiyear basis by local authorities, as the changes in land use occurring yearly, especially in European cities, are

	often limited. As a consequence, we will be unable to calculate a yearly walkability index, as expected initially, but rather one walkability index before the initiation of the project and, depending on the availability of the data, another walkability index at the end of the project. Lesson learned: ○ Data collection can vary across cities and constant interaction with local authorities is needed. ○ Given the nature of the input data, calculating a yearly walkability index is not feasible. ○ Two Walkability index (pre/post intervention) would be calculated on the basis of the availability of the data.
Case study author	Vincenzo Giannico (vincenzo.giannico@uniba.it) *University of Bari, Italy*
References	Fan, P., Xu, L., Yue, W., and Chen, J., 'Accessibility of public urban green space in an urban periphery: The case of Shanghai', *Landscape and Urban Planning*, Vol. 165, 2017, pp. 177-192.

5.2.4 Green Space Management – Annual Trend in vegetation cover

NBS name and location	This indicator is part of a framework applied at European level to map and assess urban ecosystems condition and ecosystem services
Brief description of NBS	The Green Space Management – Annual Trend in vegetation cover indicator was implemented to assess changes in vegetation cover within the *Urban Green Spaces* (NBS Type 3) in 700 European Functional Urban Areas (FUAs; Figure 5-11) as part of the Mapping and Assessment of Ecosystems and their Services (MAES) initiative: https://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/index_en.htm

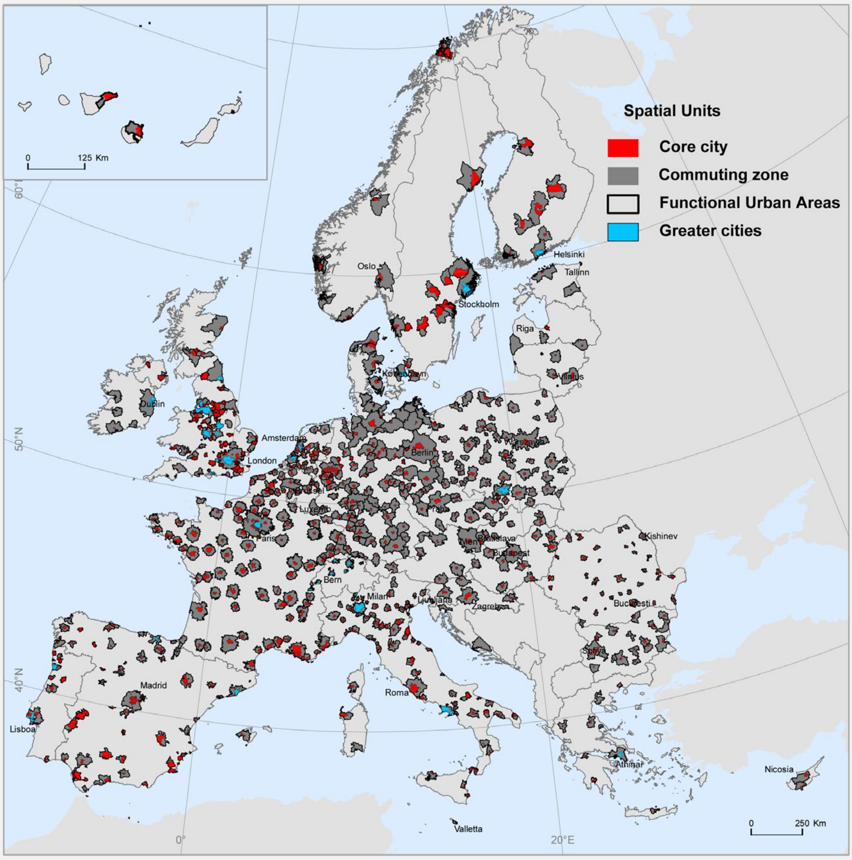


Figure 5-11. Distribution of European functional urban areas (FUAs; (EU 28 + Norway and Switzerland) (source: Maes et al., 2020, Chapter 3.1: Urban Ecosystems).

Additional Indicators of relevance	At European level the following indicators have been implemented: 7.1 Green spaces Accessibility 7.2 Share of green urban areas 8.1 Ecosystem services provision (flood control, nature-based recreation, pollination) 8.2 **Annual trend in vegetation cover by urban green infrastructure** 8.31.1 ESTIMAP nature-based recreation 8.38 Land composition 8.39 Land use change and green space configuration 8.40 Soil sealing
Explanation for selection of Additional Indicators	We defined Urban Green Spaces in European cities according to the EU GI Strategy (EC, 2013), as "*a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services*" (EC, 2013). We carried out the analysis including all natural and semi-natural areas together with all private and public green spaces within the core cities and the commuting zones. The capacity of Green Spaces to provide ecosystem services is linked to the quality and extent of vegetation cover. This indicator

	examines how and in which direction vegetation cover changed between 1996 and 2018. Trend detection in Normalized Difference Vegetation Index (NDVI) time series can help to identify and quantify recent changes in ecosystem properties.
Description of Additional Indicator Application	Figure 5-12 shows the steps needed to derive the indicator.

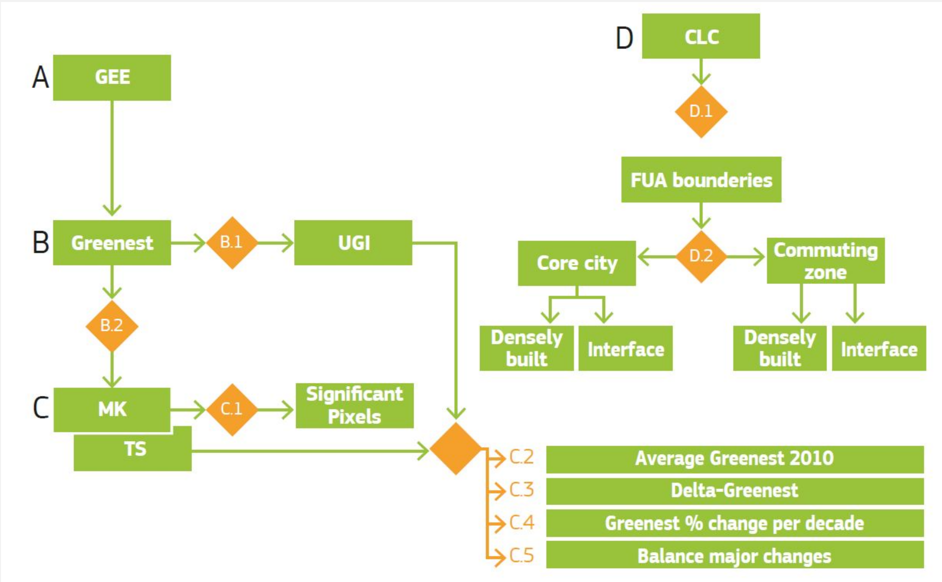


Figure 5-12. Suggested algorithm for the process (source: Maes et al., 2020, Chapter 3.1: Urban Ecosystems, Factsheet 3_1_109).

A. Data were physically downloaded from Google earth engine (GEE)
B. From the original maps the Urban green Infrastructure (UGI) mask was created:
   - B.1. areas where at least once between 1996 and 2018 the highest-NDVI was greater than 0.4.
C. The Trend analysis employed a non-parametric approach, namely the Theil–Sen regression. The slopes of the regression approach were tested for their statistical significance using the p-value of the Mann–Kendall[50] test for slopes (Corbane et al., 2018; Forkel et al., 2013; Jin et al., 2019; Novillo et al., 2019; Teferi, et al., 2015; Wang et al., 2018;).
   - C.1 Only pixels where the p-value (Mann–Kendall) was less than 0.05 (95% confidence interval) have been considered to have a significant medium-term trend and used as a mask to extract all the indicators.
   - C.2 we reported the average greenest value in 2010 as reference value.
   - C.3 From the Theil–Sen positive or negative slope we extracted the Delta Greenest, which represent the **change direction** over the 22 years of analysis.
   - C.4 To make the interpretation easier the annual trends were reported in terms of percentage of change per decade (using the equation proposed by Teferi et al., 2015) .
   - C.5 The TS-Slope was reclassified in 5 classes representing key gradual to abrupt change types. They were defined using the minimum measurable change (+-0.001)

[50] Mann–Kendall is a temporal trend estimator that is more robust than the least-squares slope because it is much less sensitive to outliers and skewed data (https://clarklabs.org/terrset/).

as thresholds for areas with no changes (Guan et al., 2018; Jin et al., 2019; Verbyla, 2008).

D. CLC map was reclassified using the land mosaic model in Densely built up and interface zone

 ○ Indicators (C1-C2-C3-C4-C5) were extracted in Core cities and Commuting zone within Densely built up and interface zone **only for significant pixels of UGI**.

Spatially explicit data are available for the 700 FUA. The indicator could be used at a city level to study vegetation development within urban parks.

Figure 5-13 shows the percentage of change per decade in vegetation cover. 26% of European cities present a downward trend, meaning that there is a tendency to loose vegetation. The balance between abrupt changes (Figure 5-14) confirms the trend.

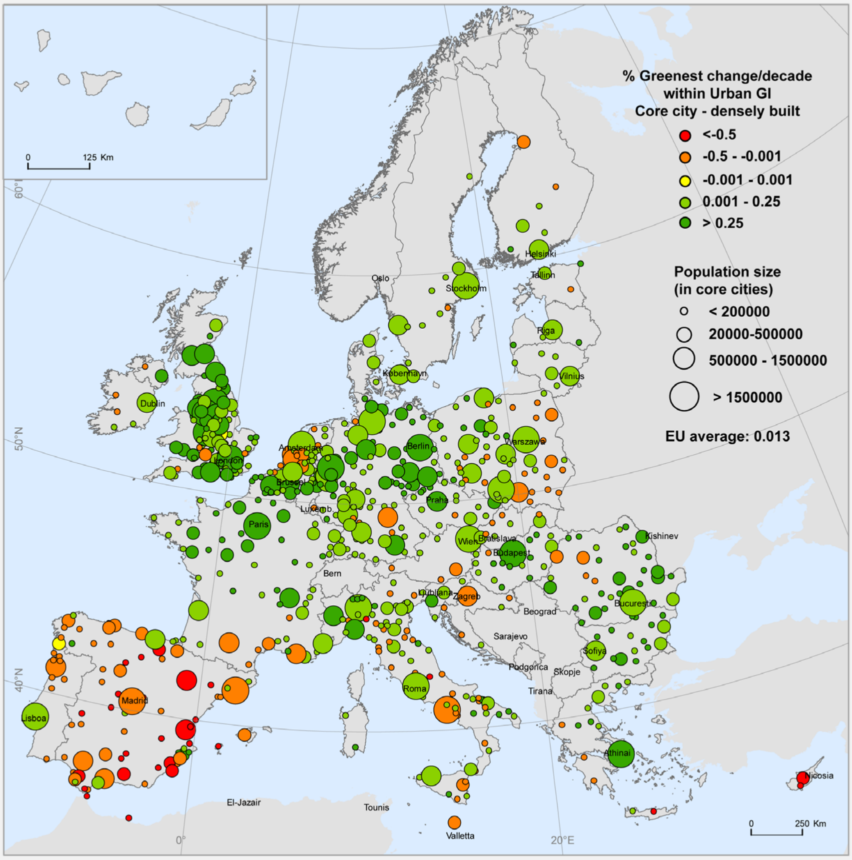


Figure 5-13. Trends in vegetation cover (% change/decade), within densely built areas in core cities. The pie chart shows the proportion of cities for each category (source: Maes et al., 2020, Chapter 3.1: Urban Ecosystems).

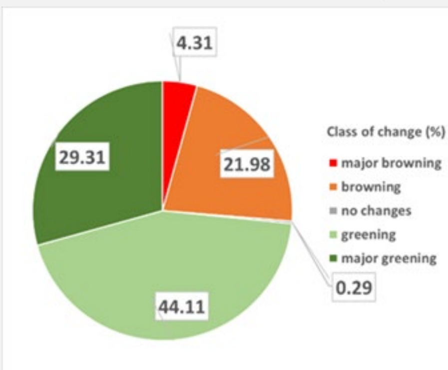


Figure 5-14 shows the difference between major greening and major browning in densely built areas of core cities. It represents a “compensation indicator”, if it is positive the upward trend was higher than the downward trend and greening areas compensated the loss of green spaces. If it is negative, the land development pattern did not include any solution to compensate the green loss. This indicator provide insights at urban/regional/national level about the compensation policies taken to avoid damages created by land take, soil sealing or climate change.

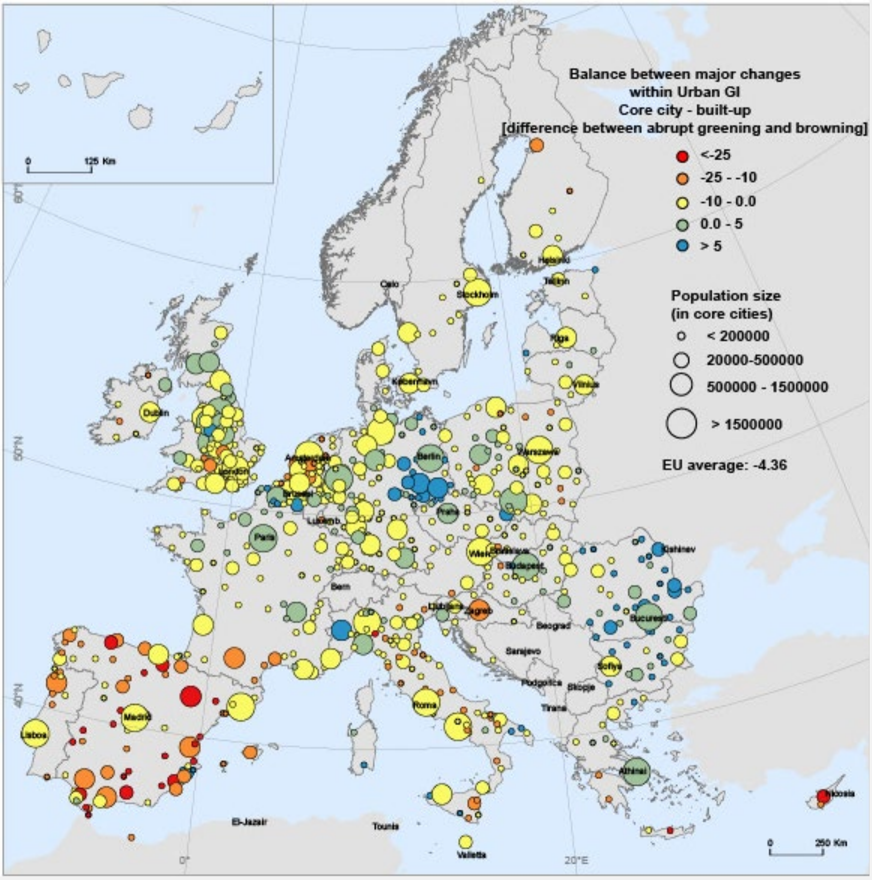
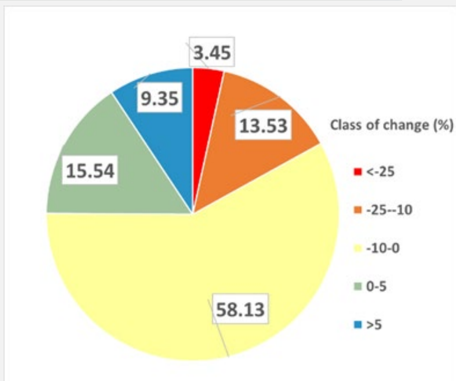


Figure 5-14. Balance between abrupt greening and browning changes within densely built areas in core cities. The pie chart shows the proportion of cities for each category (source: Maes et al., 2020, Chapter 3.1: Urban Ecosystems).



Stakeholders involved	MAES represents the core activity of Action 5 – Target 2 of the EU Biodiversity strategy to 2020. The all process, started in 2013 involved EU Member States, The Commission (DG ENV, DG-JRC), The European Environmental Agency (EEA) and several other stakeholders. Specifically a workshop, held in Brussels in June 2019, provided the opportunity for stakeholders to engage in the first EU wide ecosystem assessment.

Barriers encountered and lessons learned	Main barriers are linked to: expertise requested for the implementation of the indicator.
Case study author	Grazia Zulian (grazia.zulian@ec.europa.eu) *JRC D3 Land Resources*
References	Corbane, C., Pesaresi, M., Politis, P., Florczyk, J.A., Melchiorri, M., Freire, S., Schiavina, M., Ehrlich, D., Naumann, G., and Kemper T., 'The grey-green divide: multi-temporal analysis of greenness across 10,000 urban centres derived from the Global Human Settlement Layer (GHSL)', *International Journal of Digital Earth*, 2018, pp. 101–118. EC, 'Green Infrastructure (GI) — Enhancing Europe's Natural Capital', COM(2013) 249 final, 2013, p. 13. Forkel, M., Carvalhais, N., Verbesselt, J., Mahecha, M.D., Neigh, C.S.R., and Reichstein, M., 'Trend Change detection in NDVI time series: Effects of inter-annual variability and methodology', *Remote Sensing*, Vol. 5, No 5, 2013, pp. 2113–2144. Jin, J., Gergel, S.E., Lu, Y., Coops, N.C., and Wang, C., 'Asian Cities are Greening While Some North American Cities are Browning: Long-Term Greenspace Patterns in 16 Cities of the Pan-Pacific Region', *Ecosystems*, 2019, pp. 383-399. Maes, J., Teller, A., Erhard, M., Condé, S., Vallecillo, S., Barredo, J.I., Paracchini, M.L., Abdul Malak, D., Trombetti, M., Vigiak, O., Zulian, G., Addamo, A.M., Grizzetti, B., Somma, F., Hagyo, A., Vogt, P., Polce, C., Jones, A., Marin, A.I., Ivits, E., Mauri, A., Rega, C., Czúcz, B., Ceccherini, G., Pisoni, E., Ceglar, A., De Palma, P., Cerrani, I., Meroni, M., Caudullo, G., Lugato, E., Vogt, J.V., Spinoni, J., Cammalleri, C., Bastrup-Birk, A., San Miguel, J., San Román, S., Kristensen, P., Christiansen, T., Zal, N., de Roo, A., Cardoso, A.C., Pistocchi, A., Del Barrio Alvarellos, I., Tsiamis, K., Gervasini, E., Deriu, I., La Notte, A., Abad Viñas, R., Vizzarri, M., Camia, A., Robert, N., Kakoulaki, G., Garcia Bendito, E., Panagos, P., Ballabio, C., Scarpa, S., Montanarella, L., Orgiazzi, A., Fernandez Ugalde, O., and Santos-Martín, F., 'Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment', EUR 30161 EN, Publications Office of the European Union, Ispra, 2020. Novillo, C., Arrogante-Funes, P., and Romero-Calcerrada, R., 'Recent NDVI Trends in Mainland Spain: Land-Cover and Phytoclimatic-Type Implications', *ISPRS International Journal of Geo-Information*, Vol. 8, No 1, 2019, p. 43. Teferi, E., Uhlenbrook, S., and Bewket, W., 'Inter-annual and seasonal trends of vegetation condition in the Upper Blue Nile (Abay) Basin: Dual-scale time series analysis', *Earth System Dynamics*, Vol. 6, No 2, 2015, pp. 617–636. Wang, J., Zhou, W., Qian, Y., Li, W., and Han, L., 'Quantifying and characterizing the dynamics of urban greenspace at the patch level: A new approach using object-based image analysis', *Remote Sensing of Environment*, Vol. 204, 2018, pp. 94–108.

5.2.5 *Green Space Management - ESTIMAP nature-based recreation*

NBS name and location	This indicator is part of a framework applied at European level to map and assess urban green spaces and ecosystem services.
Brief description of NBS	The indicator was implemented to assess the capacity of **urban ecosystems** to provide nature based recreation opportunities in 700 European Functional Urban Areas (FUAs; see Figure 5-11 in case study 5.2.4 Green Space Management – Annual Trend in vegetation cover). This work was part of the EnRoute project: https://oppla.eu/groups/enroute https://publications.jrc.ec.europa.eu/repository/handle/JRC115375 Several cities in ***EnRoute*** applied the model at a local scale in close collaboration with the municipalities: Poznan: https://oppla.eu/casestudy/19236 Tento: https://oppla.eu/casestudy/19228 Oslo: https://oppla.eu/casestudy/19231
Additional Indicators of relevance	At European level the following indicators have been implemented: 7.1 Green spaces Accessibility 7.2 Share of green urban areas 8.1 Ecosystem services provision (flood control, nature-based recreation, pollination) 8.2 Annual trend in vegetation cover in urban green infrastructure 8.31.1 **ESTIMAP nature-based recreation** 8.38 Land composition 8.39 Land use change and green space configuration 8.40 Soil sealing Spatially explicit data are available for the 700 FUA.
Explanation for selection of Additional Indicators	Nature based recreation or "Physical and experiential interactions with natural environment" (CICES, https://cices.eu/) includes a wide list of possible experience and activities such as biking; boating; climbing; hiking; horseback riding, walk the dog in a nice area; enjoy a local play ground ; find an urban park nearby. ESTIMAP nature-based recreation was developed to map the combination of recreation opportunities available in a given location. The original model (Liquete et al., 2016; Paracchini et al., 2014; Vallecillo et al., 2019; Zulian et al., 2013), up to now applied at European scale, was adapted to fit the urban setting. In previous applications the approach was used in urban context (Zulian et al., 2017), but focused only on specific local applications and cities, such as in Barcelona (Baró et al., 2016) or Trento (Cortinovis, Zulian and Geneletti, 2018). Urban ESTIMAP -recreation consists of three basic sections: o The Recreation Potential (RP), which estimates the potential capacity of ecosystems to support nature-based recreational activities. It is based on land suitability for recreation and a combination of the natural features that influence recreational opportunity provision (e.g., proximity to lakes; viewpoints of geological or geomorphological interest …)

- The Opportunity map (OS) expresses the presence of facilities to enjoy and reach areas with potential opportunities.
- The Recreation Opportunity Spectrum map (ROS) combines the Opportunity map (OS) and the Recreation Potential (RP).

From a modelling point of view the whole approach is based on 'Advanced multiple layer Look-up Tables" (LUT) and "proximity" concepts. Advanced LUT consist of a combination of elements, scored according to their suitability to provide recreation opportunities. In this application the scores for each input were generated from either the literature or expert input (Schröter et al., 2015). The final outcomes are based on cross tabulation and spatial composition derived from the overlay of different thematic maps (Zulian et al., 2017).

Figure 5-16 shows an example of ROS map, applied to the FUA of Padova (Italy).

Figure 5-17 shows the share of areas with high recreation potential within European FUAs.

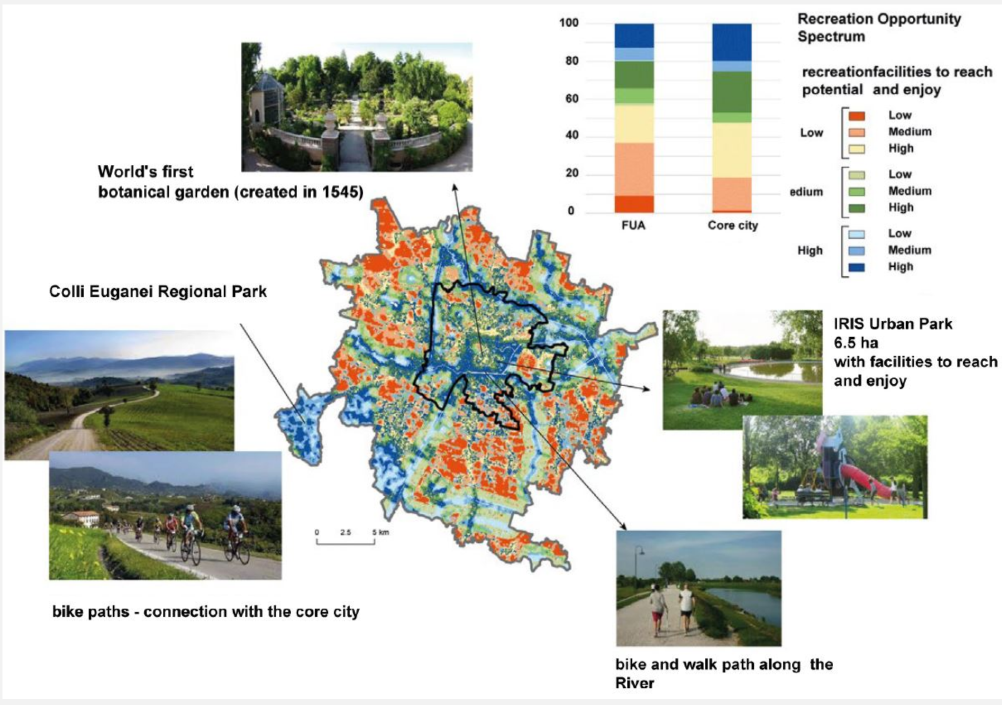


Figure 5-15. The approach for mapping recreation opportunities in cities explained for the functional urban area of Padova, Italy (source: Maes et al., 2019, Box 2).

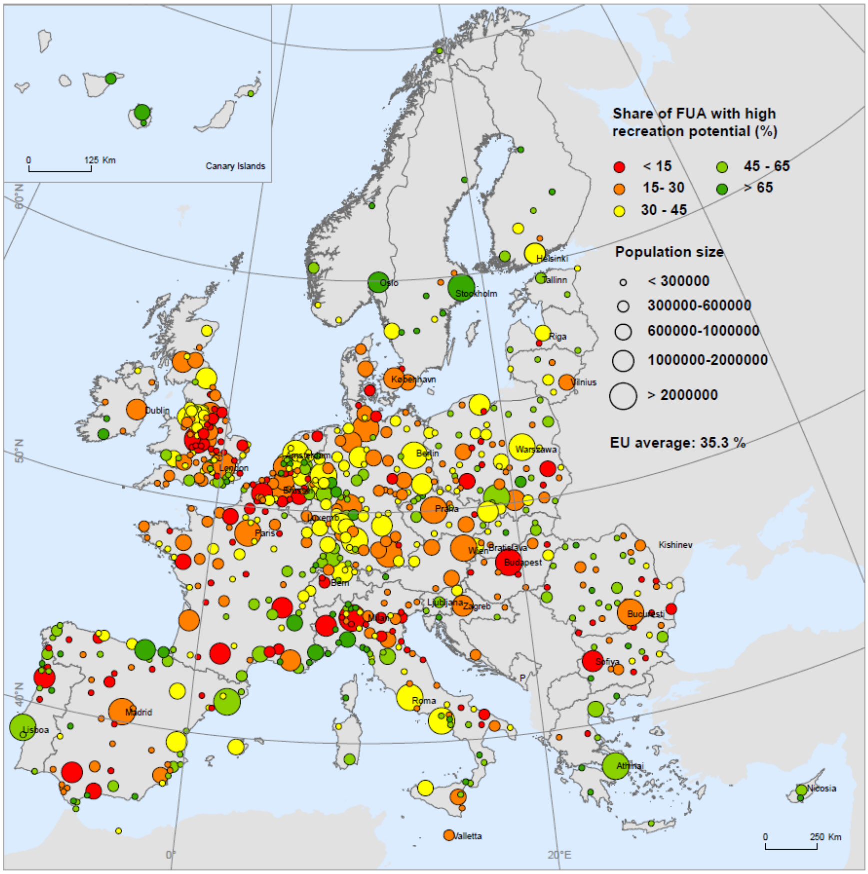


Figure 5-16. Surface area with high recreation potential in European functional urban areas (FUAs) (source: Maes et al., 2019).

Stakeholders involved	EnRoute is a project of the European Commission in the framework of the EU Biodiversity Strategy and the Green Infrastructure Strategy. EnRoute provides scientific knowledge of how urban ecosystems can support urban planning at different stages of policy and for various spatial scales and how to help policy-making for sustainable cities. A key pillar of the project is science-policy interface. Local stakeholders were involved in all the activities carried on at a local scale.
Barriers encountered and lessons learned	Main barriers are linked to: expertise requested for the implementation of the indicator.
Case study author	Grazia Zulian[1], Georgia Kakoulaki[2] *[1]JRC D3 Land Resources* *[2]JRC C2*
References	Cortinovis, C., Zulian, G., and Geneletti, D., 'Assessing Nature-Based Recreation to Support Urban Green Infrastructure Planning in Trento (Italy)', *Land*, Vol. 7, No 4, 2018, p. 112. Liquete, C., Piroddi, C., Macías, D., Druon, J.N., and Zulian, G., 'Ecosystem services sustainability in the Mediterranean Sea: Assessment of status and trends using multiple modelling approaches', *Scientific Reports*, Vol. 6, 2016, Art. No 34162.

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Schröter, M., Remme, R.P., Sumarga, E., Barton, D.N. and Hein, L., 'Lessons learned for spatial modelling of ecosystem services in support of ecosystem accounting', *Ecosystem Services*, Vol. 13, 2015, pp. 64–69.

Vallecillo, S., La Notte, A., Zulian, G., Ferrini, S., and Maes, J., 'Ecosystem services accounts: Valuing the actual flow of nature-based recreation from ecosystems to people', *Ecological Modelling*, Vol. 392, 2019, pp. 196–211.

Zulian, G., Paracchini, M.L., Maes, J., and Liquete, C., 'ESTIMAP: Ecosystem services mapping at European scale', *Publications Office of the European Union*, Luxembourg, 2013.

Zulian, G., Stange, E., Woods, H., Carvalho, L., Dick, J., Andrews, C., Baró, F., Vizciano, P, Barton, D.N., Nowel, M., Rusch, G.M., Aurunes, P., Fernandes, J., Ferraz, D., Ferreira dos Santos, R., Aszalós, R., Arany, I., Czúcz, B., Priess, J.A., Hoyer, C., Bürger-Patricio, G., Lapola, D., Mederly, P., Halabuk, A., Bezak, P., Kopperionen, L., and Viinikka, A., 'Practical application of spatial ecosystem service models to aid decision support', *Ecosystem Services*, Vol. 29 C, 2018, pp. 465-480.

5.2.6 *Green Space Management – Land composition*

NBS name and location	This indicator is part of a framework applied at European level to map and assess urban ecosystems condition and ecosystem services
Brief description of NBS	The indicator was implemented to assess **Land composition** in 700 European Functional Urban Areas (FUAs; see Figure 5-11 in case study 5.2.4 Green Space Management – Annual Trend in vegetation cover). This work was part of the **EnRoute** project and the MAES initiative. https://oppla.eu/groups/enroute https://publications.jrc.ec.europa.eu/repository/handle/JRC115375 **Mapping and Assessment of Ecosystems and their Services – MAES:** https://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/index_en.htm
Additional Indicators of relevance	At European level the following indicators have been implemented: 7.1 Green spaces Accessibility 7.2 Share of green urban areas 8.1 Ecosystem services provision (flood control, nature-based recreation, pollination) 8.2 Annual trend in vegetation cover in urban green infrastructure 8.31.1 ESTIMAP nature-based recreation **8.38 Land composition** 8.39 Land use change and green space configuration 8.40 Soil sealing
Explanation for selection of Additional Indicators	Land composition is a measure of the spatial distribution of elements or components of a landscape. It is used to consider the co-occurrence of land types within each FUA. It represents the arrangements of ecosystem types within and around cities (Figure 5-17). To quantify land composition we use the Landscape Mosaic (LM), model available in Guidos tool box https://forest.jrc.ec.europa.eu/en/activities/lpa/gtb/ (Vogt and Riitters, 2017). This indicator is useful to describe the context where NBS are deployed.

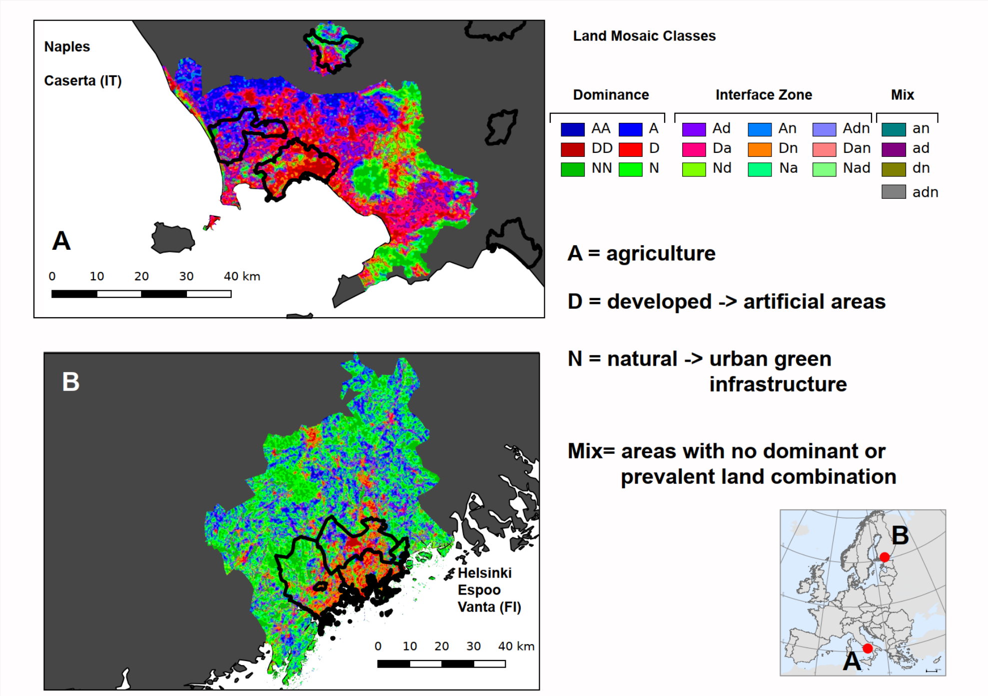

Figure 5-17. Land Mosaic maps in Helsinki (FI) and Naples (IT). A = Agriculture; D = Developed; N = natural; Mix = mixed presence of all land classes (source: Maes et al., 2019).

Description of Additional Indicator Application	Spatially explicit data are available for the 700 FUA. In **EnRoute** the indicator was applied to explore the capacity of urban ecosystems to provide Ecosystem services city types based on land composition and population density. Urban Atlas (https://land.copernicus.eu/local/urban-atlas) was used as land cover dataset. Figure 5-18. shows EU FUA classified with reference to land composition, population density and size.

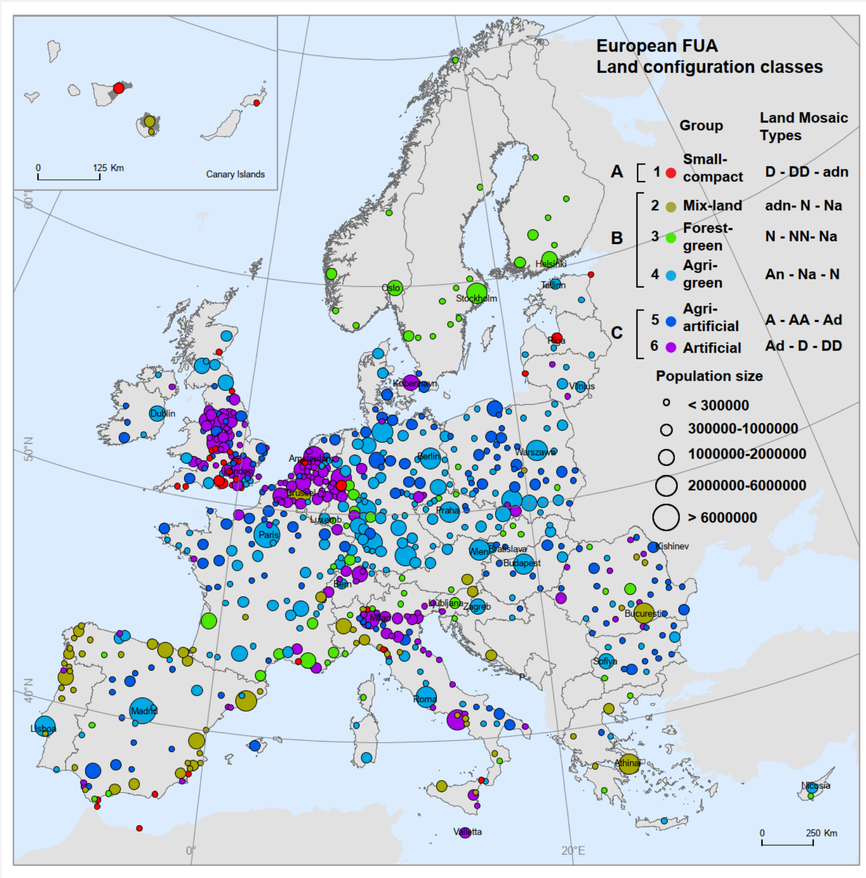

Figure 5-18. Spatial distribution of European functional urban areas (FUAs) classified by land composition, size and population density. The map includes FUAs in Norway and Switzerland (source: Maes et al., 2019).

Figure 5-19 shows the behaviour of two indicators (8.31.1 ESTIMAP nature based recreation and 7.2 share of urban green) with respect to the typology of cities. The indicators exhibit a high variability in average per city type as well as a high variability in the range of values. This is especially evident for the share of green spaces in core cities.

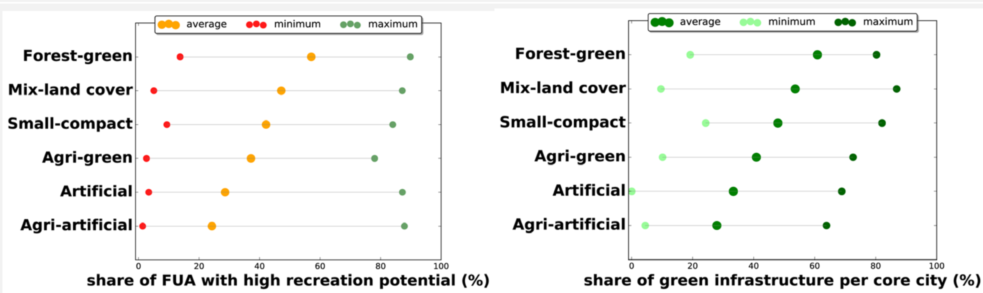

Figure 5-19. Average and range of the share of FUA with high recreation potential and share of green spaces per core city (source: Maes et al., 2019).

In **MAES** the indicator was applied to analyse the changes in land composition (Figure 5-20). Corine land Cover (https://land.copernicus.eu/pan-european/corine-land-cover) was used as land cover dataset.

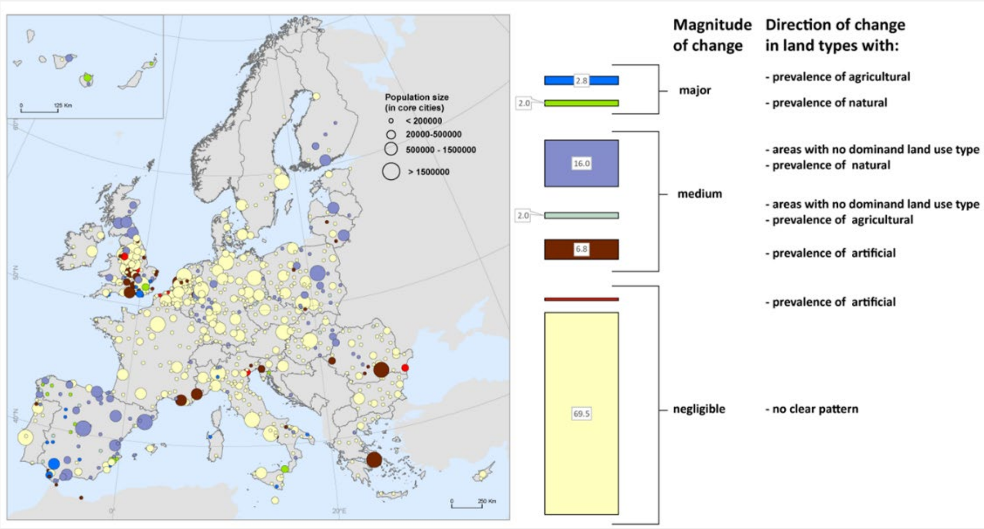

Figure 5-20. FUAs classified in terms of magnitude and direction of change between 2000 and 2018. (source: Maes et al., 2020, Chapter 3.1: Urban Ecosystems; Factsheet 3.1.107).

Stakeholders involved	**EnRoute** is a project of the European Commission in the framework of the EU Biodiversity Strategy and the Green Infrastructure Strategy. EnRoute provides scientific knowledge of how urban ecosystems can support urban planning at different stages of policy and for various spatial scales and how to help policy-making for sustainable cities. A key pillar of the project is science-policy interface. Local stakeholders were involved in all the activities carried on at a local scale. **MAES** represents the core activity of Action 5 – Target 2 of the EU Biodiversity strategy to 2020. The all process, started in 2013 involved EU Member States, The Commission (DG ENV, DG-JRC), The European Environmental Agency (EEA) and several other stakeholders. Specifically, a workshop, held in Brussels in June 2019 provided the opportunity for stakeholders to engage in the first EU wide ecosystem assessment.
Barriers encountered and lessons learned	Main barriers are linked to: expertise requested for the implementation of the indicators.
Case study author	Grazia Zulian (grazia.zulian@ec.europa.eu) *JRC D3 Land Resources*
References	Maes, J., Zulian, G., Günther, S., Thijssen, M., and Raynal, J., 'Enhancing Resilience Of Urban Ecosystems through Green Infrastructure. Final Report', *Publications Office of the European Union*, Luxembourg, 2019. Maes, J., Teller, A., Erhard, M., Condé, S., Vallecillo, S., Barredo, J.I., Paracchini, M.L., Abdul Malak, D., Trombetti, M., Vigiak, O., Zulian, G., Addamo, A.M., Grizzetti, B., Somma, F., Hagyo, A., Vogt, P., Polce, C., Jones, A., Marin, A.I., Ivits, E., Mauri, A., Rega, C., Czúcz, B., Ceccherini, G., Pisoni, E., Ceglar, A., De Palma, P., Cerrani, I., Meroni, M., Caudullo,

	G., Lugato, E., Vogt, J.V., Spinoni, J., Cammalleri, C., Bastrup-Birk, A., San Miguel, J., San Román, S., Kristensen, P., Christiansen, T., Zal, N., de Roo, A., Cardoso, A.C., Pistocchi, A., Del Barrio Alvarellos, I., Tsiamis, K., Gervasini, E., Deriu, I., La Notte, A., Abad Viñas, R., Vizzarri, M., Camia, A., Robert, N., Kakoulaki, G., Garcia Bendito, E., Panagos, P., Ballabio, C., Scarpa, S., Montanarella, L., Orgiazzi, A., Fernandez Ugalde, O., and Santos-Martín, F., 'Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment', EUR 30161 EN, Publications Office of the European Union, Ispra, 2020. Vogt, P. and Riitters, K., 'GuidosToolbox: universal digital image object analysis', *European Journal of Remote Sensing*, Vol. 50, No 1, 2017, pp. 352–361.

5.2.7 *Biodiversity Enhancement – Number of conservation priority species*

NBS Name and Location	Growchapel and Bellahouston Open Spaces sites **Glasgow, UK**
Brief description of NBS	As part of Glasgow City Council's Open Space Strategy, they are rolling out a programme of nature-based solutions to provide targeted multifunctionality to underused open spaces across the city. The programme empowers NGOs and community groups to utilise local spaces and deliver permanent and meanwhile uses on them including the development of nature-based solutions. Interventions comprise anything from art installations, to pocket parks and urban grow-your-own spaces (Figure 5-21). Multifunctionality is at the heart of the design and Connecting Nature is supporting the out-scaling of the programme through greater focus on a nature-based solution approach, more support for NGOs and community groups to deliver sustainable stewardship plans, and a spatial dataset of ecosystem service needs across the city to support decision-making in relation to the design of the underused spaces. https://connectingnature.eu/glasgow https://connectingnature.eu/oppla-case-study/19384
Additional Indicators of relevance	10.16 Number of conservation priority species 7.1 Greenspace accessibility 9.1 Greenspace connectivity
Explanation for selection of Additional Indicators	Whilst biodiversity net-gain is a target of Glasgow City Council's Open Space Strategy, these projects are typically delivered in small spaces and do not have the budgets to cover comprehensive biodiversity evaluations (e.g., Recommended biodiversity indicators like species diversity and functional connectivity). As such, a more targeted biodiversity indicator was needed. Evaluation of priority species associated with the spaces was seen as a win-win for the council as, it represented a more focused evaluation methodology, and it aligned more closely with strategic objectives of the local authority and existing monitoring programmes.

Description of Additional Indicator Application	Before and after priority species evaluation would be carried out to assess any impact of the implemented nature-based solution. This would comprise a combination of local record searches and direct site evaluation.
Stakeholders involved	This evaluation would be carried out in collaboration with other monitoring schemes in the city (e.g., RSPB sparrow monitoring) and with other departments in within the council (e.g., biodiversity team).
Barriers encountered and lessons learned	Establishing contacts with appropriate departments and organisations was a challenge. Also identifying necessary expertise to carry out surveys.
Case study author	Stuart Connop (s.p.connop@uel.ac.uk) *University of East London, UK*
References	Connecting Nature Environmental Indicators review: https://connectingnature.eu/nature-based-solution-evaluation-indicators-environmental-indicators-review

Figure 5-21. Glasgow meanwhile space conversion providing a temporary grow-your-own space for the local community (© Glasgow City Council).

5.2.8 Air Quality – Trends in NOx and SOx emissions

NBS name and location	Urban garden biofilter for air pollution **Underground car park in Portugalete Square** **Plaza de la Libertad, 5, 47002 Valladolid (Spain)**
Brief description of NBS	**Urban Garden Biofilter** is an air filter framed in an urban garden for the emissions of **underground car parks or other stationary sources** of pollutant compounds in urban environments. This NBS has been firstly prototyped for URBAN GreenUP Project (GA nº 730426). The NBS is composed of three main elements, the extractor system to extract the polluted air from underground car park, the plenum section to distribute the air under the Biofilter and the Biofilter itself to clean the air and metabolize pollutants (Figure 5-22). It is composed by several layers for support, pollutants absorption and protection and finally is cover by vegetation. The absorption/capture of air pollutants is made by the different layers and the metabolisation of these pollutants is made by the soil microbiota and the vegetation. This NBS has been developed by CARTIF in a previous research project. Project results show that it can be captured most of NO_x and PM (>90%) from indoor air (pollutants concentration 0.5-1 ppm). This NBS can be adapted to existing car parks or tunnels or included in the design of new infrastructures. It can be created a new line for indoor air extraction and conduct it to the plenum zone. Then, the air will be cleaned by passing thought the biofilter materials. Due to the specific design of the biofilter layers, pressure drop of the filter is very low and simple extractor fan is used.

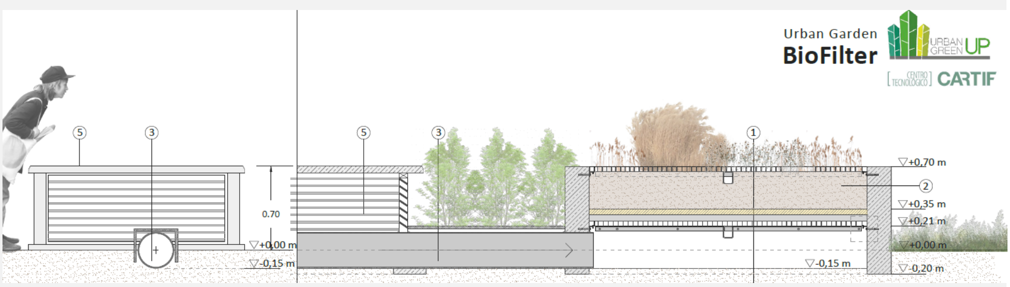

Figure 5-22. URBAN GreenUP Project: Biofilter cross section (© CARTIF).

Additional Indicators of relevance	6.9 Trends in emissions NO_x and SO_x

	6.10 Monetary values: value of air pollution reduction; total monetary value of urban forests including air quality, run-off mitigation, energy savings, and increase in property values. **6.11 Air quality parameters. NO_X and PM.** 6.13 Concentration of particulate matter ($PM_{2.5}$ and PM_{10}) at respiration height along roadways and streets.
Explanation for selection of Additional Indicators	In future, if this NBS is widely installed it can be used recommended indicators for Air Quality challenge. Recommended indicators have a scale of measurement from district to region and they have not sensibility enough to study the impact of this NBS. Therefore, in the meantime it is needed additional indicators to assess the impact on air pollutants emission reduction with indicators such as the ones mentioned before.
Description of Additional Indicator Application	In this case, the main indicator for impact assessment is 6.11 and additionally the other ones. 6.11 implies the installation of three equipment for continuous monitoring of NO_2, O_3 and PM (inside of the car park, next to the biofilter and separated from the biofilter but in the same square or street). This indicator is completed with the other in order to value and compare biofilter impact with other NBS such as tree or bush lines.
Stakeholders involved	Different municipality areas (at least urbanism, environment and heritage), car park property, construction companies
Barriers encountered and lessons learned	The main difficult aspect is found in the design and project phase for the implementation of this NBS. Impact assessment can be carried out by using one or several of the indicators depending on the budget or monitoring tool available. Indicator 6.11 is highly recommended and monitoring locations should be done by experts for the first studies because this is an innovative solution. The implementation of this NBS is still ongoing so no experience has been collected from the monitoring. However, when ongoing pilot studies and field analysis finish, the assessment framework can be made simpler by using indicators such as 6.9 or 6.13.
Case study authors	Raúl Sánchez[1], Jose Fermoso[1], Francisco Verdugo[1], Raquel Marijuan[1], Silvia Gómez, María González[1], José María Sanz[1], Esther San José[1], Alicia Villazán[2], Isabel Sánchez[2], Elena Sánchez[2], Natividad Sanz[3], José Antonio Pérez[4], Laura Crespo[5] *[1]CARTIF Foundation. P.T. Boecillo, 205, 47151, Boecillo, Valladolid, Spain* *[2]VALLADOLID City Council. Plaza Mayor 1, 47001, Valladolid, Spain* *[3]ISOLUX CORSAN aparcamientos. Plaza Portugalete, s/n, 47002 Valladolid, Spain.* *[4]CONYTRAIR. Ctra. Cabezón, 6, 47155 Santovenia de Pisuerga, Valladolid.* *[5]LAURA CRESPO ARCHITECT, Valladolid, Spain*

5.2.9 *Knowledge and Social Capacity Building for Sustainable Urban Transformation – Connectedness to nature*

NBS Name and Location	Living Lab districts **In the cities of Turin (Italy), Zagreb (Croatia) and Dortmund (Germany)**
Brief description of NBS	During the proGIreg project (https://progireg.eu/), this indicator will be assessed on the general population in the Living (LL) district and 300 in a different, comparable city district ("control district") in each European Front-Runner City (FRC).
Additional Indicators of relevance	**16.3 Mindfulness/ Connectedness to nature** 22.13 Perceived restorativeness of NBS/ green space
Explanation for selection of Additional Indicators	This indicator is widely used in social sciences since it provides a reliable assessment of the relationship between human being and the natural environment
Description of Additional Indicator Application	Connectedness with nature is defined as the sense of oneness to nature. This indicator is part of the socio-cultural inclusiveness evaluation as a component of a survey for the assessment health, social and economic benefits of NBSs. The "Connectedness to nature scale" (CNS; Mayer, 2004), a validated tool for assessing this indicator, will involve 300 persons in each district during two time points, i.e., pre- and post- NBS implementations (after three years). The scale includes 14 items with a 5-point Likert scale ranging from "Strongly disagree" to "Strongly agree".
Stakeholders involved	Civil local authorities and university students for data collection during baseline have been involved
Barriers encountered and lessons learned	The three European FRCs followed a standardized procedure for recruitment and data collection, in accordance with the proGIreg scientific WP. Despite the support of the scientific WP through informal exchange of information and formal meetings in order to implement strategies to reach the target number of completed questionnaires, the final outcome differed within the FRCs. The city of Dortmund has collected 140 interviews (48 in the LL and 92 in the control district), the city of Turin has collected 398 interviews (221 in the LL and 177 in the control district). Only the city of Zagreb managed to reach and even exceeded the determined target number of interviews, previously set at 600 (302 from the LL and 313 from the control district). All cities sent a first information letter to the population in order to invite to participate in our research. In Turin, the invitation letters were sent a second time. As expected, the response rate was very variable between cities and was between 15% and 40%. The information reported by the cities provides useful insights for future planning of questionnaires, of which Connectedness with

	nature scale is part. Participants from each FRC complained about some aspects of the general questionnaire such as the excessive length and the presence of uncomfortable questions. No complaints were specifically addressed to the Connectedness with nature scale. Lessons learned regards the strategies that each FRC implemented to overcome the barriers encountered in reaching the target number of participants, briefly summarized below. - Application of a door-to-door technique to directly approach the target population - Organization of public events in the neighbourhoods concerned in order to increase the sample size. - Second sending of invitation letters following the unsatisfactory response of the population to the first sending. - Possibility of hiring specialized personnel to conduct the survey.
Case study author	Giuseppina Spano (giuseppina.spano@uniba.it) *University of Bari, Italy*
References	Mayer, F., 'The connectedness to nature scale: A measure of individuals' feeling in community with nature', *Journal of Environmental Psychology*, Vol. 24, 2004, pp. 503-515.

5.2.10 Social Justice and Social Cohesion – Perceived social support

NBS Name and Location	Living Lab districts **In the cities of Turin (Italy), Zagreb (Croatia) and Dortmund (Germany)**
Brief description of NBS	During the proGIreg project (https://progireg.eu/), this indicator will be assessed on the general population in the Living (LL) district and 300 in a different, comparable city district ("control district") in each European Front-Runner City (FRC).
Additional Indicators of relevance	20.4.1 Perception of socially supportive network **20.4.2 Perceived social support**
Explanation for selection of Additional Indicators	Empirical evidences showed that supportive social groups and effective and helpful social networks are associated with a good mental and physical health. This indicator is measured in the neighbour-hood context since a perception of high social support fosters social inclusion and justice.

Description of Additional Indicator Application	Perceived social support is defined as the perception of various ways in which individuals aid others. This indicator is obtained using an 8-point scale on general social support and a 6-point scale on social support in the neighbourhood.
Stakeholders involved	Civil local authorities and university students for data collection during baseline have been involved
Barriers encountered and lessons learned	The three European FRCs followed a standardized procedure for recruitment and data collection, in accordance with the proGIreg scientific WP. Despite the support of the scientific WP through informal exchange of information and formal meetings in order to implement strategies to reach the target number of completed questionnaires, the final outcome differed within the FRCs. The city of Dortmund has collected 140 interviews (48 in the LL and 92 in the control district), the city of Turin has collected 398 interviews (221 in the LL and 177 in the control district). Only the city of Zagreb managed to reach and even exceeded the determined target number of interviews, previously set at 600 (302 from the LL and 313 from the control district). All cities sent a first information letter to the population in order to invite to participate in our research. In Turin, the invitation letters were sent a second time. As expected, the response rate was very variable between cities and was between 15% and 40%. The information reported by the cities provides useful insights for future planning of questionnaires, of which the scale on perceived social support is part. Participants from each FRC complained about some aspects of the general questionnaire such as the excessive length and the presence of uncomfortable questions. No complaints were specifically addressed to the perceived social support scale. Lessons learned regards the strategies that each FRC implemented to overcome the barriers encountered in reaching the target number of participants, briefly summarized below. - Application of a door-to-door technique to directly approach the target population - Organization of public events in the neighbourhoods concerned in order to increase the sample size. - Second sending of invitation letters following the unsatisfactory response of the population to the first sending. - Possibility of hiring specialized personnel to conduct the survey.
Case study author	Giuseppina Spano (giuseppina.spano@uniba.it) *University of Bari, Italy*
References	Pearson, J.E., 'The definition and measurement of social support', *Journal of Counseling and Development*, Vol. 64, 1986, p. 390-395.

5.2.11 Health and Wellbeing – Prevalence, incidence, and morbidity of chronic stress

NBS Name and Location	Stalled Spaces **Glasgow, Scotland**
Brief description of NBS	**Description** Stalled Spaces (Figure 5-23) is a programme launched by Glasgow City Council to support community groups and local organisations across the city develop temporary projects on stalled sites or under-utilised open spaces. In particular, the Stalled Spaces programme gives local organizations the opportunity to temporarily use a plot of these spaces in a way which will bring multiple benefits to the local communities. Projects supported by the programme deliver a range of initiatives based on the needs of the community. It means that community stakeholders decide how to use these spaced and how to adapt them to cover their needs. Examples of these initiatives are: growing spaces, pop-up gardens, wildlife areas, urban gyms or natural play spaces, temporary art in the form of pop-up sculptures, and spaces for events or exhibitions. **Relevance** The programme was started in 2011 and only in its first five years has helped deliver over 100 projects that have successfully brought over 25 ha of vacant, underutilised or stalled sites under temporary community use.
Additional Indicators of relevance	**22.22 Prevalence, incidence, morbidity of chronic stress** **Short name:** Chronic stress **Definition:** Within Connecting Nature, stress is defined as the process by which an individual responds psychologically, physiologically, and often with behaviours, to a situation that challenges or threatens well-being (Baum et al., 1985 as cited in Ulrich et al., 1991, p. 202). The psychological component includes cognitive appraisal of the situation, emotions such as fear, anger, and sadness, and coping responses (Ulrich et al., 1991).
Explanation for selection of Additional Indicators	1. **Theoretical pertinence.** Two theoretical frameworks that establish an association between exposition to / engagement with nature and stress alleviation have been identified: Attention Restoration Theory (ART) (Kaplan, 1995) and Stress Recovery Theory (SRT) (Ulrich et al., 1991). 2. **Impact of the health problem.** Chronic stress associated to modern urban lifestyles is a serious health problem with an increasing incidence around the world. Moreover, psychological stress is considered as a significant factor in the onset, course and exacerbation of other chronic diseases (depression, cardiovascular diseases…) and it has been related to the higher overall mortality (Cohen et al., 2007; Hammen, 2005; Klein et al., 2016).

	3. **Appropriateness of the NBS characteristics.** The multiple initiatives launched in the frame of the Stalled Spaces Programme over the last decade have not only contributed to regenerate some areas in Glasgow, but also to revitalize local communities, to reconnect people with nature, to generate opportunities for social interaction, to stimulate social cohesion or to support physical activity. Each of these achievements constitutes mechanisms to alleviate chronic stress associated to urban lifestyle and needs to be explored further to understand how they work and how they could be reinforced to become more effective. 4. **Indicator strengths.** Chronic stress is considered as a reliable indicator to assess physical and mental health and general wellbeing. In addition, it is appropriate to explore whether the exposition to a NBS contributes to mitigate stress.
Description of Additional Indicator Application	The tool selected and applied by Glasgow to measure the chronic stress indicator in the Stalled Spaces programme is **the 10-items Perceived Stress Scale** (Cohen et al., 1983) included in a survey with other indicators specifically chosen to assess the multiple benefits associated to the implementation of this programme. This scale is a self-report measure that provides psychological subjective data. In particular, it intends to capture the degree to which persons perceive situations in their daily life as excessively stressful in relation to their ability to cope with them. Methodology and data analysis require high expertise in psycho-social research but quantitative data collection does not require expertise.
Stakeholders involved	Glasgow City Council; Connecting Nature partners; Data collection experts (responsible for collecting subjective psychological data)
Barriers encountered and lessons learned	**Barriers encountered** Given the complex psychophysiological pathways of stress, measurement is usually approached holistically through collection of both subjective psychological (i.e., subjective rating scales, self-report measures) and objective physiological data (most frequently, salivary analysis due to the validity, reliability and ease of collection of salivary data). However, collecting biochemical data for evaluating a NBS is considered as a major challenge by the majority of cities for two main reasons: (i) data collection and analysis of biochemical samples require high clinical expertise, resources and capacities which are frequently difficult to acquire for cities; (ii) barriers usually encountered during fieldwork planning -and in particular those related to the recruitment of participants - for any study increase when clinical procedures are included in the design. This means that this objective physiological measure is feasible in the experimental research usually conducted by academic and health organizations, but not in the frame of a routine evaluation conducted by cities. **Lessons learned** 1. The experience of Glasgow has demonstrated that it is essential to provide a detailed description of the characteristics of the NBS under evaluation and, in particular, of the activities deployed in it (i.e., gardening, urban gyms,

	play spaces...). The high diversity of uses allocated to the Stalled Spaces in Glasgow constitutes an unexceptional opportunity to identify which activities have a most positive impact in the stress alleviation (i.e., comparing activities that enhance physical activity with those that promote social interaction). 2. In order to gain a holistic understanding of the NBS impact on the physical and mental health, it is also recommended to measure this indicator in combination with other indicators that could contribute to enrich data analysis and interpretation. In particular, it is suggested to also collect data about place attachment; general wellbeing and happiness; and depression and anxiety. 3. It is strongly recommended to collect data on symbolic / affective meanings assigned to NBS using participatory data collection methods and qualitative techniques. These data are useful to understand why and how the exposition to, and the engagement with, the NBS could contribute to alleviate chronic stress.
Case study authors	Adina Dumitru[1] (adina.dumitru@udc.es), David Tomé-Lourido[1], Susana Pablo[1] *[1]University of A Coruña, Spain*
References	Cohen, S., Kamarck, T., and Mermelstein, R., 'A global measure of perceived stress', *Journal of Health and Social Behavior*, Vol. 24, No 4, 1983, pp. 385-396. Cohen, S., Janicki-Deverts, D., and Miller, G. E., 'Psychological stress and disease', *Journal of the American Medical Association*, Vol. 298, No 14, 2007, pp. 1685-1687. Glasgow City Council, *Open Space Strategy*, 2020. Hammen, C., 'Stress and Depression', *Annual Review of Clinical Psychology*, Vol. 1, 2005, pp. 293-319. Kaplan, S., 'The Restorative Benefits of Nature: Toward an Integrative Framework', *Journal of Environmental Psychology*, Vol. 15, 1995, pp. 169-182. Klein, E.M., Brähler, E., Dreier, M., Reinecke, L., Müller, K.W., Schmutzer, G.G., Wölfling, K., and Beutel, M.E., 'The German version of the Perceived Stress Scale – psychometric characteristics in a representative German community sample', *BMC Psychiatry*, Vol. 16, 2016, pp. 1-10. Ulrich, R.S., Simons, R.F., Losito, B.D., Fiorito, E., Miles, M.A., and Zelson, M., 'Stress recovery during exposure to natural and urban environments', *Journal of Environmental Psychology*, Vol. 11, No 3, 1991, pp. 201-230. White, J.T. and Bunn, C., 'Growing in Glasgow: Innovative practices and emerging policy pathways for urban agriculture', *Land Use Policy*, Vol. 68, 2017, pp. 334-344.

Figure 5-23. Stalled Spaces Programme (© Glasgow City Council).

5.2.12 *Health and Wellbeing – Perceived chronic loneliness*

NBS Name and Location	Bellahouston Demonstration Garden **Glasgow, Scotland**
Brief description of NBS	Bellahouston Demonstration Garden was established in the city of Glasgow, providing allotment-style growing spaces to be used by different charities and educational establishments (Hölscher et al., 2019; White and Bunn, 2017). The NBS arises from the Allotment and Neighbourhood and Sustainability strategies, carried out by the Glasgow City Council, highlighting the restorative and therapeutic benefits of gardening, due to social interaction in the community (White and Bunn, 2017). The objective of this growing space located in the walled Garden at Bellahouston Park is twofold, on the one hand to provide healthy and sustainable food to the neighbours, and on the other hand to create a community space with social and health benefits for the citizens of Glasgow.
Additional Indicators of relevance	**22.9 Perceived chronic loneliness** Within Connecting Nature, this indicator is conceptualized as a subjective experience of being socially isolated and absent both relational and collective connectedness (Russell et al., 1980).

Explanation for selection of Additional Indicators	The strategies implemented for the creation of demonstration gardens and growing spaces in Glasgow seek to promote social interaction and engaging people who felt isolated from the community (White and Bunn, 2017). Social isolation has a lasting impact on health and wellbeing (e.g., increased levels of stress, depression, or cardiovascular concerns) (Holt-Lunstad et al., 2010; Holt-Lunstad et al., 2015; Pantell et al., 2013), while social cohesion and green space are associated with positive outcomes like reduced smoking, alcohol consumption, obesity, or cognitive decline (Jennings and Bamkole, 2019; Wendelboe-Nelson et al., 2019). Green spaces contribute to social cohesion through fostering positive social interactions and social engagement (Jennings and Bamkole, 2019). Natural features also enhance feelings of place attachment and identity, promoting a sense of community that contributes to a decrease in feelings of loneliness (Prezza et al., 2001). A lower presence of green spaces in people's living environment was found to be related to greater feelings of loneliness and perceived shortage of social support (Maas et al., 2009). The association between green spaces, perceived social support and loneliness was found to be the strongest in highly urbanized areas (Maas et al., 2009). These research results, as well as the existing reality in the city led the Connecting Nature team to consider Chronic loneliness as a significant indicator to know the influence of the Bellahouston Demonstration Garden (Figure 5-24) on the well-being of its users.
Description of Additional Indicator Application	The indicator is assessed using a standardized quantitative instrument: The Three-Item Loneliness Scale (Hughes et al., 2004). This tool is a short form of the revised UCLA Loneliness scale (Russell et al., 1980) which measures the experience of loneliness. This scale includes three items measured on a 3-point Likert scale (1 = hardly ever; 2 = some of the time; 3 = often). For final scoring purposes, each person's scale responses to the three items are summed, with higher scores indicating greater experienced loneliness (Hughes et al., 2004). Methodology and data analysis require high expertise in psycho-social research but quantitative data collection requires no expertise. During the Connecting Nature project, the data gathering is conducted after the NBS implementation, but it allows making comparisons between different areas of the city or population groups (i.e., users vs no users). It is suggested to conduct two data collection waves to assess the longitudinal effects over time.
Stakeholders involved	Connecting Nature; Glasgow City Council; Glasgow Community Planning Partnership; Data collection experts
Barriers encountered and lessons learned	Although the officers leading the Food Growing Strategy were aware that the Bellahouston Demonstration Garden provided social, environmental, health and economic benefits, they had difficulties both in reflecting these advantages in official papers,

	and in holding conversations with the community and funding bodies (Hölscher et al., 2019). Therefore, within the Connecting Nature project a suitable business model was identified to scale up and replicate the project to other areas of the city (van de Sijpe et al. 2019). In this way, the Connecting Nature project provided the knowledge to develop food growing business within the Food Growing Strategy of the city council, conducting conversations with the community and identifying possible funding routes.
Case study authors	Adina Dumitru[1] (adina.dumitru@udc.es), David Tomé Lourido[1], Susana Pablo[1] *[1]University of A Coruña, Spain*
References	Hölscher, K., Lodder, M., Collier, M., Frantzeskaki, N., Sillen, D., Notermans, I., Allaert, K., Dumitru, A., Connop, S., Vandergert, P., McQuaid, S., Quartier, M., van de Sijpe, K., Vos, P., Dick, G., Kelly, S., Mowat, L., Sermpezi, R., Dziubala, A., Madajczyk, N., and Osipiuk, A., *Deliverable 5: Nature-based Solutions Framework for frontrunner cities*, 2019, CONNECTING Nature, Grant Agreement number 730222. Holt-Lunstad, J., Smith, T.B., and Layton, J.B., 'Social relationships and mortality risk: a meta-analytic review', *PLoS medicine*, Vol. 7, No 7, 2010, pp. 1-20. Holt-Lunstad, J., Smith, T.B., Baker, M., Harris, T., and Stephenson, D., 'Loneliness and social isolation as risk factors for mortality: a meta-analytic review', *Perspectives on Psychological Science*, Vol. 10, No 2, 2015, pp. 227-237. Hughes, M.E., Waite, L.J., Hawkley, L.C., and Cacioppo, J.T., 'A short scale for measuring loneliness in large surveys: Results from two population-based studies', *Research on Aging,* Vol. 26, No 6, 2004, pp. 655-672. Jennings, V. and Bamkole, O., 'The relationship between social cohesion and urban green space: An avenue for health promotion', International Journal of Environmental Research and Public Health, Vol. 16, No 3, 2019, pp. 452. Maas, J., Van Dillen, S.M., Verheij, R.A., and Groenewegen, P.P., 'Social contacts as a possible mechanism behind the relation between green space and health', *Health and Place,* Vol. 15, No 2, 2009, pp. 586-595. Pantell, M., Rehkopf, D., Jutte, D., Syme, S.L., Balmes, J., and Adler, N., 'Social isolation: a predictor of mortality comparable to traditional clinical risk factors', *American Journal of Public Health*, Vol. 103, No 11, 2013, pp. 2056-2062. Prezza, M., Amici, M., Roberti, T., and Tedeschi, G., 'Sense of community referred to the whole town: Its relations with neighboring, loneliness, life satisfaction, and area of residence', *Journal of Community Psychology*, Vol. 29, No 1, 2001, pp. 29-52. Russell, D., Peplau, L.A., and Cutrona, C.E., 'The revised UCLA Loneliness Scale: concurrent and discriminant validity evidence', *Journal of Personality and Social Psychology*, Vol. 39, No 3, 1980, pp. 472-480. van de Sijpe, K., Vos, P., Dick, G., Mowat, L., Dziubala, A., Zwierzchowska, I., Vandergert, P., Jelliman, S., Connop, S., Nash, C., and González, G., *Deliverable 9: An interim report on progress towards initiation of city-wide nature-based solutions exemplars*, 2019, CONNECTING Nature, Grant Agreement number 730222. Wendelboe-Nelson, C., Kelly, S., Kennedy, M., and Cherrie, J. W., 'A scoping review mapping research on green space and associated mental health benefits', *International Journal of Environmental Research and Public Health*, Vol. 16, No 12, 2019, 2081. White, J.T. and Bunn, C., 'Growing in Glasgow: Innovative practices and emerging policy pathways for urban agriculture', *Land Use Policy*, Vol. 68,2017, pp. 334-344.

Figure 5-24. Bellahouston Demonstration Garden (© Glasgow City Council).

5.3 Conclusions

The case studies herein illustrate the strength of the 'buffet' style approach of the NBS impact indicator framework presented in this handbook. The inherent heterogeneity of NBS – in type, form and scale of application – preclude a one-size-fits-all approach to NBS impact assessment. In this context, the Recommended indicators provide a suggested minimum suite of indicators in order to obtain a holistic assessment of NBS performance and impact, with the selection of specific Additional indicators serving to address specific concerns and thus augment the achieved understanding. The preceding case studies show how a combination of Recommended and Additional indicators may be applied to a specific NBS in order to develop a comprehensive understanding of NBS performance and impact, thereby enabling adaptive management of the NBS asset.

NAIAD

Nature Insurance value: Assessment and Demonstration

Thames basin (GB) Medina del Campo aquifer (ES) Lower Danube basin (RO)
Lez basin (FR) La Brague basin (FR) Glinscica catchment (SI)
Copenhagen (DK) Lodz (PO) Rotterdam (NL)

NAIAD is aimed to develop a strong conceptual framework for evaluating the assurance and the insurance value of ecosystem services. The project has developed the concept of natural assurance schemes, and the range of tools and methods to design them. These range from physical, social and economic assessments, integration and co-design with stakeholders, to the development of business models and financing arrangements to their full implementation and monitoring. Stakeholders involved included insurers, river basin agencies, local authorities, farmers in the validation and application in nine case study sites across Europe. It finally aims to contribute to academic knowledge and policy action on NBS planning and integration, and contribute to raise awareness on NBS and the associated socio-economic opportunities at all scales.

Drawing on knowlegde from projects funded by the European Union

Image: Petit Buëch - Photo © Smigiba.fr

SCOPE **NBS for Disaster Risk Reduction, i.e. floods and droughts**

Approach to Impact Assessment

The NAIAD framework is designed for effectiveness assessment and decision-making with respect to the choice of best NBS measures and strategies. The different steps of disaster risk reduction and contributions of NBS are studied within the NAIAD project considering technical, physical but also social, human, environmental and economic features. A specific methodology is designed to determine the indicators. Relevant indicators are defined by experts and stakeholders through workshops. A two-level approach is proposed making a difference between technical analysis and decision-making contexts. Expert and technical assessments are used as inputs in a multicriteria decision-making framework which allows to address all kinds of technical, environmental, economic, or social features, and to consider stakeholder preferences as identified during participative workshops.

Involved Stakeholders and roles

A core operating principal of NAIAD is to proactively engage with stakeholders in the case studies throughout the application of its conceptual and assessment methodologies for Natural Assurance Schemes. The interdisciplinary nature of the whole approach fundamentally makes it relevant to a wide range of stakeholders, including decision makers, practitioners, scientists, end users and communities. Each stakeholder will have their own particular knowledge and perspectives of the integrated physical, social, cultural and economic systems in which the case study is situated, with all these needing to be shared and synthesised during the assessments. In addition, the stakeholders served an important function in terms of "road testing" and validating the tools and methods developed and presented in this volume.

- **Municipal Administrations**
- **Regional/national statistics authority**
- **Planning experts**
- **Scientists / Academia**
- **NGOs**
- **River basin authorities**
- **Insurance sector**
- **Farmers**

Main Challenges addressed

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**
9. **Participatory Planning and Governance**
10. **Social Justice and Social Cohesion**
11. **Health and Wellbeing**
12. **New Economic Opportunities & Green Jobs**

Lessons learned

The first lesson learned on impact assessment from the NAIAD project is the importance of tailoring the approach to the catchment or pilot peculiarities. Providing an objective, easily understandable method to assess indicators of physical, social and economic effectiveness of NBS is essential to guarantee security but also to increase acceptance by stakeholders.

Different tools for impact assessment developed in NAIAD are tailored to the different demos allowed to get specific results for consensually agreed impact indicators, with high level of acceptance and satisfaction from stakeholders considering both technical, physical, environmental, economic, social and human effects and co-benefits of measures and strategies. One example is the Flood-Ex-cess-Volume (FEV) method that has been developed to quickly assess cost-efficacy of flood-mitigation strategies and proved useful in stakeholder workshops for raising public awareness of flood risk assessment before choosing a NBS strategy.

Learn more
www.naiad2020.eu

The NAIAD project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730497

OPERANDUM

Open-air laboratories for Nature Based Solutions to manage hydro-meteo risks

OAL-Australia OAL-Austria OAL-ChinaMainLand OAL-ChinaHongKong OAL-Finland OAL-Germany OAL-Greece OAL-Ireland OAL-Italy OAL-UK

OPERANDUM will deliver tools and methods for the demonstration and market uptake of Nature-Based Solutions to reduce hydro-meteorological risks. Nature-Based Solutions (NBS) are solutions that are inspired and supported by nature. These solutions provide environmental, social and economic benefits and help build resilience by bringing natural features into cities and landscapes. In the OPERANDUM project, site-specific and innovative NBS are co-designed, co-developed, deployed, tested and demonstrated with partners and local stakeholders in open-air laboratories. These open-air laboratories (OALs) are natural and rural Living Labs that cover a wide range of hazards with different climate projections, land use and socio-economic characteristics.

Drawing on knowlegde from projects funded by the European Union

Image: Bellocchio Lagoon (OAL-Italy) - Photo © Filippo Zanni for Arpae, 2016

SCOPE **To provide evidence, best practices, replication and scalability of existing and novel NBS, foster uptake of solutions to increase market exploitation**

Approach to Impact Assessment

The project's approach is based on 10 Open-Air Laboratories: areas exposed to specific hydro-meteorological risks where the efficacy of existing and novel NBS are assessed at local scale. OALs provide concrete, flexible and transportable frameworks in order to expand the adoption of green/blue/hybrid infrastructures across Europe and in developing countries. The OALs in OPERANDUM demonstrate NBS for different climatic zones and different climate change scenarios in Europe. The implemented NBS build upon multi-disciplinary expertise and full understanding of the role of ICT and takes into account market exploitation and national, EU and international policies.

Involved Stakeholders and roles

Due to the complexity of the Project a multiple level structure of engagement strategy is required. Starting from the local community, the Project involves stakeholders at national and international level to leverage widest possible NBS acceptance to promote its diffusion as a good practice and push business exploitation. The stakeholder engagement strategy is based on the stakeholder mapping to identify the main target categories of OPERANDUM. An important step in the stakeholder engagement process is represented by the prioritizing of stakeholders: a Power-Interest Matrix has been adopted as a useful tool to assessing the level of engagement required of different stakeholder groups. Furthermore, for each stakeholders category, reasons of interest and expectations have been identified to obtain a greater understanding of stakeholders motivations, interests, needs, and requirements.

- **Municipal Administrations**
- **Citizen**
- **Planning experts**
- **Scientists / Academia**
- **Green businesses**
- **Regional/national authority**
- **National/regional park`s authorities**
- **International bodies**
- **Policy makers**

Main Challenges addressed

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**
9. **Participatory Planning and Governance**
10. **Social Justice and Social Cohesion**
11. **Health and Wellbeing**
12. **New Economic Opportunities & Green Jobs**

Lessons learned

The challenges found across the OALs so far (OPERNADUM is still halfway) are related to the awareness, attitudes and trust, diversity of goals and interests, financial, legislative, resources (skills or time). We found that monitoring during the co-creation process and evaluation at the end of the process are important phases to faciltate the adoption of changes, improve the process, and enhance learning among partners. Defining common strategy for stakeholder engagement that includes tactics, formats, ethical rules and indicators for monitoring, is found to be of a paramount importance. The involvement of stakeholders has to be promoted in every step of the project and it's essential to maintain current communication or collaboration practices according to the needs of each phase. The novel platform, the OPERANDUM-GeoIKP has been designed ad-hoc to reach target users (stakeholders) including citizens, public authorities, policy makers. It is mandatory that information is conveyed using the up-to-date scientific evidence as well as worked examples.

Learn more
www.operandum-project.eu

The OPERANDUM project has received funding from the European Union`s Horizon 2020 research and innovation programme under grant agreement No 776848.

PHUSICOS

Solutions to reduce risk in mountain landscapes

Gudbrandsdalen Valley (NO) · The Pyrenees (ES/FR) · Isar River Basin, Munich (DE) · Serchio River Basin / Massacciuccoli Lake (IT) · Kaunertal Valley (AT)

PHUSICOS, meaning 'According to nature', in Greek φυσικός, aims to demonstrate how nature-inspired solutions reduce the risk of extreme weather events in rural mountain landscapes. The focus of PHUSICOS is on demonstrating the effectiveness of NBS and their ability to reduce the impacts from hydro-meteorological hazards (flooding, landslide, erosion, drought, snow avalanche) in rural mountain landscapes. The NBS considered and implemented in PHSUICOS are cost-effective and sustainable measures inspired by nature that attenuate, and in some cases prevent, the impacts of natural hazard events and thereby the risks that affect the exposed regions.

Drawing on knowlegde from projects funded by the European Union

Image: Small landslide in Kvam, Norway - Photo © Ingar Haug Steinholt, NGI

Approach to Impact Assessment

The PHUSICOS NBS Impact Assessment Framework is based on a multicriteria decision analysis, which assesses, through a matrix containing indicators aggregated in different sub-criteria, the risk reduction performance and the co-benefits of a design scenario for a specific site. Indicators are selected after an extensive review of the main existing NBS project networks and platforms, as well as the challenges indicated by the EKLIPSE project. The five main categories (ambits) considered in the evaluation of an NBS in the PHUSICOS framework are 1) Risk reduction, 2) Technical and feasibility aspects, 3) Environment and ecosystems, 4) Society, and 5) Local Economy.

Involved Stakeholders and roles

Stakeholder involvement and participation is a key component in the successful design, planning and implementation of NBS. PHUSICOS uses a Living Labs approach to frame and carry out the participatory processes with stakeholders at the different case study sites. Rather than a single definition, PHUSICOS has emphasized focusing on Living Lab principles to ensure tailor-made processes for co-creating and co-developing NBSs including fostering innovation and learning, diversity, user-centered, locally relevant context, and open-mindedness. The PHUSICOS Living Labs also highlight the need to engage stakeholders from four main networks: public organizations, private companies, users (or end-users), and knowledge institutions (academia). These different groups of stakeholders are providing initial reflections and identifying indicators that are most relevant based on their knowledge and needs with regard to implementing and monitoring NBS.

- **Municipal Administrations**
- **Regional/national statistics authorities**
- **Citizen**
- **Planning experts**
- **Scientists / Academia**

Main Challenges addressed

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

9. Participatory Planning and Governance

10. Social Justice and Social Cohesion

11. Health and Wellbeing

12. New Economic Opportunities & Green Jobs

Lessons learned

As part of the process of monitoring relevant indicators to assess the impact and efficacy of NBSs, stakeholders in the Living Labs have been engaged to provide input to the development of these monitoring systems. Thus far, reflections have been collected from the Serchio River Basin demonstrator case study site at Massacciuccoli Lake in Italy. In dialogue with local farmers, buffer strips to reduce the hydro-meteorological risk and improve the water quality are being implemented. Feedback on monitoring indicates that for each of the five main categories (ambits) in the PHUSICOS NBS evaluation framework, at least one of the proposed indicators is considered useful; with those focusing on implementation and maintenance costs as well as the policy context as the most valuable. Furthermore, publicly sharing monitoring results is viewed positively, also as a means of promoting NBS to the public.

Learn more
www.phusicos.eu

The PHUSICOS project has received funding from the European Union`s Horizon 2020 research and innovation programme under grant agreement No 776681.

RECONECT

Regenerating Ecosystems with Nature-based solutions for hydro-meteorological risk rEduCTion

Elbe Estuary (DE) | Seden Strand Odense (DK) | Todera River Basin (DK) | Park Portofino (IT) | Ijssel River Basin (NL) | Inn River Basin (AT) | Greater Aarhus (DK) | Thur River Basin (CH) | Var River Basin (FR) | Les Boucholeurs (FR) | Kamchia River Basin (BG) | Pilica River Basin (PL) | Sava River Basin (RS/HR) | Chao Praya River Basin (TH) | Greater Tainan Coastline (TW) | Rio do Couves (BR) | Klang River Basin (MY) | Yangtze River Basin (CN) | Chindwin River Basin (MM) | Tarago River Basin (AU) | Trinity River Basin (US) | Piura River Basin (PE) | Rio Frio (CO) | Cañaveralejo, Lili and Melendez River Basins (CO) | Coastline of St. Maarten (SX)

RECONECT aims to rapidly enhance the European reference framework on Nature-Based Solutions (NBS) for hydro-meteorological risk reduction by demonstrating, referencing, upscaling and exploiting large-scale NBS in rural and natural areas. In an era of Europe's natural capital being under increased cumulative pressure, RECONECT will stimulate a new culture of co-creation of 'land use planning' that links the reduction of hydro-meteorological risk with local and regional development objectives in a sustainable and financially viable way.To do that, RECONECT draws upon a network of carefully selected Demonstrators and Collaborators that cover a wide and diverse range of local conditions, geographic characteristics, institutional/governance structures and social/cultural settings to successfully upscale NBS throughout Europe and Internationally.

Drawing on knowlegde from projects funded by the European Union

Image: Seden Strand Odense - Photo © RECONECT Project

SCOPE **RECONECT demonstrates, references and upscales Nature-Based Solutions in rural and natural areas**

Approach to Impact Assessment

In RECONECT, NBS Impact Assessment is carried out in relation to three categories of challenges i.e., WATER, NATURE and PEOPLE. Where possible, monitoring data is being, or will be, collected and transmitted through real-time SCADA/telemetry services and also through social science surveys. These data will be used to evaluate the NBS impacts in relation to benefits, co-benefits as well as the negative effects.

Monitoring and evaluation of NBS against the WATER challenges address questions related to hydro-meteorological risks. Monitoring and evaluation of NBS against the NATURE challenges address questions related to habitat structure and the biodiversity of flora and fauna. Monitoring and evaluation of NBS against the PEOPLE challenge address questions concerning social and economic benefits, with implications for human health and well-being and resilience to impacts from hydro-meteorological events.

Involved Stakeholders and roles

A co-monitoring and co-evaluation framework is being developed for Demonstrators A and B. There are two kinds of RECONECT monitoring activities within this framework. The first one is monitoring to assess the state of the system (e.g. the general conditions in the NBS area), i.e., baseline monitoring before construction of NBS, and the second one is monitoring to assess the performance of implemented NBS towards the achievement of the project's goals/sub-goals.

- **Municipal Administrations (FR/FL)**
- **Regional/national statistics authority**
- **Citizen**
- **Planning experts**
- **Scientists / Academia**
- **NGOs**

Main Challenges addressed

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**
9. **Participatory Planning and Governance**
10. **Social Justice and Social Cohesion**
11. **Health and Wellbeing**
12. **New Economic Opportunities & Green Jobs**

Lessons learned

There is some information available that can be used to evaluate the impact of NBS on hydro-meteorological risk reduction and biodiversity enhancement. However, there is still a lack of knowledge in terms of monitoring and impact evaluation for PEOPLE benefits (e.g., human health and well-being).

Learn more
www.reconect.eu

The RECONECT project has received funding from the European Union`s Horizon 2020 research and innovation programme under grant agreement No 776866

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OPEN DATA FROM THE EU

The EU Open Data Portal (**http://data.europa.eu/euodp/en**) provides access to datasets from the EU. Data can be downloaded and reused for free, for both commercial and non-commercial purposes.

The Handbook aims to provide decision-makers with a comprehensive NBS impact assessment framework, and a robust set of indicators and methodologies to assess impacts of nature-based solutions across 12 societal challenge areas: Climate Resilience; Water Management; Natural and Climate Hazards; Green Space Management; Biodiversity; Air Quality; Place Regeneration; Knowledge and 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.

Indicators have been developed collaboratively by representatives of 17 individual EU-funded NBS projects and collaborating institutions such as the EEA and JRC, as part of the European Taskforce for NBS Impact Assessment, with the four-fold objective of: serving as a reference for relevant EU policies and activities; orient urban practitioners in developing robust impact evaluation frameworks for nature-based solutions 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. They reflect the state of the art in current scientific research on impacts of nature-based solutions and valid and standardized methods of assessment, as well as the state of play in urban implementation of evaluation frameworks.

Studies and reports

Publications Office
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