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Overview of socio-economic long-term benefits of GI/NBS

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List of Abbreviations

- BMI: Body Mass Index
- CLM: Climate Limited-area Modelling Community
- CVD: Cardiovascular Disease
- EEA: European Environment Agency
- EPA: Environmental Protection Agency
- Eq: Equivalent
- ES: Ecosystem Services
- GI: Green Infrastructure
- GIS: Geographic Information System
- HEC-HMS: Hydrologic Engineering Center-Hydrologic Modelling System
- IPCC: Intergovernmental Panel on Climate Change
- IUCN: International Union for Conservation of Nature
- MESALES: Modèle d'Evaluation Spatiale de l'ALéa Erosion des Sols[1] (Regional Modelling of Soil Erosion Risk)
- MS: Member State
- NbS: Nature-based Solutions
- NOAA: National Oceanic and Atmospheric Administration
- OECD: Organization for Economic Cooperation and Development
- SWAT: Soil & Water Assessment Tool
- WHO: World Health Organization

[1] Some names have been kept in their original language to maintain coherence to their respective acronyms.

A. Executive summary

This document is produced within the framework of the Interreg GreenScape CE project. It provides a comprehensive set of evaluation indicators to assess the benefits, co-benefits, and potential drawbacks that NBS can provide in urban areas. While these indicators are broadly applicable, the project specifically analyzes their implementation in five pilot urban areas: Zagreb, the Metropolitan area of Milan, Ptuj, Szegedin, and Warsaw. These pilot areas face unique climate challenges, and utilising NbS is an attracting strategy to address negative climate impacts while improving the resilience and liveability of these urban areas.

The concept of NbS has emerged as both a challenge and an opportunity for urban communities to transition toward greater sustainability and climate change adaptation. However, NbS represent a complex challenge for many city planners and policymakers as they often lack solid evidence on their performance and adequate communication of their benefits and co-benefits is missing.

The document‘s ambition is to provide a comprehensive suite of evaluation indicators that stakeholders involved in NbS planning, delivery, and stewardship can select and apply. This approach aims to create a mechanism to support cities in the process of upscaling and out-scaling NbS. The chosen indicators address several areas related to the challenges that NbS aim to mitigate in the urban scope, including human health and well-being, economic impacts, environmental benefits, and social benefits.

Indicators can be used **ex-post to quantitatively measure the benefits an NbS** has provided or eventually to **make ex-ante assessments of the desired benefits** of a proposed NbS implementation.

The document is structured as follows:

Chapter B opens with an introduction on NBS and their potential. It then provides an explanation of the document’s objectives and an overview of how the indicators presented in the document can be applied in urban contexts and by the GreenScape CE pilot cities. It concludes then with a list of definitions that are useful to fully understand the document.

Chapter C, which constitutes the core of the Deliverable, aims to present the list of the indicators. The indicators are related to 4 thematic topics, namely: **human health and well-being, economic impacts, environmental benefits, and social benefits**. For each indicator is provided: a brief definition, the proposed unit of measurement, potential data sources for calculation, the benefits derived from their calculation and some references.

Chapter D aims to present a selection of evaluation indicators that was derived from the challenges faced by each pilot city, in order to provide tailored insights to each pilot case.

Finally, Chapter E summarises the findings and provides some considerations for their potential use. By using the proposed indicators, stakeholders can better understand the multifaceted impacts of NbS and make more informed decisions to enhance urban sustainability and resilience."

B. Introduction

1. Background

Nature-based Solutions (NbS) are defined by the European Commission as "Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions. NbS must therefore benefit biodiversity and support the delivery of a range of Ecosystem Services" (European Commission, 2016, p. 1).

These solutions integrate natural features and processes into cities and rural landscapes through locally adapted, resource-efficient and systemic interventions. By doing so, they not only enhance the natural environment in urban areas but also foster human well-being and economic sustainability.

The concept of NbS has emerged as both a challenge and an opportunity for urban communities to transition toward greater sustainability and climate change adaptation. Implementing NbS can address multiple urban challenges, such as reducing the urban heat island effect, enhancing biodiversity, and improving air and water quality. These solutions can also foster social cohesion and contribute to the local economy by providing new opportunities for green jobs and tourism.
However, NBS represent a complex challenge for many city planners and policymakers. Barriers such as limited capacity, lack of understanding and supportive policies, organizational inertia, and various pressures hinder the widespread implementation of NbS.

One significant obstacle to mainstreaming urban NbS is the **lack of robust evidence on their performance and the inadequate communication of their benefits and co-benefits.**

Nevertheless, the benefits of NbS in urban environments are an increasingly explored and significant area of study. They contribute to the availability of urban green areas (Kabisch et al., 2016), support functional healthy ecosystems, and offer multiple environmental, social, and economic benefits (Terton, 2017). Moreover, connecting people with nature can enhance individual and community well-being (Díaz et al., 2015).

The environmental benefits of urban green spaces—such as green walls, green roofs, urban parks, gardens, and street trees—are well documented. These include improved air quality, reduction of the urban heat island effect, temperature moderation through shading, and defence against natural hazards and climate extremes like flooding and hurricanes. They also play a critical role in water quality management and the protection of riverbanks (Naumann et al., 2014; Potschin et al., 2014; Terton, 2017).

From an economic perspective, NbS often proves to be more cost-effective than traditional grey infrastructure (Terton, 2017). Several studies have quantified the monetary value of NbS and the ecosystem service (ES) they provide (Turner et al., 2003; Potschin et al., 2014; Díaz et al., 2015). NbS also provides recreational benefits and opportunities for outdoor activities (Özgüner & Kendle, 2006) and many cultural benefits.

Social benefits of urban green spaces include physical and mental health improvements, better management of life issues due to proximity to vegetation, educational opportunities, citizen engagement, and reinforcement of cultural identities (de Vries et al., 2003; Swanwick, 2009; Hansmann, Hug & Seeland, 2007; Kabisch et al., 2016; Terton, 2017).

To mainstream NbS and unlock their potential for up-scaling and out-scaling, a more holistic evaluation framework is necessary. Such a framework would help understand the full range of benefits, co-benefits, and potential drawbacks, enabling informed cost-benefit decisions and more effective implementation strategies.

In summary, while NbS present a promising path towards urban sustainability and resilience, their success depends on overcoming implementation barriers and enhancing the evidence base for their multiple benefits.

2. Aim of the document

This deliverable aims to **develop a comprehensive set of evaluation indicators to assess the benefits, co-benefits, and potential drawbacks that NbS can provide in urban environments.**

The selected indicators cover areas that facilitate more efficient evaluation of both short and long-term challenges addressed by natural solutions. In complex urban settings, the promotion and assessment of NBS should consider a range of factors, including local geography, meteorology, natural resources, financial management, strategic planning and diverse social and demographic factors. To ensure long-term benefits for diverse and dynamic urban environments, including their population, it is crucial to enable continuous, dynamic evaluation of NbS plans and ongoing projects for various stakeholders.

The document's ambition is to provide a comprehensive suite of evaluation indicators that stakeholders involved in NBS planning, delivery, and stewardship can select and apply. This approach aims to create a mechanism to support cities in the process of upscaling and out-scaling NbS. The chosen indicators address several areas related to the challenges that NbS aim to mitigate in the urban scope, including human health and well-being, economic impacts, environmental benefits, and social benefits.

Indicators can be used **ex-post to quantitatively measure the benefits** an NbS has provided or eventually to make **ex-ante assessments of the desired benefits** of a proposed NbS implementation.

By using the proposed indicators, stakeholders can better understand the multifaceted impacts of NbS and make more informed decisions to enhance urban sustainability and resilience. Within the GreenScape CE project scope, these indicators can also empower pilot cities to choose, monitor, and optimise NbS solutions that meet their specific needs. Ultimately, the outcomes of this deliverable could provide valuable insights for other cities looking to replicate the successful strategies implemented by the pilot cities.

3. How these indicators can be used by the GreenScape CE pilot cities?

The GreenScape CE project has among its priorities to impact cities positively through cutting-edge, science-based knowledge and aims to go beyond the mainstream usage of NbS in urban areas by promoting a participatory approach to address common challenges. Accordingly, this deliverable is designed to provide a solid foundation for smart planning, based on carefully selected indicators and references for adopting NbS and integrating GI in cities. This comprehensive document considers various aspects of tailored NbS for tackling issues faced by the pilot cities to support and guide their planning while adhering to best practices.

Each section mentioned in the thematic topics below provides an **overview of crucial indicators and includes a respective table with detailed information for further understanding**. This structure allows the reader to evaluate the best NbS strategy for a particular challenge by assessing its unit of measure, benefits, potential data sources, and references, including useful tools that can model and/or offer clear instructions on employing the chosen indicator.

For instance, bioswales and rain gardens are NbS commonly used to manage runoff from large impermeable areas such as parking lots or avenues. They absorb, store, and convey surface water flow while removing pollutants and sediment. Proper design ensures these areas handle expected maximum flow rates, protect

underlying aquifers and maintain functionality during subsequent weather events, therefore aligning with the rainfall storage indicator.

In the respective environmental indicators section, Table 3, detailed content to measure and evaluate this parameter is available, allowing verification of its potential and monitoring of the related NbS concerning water absorption capacity (i.e., metrics - the volume of water absorbed per square metre, alongside with reliable data sources - hydrological studies/urban planning departments/research institutions, benefits – as already mentioned, and reliable references, such as the United Nations guide entitled "Green infrastructure: guide for water management") during all the phases of the project.

Apart from this case, several other indicators can serve as measurement tools depending on local peculiarities. In this context, cities are invited to make use of the presented indicators to best meet their needs.

This includes considering that the four categories complement each other: the first one, **human health and well-being**, tracks improvements in citizens' physical and mental health, considering variables such as savings in healthcare costs and increased recreational opportunities, to assess the extent to which NbS initiatives can enhance residents' quality of life and wellbeing.

Meanwhile, **economic impacts** indicators, such as cost-effectiveness compared to grey infrastructure, job creation, and increased property values, allow cities to verify the economic returns of NbS implementations, demonstrating their value in municipal planning while opening space for a holistic perspective.

On the other hand, the **environmental benefits** indicators, which include parameters such as air quality improvement, temperature regulation, water management and biodiversity enhancement, enable cities to monitor positive changes in the natural surroundings resulting from NbS implementation, e.g. reduced urban heat island effect and better stormwater management.

Social benefits indicators, in turn, cover aspects related to social cohesion, cultural benefits, and area availability and accessibility, helping cities to evaluate NbS capacity to promote stronger bonds in communities, enhance justice, and provide cultural and recreational benefits.

As mentioned, **these indicators can be used both before and/or after the implementation of NbS strategies to measure the benefits provided by NbS or predict the desired outcomes of proposed projects**. In the long run, they can assist pilot cities in applying NbS effectively, ensuring that projects are well-planned, executed, and assessed for maximum impact.

4. Definitions of concepts

The following list of concepts that will be taken up in the document are fundamental for its full understanding:

- **Citizen security** - Citizen security involves establishing and protecting democratic civic order, eliminating violence, and ensuring safe, peaceful coexistence. It safeguards human rights, including the right to life, personal integrity, home inviolability, and freedom of movement (United Nations Development Programme, 2013).
- **Economic prosperity** - A state of financial well-being and economic growth within a community, region, or nation, characterized by increasing wealth, expanding opportunities, and improving living standards (Economic Prosperity Definition | Law Insider, n.d.). In the context of urban development, this can be enhanced through the implementation of NbS, which contribute to economic growth by creating jobs, increasing property values, reducing infrastructure costs, and promoting sustainable resource management.

- **Environmental justice and health equity** - Balanced and fair distribution of environmental and health benefits and burdens among people, regardless of their sociodemographic characteristics. This includes ensuring inclusiveness and fairness in participation and decision-making, addressing the distribution of environmental benefits and negative impacts, and acknowledging discrepancies between social groups (Environmental Protection Agency, 2024).
- **Gentrification** - Process that involves the reinvestment in declining neighbourhoods, which ends up attracting wealthier residents and changing the community dynamics, eventually leading to the exclusion of some groups (Tulier et al., 2019).
- **Indicators** – Measurement instruments that can be used to assess the potential performance and impact of an intervention (in this case: an NbS), enabling informed conclusions about its effectiveness (Heink & Kowarik, 2010).
- **Social cohesion** – The capacity of a society to ensure the well-being of all its members - minimising disparities and avoiding marginalisation – to manage differences and divisions and ensure the means of achieving welfare for all members (Council of Europe, 2010).
- **Well-being** – Overall positive state defined by quality of life and the ability of individuals and/or societies to feel able to make meaningful contributions with a sense of purpose. It is a vital resource for everyday life, influenced by social, economic, and environmental conditions (World Health Organization, 2021).

C. Thematic topics

Each of the following sections on a thematic topic provides an overview of crucial indicators and includes a respective table with detailed information for greater understanding. This structure allows the reader to evaluate the best NbS strategy for a particular challenge, assessing its unit of measurement, benefits, potential data sources and references, including useful tools that can model and/or offer clear instructions on the use of the chosen indicator.

5. Human health and well-being indicators

The effects of climate change, such as heatwaves, lead to urban areas becoming increasingly uncomfortable, with vulnerable members of society feeling such impacts the most. High temperatures also raise the levels of ozone and other pollutants in the air that exacerbate cardiovascular and respiratory disease.

Numerous authors emphasize that modern urban wellbeing challenged by chronic stress and insufficient physical activity can be healthily nurtured by natural environment exposure, which promotes mental and physical health and reduces morbidity and mortality in urban residents by providing 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).

By implementing NbS, cities generate added and positive cost-benefit value for their residents. Health and well-being impact assessment and selected indicators provide opportunity for both decision-makers and citizens, to dynamically improve urban life quality, health and well-being when planning and implementing NBS interventions. Envisioned NbS interventions will have both short and long-term impacts on health, of varying degrees of directness.

Environmental health equity is a growing and critical area of environmental health science. Researchers in Exposure Science and Environmental Epidemiology have long focused on characterizing the disproportionate burden of environmental harm among marginalized communities, and consequent health impacts. They use a range of methods from large-scale epidemiologic studies to citizen science approaches.

Complex mixtures of urban exposures pose an environmental justice challenge, given the cumulative burdens and vulnerability of the urban population (Zota & Shamasunder, 2021). The parallel issues of occupational exposures and human-induced urban contaminants further complicate the assessment of health impacts in urban environments.

For this reason, it's crucial to **plan smarter NBS solutions that minimize negative health impacts or even create positive health outcomes**, rather than relying only on traditional NbS planning criteria focused on environmental, climate adaptation, energy efficiency or disaster risk management criteria.

There is robust evidence indicating significant positive correlations between the quantity of green space (objectively measured around the residence) and perceived mental health as well as all-cause mortality. Additionally, there is moderate evidence for an association with perceived general health (Van dem Berg et al., 2015).

Consequently, one of the key deliverables of the GreenScape CE project – an advanced visual mapping tool [2]– meticulously incorporates green space distance and connectivity for enhancing the planning, implementation and monitoring of NBS, ensuring more effective and sustainable urban development.

[2] https://greenscapece.visualmapping.eu/

Environmental degradations, in particular air pollution and extreme weather conditions due, at least partly, to climate change, expose people to health risk and excess mortality and excess burden for entire health system (Organization for Economic Cooperation and Development, 2023). Considering, among other factors, the financial aspect of health care costs, health care systems must play an active role in reducing environmental risk factors. The introduction of NbS represents one of the most powerful preventive measures to achieve this goal.

Chosen set of indicators represent multisectoral approach based on public health methodology of health risk assessment related to environmental impacts and risks in line to methodology of the best European and USA schools (Karolinska Institute, Sweden and Harvard T.H. Chan School of Public Health, USA) and innovation approach to food health certificate experience of project partner Andrija Stampar Teaching Institute of Public Health (ASTIPH) (ASTIPH, 2017).

Selected set of human health and well-being indicators were chosen based to relation category of health and environmental liaisons (Table 1). These leading causes of death worldwide and substantially contributors to loss of health and excess health system costs were included in indicator list: overall mortality, weather-related mortality, mental health issues, cardiovascular disease (CVD) & cerebrovascular diseases burden, obesity burden, Diabetes Type 2 burden, chronic respiratory diseases burden, allergies (pollen) burden, aeroalergy index of plant species for greenscaping, share of people using green spaces for health and well-being, light pollution index, noise pollution index, public health index for EU member states.

Planning, (co)financing and surveillance of realised NbS solutions concerning the selected indicators provide identification of the best “urban area tailored made” NbS, not only from cost-benefit aspects but also from the comprehensive added value of NbS in line with health and urban life quality approach.

Table 1: Indicators for human health and well-being

Human health and well-being indicators				
Indicator	**Unit of measurement**	**Potential data sources**	**Benefits**	**References**
Cardiovascular disease (CVD) & Cerebrovascular diseases	Vascular diseases morbidity rate per 100 000 population per Member State. NbS Evaluation tool risk categorisation thresholds: CVD morbidity over 400/100,000 population (Member States: RO, BG, HU, HR, SK, CZ, PO, DE areas, LT, LV), mortality or annual mortality rate; total CVD annual morbidity rate; total CVD per 100,000 population	EU (OECD, EUROSTAT) and local public health indicator databases, hospital databases, primary health care databases, scientific literature	Reduced mortality and morbidity from CVD: development and comprehensive monitoring of NbS infrastructure and health liaisons improves spatio-temporal surveillance of urban environment with health impacts and life quality. This all together improves proposal of preventive and corrective prevention measures for enhancement of positive and reduction of negative environmental health impacts.	OECD Health Statistics: Mortality from circulatory diseases EUROSTAT database on circulatory diseases deaths
Obesity	Proportion (%) of obese people per Member State. NbS evaluation tool threshold: BMI over 25 kg/m2 - above or equal 57% of population threshold. Member states above threshold: HR, HU, SK, PO, CZ, RO, PL, LV, EE, LT, GR	EU, national and local public health databases, hospital databases, primary health care databases, EU database of obesity burden	Improved physical activity and reduced obesity: development and comprehensive monitoring of NBS infrastructure and health liaisons improves spatio-temporal surveillance of urban environment with health impacts and life quality. This all together improves proposal of preventive and corrective prevention measures for enhancement of positive and reduction of negative environmental health impacts.	OECD Health Statistics: Obesity EUROSTAT database: Overweight and obesity – BMI statistics
Diabetes Type 2	Proportion (%) of population with Diabetes Mellitus Type 2 per Member state. NbS evaluation tool threshold: Share of adults with diabetes above EU average (6% of total population) Member states: PT, RO, MT, CY, DE, SK, HU, ES, SI, CZ, AT, DK	EU, national and local public health databases, hospital databases, primary health care databases, EU database of Diabetes Type 2 burden	Improved availability of infrastructure for physical activity and reduction of Diabetes Type 2 - Development and comprehensive monitoring of NbS infrastructure and health liaisons improves spatio-temporal surveillance of urban environment with health impacts and life quality. This all together improves proposal of preventive and corrective prevention measures for enhancement of positive and reduction of negative environmental health impacts.	OECD Health at a Glance: Europe (report table at pg. 107 MS distribution. E10-E14 diagnosis in annual reports) Nacionalni registar osoba sa šećernom bolešću CroDiab (XLSX, 10.4 KB)

Allergies (pollen) burden, aeroallergy index of plant species for greenscaping	Number of pollinator species per Member state area or city. NbS evaluation tool thresholds per pollen type: Tree daily pollen count > 90; Grass pollen > 20; Weed pollen > 50 (more realistic indicator but variable threshold per MS) or Proportion (%) of people suffering from allergies per 100,000 inhabitants, by age/sex	EU strategic documents and databases and scientific literature. Since NUMBER OF SENSITIVE EU POPULATION vary based on allergen species. E.g. for ragweed e.g. mostly HR, HU, IT, FR south, environmental pollen levels in air represent good exposure assessment decision making and measure tool.	Increase of allergy burden (medicine drug use and sick days leave) in case of high aeroallergy index of green infrastructure and NBS solutions - Development and comprehensive monitoring of NBS infrastructure and health liaisons improves spatio-temporal surveillance of urban environment with health impacts and life quality. This all together improves proposal of preventive and corrective prevention measures for enhancement of positive and reduction of negative environmental health impacts.	"Mental Health in Allergic Rhinitis: Depression and Suicidal Behavior - PMC (nih.gov) Assessing the value of urban and blue spaces for health and well-being (WHO) Climate ADAPT – Aero-allergens
Mental health issues	Major depressive disorder, mortality rates from suicide and intentional self-harm per 100,000 population, mental health care visits. NbS evaluation tool thresholds: Above EU-28 average (>17,3% of population) Member states: FI, NL, FR, IE, PT, EE, ES, SE, DE, BE, GR, AT, LU)	EU, national and local public health databases, hospital databases, primary health care databases, scientific literature, EU database of mental health indicators distribution in EU by OECD.	Reduced number of mental health burden (hospitalization duration, medicine drug use, etc) - Development and comprehensive monitoring of NbS infrastructure and health liaisons improves spatio-temporal surveillance of urban environment with health impacts and life quality. This all together improves proposal of preventive and corrective prevention measures for enhancement of positive and reduction of negative environmental health impacts.	OECD Health at a Glance: Europe (Figure 1.6. Estimated direct and indirect costs related to mental health problems across EU countries. OECD.2023)
Overall (and air quality related) mortality	Annual mortality rate per 100,000 population per Member State (MS)	EU, national and local public health databases, hospital databases, primary health care databases, scientific literature, EU level OECD Data Explorer database	Reduced mortality: development and comprehensive monitoring of NbS infrastructure and health liaisons improves spatio-temporal surveillance of urban environment with health impacts and life quality. This all together improves proposal of preventive and corrective prevention measures for enhancement of positive and reduction of negative environmental health impacts.	Death related to air quality in EU. Figure 4.20. Deaths due to exposure to outdoor PM2.5 and ozone EU map, 2016. Health at glance, OECD

Weather-related mortality	Mortality rate - heat-related causes (Summer, age 65-75)	Scientific literature	Reduced weather related mortality - Development and comprehensive monitoring of NBS infrastructure and health liaisons improves spatio-temporal surveillance of urban environment with health impacts and life quality. This all together improves proposal of preventive and corrective prevention measures for enhancement of positive and reduction of negative environmental health impacts.	OECD Health at a Glance: Europe (4.21. Deaths due to extreme weather conditions - heat waves and cold waves- , cumulative from 2000 to 2016) The effect of global warming on mortality
Share of people using green spaces for health and wellbeing	Proportion (%) of people visiting green space: 1. three or more times a week 2. less than once a month Proportion (%) of people using green by: age; gender; ethnic or cultural group; socioeconomic status	Citizen science databases	Increased proportion of population share - Development and comprehensive monitoring of NBS infrastructure and health liaisons improves spatio-temporal surveillance of urban environment with health impacts and life quality. This all together improves proposal of preventive and corrective prevention measures for enhancement of positive and reduction of negative environmental health impacts.	Magdalena van den Berg, Wanda Wendel-Vos, Mireille van Poppel, Han Kemper, Willem van Mechelen, Jolanda Maas. Health benefits of green spaces in the living environment: A systematic review of epidemiological studies, Urban Forestry & Urban Greening, 14, (4), 2015, 806-816, ISSN 1618-8667

Light pollution exposure level	Reduced light pollution index - Health impact assessment: Sleeping patterns modification, cancer, depression and weight gain. NbS evaluation tool threshold: index of light difference between the average light emissions in 2014/15 and 2020/21. Values of increasing (red colour) or decreasing (blue colour) artificial light vary between 0.5 - 10 nW/cm2/sr. Decreasing light emission e.g. in blue Zagreb, increasing (in red) e.g. almost all bigger cities in IT, DE, Pl, capitals in BG, RO, CZ	EU, national and local databases and maps	Light pollution is the presence of any unwanted, inappropriate, or excessive artificial lighting. Reduced light pollution - Development and comprehensive monitoring of NbS infrastructure and health liaisons improves spatio-temporal surveillance of urban environment with health impacts and life quality. This all together improves proposal of preventive and corrective prevention measures for enhancement of positive and reduction of negative environmental health impacts.	Eionet Portal 2022/8: review and Assessment of Available Information on Light Pollution in Europe European Environment Agency - Light pollution
Noise pollution exposure level	Various - possible parameters: Noise exposure x mental health; Annoyance and sleep disturbance; Cardiovascular and metabolic effects; Cognitive development in children; Number of quite areas per pilot area; Visual qualities of the area; Distance from the noise sources; Subjective perception of the area; Accessibility to the area and size of the area; Land use type and functionality of the area. NbS evaluation tool threshold: limit of 55 dB(A) (LDEN: day-evening-night average) Noise exposure assessment (outdoor noise as an annual average): Road (Lden 53 dB; Lnight 45 dB) Rail (Lden 54 dB; Lnight 44 dB) Air (Lden 45 dB Lnight 40 dB)	EU, national and local databases and maps, "Environmental noise in Europe — 2020 — European Environment Agency (europa.eu), Health Impact Assessment - public documents	Reduced noise pollution - Development and comprehensive monitoring of NBS infrastructure and health liaisons improves spatio-temporal surveillance of urban environment with health impacts and life quality. This all together improves proposal of preventive and corrective prevention measures for enhancement of positive and reduction of negative environmental health impacts.	Environmental risk factors and cardiovascular diseases: a comprehensive expert review

6. Economic impact indicators

Economic prosperity is crucial for the quality of life of individuals and necessary for a nation to be competitive in the global economy. When mixed with smart community management, economic prosperity becomes a primary driver of high quality-of-life for all the residents in and around the community.

One of the primary benefits of economic prosperity is *job creation*. As the economy grows, more businesses are established and existing businesses expand, leading to an increase in demand for labour. This translates to job opportunities for residents, who can then earn a living wage and support their families. A strong economy creates an environment that fosters innovation and entrepreneurship, and this attracts talented individuals who can help create new products and services, further driving economic growth.

However, for sustainable economic prosperity to be achieved not only economic growth needs to be ensured in the long-term, but also environmental health aspects and social equity regarding the distribution of generated benefits.

Key criteria of NBS are their cost-effectiveness and their capacity to simultaneously provide environmental, social and economic benefits to the society.

The adoption and implementation of NBS has the potential to create new economic opportunities and jobs in the green sector by enabling low-carbon, resource-efficient and socially inclusive economic growth. Moreover, NBS contribute to sustainable economic prosperity by, for example, lowering stormwater management expenses, reducing energy costs, and avoiding flooding-related costs (see Table 2).

Key criteria of NBS are their cost-effectiveness, and their capacity to simultaneously provide environmental, social and economic benefits in support of resilience building. The diverse economic benefits of NBS emphasize their potential to save money both for households and governments, especially when adopting a long-term investment perspective.

As previously mentioned, the topic of sustainable economic prosperity has strong linkages to the issues of health and well-being, mainly in terms of reduced or avoided health costs, as well as social cohesion and justice. Besides the positive and desired outcomes of economic prosperity, it is also possible that adverse effects or unintended consequences such as *gentrification* and displacement of long-established residents can occur because of increased NBS deployment.

In the case of gentrification, for example, creating new green features or improving the quality and aesthetic appeal of existing features can lead to increased property values, rents, competition in housing markets and prices (alongside numerous other factors).

These changes can in turn displace local populations who can no longer afford to live in the area, resulting in an unequal distribution of benefits. In such cases, the original residents and users of the space are deprived of nearby access and enjoyment of quality green spaces while the benefits are enjoyed by the newer affluent portions of the population moving into the area.

Evaluating the economic benefits of NBS is still an ongoing effort. Compared to other areas such as human health and well-being, where more comprehensive metrics have been developed, the number of studies that have established and utilized indicators to assess the impact of NBS on sustainable economic prosperity remains limited.

The economic opportunities that are created by the adoption and implementation of NBS as a consequence of their social attractiveness and restorative value can be evaluated using the indicators listed in the Table 2.

Table 2: Economic impact indicators

Economic indicators				
Indicator	**Unit of measurement**	**Potential data sources**	**Benefits**	**References**
Green jobs related to NbS (gardening, maintenance)	Number of employees or fulltime equivalent jobs (FTE)	Public employment agency, public administration in charge of green spaces, if site specific: survey or qualitative interviews	NbS and urban regeneration projects create jobs for the realisation and maintenance of urban green space. They also promote new, often socio-entrepreneurial business ideas (e.g. therapeutic programmes, outdoor workout, vertical gardening, urban food production, etc.). The International Labour Organization (ILO) defines green jobs within three categories: primary green activities (i.e., organic agriculture, sustainable forestry), secondary activities (i.e., renewable energy, clean industry, sustainable construction) and tertiary activities (i.e., recycling, sustainable tourism, and sustainable transport).	URBAN GreenUP KPIs (pag. 113) CLEVER Cities Impact indicators (Theme 4: Concepts & indicators for impact, pag.15)
Green investment programmes/funds	Amount of inward private and public investment in properties/businesses in project area	City administration data, business reports, data provided by real estate companies/agents	Green surroundings attract businesses (especially SMEs) that move in the respective areas	Green Infrastructure's contribution to economic growth: a review
Number of businesses and their business rates	Revenue from businesses in the NbS intervention areas; Number of new shops/businesses opening in the environment of the NbS	Data from Opening Licences Department, companies business reports, economic data published by statistical offices, if site specific: Qualitative interviews or survey	Green surroundings attract businesses and increase the attractiveness of city centres. It guides and slows down the flow of consumers in a city, and leads to a shift of spending power to businesses situated in more pleasant surroundings.	URBAN GreenUP KPIs (pag. 117)

(Storm) water management costs	Expenses for stormwater treatment facilities and erosion control measures; Expenses of property owners to protect their property; Predictions of flooding occurrences and their levels; Potential economic damage on properties and infrastructures	Meteorological service, public administration/public utilities, insurance companies	Due to delayed and reduced stormwater runoff and better drainage, new storm water systems could potentially have a smaller capacity for water flow, while old storm water systems could support water flow for longer. Moreover, NBS help reducing the amount of untreated runoff discharged to surface waters. Better drainage and reduced water flows can help to prevent overflowing stormwater drains, thus lowering the risk of urban floods. When planned in a specific way, urban green areas can even function as water retention basins in case of stormwater events, etc. Avoided costs include costs for the reconstruction/repair of infrastructure, property, habitats, etc	CLEVER Cities Impact indicators (Theme 4: Concepts & indicators for impact, pag.17) NAIAD (https://naiad2020.eu/)
Energy costs for heating/cooling	Temperature differences (interior/exterior) or incoming and reflected radiation data, electricity prices	Dedicated study with technical measurement equipment needed for temperature differences, radiation data, Stock market for electricity	NBS elements such as green roofs stop incoming solar radiation and therefore have the capacity to cool buildings in summer, thus reducing energy consumption. Older buildings also profit from insulation in winter, thus reducing costs for heating.	URBAN GreenUP KPIs (pag. 113)
Change in the mean economic value of property value for residential/commercial and industrial use (rental & sale)	Average property price Price per m2 Percentage change in average property value or average price before/after the investment	Data provided by real estate agents/ companies, city administration (the latter also for socioeconomic data)	Property values increase near green spaces. NBS investment can therefore offer higher returns for the property sector. Higher property values in themselves are also believed to improve an area's image. However, this can also lead to disbenefits for certain segments of the population such as gentrification.	URBAN GreenUP KPIs (pag. 117)
Recreation and ecoturism	Number of recreational and eco facilities or revenue generated by NbS	Tourism data published by statistical offices, survey (if site specific)	Different NbS elements as well as the space they provide for cultural events contribute to a city's attractiveness for tourists. Tourists bring extra spending, support existing businesses that cater for them and encourage new ones.	EKLIPSE Impact evaluation framework

7. Environmental benefits indicators

According to the European Environment Agency an environmental indicator is a value or parameter able to describe the state of the environment, its effects on humans, ecosystems and materials, the pressures on it, the driving forces behind these pressures, and the responses guiding the system. The main reason to select or aggregate an indicator is to guide actions. Therefore, these indicators are among the essential tools for evaluating NbS impact on urban environments, above all when considering climate resilience and biodiversity enhancement. The ones provided in this section are designed to assist the pilot cities with every stage of environmental policymaking. Table 3 presents indicators alongside with tangible parameters that can demonstrate the ecological benefits of NbS strategies, including widely recognised tools and indexes in the references. By identifying factors such as air quality, capacity for storing rainfall, and the rate at which carbon is captured and stored, the assessment of NbS in relation to their ecosystem services becomes clear.

Other indicators like water quality monitoring and measures of habitat preservation underscore how NBS contribute to protecting natural resources and supporting local ecosystem metabolism. In addition, the selected indicators validate further common urban challenges NbS aids with, e.g. heat islands and soil erosion, presenting how they can support the process of tackling climate change by improving local responses against extreme weather events while contributing to overall environmental sustainability. Integrated with the indicators mentioned in sections A, B and D these metrics allow a comprehensive framework for evaluating NBS potential across diverse urban settings, ensuring evidence-based decision-making and fostering community engagement in green infrastructure approaches (Merino-Saum et al., 2020).

For enhanced planning and thorough analysis, standardising measurement methods and data collection is key procedure to develop consistent and reliable assessment of environmental performance over time. This process should be based on national objectives and international goals and commitments (Organization for Economic Cooperation and Development, 2024). However, challenges like data availability and scalability may arise, necessitating adaptable strategies and collaborative efforts among stakeholders during project design.

That being said, using environmental indicators plays a crucial role in crafting resilient and liveable urban ecosystems through informed decisions (Tyler et al., 2016). They help in assessing the effectiveness of NBS in meeting socioenvironmental objectives, ensuring that urban areas are not only sustainable but also adaptable to future changes. Either way, it is relevant to highlight that the chosen indicators reflect the most appropriate state-of-the-art variables for GreenScape CE project, though they are not exhaustive. These indicators intend to offer qualitative and quantitative data of NbS impact on the environment to guide decision-makers in implementing practical sustainable development being subject to adjustments if necessary.

Table 3: Environmental benefits indicators

Environmental indicators				
Indicator	**Unit of measurement**	**Potential data sources**	**Benefits**	**References**
Air quality regulation (European Index)	Very good, Good, Medium, Poor, Very poor, Extremely poor (The parameters are based on pollutant concentrations in µg/m3)	National air quality monitoring networks, European Environment Agency (EEA), Local environmental agencies	Improved public health, compliance with air quality standards, enhanced quality of life	European Air Quality Index Calculation Europe's Air Quality Status 2024 WHO Air Quality Information and Tools
Rainfall storage (water absorption capacity of NbS)	Volume of water absorbed per square meter (l/m2) (This parameter is connected to rainfall intensity local data which deserves attention when elaborating a NbS implementation plan)	Hydrological studies, urban planning departments, research institutions	Reduced urban flooding, enhanced groundwater recharge, improved water quality	Green Infrastructure: Guide for Water Management (Guidance and Tools for Quantification and Valuation of Benefits) Benefit Accounting of Nature-Based Solutions for Watersheds (Suggested approach: Volume Captured Method) Extra Tools for Hydrologic Modelling: SWAT and HEC-HMS.
Moderation of extreme events	Various - possible parameters: Peak flow reduction (m3 per second); Reduction in flood volume (m3); Number of flooding events reduced (for a given area); Reduction in runoff due to NbS (mm/%); Decrease in inundation risk for critical urban infrastructures	Flood management authorities, meteorological agencies, hydrological models, GIS data	Reduced flood risk, protection of infrastructure, enhanced community resilience	The European Extreme Events Climate Index IPCC Impacts, Adaptation, and Vulnerability For Further Parameters and Formulas: Dataclime Platform - E³CI Data for European Cities
Water safety and quality	Various - possible parameters: Concentrations of nutrients (N, P) (mg/L); Levels of dissolved oxygen (mg/L); Presence of contaminants (e.g., heavy metals, pesticides) (µg/L); Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) (mg/L); Groundwater quality index score	Environmental monitoring agencies, water utility companies, research institutions	Improved public health, protection of aquatic ecosystems, compliance with water quality standards	EPA Water Data and Tools WHO Water Sanitation and Health Guidelines EU Water Acquis: A Comprehensive Guide
Habitat for species	Number of species present	Biodiversity monitoring programs, conservation organizations, academic research	Biodiversity conservation, ecosystem health, improvement of urban green spaces	EU Habitats Directive IUCN Biodiversity Data

Carbon sequestration and storage in vegetation/soil	Ability of carbon sequestration (tons of CO_2 eq per year)	Carbon accounting databases, environmental research institutions, forestry departments, own calculations for the planned development	Mitigation of climate change, improved air quality, enhanced soil health	EEA Soil Carbon Modeling Carbon Storage in Urban Vegetation Carbon Sequestration and Storage Potential of Urban Green
Local climate regulation	Various possible parameters: Average maximum temperature (°C); Average relative humidity (%); Average land surface temperature (°C/month or year)	Meteorological agencies, urban climate models(such as CityEngine and ENVI-met), environmental monitoring programs	Improved thermal comfort, reduced urban heat island effect, energy savings	NOAA Climate Change: Global Temperature European Climate Risk Typology ESA Land Surface Temperature
Surface reflectance - albedo	Albedo value (0-1, higher is better)	Remote sensing data, satellite imagery, climate models, own calculation	Reduced urban heat island effect, improved thermal comfort, energy savings	Estimating Visible Band Albedo from Aerial Orthophotographs in Urban Areas COSMO-CLM Regional Climate Simulations Surface Albedo Data from 1981 to Present
Tree shade for local heat reduction	Various possible parameters: Percentage of urban area covered by tree shade (%); Vegetation cover percentage (%); Temperature reduction under tree shade (°C); Surface temperature difference between shaded and unshaded areas (°C)	Urban forestry programs, health departments, meteorological data	Improved thermal comfort, reduced heat-related illnesses, energy savings	EU Directorate-General for Environment i-Tree Tool for Assessing and Managing Forests & Community Trees
Erosion risk management	Soil erosion rate (tons/hectare/year) or erosion risk index score	Soil conservation services, environmental monitoring agencies, academic research	Reduced soil loss, improved water quality, enhanced agricultural productivity	Online Manual for Risk and Recovery Mapping (Soil Erosion Risk Assessment) EEA Soil Erosion Risk Assessment in Europe MESALES Model
Ecological connectivity	Green connectivity density or green area connectivity index	Biodiversity monitoring programs, urban planning departments, conservation organizations	Enhanced biodiversity, improved ecosystem services, increased habitat connectivity	EU Directorate-General for Environment Urban Green Connectivity Assessment Useful Tools: Fragstats and Circuitscape GreenScape CE Visual mapping platform

Noise mitigation by vegetation	Noise reduction level (dB) or number of complaints about noise before and after vegetation intervention	Environmental noise monitoring, urban planning departments, public health agencies	Improved public health, enhanced quality of life, increased property values	Influence of Green Areas on the Urban Sound Environment Novel Solutions for Quieter and Greener Cities

8. Social benefits indicators

Research has shown that NbS enhance the quality of life for urban residents by fostering connections with nature, improving physical and mental health and creating pleasant and sustainable urban spaces. Implementing NbS projects also strengthens community engagement and social cohesion, fostering a sense of pride and ownership among residents. These solutions can promote social cohesion by creating safe, attractive pathways between neighbourhoods, work areas, and natural amenities, and by providing inclusive public green spaces for social activities.

Therefore, it is imperative to incorporate NbS in urban planning and design for creating liveable cities, providing good health and supporting the ecosystems.

NBS are also closely linked to the concept of environmental justice, emphasizing equal access to green spaces to enhance social cohesion and cultural integration of marginalized groups such as the elderly, immigrants, and people with disabilities (Ibes, 2015; Kweon et al., 1998; Raymond et al., 2017; Raymond et al., 2016; van Den Berg et al., 2017).

The quality and distribution of urban green spaces affect the opportunities for different socio-economic and demographic groups to benefit from these areas. Accessibility is influenced by both geographic proximity and cultural and safety perceptions, which impact park usage patterns. In some neighbourhoods, limited or inadequately sized green spaces can lead to overcrowding, while in others, spaces that do not meet the needs of local groups may be underutilized. High-quality physical environments enhance outdoor activities and social interactions, contributing to stronger social cohesion in the cities.

The design, maintenance, and local context of NbS projects affect their impact on community safety. Introducing new green spaces in disadvantaged and underserved areas has been found to reduce violent crime and improve perceptions of safety in the population. Well-maintained landscapes discourage crime, as evidenced by studies showing lower crime rates in improved vacant lots compared to those left neglected.

Conversely, poorly maintained or designed green spaces can diminish actual and perceived safety. Neglected vegetation and litter create an unsafe atmosphere. Poorly designed urban green areas can become hotspots for antisocial behaviours and crime (such as vandalism, theft, and violent acts like assault). Visual barriers, such as overgrown vegetation or inadequate lighting, can decrease perceived safety. Applying principles of crime prevention through environmental design can reduce crime by ensuring spaces are well-designed and maintained.

It's also important to consider cultural attitudes towards green spaces, as impacts can differ among individuals and groups within a city and across various locations. For example, in some parts of Northern Europe, urban forests are perceived differently by various demographic groups. While some residents find forests relaxing, others, such as immigrants from Asian and African regions, may perceive them as places of fear. These cultural attitudes should be considered when designing NbS for urban regeneration projects.

Some additional indicators shown in Table 4 focus on perceived social interactions, safety and crime.

Table 4: Social benefits indicators

Social indicators				
Indicator	**Unit of measurement**	**Potential data sources**	**Benefits**	**References**
Availability of parks and/or ecosystem services with respect to specific individual or household socioeconomic profiles	Availability of (public) green space within 300m walking, segregated by household socio-economic characteristics (e.g. income, degree of education, ethnic background/nationality, age)	Geospatial data, census data, surveys GreenScape CE Visual Mapping Platform	This is crucial for promoting environmental equity and social justice in urban areas. Ensuring equal access to these resources across different income levels and demographics can help reduce health disparities, improve quality of life, and create more inclusive and sustainable communities.	EKLIPSE Impact evaluation framework Effects of Urban Green Space on Environmental Health, Equity and Resilience
Access/barriers to green spaces	Proportion (%) of people perceiving: 1. good access (300m distance – approximately 5 minutes walk from residential areas) 2. barriers to green space/NbS average distance to nearest green space (over 500m distance from residential areas)	Dedicated study GreenScape CE Visual Mapping Platform	Easily accessible green spaces foster community connections, enhance environmental quality, and contribute to the overall liveability and sustainability of urban environments.	Classification of institutional barriers affecting the availability, accessibility and attractiveness of urban green spaces
Walking cycling in and around areas of interventions	Proportion (%) of people using NBS for walking, cycling and other outdoor activities (e.g. gardening)	Dedicated study People-counter data	Promoting walking and cycling in areas of urban intervention enhances sustainable mobility, improving public health and reducing carbon emissions. These active transportation modes also contribute to more vibrant, liveable neighbourhoods by increasing social interactions and supporting local businesses, while simultaneously alleviating traffic congestion and parking issues.	Nature-Based Solutions to Climate Change Adaptation in Urban Areas
Food security (and food price monitoring tool EU)	Various possible parameters: Percentage of population experiencing food insecurity (%) or average cost of a basic food basket x local income? Percentage of uncompliant food safety laboratory analysis (eg. in ZG city monitoring noncompliant cca 5% of samples)	European Union - food price monitoring tool, Eurostat, European Environmental Agency (EEA) - food systems, national statistical institutes	Comprehensively planned and monitored green and blue NBS solutions reduce food insecurity risk, food availability and contamination.	EU Food Price Monitoring Tool Food Security and Affordability
Crime in the immediate vicinity of a green area	Crime rate (incidents per x population) or number of reported crimes in/near green areas (i.e., 300m distance – approximately 5 minutes walk)	Crime statistics (segregated by type and location)	Maintaining green parks and gardens in cities has the potential to lower the risk of crime. More green space in a city is linked with lower risk of crime against property – such as burglary, arson and vandalism – and less risk of violent offences.	Green Spaces in Cities Linked to Crime Risk

Level of services contributing to the safety of users in the neighbourhood (e.g. lighting of public space areas, access control, presence of technical or specialized staff, etc.)	Various possible parameters: Maintenance frequency of safety devices installed (e.g., lights, cameras); Extension of video-controlled public parks (% or ha); Rate of public parks closed for the nights	Municipalities databases on safety devices installed in the urban area	A high level of safety devices in neighbourhoods, such as proper lighting, access control systems, and the presence of specialized staff, can significantly enhance public security. These measures not only deter criminal activity but also increase residents' sense of safety, leading to improved quality of life and community engagement.	EKLIPSE Impact evaluation framework The Impact of NBS on Perceptions of Safety in Public Space

D. Pilot cities, challenges and optimal NBS indicators

The GreenScape deliverable entitled *D1.1.1. Typology and Criteria for planning GI and NBS on the local level previously developed had already assessed* the five project pilot cities - Metropolitan Area of Milan, Italy; Ptuj, Slovenia; Szegedin, Hungary; Warsaw, Poland and Zagreb, Croatia - characteristics and challenges. The same document indicated typologies of NBS applicable to urban contexts, highlighting the essential criteria to consider when planning such measures.

Considering this, we present some of these findings in parallel with their visuals to provide tailored insights into each case.

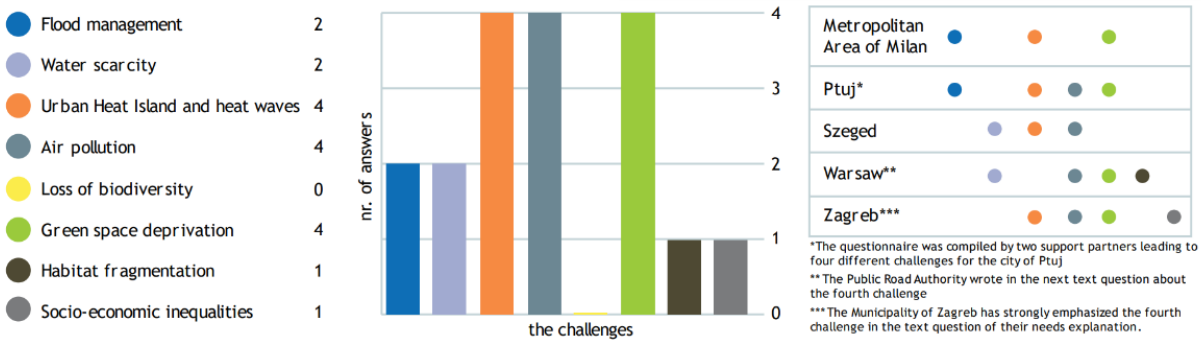

Figure 1: Key challenges faced by GreenScape CE pilot cities

Figure 1 illustrates the findings, revealing that the main challenges faced by the pilot cities revolve around the Urban Heat Island (UHI) effect and heat waves, along with air pollution and green space deprivation. Almost all the cities have highlighted these issues as primary concerns. In addition, flood management and water scarcity are significant challenges for most urban settings. On the other hand, habitat fragmentation is notably a major issue specifically for the city of Warsaw and socio-economic inequalities for the city of Zagreb.

Given the specific issues faced by each city, we have proposed a list of potential NbS indicators that could be used to address their respective challenges. The selection of these indicators was guided by the specific challenges identified for each city. The indicators listed below are not exhaustive but represent a starting point for further discussion and refinement based on local priorities and available data.

- **Metropolitan Area of Milan, Italy**

City's main challenges:

- Flood management
- Green space deprivation
- Urban heat islands and heatwaves

Most suitable indicators to be considered:

- **Human Health and Well-being Indicators**: Weather-related mortality; Share of people using green spaces for health and wellbeing.

- **Economic Indicators:** (Storm) water management costs; Energy costs for heating/cooling; Change in the mean economic value of property value for residential/commercial and industrial use (rental & sale).
- **Environmental Indicators:** Rainfall storage; Moderation of extreme events; Water safety and quality; Carbon sequestration and storage in vegetation/soil; Local climate regulation; Surface reflectance - albedo; Tree shade for local heat reduction.
- **Social Indicators:** Availability of parks and/or ecosystem services with respect to specific individual or household socioeconomic profiles; Access/barriers to green spaces.

- **Ptuj, Slovenia**

City's main challenges:

- Air pollution
- Flood management
- Green space deprivation
- Urban heat islands and heatwaves

Most suitable indicators to be considered:

- **Human Health and Well-being Indicators:** Overall (and air quality related) mortality; Weather-related mortality; Allergies (pollen) burden, aeroallergy index of plant species for greenscaping; Share of people using green spaces for health and wellbeing.
- **Economic Indicators:** (Storm) water management costs; Energy costs for heating/cooling; Change in the mean economic value of property value for residential/commercial and industrial use (rental & sale).
- **Environmental Indicators:** Air quality regulation (European Index); Rainfall storage; Moderation of extreme events; Water safety and quality; Carbon sequestration and storage in vegetation/soil; Local climate regulation; Surface reflectance - albedo; Tree shade for local heat reduction.
- **Social Indicators:** Availability of parks and/or ecosystem services for specific individual or household socioeconomic profiles; Access/barriers to green spaces.

- **Szegedin, Hungary**

City's main challenges:

- Water scarcity
- Air pollution
- Urban heat islands and heatwaves

The most suitable indicators to be considered:

- **Human Health and Well-being Indicators:** Overall (and air quality related) mortality; Weather-related mortality; Allergies (pollen) burden, aeroallergy index of plant species for greenscaping.

- **Economic Indicators:** (Storm) water management costs; Energy costs for heating/cooling.
- **Environmental Indicators:** Air quality regulation (European Index); Rainfall storage (water absorption capacity of NbS); Moderation of extreme events; Water safety and quality; Carbon sequestration and storage in vegetation/soil; Local climate regulation; Surface reflectance - albedo; Tree shade for local heat reduction.
- **Social Indicators:** Availability of parks and/or ecosystem services with respect to specific individual or household socioeconomic profiles; Access/barriers to green spaces.

- **Warsaw, Poland**

City's main challenges:

- Water scarcity
- Air pollution
- Green space deprivation
- Habitat fragmentation

The most suitable indicators to be considered:

- **Human Health and Well-being Indicators:** Cardiovascular disease (CVD) & Cerebrovascular diseases; Obesity; Overall (and air quality related) mortality; Allergies (pollen) burden, aeroallergy index of plant species for green scaping; Share of people using green spaces for health and wellbeing;
- **Economic Indicators:** (Storm) water management costs; Recreation and ecotourism.
- **Environmental Indicators:** Air quality regulation (European Index); Rainfall storage (water absorption capacity of NbS); Water safety and quality; Habitat for species; Ecological connectivity.
- **Social Indicators:** Availability of parks and/or ecosystem services for specific individual or household socioeconomic profiles; Access/barriers to green spaces; Walking cycling in and around areas of interventions.

- **Zagreb, Croatia**

City's main challenges:

- Urban heat islands and heatwaves
- Air pollution
- Green space deprivation
- Socio-economic inequalities

The most suitable indicators to be considered:

- **Human Health and Well-being Indicators:** Cardiovascular disease (CVD) & Cerebrovascular diseases; Obesity; Allergies (pollen) burden, aeroallergy index of plant species for green scaping; Weather-related mortality; Share of people using green spaces for health and wellbeing.

- **Economic Indicators:** (Storm) water management costs; Energy costs for heating/cooling; Change in the mean economic value of property value for residential/commercial and industrial use (rental & sale).
- **Environmental Indicators:** Air quality regulation (European Index); Rainfall storage; Moderation of extreme events; Water safety and quality; Carbon sequestration and storage in vegetation/soil; Local climate regulation; Surface reflectance - albedo; Tree shade for local heat reduction.
- **Social Indicators:** Availability of parks and/or ecosystem services for specific individual or household socioeconomic profiles; Access/barriers to green spaces.

E. Conclusions

While the benefits of NbS are widely acknowledged, a major challenge to their broad implementation remains the insufficient evidence of their effectiveness and the inadequate communication of their benefits.

This deliverable aimed to present a comprehensive set of evaluation indicators to assess the advantages, co-benefits and potential disadvantages of NBS in the five urban areas participating in the project: Zagreb, the Milan metropolitan area, Ptuj, Szeged and Warsaw. Each of these pilot areas is experiencing unique climate challenges, making NBS an attractive strategy to mitigate negative climate impacts while improving urban resilience and liveability.

The document's ambition was to provide a robust suite of evaluation indicators that stakeholders involved in NBS planning, implementation, and management can select and apply. This approach is designed to support cities in their efforts to scale up and replicate successful NbS initiatives. The chosen indicators span various domains that NbS aim to address in urban contexts, including human health and well-being, economic impacts, environmental benefits, and social advantages.

However, several important considerations must be taken into account when applying these indicators:

1. Data availability: local information at the appropriate scale is not always readily accessible and may be entirely absent in certain contexts. Consequently, data collection for calculating these indicators is expected to be both time-consuming and resource-intensive, particularly when ad hoc data-gathering methods (such as population surveys) are required.
2. Measuring effective impact: demonstrating causality and measuring the impact of specific local NBS, especially within the GreenScape context, presents significant challenges. The complexity of urban ecosystems makes it difficult to isolate the effects of individual interventions.
3. Temporal consideration: the timing of results is crucial, as the benefits of NBS are often not immediate. Long-term monitoring and evaluation are necessary to fully capture the impacts of these solutions.

By addressing these considerations and utilizing the proposed indicators, stakeholders can gain a more comprehensive understanding of the multifaceted impacts of NBS. This knowledge will enable more informed decision-making to enhance urban sustainability and resilience. Within the scope of the GreenScape CE project, these indicators can empower cities to select, monitor, and optimize NbS solutions that address their specific needs and challenges.

Ultimately, this deliverable is intended to serve as a foundation for future considerations and discussions among project partners. It provides a springboard for collaborative dialogue to determine which NbS are most suitable and effective for the five pilot cities included in the GreenScape CE project.

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