City-centered approach to catalyze nature-based solutions through the EU Regenerative - Urban Lighthouse for pollution alleviation and regenerative development

DELIVERABLE NO

Deliverable Title

Responsible Partner: IETU

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Annexes	KPIs Cards

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2.	Date	All beneficiaries	All beneficiaries	Incorporate comments from partners (shortening the list of KPIs)

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3.	13/09/2023	IETU	Starzewska-Sikorska A.	Adding chapter 5 on KPIs regenerative spatial planning
4.	19/09/2023	QUB	Jennifer McKinley	Internal peer review and quality assurance check
5.	28/09/2023	E-Institute	Ksenija Napast	Proofreading and final editing

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ACRONYMS AND ABBREVIATIONS TABLE

Acronym / Abbreviation	Meaning
E-Institute	E-ZAVOD, ZAVOD ZA PROJEKTNO SVETOVANJE, RAZISKOVANJE IN RAZVOJ CELOVITIH RESITEV
UNIPASSAU	UNIVERSITAT PASSAU
ICS	INSTITUTE OF COMMUNICATION STUDIESSKOPJE
LEITAT	ACONDICIONAMIENTO TARRASENSE ASSOCIACION
GCE	UNIVERSITEIT ANTWERPEN
PATRAS	DIMOS PATREON
POR	POR CONSULT DOO ZA POSLOVNO SAVJETOVANJE
PRATO	COMUNE DI PRATO
AITIIP	FUNDACION AITIIP
OC	OPENCONTENT SOCIETA COOPERATIVA
Belfast Council	Belfast City Council
BURST	BURST NONPROFIT KFT
ICLEI	ICLEI EUROPASEKRETARIAT GMBH
RRA-PODRAVJE	REGIONALNA RAZVOJNA AGENCIJA ZA PODRAVJE – MARIBOR
BOKU	UNIVERSITAET FUER BODENKULTUR WIEN
BP18	BUDAPEST FOVAROS XVIII. KERULET PESTSZENTLORINC-PESTSZENTIMRE ONKORMANYZATA
BREDA	GEMEENTE BREDA
BeeoDiv	BEEODIVERSITY
QUB	THE QUEEN'S UNIVERSITY OF BELFAST
OPERATE	FONDAZIONE OPERATE
UniLeeds	UNIVERSITY OF LEEDS
IETU	INSTYTUT EKOLOGII TERENOW UPRZEMYSLOWIONYCH
Katowice City	KATOWICE - MIASTO NA PRAWACH POWIATU

EC	European Commission
GA	Grant Agreement
M no.	Month, e.g., 1 of project implementation
NBS	Nature Based Solutions
EU	European Union
KPI	Key performance indicator

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1 INTRODUCTION

Task 2.2 constitutes the part of the WP2 entitled: Overall NBS Assessment and aims to meet objective O.2.2: To develop particular Key Performance Indicators for air quality and climate neutrality and verify them in 5 city demonstrations.

Therefore, the main objective of task 2.2 is to create a list of Key Performance Indicators (KPIs), which will give a basis for the assessment of NBS ecological, economic, social, health and regenerative impact in order to show the benefits of using NBS in cities in the transition into a regenerative future. The task as part of WP2 is placed between Task 2.1 and Task 2.3. In Task 2.1, the Registry of NBS for air quality and climate neutrality has been elaborated, directly connected with the KPIs as indicators of NBS impact. Therefore, each KPI description should include information to which NBS it relates. Task 2.3 will concern matchmaking for tailored NBS implementation in cities, which means assessment of benefits caused by NBS implementation as an answer to specific challenges of a city in the case of the project 5 cities. This assessment will be performed using selected KPIs related to city challenges.

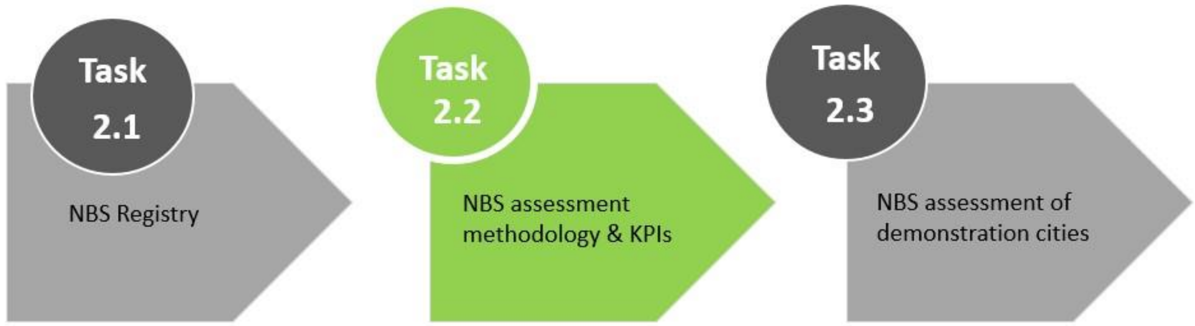

Figure 1 Relation between tasks 2.1, 2.2, 2.3

The results of Task 2.2 in the form of the list of KPIs and the KPIs cards will be used in other work packages of the project (Figure 2).

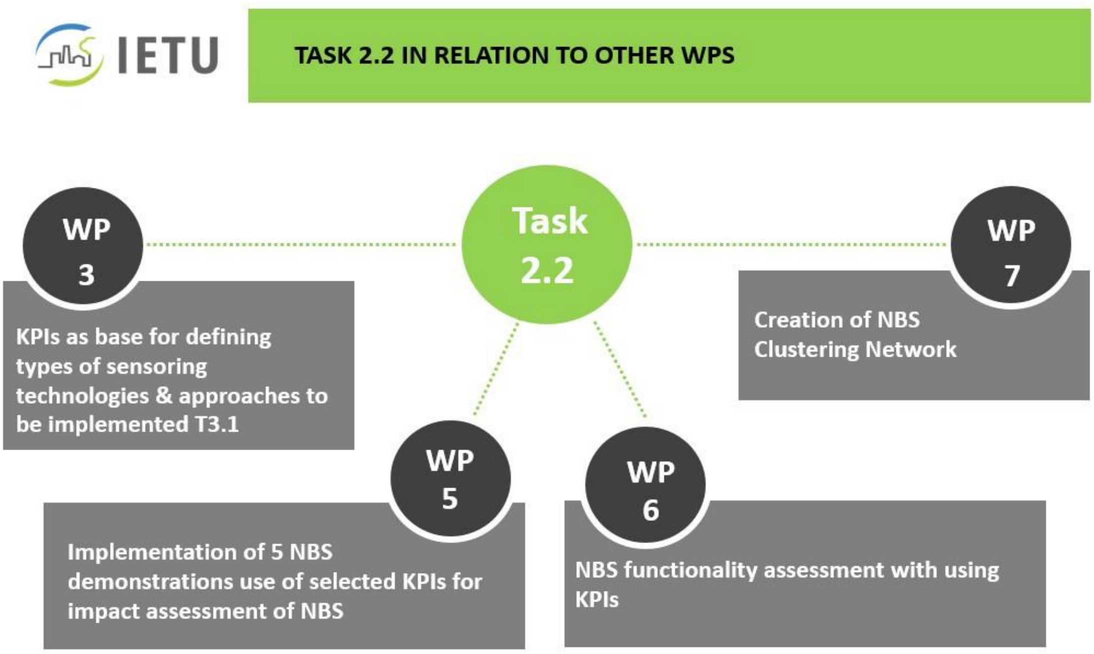

Figure 2 Relation between task 2.2 and project WPs

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2 METHODOLOGY OF ASSESSMENT OF NBS IMPACT ON AIR QUALITY AND CLIMATE NEUTRALITY

The NBS performance assessment methodology connects three elements: NBS, KPIs and urban challenges. In this system, Key Performance Indicators constitute a tool for assessing NBS impact or for evaluating benefits resulting from the application of nature-based solutions in an urban area. These benefits are expected to be analysed in relation to the following urban challenges, defined in the UPSURGE AF document, which are related to air quality and urban climate neutrality:

- Air quality (NOx, PM, VOC *etc.*)
- Vulnerability against climate change,
- Heat Island effect,
- Water pollution,
- Contaminated/degraded/eroded soils,
- Water scarcity and water retention potential,
- Biodiversity,
- Ecosystem connectivity,
- Gender,
- Age-related vulnerabilities,
- Divergences in socio-economic status,
- Cultural and racial inequities,
- Health and wellbeing,
- Housing,
- Employment and jobs,
- Crime,
- Mobility.

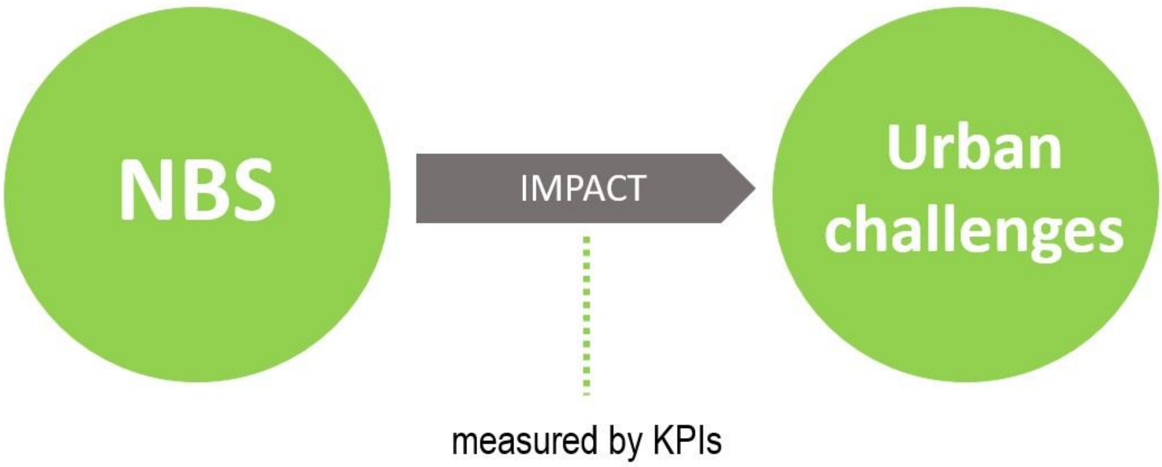

Figure 3 Relation between NBS, KPIs and urban challenges

The function of KPI is an indication of change in a selected challenge (urban development indicators) as an effect of NBS application. The analysis can concern various time and spatial scales, from local connections with one particular NBS to a scale of a whole city. Also, it can be focused on a strategic long term framework for the purpose of building an Urban Greening Plan.

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The general formula of NBS impact assessment by means of KPIs can be presented as follows:

$$V(Ch_n) = KPI_{Chn}\ (NBS)\text{, where}$$

$V(Ch_n)$ – value of a changed n challenge,

KPI_{Chn} (NBS) – KPI applied for a selected NBS in relation to n challenge.

According to the UPSURGE framework the implementation of nature based solutions in urban areas is considered as a beneficial measure to support an urban regenerative transition. Therefore, to prepare adequate policy actions, specific tools for assessment of the results of NBS applications should be developed. Also, the assessment needs a list of challenges which are to be monitored and whether beneficial effects are achieved after NBS implementation. Key Performance Indicators are a tool for this monitoring.

A Regenerative Index and Urban Insetting Protocols will include policy actions to support regenerative urban development. The policy actions will be used as a basis for a digital and tailor-made tool to monitor and assess environmental, economic, social and health related impacts. To this end, urban challenges have been defined, describing in detail two main problems UPSURGE addresses: air quality and urban climate neutrality.

These challenges are associated with Key Performance Indicators defined by parameters for monitoring of the results and impact of activities, including the application of nature-based solutions in cities. This impact can be assessed in various dimensions of time (hour, day, month, season, year) and space: from local (in the vicinity of an NBS), district or urban.

The data sources are also different: there will be parameters, especially environmental related ones, to be measured by sensors placed close to NBS location as well as information on economic, social and health related topics resulting from city/district statistics, social studies or questionnaires.

The needs of the project UPSURGE parameters to be measured by sensors have been assessed by 5 project demonstration cities: Breda, Budapest, Maribor, Belfast and Katowice. These parameters will be used in building selected KPIs, concerning mainly the environmental performance of NBSs.

In order to assess the NBS impact and their role in improving problems faced by cities at the beginning of the project, the current state will be identified as a baseline to show the change after NBS implementation.

Assessment of NBS impact expressed using KPIs is performed with methods defined individually for each KPI. These methods are presented in the KPIs Identity Cards'

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3 CREATION OF THE LIST OF KPIs

3.1 Analysis of projects

The initial list of KPIs in the form of a review has been prepared based on the analysis of the following projects:

- URBiNAT
- UrbanGreenUP
- UNALAB handbook
- Think Nature Handbook
- Naturvation Atlas
- OPPLA case study finder
- EU Report evaluating impact of NBS
- Nature4cities - Urban Nature Navigator - UnaLab.

This initial list of KPIs has been constructed as a result of reviewing the above-listed projects while looking at the challenges similar to those identified in UPSURGE. These challenges selected from the projects have been shown in Table 1 together with the UPSURGE challenges in order to prove how they match.

Table 1 UPSURGE 17 challenges matched with challenges from the analysed projects

UPSURGE 17 challenges (SDG):	Challenges from the analysed projects
Air quality (NOx, PM, VOC, etc.)	Air quality
Vulnerability against climate change,	Climate adaptation and mitigation
	Resource efficiency
	The direct economic value of NBS
	Social capacity building for sustainable urban transformation
Heat Island effect,	Environment
Water pollution,	Water management
Contaminated/degraded/eroded soils,	Soil management
	Place regeneration
Water scarcity and water retention potential,	Flood management
	Coastal resilience
Biodiversity,	Nature and biodiversity
Ecosystem connectivity,	Green space management
	Urban regeneration
Gender	Environmental justice and social cohesion
Age-related vulnerabilities	Social justice

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Divergences in socio-economic status	Social justice
	Social cohesion
Cultural and racial inequities	Social justice
Health and wellbeing	Public health and wellbeing
Housing	Urban planning and governance
Employment and jobs	Green economy
	Potential of economic opportunities and green jobs
Crime	People security
Mobility	People security

3.2 Initial list of KPIs

The initial list of KPIs has been developed, which presents KPIs matched with UPSURGE 17 challenges. It includes more than 350 positions, out of which the final list of 50+ KPIs has been created. The list has been attached to the report. (Annex 1 – initial list of KPIs).

3.3 Assessment of KPIs suitability with the RACER method

It has been assumed that the final list of KPIs for the project's needs should be elaborated based on the co-creation of the whole project partnership. Therefore, the following steps have been applied:

1. Project Partners (PP) select challenges for which they are able to assess KPIs (the initial list of KPIs for individual challenges is ready)
2. The list of challenges assigned to each project partner sent to this project partner
3. Assessment of KPIs by the project partner
4. Final list of 50+ KPIs

Figure 4 Stages of developing KPIs

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Assessment of KPIs has been performed by using the RACER method (RACER framework. According to the EC's Impact Assessment Guidelines).

RACER: Relevant, Accepted, Credible, Easy to monitor, Robust. (Science Communication Unit, University of the West of England, Bristol 2012)

Relevant = closely related to the objectives to be achieved
Accepted = by local authorities, stakeholders and other users
Credible = accessible to non-experts, unambiguous and easy to interpret
Easy to monitor = can be monitored and data collected with reasonable effort
Robust = not easy to manipulate

Rank:

completely fulfilled	1	
partly fulfilled	0,5	
not fulfilled	0	

Below, there are sub-criteria presented enabling precise assessment of KPIs.

Relevant = closely related to the objectives to be achieved.

R1: Link to the project objective:

Is the indicator suitable for describing initial planning problems?

R2: Support for policy measures:

Is the indicator linked to specific policies and/or objectives?

R3: Comparability:

Is it possible, with reasonable effort, to standardise the methodology to obtain fully comparable results?

Accepted = by local authorities, stakeholders and other users.

A1: Policy makers:

Does the indicator have the potential to be applied/tested in developing or assessing policies?

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A2: Practitioners:

Does the indicator have the potential to be or is used by an urban planner in operational urban planning praxis?

A3: Other stakeholders:

Does the indicator have the potential to be accepted by other stakeholders?

Credible = accessible to non-experts and easy to interpret

C1: Unambiguous results:

Do the results of the indicators convey a clear, unambiguous message?

C2: Transparency:

Does the indicator have a transparent methodology?

C3: Documentation of assumptions and limitations:

Are the underlying data, calculation methods and assumptions fully disclosed, interpretable and reproducible to ensure consistent application across EU Member States?

Easy to monitor = can be monitored and data collected with reasonable effort

E1: Availability of data to calculate the indicator:

Does the methodology require the input of data that has already been collected (ideally in electronic form) or that has yet to be produced? Is it possible to update these easily?

E2: Technical feasibility:

Is the indicator simple enough to be carried out with software and expertise appropriate to the scale of application and typical capabilities of the institution carrying out the calculations?

E3: Reproducibility:

Is it possible to use the indicator in numerous (similar but different)?

Robust = not easy to manipulate

R1: Data quality:

Does the KPI use robust real-world data and estimation techniques that are suitable for all stated purposes?

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R2: Sensitivity:

Does the methodology include an assessment of the uncertainty of the data obtained?

R3: Scope:

Does the indicator impact on NBS at different city levels?

3.4 List of KPIs selected after evaluation by Partners

The final list of KPIs has been created based on the results of the co-creation process of assessing KPIs with the RACER method. The list below includes KPIs, which have been given the highest ranks.

In the list, these KPIs have been indicated, which will be based on parameters measured by sensors in the project. For these KPIs, the data will be provided by sensing systems deployed within Task 3.3:

- Subsystem of stationary sensors established at demonstration sites,
- Subsystem of mounted sensors on unmanned aerial vehicles at each demo location,
- Subsystem of mobile sensing devices on two levels:
    1. Citizen infrastructure (at least 100 citizens per demo location to monitor pollution and environmental conditions)
    2. Transport-based moveable sensing units 5 in each demo location - Subsystem of bee monitoring.

Table 2 List of KPIs

	No.		GROUP KPIs name	KPI/indicator	Parameters measured by sensors	Ranking ALL
Air quality	1.	1.1.1	Air pollutant concentrations	Air pollutant concentrations	+ Air pollutant concentration	92,5
	2.	1.2.1	Concentration levels limits	Concentration levels limits (number of days with exceedances)	+ Air pollutant concentration	85,5
	3.	1.3.1	Air quality index	Air quality index	+ Air pollutant concentration	71,5
	4.	1.5.1	Ambient pollen concentration	Ambient pollen concentration	+ Ambient pollen concentration	73
Climate vulnerability	5.	2.5.4	Flood	Flooded area	+ Rainfall intensity; Rainfall duration	33
	6.	2.7.1	Soil	Soil temperature	+ Temperature	37

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	7.	2.7.2	Soil	Soil sealing		34,5
	8.	2.10.1	Climate policy	Degree of development of climate resilience strategy		34,5
	9.	2.10.3	Climate policy	Adaptation of local plans and regulations to include NB		34,5
UHI Effect	10.	3.1.1	Urban Heat Island (UHI) effect	Urban Heat Island (UHI) effect	+ Temperature	60
	11.	3.3.3	Mean or peak daytime local temperatures / Air temperature - mean, peak	Mean or peak daytime local temperature	+ Temperature	60
	12.	3.4.1	Heat waves incidences (hot days, tropical nights)	Heatwave risk (days)	+ Temperature	59,5
	13.	3.4.2	Heat waves incidences (hot days, tropical nights)	Heatwave risk (tropical nights)	+ Temperature	59,5
Water pollution	14.	4.1.1	Water quality	Pollutant discharge to local waterbodies		22
	15.	4.1.2	Water quality	Basic water quality (pH, temperature, EC, DO, flow rate)	+ Temperature; pH; Flow rate; Electrical conductivity, etc.	21,5
Soils	16.	5.1.2	Soil organic matter	Soil organic matter content		42
	17.	5.2.1	Carbon in soil	Measured soil carbon content		35
	18.	5.2.3	Carbon in soil	Soil carbon to nitrogen ratio		39,5
	19.	5.11.1	Derelict land reclaimed for NBS	Derelict land reclaimed for NBS		39,5
Water	20.	6.1.1	Water balance	Infiltration capacity	+ Water level; Volume of water; Substrate capacity	36
	21.	6.3.1	Water slowed down	Volume of water slowed down	+ Water flow	30,5
	22.	6.4.2	Irrigations	Rainwater or greywater use for irrigation purposes	+ Water level; Volume of rainwater/greywater; The amount of water used	32
Biodiversity	23.	7.1.2	Biotope area factor - BAF	BAF - Biotope Area Factor		44,5
	24.	7.5.3	Pollinator species changes	Pollinator species presence		45
	25.	7.5.5	Pollinator species changes	Density and seasonal spread of floral resources for pollinators		45

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	26.	7.7.1	Increase of plants and animals species	Plant species richness		45
Ecosystem connectivity	27.	8.6.1	Community garden area	Community garden area		15
	28.	8.7.1	Ratio of open spaces to built form	Ratio of open spaces to built form		13,5
	29.	8.10.1	Ecosystem benefits of NBS	Benefits provided pre and post interventions		13,5
	30.	8.15.1	Total vegetation cover	Total vegetation cover		13,5
Gender	31.	9.1.1	Diversity of participants in the process around the NBS	Involvement of citizens from traditionally under-represented groups		47,5
	32.	9.2.1	Consciousness of citizenship	Consciousness of citizenship		49
Age vulnerability	33.	10.1.2	Children vulnerability	Exploratory behaviour in children		16,5
	34.	10.2.1	Quality of life	Quality of life for elderly people		16
Socio-economic	35.	11.1.2	Community involvement	Community involvement in planning		30
	36.	11.1.3	Community involvement	Diversity of stakeholders involved		30
	37.	11.2.3	NBS Management	Investment cost for NBS (construction and equipment)		30
Cultural racial	38.	12.3.1	Access to cultural facilities	Access to cultural facilities		7,5
	39.	12.5.2	Recreational & cultural activities	Number of new activities in the tourism sector in the study area		7,5
	40.	12.5.4	Recreational & cultural activities	Number of visitors per day that are seen as fully or partially connected to the NBS		9
Health	41.	13.3.2	Influence of air quality	Proportion of the population exposed to ambient air pollution	+ Air pollutant concentration	7,5
	42.	13.4.1	Influence of noise	Noise	+ Sound level	12,5
	43.	13.7.7	Quality of Life	Distribution of public green space – total surface or per capita.		6,5
Housing	44.	14.2.1	Changes in economic opportunities and green jobs	Change in mean or median land and property value		23,5
	45.	14.3.1	Property betterment	Perception of property betterment		23
	46.	14.4.1	GENtryfication	GEN - Gentrification		22,5
Jobs	47.	15.2.1	Business development	Establishment of new businesses in the area surrounding NBS		12
	48.	15.2.3	Business development	Proportion of ground floor surface of buildings within a specified distance (300 m) from NBS used for commercial or public purposes		12

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Crime	49.	16.1.1	Crime rates	CC - CRIME COUNTS		27,5
	50.	16.1.4	Crime rates	Crime reduction		27
Mobility	51.	17.1.1	Percentage of pedestrians and bicycle roads	Proportion of road network dedicated to pedestrians and/or bicyclists		50,5
	52.	17.3.2	Increase in walking and cycling after interventions	Increase in walking and cycling in and around areas of interventions		51,5

3.5 Creation of the final list of KPIs

The methodology in Task 2.3 – Matchmaking for Tailored NBS Implementation in Cities – was aiming at connecting three elements: urban challenges concerning environmental and socio-economic status, NBSs from the Registry developed in Task 2.1 and KPIs serving for assessment of NBS performance in relation to these challenges. Therefore, additional KPIs have been added, which are related to the specific questions for cities developed in Task 2.3. These questions concern details of the individual urban challenges.

The final list of KPIs is presented below in Table 3.

Table 3 Final list of KPIs

	No.	GROUP KPIs name	KPI/indicator
Air quality	1.	Air pollutant concentrations	Air pollutant concentrations
	2.	Concentration levels limits	Concentration levels limits (number of days with exceedances)
	3.	Air quality index	Air quality index
	4.	Air pollutant concentration reduction by plants	Annual O3, SO2, NO2, CO, and PM2.5 capture/removal by vegetation
	5.	Ambient pollen concentration	Ambient pollen concentration
	6.	Avoided or reduced GHG emissions - buildings	Avoided greenhouse gas emissions from reduced building energy consumption
Climate vulnerability	7.	Risk exposure	Potential areas exposed to flood risks: Urban/residential areas
	8.	Risk exposure	The mean number of people adversely affected by natural disasters each year
	9.	Flood	Flooded area
	10.	Water availability	Effective Drought Index
	11.	Soil	Soil temperature
	12.	Soil	Soil sealing
	13.	Climate policy	Degree of development of climate resilience strategy

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	14.	Climate policy	Adaptation of local plans and regulations to include NBS
	15.	Local ambient air temperature	Days with maximum temperature >90th percentile
	16.	Local ambient air temperature	Days with minimum temperature <10th percentile
	17.	Climate disasters	area struck by destructive windstorms
	18.	Climate disasters	area struck by wildfire events
	19.	Air physical parameters	relative humidity
UHI Effect	20.	Urban Heat Island (UHI) effect	Urban Heat Island (UHI) effect
	21.	Land surface temperature	Maximum surface temperature reduction (°C)
	22.	Mean or peak daytime local temperatures / Air temperature - mean, peak	mean daytime temperature
	23.	Heat waves incidences (hot days, tropical nights)	Heatwave risk (day)
	24.	Heat waves incidences (hot days, tropical nights)	Heatwave risk (tropical nights)
Water pollution	25.	Water quality	Pollutant discharge to local waterbodies
	26.	Water quality	Basic water quality (pH, temperature, EC, DO, flow rate)
	27.	Eutrophication	Eutrophication
	28.	Water Quality	Total Suspended Solids (TSS) content
	29.	Water Quality	Nitrogen and phosphorus concentration or load
Soils	30.	Soil organic matter	Soil organic matter index
	31.	Soil organic matter	Concentration or load
	32.	Carbon in soil	Measured soil carbon content
	33.	Carbon in soil	Soil carbon to nitrogen ratio
	34.	Soil water retention capacity	Soil water retention capacity
	35.	Soil Available Water (SAW)	Soil Available Water (SAW)
	36.	Surface area of restored and/or created wetlands	Surface area of restored and/or created wetlands
	37.	Soil erosion	Erosion risk (soil loss estimate)
	38.	Soil pollution	Polluted soils
	39.	Derelict land reclaimed for NBS	Derelict land reclaimed for NBS
	40.	Soil pollution	CH pollution level of soil
	41.	Soil pollution	Heavy metal pollution levels of soil
	42.	Soil pollution	Pesticide levels of soil
Water	43.	Water balance	Infiltration capacity

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	44.	Water slowed down	Volume of water slowed down
	45.	Irrigations	Rainwater or greywater use for irrigation purposes
	46.	Water availability	Water Exploitation Index
Biodiversity	47.	Biotope area factor - BAF	BAF - Biotope Area Factor
	48.	Changes in land use of natural areas	Percentage of protected natural areas
	49.	Changes in land use of natural areas	Percentage of tree canopy cover
	50.	Changes in the number of native species	Number of native species
	51.	Changes in the number of native species	City Biodiversity Index
	52.	Pollinator species changes	Pollinator species presence
	53.	Pollinator species changes	Density and seasonal spread of floral resources for pollinators
	54.	Number of non-native species introduced	Number of non-native species introduced
	55.	Number of non-native species introduced	Number of invasive alien species
	56.	increase of plants and animals species	plant species richness
	57.	Green areas	Percentage of private green areas in the city area
	58.	Number of veteran trees per unit area	Number of veteran trees per unit area
Ecosystem connectivity	59.	Proportion of natural areas within a defined urban zone	Proportion of natural areas within a defined urban zone
	60.	Public green space distribution	Public green space distribution
	61.	Community garden area	Community garden area
	62.	Ratio of open spaces to built form	Ratio of open spaces to built form
	63.	Ecosystem benefits of NBS	Benefits provided pre and post interventions
	64.	Edge density of GUAs	Edge density of Green Urban Areas (GUAs)
	65.	Distribution of blue space	Distribution of blue space
	66.	Effective green infrastructure at the urbanrural interface	Effective green infrastructure at the urban-rural interface
	67.	Total vegetation cover	Total vegetation cover
	68.	Diversity of participants in the process around the NBS	Involvement of citizens from traditionally under-represented groups
Gender	69.	Diversity of participants in the process around the NBS	REC – Recognition
	70.	Consciousness of citizenship	Consciousness of citizenship
Age vulnerabilit y	71.	Children vulnerability	Prevalence of attention deficit/ hyperactivity disorder (ADHD)
	72.	Quality of life	Quality of life for elderly people
Socio-economic	73.	Community involvement	Community involvement in planning
	74.	Community involvement	Diversity of stakeholders involved
	75.	NBS Management	Investment cost for NBS (construction and equipment)

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	76.	Identity/behaviour	Perceptions of citizens on urban nature - Green spaces quality
	77.	Poverty and exclusion	Areas with high unemployment rate
	78.	Sustainable Urban Transformation	Children involved in environmental educational activities
	79.	Sustainable Urban Transformation	Citizens' awareness regarding urban nature and ecosystem services
Cultural racial	80.	Access to cultural facilities	Access to cultural facilities
	81.	Recreational& cultural activities	Number of new activities in the tourism sector in the study area
	82.	Recreational& cultural activities	number of visitors per day that is seen as fully or partially connected to the NBS
Health	83.	Influence of air quality	Morbidity, Mortality and Years of Life Lost due to poor air quality
	84.	Influence of air quality	proportion of the population exposed to ambient air pollution
	85.	Quality of Life	Distribution of public green space – total surface or per capita.
	86.	Influence of noise	Exposure to noise pollution
	87.	Health risk	Animal species potentially at risk
	88.	Health and Wellbeing	General wellbeing and happiness
Housing	89.	Changes in economic opportunities and green jobs	Change in mean or median land and property value
	90.	Property betterment	Perception of property betterment
	91.	GENtryfication	GEN - Gentrification
	92.	Types of buildings	Share of individual types of buildings in the total city area
	93.	Population mobility	Population mobility
Jobs	94.	Business development	Establishment of new businesses in the area surrounding NBS
	95.	Business development	Proportion of ground floor surface of buildings within a specified distance (300 m) from NBS used for commercial or public purposes
	96.	Economic Opportunities	Changes in mean house prices/rental markets
	97.	Employment structure	Area with a high number of inbound commuters/parking lots
	98.	Employment structure	Area with a high number of outbound commuters
Crime	99.	Crime rates	CC - CRIME COUNTS
	100.	Crime rates	Crime reduction
	101.	PCFS - Percentage of citizens feeling safe	PCFS - Percentage of citizens feeling safe
Mobility	102.	Percentage of pedestrians and bicycle roads	Proportion of road network dedicated to pedestrians and/or bicyclists
	103.	Increase in walking and cycling after interventions	Increase in walking and cycling in and around areas of interventions
	104.	Modal split	Number of common bicycles available for the public/number of inhabitants
	105.	Modal split	Length of public transport lines/km2 of the city area
	106.	Modal split	Number of parking lots/number of inhabitants

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	107.	Modal split	Number of cars / 1000 inhabitants

4 KPI Identity Card form

The KPI Identity Card has been designed based on the experience of other projects, which have been reviewed. The card includes short characteristics, the calculation method necessary for using a KPI, and references for more detailed information. Further, the card includes the KPI number from the final list of KPIs, as well as a number connecting each KPI with the challenge to which it is related.

The card includes information on the type of KPI connected with the character of parameters (descriptive, assessment, monitoring) and spatial scale (city, neighbourhood, site).

There is also information on required data, measurement unit and frequency of measurements.

It is the place in the card for NBS which is relevant to the KPI – it may be more than one NBS. It means an indication that NBS may have an impact while implemented and may contribute to improving the situation in a city connected with the given challenge.

The NBS are based on the NBS Registry created in task 2.1.

5 KPIs connected with regenerative spatial planning

The UPSURGE project is addressing the multitude of interconnected problems faced by cities (climate crisis, overcrowding, lack of resources, inequality, lack of regenerative governance, pollution, mental and general health) by creating a participatory, experience-based, measurable, smart and regenerative NBS reference framework and reference network within the European Urban Regenerative Lighthouse to enable wider acceptance and uptake of UPSURGE solutions.

The regenerative NBS framework will directly address the cities' regenerative spatial planning as a substrate of the regenerative spatial development of cities. The important role of regenerative spatial planning, including the NBS framework, will be supported by KPIs presenting the impact on selected spatial planning-related indicators.

Therefore, the additional KPIs (RSP_n – related to Regenerative Spatial Planning) have been developed in relation to spatial planning, apart from KPIs related directly to 17 urban challenges, for which 107 KPIs are described in previous chapters.

Table 4 KPIs (RSP_n) related to Regenerative Spatial Planning in connection with the NBS framework

KPI No.	Name of KPI	Definition/unit	Description
RSP 1	population density	Population density determines the degree of land use. Population density is the number of inhabitants per land surface (net/gross); (persons/ha, persons/km^2). The gross population density is the number of inhabitants per total surface. The net population density is the number of inhabitants per surface of land that is inhabited at all.	Population density can be calculated using GIS methods, especially when calculating the net rate. In urbanised areas, uninhabited areas should be considered as: - all classes of the agricultural areas, forest and semi-natural areas category and wetlands of the Corine Land Cover classification,

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		(https://www.britannica.com/science/population-density, https://inzyniermocno.tumblr.com/post/89542156695/wska%C5%BAniki-urbanistyczne-dla-teren%C3%B3w-zabudowy (in Polish), Natural and climatic indicators of sustainable development of cities. Guide for cities, Ministry of Climate and Environment, Poland https://www.gov.pl/web/klimat/przyrodniczo-klimatyczne-wskazniki-zrownowazonego-rozwoju-miast-przewodnik-dla-miast (in Polish))	- all classes of the category water bodies of the Corine Land Cover classification, - some classes of the artificial surfaces category of the Corine Land Cover classification, which include: from 1.2.1 to 1.2.4, from 1.3.1 to 1.3.3 as well as 1.4.1 and 1.4.2. Inhabited areas include some classes of the artificial surfaces category of the Corine Land Cover classification, which include: 1.1.1 and 1.1.2.
RSP 2	built-up volume density	Building density determines not only how crowded or built-up a neighbourhood appears but also how much the land and the building is worth. Building density is the ratio of the sum of the built-up volume to the land area (m^3/ha). (https://inzyniermocno.tumblr.com/post/89542156695/wska%C5%BAniki-urbanistyczne-dla-teren%C3%B3w-zabudowy (in Polish), https://www.sciencedirect.com/topics/social-sciences/building-density)	Built-up volume density can be calculated using GIS methods according to the following algorithm: - The built-up area is calculated as the sum of the areas of all buildings, calculated along the outer outline of the walls together with clearances and arcades (ha) - Built-up volume (gross) is calculated as the product of built-up area and building height (together with the underground floors) (m^3), in accordance with the ISO 9836:1992 standard: *Performance standards in building - Definition and calculation of area and space indicators* - Building density is calculated as the ratio of the sum of the built-up volume to the land area (m^3/ha).
RSP 3	urban sprawl/expansion intensity	Population-to-density allocation – a selected indicator used for the assessment of urban sprawl	The wide literature concerning measuring urban sprawl presents various aspects connected with using land as a resource in urban expansion. The impact of this expansion depends on its intensity and also on the type of newly used land. There is a large number of theoretical studies and many examples showing the results of the applied methods of measuring urban sprawl (Hasse, J.E., Lathrop, R.G.,2003, L Indrawati et al. 2020, Ewing R, Pendall R, Chen D. 2002). The simplest indicator of estimating urban sprawl is the proportion of new urban areas' increase to their total area. This index is produced to evaluate the spatial distribution of city expansion in different periods. The other indicator is connected with the spatial distribution of population density in relation to

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			the distance of the analysed areas from the city centre. It needs an analysis of the population density in the individual districts. The higher the density, the more intensive expansion takes place.
RSP 4	greenfield and brown(grey) field investments	Area taken under greenfield and brown(grey)field investments	The indicator is meant as an increase in the area for green (NBS) investments, and the indicator shows an increase in the area for brown(grey) investments. The indicators should be measured every 2-3 years to show the balance between these two types of areas in a city.
RSP 5	mix of uses	Degree to which different land uses (and/or related functions) commonly exist within the same smaller area	The indicator refers to the different functions present in the analysed area, which are the types of land use, including residential, commercial, offices, and public establishments. These functions are identified through a physical analysis. The indicator is defined as follows (Iannillo A., Fasolino I. 2021): IGS=1−∑(nN)2, where: n - the number of land types used present referring to a specific function; N - the total number of land type uses related to all functions.
RSP 6	city design	City design (urban layout, built form, building typologies, city canyon). The criteria used to distinguish between key typologies of urban design include the following: - Intensity of development - how intensely and efficiently land is used. - Scale and grain – the pattern, size and arrangement of buildings and their plots. - Land Use – the predominant function of the buildings. The built form of the adjoining and nearby properties is a physical description of these properties in terms of the predominant form of development, i.e. building mass and height. Building typology refers to the study and documentation of buildings according to their essential characteristics. Typological classification tends to focus on building function (use), building form, or architectural style. An urban canyon (also known as a street canyon) is a place where the street is flanked by buildings on both sides, creating a canyon-like environment. Such human-built canyons are made when streets separate dense blocks of structures, especially skyscrapers. Urban canyons affect various local conditions, including temperature, wind, light, air quality, and radio reception, including satellite navigation signals.	As for the elements of urban design, these are related to the physical and built form and consist of: - buildings; - public spaces; - streets; - transport; and landscape In urban design, the elements of a city are often considered in terms of five key components: paths, edges, districts, nodes, and landmarks. These elements work together to create the overall structure and character of a city. Due to the basic utility function, buildings are divided into the following types: - residential buildings, - industrial buildings, - transport and communication buildings, - commercial and service buildings, - tanks, silos and storage buildings, - office buildings, - buildings of hospitals and medical care facilities,

			education, science and culture buildings, as well as sports buildings, - production, service and economic buildings for agriculture, other non-residential buildings. The most important geometrical detail about a street canyon is the ratio of the canyon height (H) to canyon width (W), H/W, which is defined as the aspect ratio. The value of the aspect ratio can be used to classify street canyons as follows: - Regular canyon – aspect ratio ≈ 1 and no major openings on the canyon walls - Avenue canyon – aspect ratio < 0.5 - Deep canyon – aspect ratio ≈ 2 A sub-classification of each of the above can be done depending on the distance between two major intersections along the street, defined as the length (L) of the street canyon: - Short canyon – L/H ≈ 3 - Medium canyon – L/H ≈ 5 - Long canyon – L/H ≈ 7 Another classification is based on the symmetry of the canyon: - Symmetric (or even) canyon – the buildings that make the canyon have approximately the same height; - Asymmetric canyon – the buildings that make the canyon have significant height differences. Another specific type is the step-up canyon – a street canyon where the height of the upwind building is less than the height of the downwind building. The modification of the characteristics of the atmospheric boundary layer by the presence of a street canyon is called the street canyon effect. Street canyons affect temperature, wind speed and wind direction and, consequently, the air quality within the canyon. The effect of a street canyon on local wind and air quality can greatly differ in different canyon geometries. Effects may also contribute to poor GPS signal reception.
RSP 7	ground albedo	Radiation balance at the Earth's surface consists of net short-wave radiation and net long-wave radiation. Longwave radiation (wavelength 3 to	Surface reflectance can be measured in the laboratory, in the field, and via remote sensing.

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<table>
<tr>
<td></td>
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<td>100 μm) is an energy exchange between the Earth's surface and the atmosphere. Short-wave radiation (wavelength 0.3 to 3 μm) coming from the sun can be reflected back or scattered by air molecules or clouds when they are present, although part of it reaches the ground. Albedo is a portion of short-wave radiation that is reflected back once it reaches the ground, and it varies with the land cover.
Ground Albedo is a short-wave radiation reflectance coefficient of a surface (0-1, unitless), where 1 denotes full reflection, and 0 denotes full absorption. Surface albedo is defined as the instantaneous ratio of surface-reflected radiation flux to incident radiation flux over a given spectral interval (dimensionless).</td>
<td>a. In the laboratory, surface reflectance can be measured using spectrophotometers equipped with integrating spheres over wider spectral ranges than a human eye's photopic vision (well-lit conditions) response and using light sources other than natural light. Since the beam illuminates only part of a sample, a spatially uniform sample will yield the most fast and accurate results.
b. In the field, surface reflectance is typically measured using a pyranometer, a solar radiation meter, which measures the reflected solar irradiance. This method requires portable and relatively inexpensive equipment that can be applied to flat and curved surfaces. However, the limitations include the necessity of a clear sky, as clouds can lead to erroneous results, and a relatively large surface size to prevent radiation collection from the object's surroundings. Ideally, the in situ albedo measurements are continuous and have a temporal resolution of less than 30 minutes.
c. Remote sensing options utilise the satellite or aerial systems that that record the albedo of larger surfaces or the Earth, such as Clouds and the Earth's Radiant Energy System, or CERES. While remote sensing is feasible for measuring albedo at larger scales, this method is unsuitable for finer scale applications, and validations in the field may be necessary.
Reference tables exist for certain surfaces and land covers:
<table>
<tr><th>Land cover</th><th>Albedo</th></tr>
<tr><td>Grass and pasture</td><td>0.2 – 0.26</td></tr>
<tr><td>Snow and ice</td><td>0.2 (old) – 0.8 (new)</td></tr>
<tr><td>Bare soil</td><td>0.1 (wet) – 0.35 (dry)</td></tr>
<tr><td>Asphalt</td><td>0.05 – 0.2</td></tr>
<tr><td>Red/Brow roof tile</td><td>0.1 – 0.35</td></tr>
<tr><td>Open water</td><td>0.08</td></tr>
</table>
</td>
</tr>
<tr>
<td>RSP 8</td>
<td>plant cover</td>
<td>Total vegetation cover is the percentage of soil which is covered by green vegetation</td>
<td>Soil is covered by an assemblage of plant species and the ground without specific reference to particular taxa, life forms, structure, spatial extent, or any other specific botanical or geographic characteristics(GIS).</td>
</tr>
</table>

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			The NDVI index can also be used. (Natural and climatic indicators of sustainable development of cities. Guide for cities, Ministry of Climate and Environment, Poland, https://www.gov.pl/web/klimat/przyrodniczo-klimatyczne-wskazniki-zrownowazonego-rozwoju-miast-przewodnik-dla-miast (in Polish)) See also KPI No. 30
RSP 9	green roof coverage (require-ments)	A green roof is a roof that is used to grow living plants.	The vegetation of the green roof can be anything, including grasses, wildflowers, or agricultural products. In some situations, a low maintenance collection of grasses may be most appropriate, while in other instances, a vegetable/fruit garden can be grown to make agriculturally productive use of the area. To decrease energy and stormwater management demands, plant life should typically cover the majority of the surface area of the roof. Restrictions in size and type of vegetation are often dictated by climate and building load capacities. Due to the soil used in the construction of green roofs and soil water retention, green roofs are typically heavier than traditional roofs. As a result, they may require additional support to ensure their proper safety and functioning. They also require a membrane lining around the soil to prevent water from damaging the structure underneath. Green roof implementation can be encouraged through municipalities initiating pilot programs, providing direct or indirect financial incentives, or passing regulations. Pilot programs can be accomplished by constructing green roofs on municipal buildings to market the positive benefits of green roofs. Another tool municipalities may use to encourage green roofing is through the issuance of grants, tax credits or fee waivers for the construction of green roofs.

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			Alternatively, granting developers variances or additional floor area ratio or expedited permits subject to their structure having green roofs encourages green roof construction among developers. Ordinances requiring green roofs for new structures in certain districts (downtown, high-traffic areas) are also an effective method municipalities may utilise to promote green roofing.
RSP 10	green roof performanc e	Four indicators concern the green roof performance (Green Roof System Brochure, Urbanscape, 2015): - cooling effect and energy saving in summer due to less air-conditioning needed - thermal insulation effect and energy saving in winter due to lower energy transfer through the roof. - rainwater management control data, including water retention in the green roof and yearly/monthly run-off data (all based on real climate conditions) - temperature on top of the green roof vs. regular roof (positive effect on UHI)	Cooling effect and energy saving in summer due to less air-conditioning needed – is measured in kWh/m^2. Thermal insulation effect and energy saving in winter due to lower energy transfer through the roof is measured in kWh/m^2 per month. Water retention in the green roof and yearly/monthly run-off data (all based on real climate conditions) are measured in parameters of outflow (l/m^2), irrigation (l/m^2), retained water (l/m^2) and water balance (l/m^2). Temperature on top of the green roof vs. regular roof is presented in ^{0}C.
RSP 11	streamflow	Streamflow is meant as an amount of water passing through a specific point over time (cross section of river, channel or ditch). In most countries, the units utilised for this indicator are cubic meters per second.	Measurements are taken with streamflow gauges by measuring the length of the stream and marking the start and finish points. The longest length without changing stream conditions is desired to obtain the most accurate measurement. Streamflow is connected with total runoff.
RSP 12	surface runoff	The extent of impermeable surfaces in urban areas is continually increasing as cities develop and expand due to the construction of buildings, roads, streets, parking lots, etc. A significant consequence is greater runoff in urban areas, which can also lead to flooding. Many factors are affecting the quantity of surface runoff, including soil characteristics, land use and vegetative cover, hillslope, and storm properties such as rainfall duration, amount, and intensity. In general, surface runoff is generated in two ways: through saturation excess, where runoff is generated when the soil becomes saturated (for example, after a lengthy period of rainfall), or through infiltration excess, where runoff is generated when the rainfall intensity exceeds the infiltration rate of water into the soil (for example during a heavy precipitation event when rain falls more rapidly than it can infiltrate the soil). Surface runoff is a runoff coefficient in relation to precipitation quantities (m^3/s, liter/s or depth-equivalent mm)	Direct measurement of runoff (and its characteristics) using standard approaches, including weirs, pressure transducers/loggers, tipping-bucket gauges, etc. Large scale: Weirs, flumes, orifices. Weirs obstruct the flow, making the head behind the weir being a function of flow velocity and flow rate through the weir. Flumes are another traditional method for open channel flow measurement in a channel with converging and diverging sections. The operation principle of the flumes is that the water level is higher in the converging section than in the diverging section and that there is a direct relationship between water depth and flow rate.

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			Small scale: tipping-bucket gauges, pressure transducers for discharge monitoring. Tipping-bucket gauges record runoff volumes as numbers of bucket tips per 24-h period. The depth of the daily runoff is then calculated by dividing the volume of daily runoff by the area of the test plot. Pressure transducers allow for automatic continuous monitoring and data collection at certain intervals (e.g., 1-min). See map available at Imperviousness Density 2018 — Copernicus Land Monitoring Service can also be used to locate sealed areas. See also KPI No. 21

6 Conclusions, next steps

The UPSURGE objectives concern assisting cities in their transition into a regenerative future. This aim will be supported by catalysing nature based solutions (NBS) that use natural systems and rely on concepts such as natural capital, ecosystem services and green infrastructure. To create increased evidence and awareness of the benefits of NBS through the evaluation of their ecologic, economic, social, health and regenerative impacts, the list of Key Performance Indicators (KPIs) has been developed as the basis for this impact assessment in the project demonstration cities. The KPIs will be used before and after NBS implementation in these cities. Application of KPIs will enable verification of the list, which - as reliable - will constitute a part of the Urban Regenerative Development Clearinghouse.

The final verified list of KPIs will include indicators that have passed a practical check, improving their possibility of use in the management of urban green regeneration. It relates both to indicators based on parameters measured by sensors and those which are the result of polling, analyses and studies.

Analysis of the effectiveness of the application of NBS in addressing urban challenges is one of the main tasks of UPSURGE. The assessment of this effectiveness through the evaluation of benefits achieved in air quality and climate neutrality and also in societal and economic benefits should be performed by using Key Performance Indicators (KPIs). The defined KPIs are directly related to urban challenges and indicate NBSs, which are suitable for addressing a given challenge.

There are generally three groups of KPIs:

- The first addresses the KPIs, which are based on parameters measured by sensors located near implemented NBS in demo cities;
- The second group includes KPIs, which are also related to NBS. These KPIs concern some environmental and socio-economic benefits resulting from NBSs implementation, but in the wider scale of a city or region;
- The third group of KPIs constitute a tool for monitoring and assessing the implementation of policy actions concerning tailor-made environmental, social, economic and health related activities in the framework of regenerative urban development.

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7 BIBLIOGRAPHY

1. Iannillo A., Fasolino I. Land-Use Mix and Urban Sustainability: Benefits and Indicators Analysis. Sustainability 2021, 13(23), 13460; https://doi.org/10.3390/su132313460
2. Green Roof System Brochure, Urbanscape, 2015
3. References to Albedo:
   - project UnaLab
   - ASTM (2012). ASTM E903-12, Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres. ASTM International, West Conshohocken, PA.
   - ASTM (2016). ASTM E1918-16, Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field. ASTM International, West Conshohocken, PA.
   - Ban-Weiss, G. A., Woods, J., & Levinson, R. (2015). Using remote sensing to quantify albedo of roofs in seven California cities, Part 1: Methods. Solar Energy, 115, 777-790.
   - Shuttleworth, W.J. (1993). Evaporation. In: Maidment, D.R. (ed.), Handbook of Hydrology. New York: McGraw-Hill.
   - Levinson, R., Akbari, H., & Berdahl, P. (2010). Measuring solar reflectance—Part II: Review of practical methods. Solar Energy, 84(9), 1745-1759.
   - NASA Langley Research Center (2019) CERES. https://ceres.larc.nasa.gov/
   - Wang, Z., Schaaf, C., Lattanzio, A., Carrer, D., Grant, I., Román, M., Camacho, F., Yu, Y., Sánchez-Zapero, J. & Nickeson, J. (2019). Global Surface Albedo Product Validation Best Practices Protocol. Version 1.0. In Z. Wang, J. Nickeson & M. Román (Eds.), Best Practice for Satellite Derived Land Product Validation (p. 45): Land Product Validation Subgroup (WGCV/CEOS), doi: 10.5067/DOC/CEOSWGCV/LPV/ALBEDO.001
   - Williamson, S. N., Copland, L., & Hik, D. S. (2016). The accuracy of satellite-derived albedo for northern alpine and glaciated land covers. Polar Science, 10(3), 262-269.
   - United States Environmental Protection Agency. (1992). Cooling our communities: A guidebook on tree planting and light colored surfaces. Washington, DC: USA
4. Hasse, J.E., Lathrop, R.G. Land resource impact indicators of urban sprawl. Applied Geography 23 (2003) 159–175
5. L Indrawati et al 2020 IOP Conf. Ser.: Earth Environ. Sci. 485 012113
6. Ewing R, Pendall R, Chen D. 2002. Measuring Sprawl and Its Impacts. Washington, DC: Smart Growth America.

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8 ANNEXE: KPIS IDENTITY CARDS

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Challenge no.: 1	Challenge name: Air quality
KPI no.: 1	KPI name: Air pollutant concentrations.

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Control of concentration levels of particulate matter (PM10 and/or PM2.5) and/or NO_2 and/or SO_2 and/or O_3 and/or CO and/or selected heavy metals (HMs) and/or selected PAHs and/or selected VOCs in ambient air within the city area, the district or neighbourhood and site of NBS during the calendar year.

NBS relevant to KPI	- Trees renaturing parking - Green corridors - Moss wall - Green bus stop with selected plant species - Urban park

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Pollutant measurement data from municipalities and regional, national, or European authorities	- Quantitative	- Air quality station or sensors, in the case of HMs, PAHs and VOCs laboratory analyses

MEASUREMENT UNIT	FREQUENCY
- $\mu g/m^3$ except PAHs for which ng/m^3	- Continuous measurements with hourly, daily, monthly, and yearly averages

METHOD

Air pollution concentrations can be estimated based on measured and/or modelled concentrations in ambient air in the city, district or near the NBS intervention area. Data can be retrieved from air quality monitoring stations or from measured values during experimental campaigns. Data can also be estimated by applying air quality models, which estimate 3D concentration fields with an hourly resolution at the grid, neighbourhood, or city scale.

References

- Urban GreenUP project
- UNaLab project
- Air Quality Framework Directive (2008/50/EC)

Challenge no.: 1	Challenge name: Air quality
KPI no.: 2	KPI name: Concentration levels limits (number of days with exceedances).

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Number of days and/or years on which concentrations of atmospheric air pollutants in the city, district or neighbourhood and site of NBS exceeded the daily and/or annual threshold values during the calendar year.
The most relevant air pollutants are PM2.5 and/or PM10 and/or O_3 and/or NO_2 and/or SO_2 and/or CO and/or PAHs expressed as the concentration of benzo(a)pyrene (B(a)P).

NBS relevant to KPI	
	- Green corridors - Moss wall - Urban park/forest - Urban arboretum - Residential park - Wildlife park - Green covering - Trees renaturing shelters parking - Green bus stop with selected plant-species

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Pollutant measurement data from municipalities and regional, national, or European authorities	- Quantitative	- Air quality station or sensors, in the case of B(a)P - laboratory analyses

MEASUREMENT UNIT	FREQUENCY
- Number of documented exceedances above threshold values	- Continuous measurements with hourly, daily, monthly, and yearly averages

METHOD

Number of documented exceedances to the daily and/or annually limit value established in the Air Quality Framework Directive (Directive 2008/50/EC) for PM2.5, PM10, NO_2, SO_2, CO, ground-level O_3 and PAHs (as indicated by B(a)P).

References

- UNaLab project
- Leitat project
- Air Quality Framework Directive (2008/50/EC)

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<table>
<tr><td>Challenge no.: 1</td><td colspan="2">Challenge name: Air quality</td></tr>
<tr><td>KPI no.: 3</td><td colspan="2">KPI name: Air quality index.</td></tr>
<tr><td colspan="2">Type of KPI</td><td>Scale</td></tr>
<tr><td colspan="2">☐ Descriptive
☐ Assessment/Modelled
☒ Monitoring</td><td>☒ City
☒ Neighbourhood/district
☒ Pilot/site</td></tr>
<tr><td colspan="3">Brief Description/definition of KPI

There are many air quality indexes, e.g. national, regional, etc. One of the most popular is the European Air Quality Index. The European Air Quality Index enables users to understand better the air quality in place where they live, work or travel. In regions, cities and districts where, based on local measurements of air pollution concentrations, this index is calculated and made available on websites, users can obtain information on air quality by displaying up-to-date information. The index is based on concentration values for up to five key pollutants, including: solid particles (PM10), fine particles (PM2.5), ozone (O_3), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2). The index reflects the potential impact of air quality on health, driven by the pollutant for which concentrations are poorest due to health impacts. The index is calculated hourly for more than two thousand air quality monitoring stations across Europe, using up-to-date data reported by EEA member countries. The index indicates the short-term air quality situation and is calculated based on 1-hour measurements data of air pollutants concentration. Usually, the presented index reflects the air quality from the last full hour (if there is no data for the last hour, the index is visible from the second or maximum of the third hour back).
The index can also be used to determine the air quality at the location of the NBS, based on the 1-hour pollutant concentrations measured by the sensors.</td></tr>
<tr><td colspan="2">NBS relevant to KPI</td><td>- Urban arboretum
- Urban forest
- Green roof
- Moss wall
- Green corridors
- Green facade with climbing plants
- Green fences</td></tr>
<tr><td colspan="3">DATA AND MEASUREMENT</td></tr>
<tr><td>REQUIRED DATA

- Pollutant measurement data from municipalities and regional, national or European authorities</td><td>INPUT TYPE

- Qualitative</td><td>DATA SOURCE

- Air quality station or sensors</td></tr>
<tr><td colspan="2">MEASUREMENT UNIT

- Good
- Fair
- Moderate
- Poor
- Very Poor
- Extremely Poor</td><td>FREQUENCY

- Continuous measurements with hourly, daily, monthly, and yearly averages</td></tr>
</table>

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METHOD

The index uses the current air quality data. For NO_2, O_3 and SO_2, hourly concentrations are fed into the calculation of the index. For PM10 and PM2.5, the 24-hour running means for the past 24 hours are fed into the calculation of the index.
Additionally, it can be supplemented with local air quality data from devices installed in NBS locations. Concentration values for five key pollutants define the indicator level that reflects the air quality at each monitoring station. There are six index levels based on pollutant concentrations in · g/m^3: good, fair, moderate, poor, very poor or extremely poor air quality. The index level corresponds to the worst level for any of the five pollutants as indicated in the table below.

Pollutant	Index level (based on pollutant concentrations in · g/m^3)					
	Good	Fair	Moderate	Poor	Very poor	Extremely poor
PM2.5	0-10	10-20	20-25	25-50	50-75	75-800
PM10	0-20	20-40	40-50	50-100	100-150	150-1200
NO_2	0-40	40-90	90-120	120-230	230-340	340-1000
O_3	0-50	50-100	100-130	130-240	240-380	380-800
SO_2	0-100	100-200	200-350	350-500	500-750	750-1250

The concentration ranges are based on the relative risk of short-term exposure to pollution, as defined by the World Health Organization in its report on health risks of air pollution in Europe (HRAPIE project report).
The index levels are supplemented by health messages that provide recommendations for both the general and vulnerable populations. The latter includes both adults and children with respiratory problems and adults with heart disease.

AQ index	General population	Sensitive populations
Good	The air quality is good. Enjoy your usual outdoor activities.	The air quality is good. Enjoy your usual outdoor activities.
Fair	Enjoy your usual outdoor activities	Enjoy your usual outdoor activities
Moderate	Enjoy your usual outdoor activities	Consider reducing intense outdoor activities if you experience symptoms.
Poor	Consider reducing intense activities outdoors, if you experience symptoms such as sore eyes, a cough or sore throat	Consider reducing physical activities, particularly outdoors, especially if you experience symptoms.
Very poor	Consider reducing intense activities outdoors, if you experience symptoms such as sore eyes, a cough or sore throat	Reduce physical activities, particularly outdoors, especially if you experience symptoms.
Extremely poor	Reduce physical activities outdoors.	Avoid physical activities outdoors.

References

- URBAN GreenUP project - https://airindex.eea.europa.eu

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 1	Challenge name: Air quality
KPI no.: 4	KPI name: Annual O_3, SO_2, NO_2, CO, and PM2.5 capture/removal by vegetation.

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Vegetation can remove air pollutants (particles and gases) by the process of dry deposition.
Deposition is the transport from a point in the air to a plant surface, which is mainly related to near surface pollutant concentration, weather conditions and vegetation properties. Most plants have a large surface area per unit volume, increasing the probability of deposition compared with the smooth, manufactured surfaces present in urban areas. For example, 10-30 times faster deposition has been reported for sub-micrometre (<μm) particles on synthetic grass compared with glass and cement surfaces (Air Quality Expert Group [AQEG], 2013; Roupsard, Amielh, Maro, Coppalle, & Branger, 2013). To estimate the magnitude of this contribution models are commonly used.
Definition: Annual capture of O_3, SO_2, NO_2, CO and PM2.5 by trees and shrubs and grass.

NBS relevant to KPI	
	- Urban arboretum - Urban forest - Green roof - Moss wall - Green corridors - Hedge

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Various requirements based on the model type; see: Method	- Qualitative - Quantitative	- Various, based on the model type; see: Method

MEASUREMENT UNIT	FREQUENCY
- All expressed in units of mass, report as kg/ha/y	- Annually - Before and after the NBS implementation

METHOD

The chemical transport model WRF-Chem (National Oceanic and Atmospheric Administration [NOAA], n.d.) has a dry deposition model that can estimate the amount of pollutants removed by vegetation (O_3, NO_X, VOC, PM10 and PM2.5) with an hourly resolution per grid cell. As input data WRF-Chem requires:
i) high resolution inventory of anthropogenic emissions; ii) biogenic emissions (MEGAN model; Guenther et al., 2006);
iii) initial and boundary conditions (MOZART model; Emmons et al., 2010); and,
iv) topography and land use (United States Geological Survey [USGS] 33 classes database; Pineda et al., 2004).
These results can be used to calculate the annual amount of pollutants removed by vegetation at the grid, neighbourhood or city scale.
The i-Tree Eco model (USDA Forest Service, 2019) can also be applied to estimate the air pollutants removed by vegetation. Although it does not provide spatial variability, it can calculate hourly amounts of pollutants removed by urban forests, as well as the associated percentage of air quality improvement throughout a year. Pollution removal is calculated for ozone (O_3), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO) and particulate matter (PM2.5). To apply the i-Tree Eco model, the following data is required:
i) extent of vegetation cover and characteristics (e.g., type, age and height); ii) land use; iii) air quality; and iv) meteorology.
Results can be used to calculate the annual amount of pollutants removed by vegetation at the local scale.

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 1	Challenge name: Air quality
KPI no.: 5	KPI name: Ambient pollen concentration.

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Urban green spaces frequently have a limited number of plant species, including a higher proportion of non-native species in comparison with rural areas (McKinney, 2002). The low species diversity in many urban areas is directly linked to the formation of concentrated pollen emission sources. In particular, large-scale use of a small number of roadside tree species results in production of large quantities of a single species of pollen. Areas of concentrated pollen may not be readily dispersed by air currents. Some studies indicate that urban citizens are 20% more likely to suffer airborne pollen allergies than people living in rural areas, largely due to the uniformity of green spaces, where a small number of species that have proved highly suited to urban environmental conditions are overwhelmingly used, and the interaction of pollen with air pollutants (Cariñanos & Casares-Porcel, 2011).
Definition: number of grains of pollen per cubic meter of air.

NBS relevant to KPI	
	- Compacted Pollination's modules - Wildlife park - Urban forest - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Pollen measurement data	- Quantitative	- Measurement using the volumetric Hirst pollen and spore trap

MEASUREMENT UNIT	FREQUENCY
- Pollen grains/m^3	- Continuous collection with a 24 h or a 7-day sampling period

METHOD

The volumetric Hirst-type pollen and spore trap designed in 1952 remains one of the devices most commonly used for pollen and spore monitoring (Buters et al., 2018). The Hirst-type trap is standard in pollen monitoring networks in Europe. The Hirst-type pollen and spore trap uses a vacuum pump to continuously draw air at a known rate (e.g., 10 L/min). A wind vane attached to the sampler head ensures that the trap inlet is always facing the prevailing wind. Depending on the configuration of the trap, pollen and spores are captured on adhesive coated transparent plastic tape (Melinex) or on a microscope slide coated with an adhesive. Adhesive tapes are attached to a metal drum that rotates with time. Pollen traps can be fitted with a drum specific to a 24-h or a 7-day sampling period. At the conclusion of the sampling period, the tape with adhered pollen and spores is cut into pieces representing 24-h periods of time and mounted on a microscope slide. Where the pollen and spores are captured directly on a microscope slide, the slide must be changed every 24 h. These slides are examined by microscopy for counting and identification of pollen and spores.

References

- UNaLab project
- Buters, J.T.M., Antunes, C., Galveias, A., Bergmann, K.C., Thibaudon, M., Galán, C. … & Oteros, J. (2018). Pollen and spore monitoring in the world. Clinical and Translational Allergy, 8, 9.
- Cariñanos, P., & Casares-Porcel, M. (2011). Urban green zones and related pollen allergy: A review. Some guidelines for designing spaces with low allergy impact. Landscape and Urban Planning, 101(3), 205-214.
- McKinney, M. (2002). Urbanization, Biodiversity, and Conservation: The impacts of urbanization on native species are poorly studied, but educating a highly urbanized human population about these impacts can greatly improve species conservation in all ecosystems. BioScience, 52(10), 883-890.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 1	Challenge name: Air quality
KPI no.: 6	KPI name: Avoided greenhouse gas emissions from reduced building energy consumption.

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Building energy consumption is the fraction of greenhouse gas (GHG) emissions that can be affected by nature based solutions in an urban environment.
Definition: CO_2 emissions related to building energy consumption (direct via, e.g., residential combustion and indirect via, e.g., electric heating and cooling) with and without NBS implementation (kWh/y and t C/y saved).

NBS relevant to KPI	- Urban arboretum - Moss wall - Trees renaturing - Hedge parking

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Information about building energy sources and electrical energy use, as well as supplemental energy sources such as district heating and local combustion for heating.	- Quantitative	Data can typically be obtained from municipal sources or from records of building- or district-level energy consumption from the building owner or utility company.

MEASUREMENT UNIT	FREQUENCY
- kWh/y and t C/y saved	- Annually to enable tracking of changes to CO_2 emissions due to building energy consumption with time - At minimum before and after NBS implementation

METHOD

First, the community housing energy sources are identified and methods for their quantification on yearly basis are recorded (IPCC, 2006). These energy sources include electrical energy use, as well as supplemental energy sources such as district heating and local combustion for heating. Numerical values for the community as a whole (MWh), as well as population equivalent (MWh/person), are recorded, thus allowing for compensation for population change. All forms of energy need to be taken into account, including electricity consumption, natural gas or thermal energy for heating and cooling, and fuels. CO_2 emissions related to building energy consumption are calculated as follows:

$$\text{Emissions}_{\text{buildings}} = \text{Energy (MWh/a)} \times \text{National emission factor (t } CO_2\text{/MWh)}$$

$$\text{Decrease (\%)} = 100\% - ((\text{Emission}_{\text{buildings (after)}}/\text{Emission}_{\text{buildings (before)}}) \times 100\%)$$

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 2	Challenge name: Climate vulnerability
KPI no.: 7	KPI name: Potential areas exposed to flood risks: Urban/residential areas.

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Indicators of Potential Areas Exposed to Risks sub-criterion will assess the potential areas exposed to risk. An urban area or urban agglomeration is a human settlement with high population density and infrastructure of built environment.

NBS relevant to KPI	- Smart roofs - Construction wet roofs - Intensive green roofs - Extensive green roofs - Climate adaptive - Tree trenches and gardens bioswales - Sustainable drainage systems (SuDS)

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Geographical and topographical data (GIS).	- Quantitative	- GIS databases

MEASUREMENT UNIT	FREQUENCY
- ha	- Annually

METHOD

Estimation from maps and land-use maps.

References

- PHUSICOS project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 2	Challenge name: Climate vulnerability
KPI no.: 8	**KPI name: Mean number of people adversely affected by natural disasters each year**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

This indicator is closely related to the indicator on the costing of natural hazards / disasters, but specifically addresses the problem that while intangible costs are important in relation to assessing impacts of natural disasters that may be difficult to assign an economic value to. Hence some studies recommend to assess these costs by counting the number of people affected rather than applying an economic value to these adverse effects.
The definition of the mean number of people affected each year is given as: Mean number of people affected = $\int_A \int_p I(p)\,\rho\,dp\,dA$ where I(p) denotes the number of people exposed to the disaster that occurs at an annual frequency
p, ρ denotes the proportion of people exposed that are affected, and A denotes the area in question.
The equation assumes that there is no damage for events occurring more often than once per year. There may be several sub-indicators distinguishing between different impacts such as loss of life, relocation, and physical or mental health.

NBS relevant to KPI	- Climate adaptive gardens - Cooling trees

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Hazard maps as a function of the frequency of the natural disaster. Typically this will be in the form of raster or shape files in a GIS environment. - Impact maps covering the area showing the density of I(p) and the value of $\rho\rho$ over the area. This data should be available in the same format as the hazard maps	- Quantitative	- GIS databases

MEASUREMENT UNIT	FREQUENCY
- Unitless	- The data should in principle be collected every time there is: a) a change in the population affecting I(p) and/or ρ, and b) new information about the disaster become available.

METHOD

By definition this indicator comprise an important part of the intangible costs. For health impacts some studies model individual impacts of sub-indicators, while others advocate the use of more generic indicators across health impacts such as Disability Adjusted Life Year (DALY) and the Quality Adjusted Life Year (QALY). A review of the studies can be found in (Hammond et al., 2015).
The scale of the measurements is the physical area impacted by the disaster.

References

- RECONECT project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 2	Challenge name: Climate vulnerability
KPI no.: 9	**KPI name: Flooded area.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Indicators of Flooding Risk Resilience sub-criterion will assess the site response to Flooding phenomena based on susceptibility indicators: land use cover, run-off coefficient, rainfall intensity and duration.

NBS relevant to KPI	- Smart roofs - Construction wet roofs - Intensive green roofs - Extensive green roofs - Climate adaptive - Tree trenches and gardens bioswales - Sustainable drainage systems (SuDS)

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Floodable area maps - Rainfall data - Hydraulic geological and geotechnical information topography (Model/GIS)	- Quantitative	- Floodable area maps - Land use cover maps - Run-off coefficient data - Rainfall intensity and duration data

MEASUREMENT UNIT	FREQUENCY
- ha	- Annually

METHOD

Area submerged by discharge during the flooding event is determined by available flooding area maps. The maps show the zones exposed to different levels of risk from fluvial and tidal flooding with different colours. Alternative approaches are based on the implementation of numerical simulations, which combining GIS-based
software and hydraulic solvers, are able to detect the flooding areas, as a function of the set forcing, through one-dimensional (e.g., HECRAS of the US Army Corps of Engineers), two-dimensional (e.g., FLO-2D of the FLO-2D software Inc.) or tri-dimensional (e.g., ANUGA Hydro developed by the Australian National University).

References

- PHUSICOS project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 2	Challenge name: Climate vulnerability
KPI no.: 10	**KPI name: Effective Drought Index.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Indicators of Drought Risk Resilience sub-criterion will assess the site response to drought phenomena based on susceptibility indicators: land use cover, temperature, moisture, wet weather. Definition Byun & Wilhite (1999) developed the Effective Drought Index (EDI), which is an intensive measure that considers daily water accumulation with a weighting function for time passage.

NBS relevant to KPI	- Climate adaptive gardens - Sustainable drainage systems (SuDS) - Tree trenches and bioswales

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Metrological data (Model)	- Quantitative	- GIS databases - Metrological databases

MEASUREMENT UNIT	FREQUENCY
- Dimensionless	- Annually - At minimum before and after NBS implementation

METHOD

The EDI can be calculated with literature formulations. Rain data are needed.

References

- PHUSICOS project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 2	Challenge name: Climate vulnerability
KPI no.: 11	KPI name: Soil temperature.

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☒ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Soil temperature is intrinsically related to soil microbial activity and to biogeochemical and hydrological fluxes in the soil. Different soil temperatures would be preferred by different vegetation whose roots would provide strengths and resistance against erosion or sliding.

NBS relevant to KPI	- Green corridors - Floating garden

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE - Quantitative	DATA SOURCE
- Temperature		- Temperature measurement data

MEASUREMENT UNIT	FREQUENCY
- Celsius degree	- Continuous

METHOD

The degree or intensity of heat present in soil, especially as expressed according to a comparative scale and shown by a thermometer or perceived by touch. Measurements are performed in situ. Taking a sample by digging pits or boreholes and inserting a thermometer.

References

- OPERANDUM project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 2	Challenge name: Climate vulnerability
KPI no.: 12	KPI name: Soil sealing.

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Impermeable ground and modified ecosystems transform natural soil and alter important environmental processes (e.g., water cycle, energy balance, etc.). Mapping impermeable surfaces provides an indicator of urban development, e.g., densification/urban sprawl, and can aid assessments of drainage, urban heat island, biodiversity and health and wellbeing. Data on soil sealing collected in these ways can be used to:

- Set targets for soil unsealing;
- Monitor changes in relation to loss of permeable surfaces;
- Linking to other indicators such as land use change and stormwater management;
- Support initiatives to improve soil health and promote groundwater recharge.

NBS relevant to KPI	
	- Floating garden - Green covering shelters - Green roof (intensive or extensive) - Green corridors - Sustainable drainage system (SuDS) - Trees trenches and bioswales

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE - Quantitative	DATA SOURCE
- Land use maps - Soil maps		- Satellite/maps data

MEASUREMENT UNIT	FREQUENCY
- %	- Annually

METHOD

Remove sealing, reusing sealed sites to reduce land take/soil sealing (with impermeable surfaces), and use of permeable materials and surfaces, e.g., green roofs. Modelling and mapping are used to measure soil sealing and soil loss.

References

- Connecting Nature project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 2	Challenge name: Climate vulnerability
KPI no.: 13	**KPI name: Degree of development of climate resilience strategy.**

Type of KPI	Scale
☒ Descriptive ☐ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Many climate resilience strategies are linked with disaster and risk reduction as the impacts of climate change are commonly experienced in urban areas as flooding and/or drought, and over-heating (urban heat island effect). Nature-based solutions are a key tool for use in urban climate change mitigation and adaptation efforts.

NBS relevant to KPI	- Climate adaptive gardens - Sustainable drainage systems (SuDS) - Tree trenches and bioswales

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Information of the development and implementation of climate resilience strategy in the city	- Qualitative	- Assessment of development and implementation of climate resilience strategy in the city

MEASUREMENT UNIT	FREQUENCY
- Number (0-7)	- Annually

METHOD

The extent to which the city has developed and implemented a climate resilience strategy (using a seven-point Likert scale).

No action – 1 – 2 – 3 – 4 – 5 – 6 – 7 – Implementation, monitoring and evaluation

1. No action has been taken yet
2. The ground for adaptation has been prepared (the basis for a successful adaptation process)
3. Risks and vulnerabilities have been assessed.
4. Adaptation options have been identified
5. Adaptation options have been selected
6. Adaptation options are being implemented
7. Monitoring and evaluation is being carried out

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 2	Challenge name: Climate vulnerability
KPI no.: 14	KPI name: Adaptation of local plans and regulations to include NBS.

Type of KPI	Scale
☒ Descriptive ☐ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Policy learning to systemically incorporate ecosystem based adaptation into climate change strategies and ecosystem services into municipal planning is a critical step in shifting the prevailing paradigm of dealing with risk and disaster (Wamsler, Luederitz & Brink, 2014).

NBS relevant to KPI	- Climate adaptive gardens - Cooling trees

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE - Qualitative	DATA SOURCE
- Information of the changes in municipal rules and regulations to support implementation and "mainstreaming" of NBS as a result of a NBS project		- The extent of policy learning during or as a result of an NBS

MEASUREMENT UNIT	FREQUENCY
- Number (0-5)	- Annually

METHOD

The extent to which the NBS project has contributed to, or inspired, changes in municipal rules, regulations and behavioural change instruments to support implementation and "mainstreaming" of NBS(using a five-point Likert scale).

References

- Nuala project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 2	Challenge name: Climate vulnerability
KPI no.: 15	**KPI name: Days with maximum temperature >90th percentile.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Nature-based solutions can support climate change adaptation by reducing local ambient air temperature. They can also provide insulation from cold and/or shelter from wind. By moderating the urban microclimate, green infrastructure can support reduction in energy use and improved thermal comfort (Demuzere et al., 2014).

Definition: Percentage of days during which the maximum daily temperature exceeds the 90th percentile threshold of the daily maximum temperature (%).

NBS relevant to KPI	- Climate adaptive garden - Extensive green roofs/ smart roofs - Intensive green roofs - Green façade with climbing plants - Shade trees - Trees renaturing parking - Living walls - Floating garden - Green shaded structures - Urban park - Colling trees Single line trees

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE - Quantitative	DATA SOURCE
- Automated continuous monitoring of ambient air temperature		- Meteorological monitoring station

MEASUREMENT UNIT	FREQUENCY
- °C	- Annually; at minimum, before and after NBS implementation

METHOD

Ambient air temperature can be assessed through continuous monitoring of temperature, near the NBS intervention area, and evaluation of the maximum daily temperature before and after NBS implementation. Evaluating the effect on the heatwave reduction by assessing the daily temperatures produces more accurate results that monthly averages, which tend to "lose" the small changes that are crucial for several domains, such as health and agriculture (Alexander et al., 2006). The TX90p defines the occurrence of the extremely hot days falling above the 90th percentile (1/10th of the sample) allowing the evaluation of the extent of the extreme temperatures changes (Alexander et al., 2006). The TX90p is evaluated as: $TX_{ij} > TXin90$

where

TX_{ij} – daily maximum temperature on day i in period j

$TX_{in}90$– calendar day 90th percentile centred on a five-day window for the base period 1961-1990

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 2	Challenge name: Climate vulnerability
KPI no.: 16	**KPI name: Days with minimum temperature <10th percentile.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Nature-based solutions can support adaptation to climate change by forming local ambient air temperature. They can also provide insulation against the cold and / or shelter from the wind. By moderating the urban microclimate, green infrastructure can help reduce energy consumption and improve thermal comfort (Demuzere et al., 2014). Definition: Percentage of days on which the minimum daily temperature is below the 10th percentile of the minimum daily temperature (%).

NBS relevant to KPI	
	- Climate adaptive garden - Extensive green roofs/ smart roofs - Intensive green roofs - Green façade with climbing plants - Shade trees - Trees renaturing parking - Living walls - Floating garden - Green shaded structures - Urban park - Colling trees Single line trees

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE - Quantitative	DATA SOURCE
- Automated continuous monitoring of ambient air temperature		- Meteorological monitoring station

MEASUREMENT UNIT	FREQUENCY
- °C	- Annually; at minimum, before and after NBS implementation

METHOD

Ambient air temperature can be assessed by continuously monitoring the temperature in the vicinity of the NBS intervention area and by assessing the minimum daily temperature before and after the implementation of the NBS. Assessing the cold wave reduction effect by assessing daily temperatures gives more accurate results than monthly averages, which tend to "lose" small changes that are crucial in several areas such as health and agriculture. The TX10p measures the occurrence of extremely cold days below the 10th percentile, allowing an assessment of the extent of extreme temperature variation. TX10p is rated as: $TX_{ij} < TXin10$

where

TX_{ij} – daily minimum temperature on day i in period j

$TX_{in}10$– calendar day 10th percentile centred on a five-day window for the base period 1961-1990

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 2	Challenge name: Climate vulnerability
KPI no.: 17	**KPI name: Area struck by destructive windstorms.**

Type of KPI	**Scale**
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

European windstorms are powerful extratropical cyclones which form as cyclonic windstorms associated with areas of low atmospheric pressure. They can occur throughout the year, but are most frequent between October and March, with peak intensity in the winter months. Deep areas of low pressure are common over the North Atlantic. They frequently track across the North Atlantic Ocean towards the north of Scotland and into the Norwegian Sea, which generally minimizes the impact to inland areas; however, if the track is further south, it may cause adverse weather conditions across Central Europe, Northern Europe and especially Western Europe. The countries most commonly affected include the United Kingdom, Ireland, the Netherlands, Norway, Germany, the Faroe Islands and Iceland.
These storms can cause economic damage of several billion euros a year. They cause the largest insurance loss against natural disasters in Europe.

NBS relevant to KPI	- Woods - Free standing living wall - Climate adaptive gardens - Cooling trees

DATA AND MEASUREMENT

REQUIRED DATA	**INPUT TYPE** - Quantitative	**DATA SOURCE**
- Area struck by destructive windstorms per year		- Metrological databases - Data of municipal services

MEASUREMENT UNIT	**FREQUENCY**
- ha/year	- Annually

METHOD

Area struck by destructive windstorms throughout the year.

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 2	Challenge name: Climate vulnerability
KPI no.: 18	KPI name: Area struck by wildfire events.

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

A wildfire is an unplanned, uncontrolled and unpredictable fire in an area of combustible vegetation starting in rural and urban areas. Some forest ecosystems in their natural state depend on wildfire.
Earth's carbon-rich vegetation, seasonally dry climates, atmospheric oxygen, and widespread lightning and volcanic ignitions create good conditions for fires.
Wildfire behaviour and severity result from a combination of factors such as available fuels, physical setting, and weather. Climatic cycles that include wet periods that create substantial fuels and then are followed by drought and heat often proceed severe wildfires. These cycles are made worse by heat waves and droughts caused by climate change.
Wildfires can cause damage to property and human life, although naturally occurring wildfires may have beneficial effects on native vegetation, animals, and ecosystems that have evolved with fire.
The increase in severity of fires creates a positive feedback loop by releasing naturally sequestered carbon back into the atmosphere, increasing the atmosphere's greenhouse effect contributing to climate change.

NBS relevant to KPI	- Climate adaptive gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE - Quantitative	DATA SOURCE
- Area struck by wildfire events per year		- Data of City Fire Department - Data of municipal services

MEASUREMENT UNIT	FREQUENCY
- ha/year	- Annually

METHOD

Area struck by wildfire events throughout the year.

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 2	Challenge name: Climate vulnerability
KPI no.: 19	**KPI name: Relative humidity.**

Type of KPI	**Scale**
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Humidity is the concentration of water vapor present in the air. Water vapor, the gaseous state of water, is generally invisible to the human eye. Humidity indicates the likelihood for precipitation, dew, or fog to be present.
Relative humidity, often expressed as a percentage, indicates a present state of absolute humidity relative to a maximum humidity given the same temperature.
Humidity depends on the temperature and pressure of the system of interest. The same amount of water vapor results in higher relative humidity in cool air than warm air. Humidity plays an important role for surface life. For animal life dependent on perspiration (sweating) to regulate internal body temperature, high humidity impairs heat exchange efficiency by reducing the rate of moisture evaporation from skin surfaces.
The heat index (HI) is an index that combines air temperature and relative humidity, in shaded areas, to posit a human-perceived equivalent temperature, as how hot it would feel if the humidity were some other value in the shade. The result is also known as the "felt air temperature", "apparent temperature", "real feel" or "feels like". For example, when the temperature is 32°C with 70% relative humidity, the heat index is 41°C.

NBS relevant to KPI	- Vertical greening system - Climate adaptive gardens - Smart soils

DATA AND MEASUREMENT

REQUIRED DATA	**INPUT TYPE** - Quantitative	**DATA SOURCE**
- Relative humidity		- Measurements

MEASUREMENT UNIT	**FREQUENCY**
- %	- Annually

METHOD

A device used to measure humidity of air is called a psychrometer or hygrometer. The humidity of an air and water vapor mixture is determined through the use of psychrometric charts if both the dry bulb temperature (T) and the wet bulb temperature (T_w) of the mixture are known.
For process on-line measurements, the most commonly used sensors nowadays are based on capacitance measurements to measure relative humidity, frequently with internal conversions to display absolute humidity as well. These are cheap, simple, generally accurate and relatively robust. All humidity sensors face problems in measuring dust-laden gas.

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 3	Challenge name: UHI Effect
KPI no.: 20	**KPI name: Urban Heat Island (UHI) effect.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Significant difference is observed in air temperature between the city and its surroundings. The UHI effect is caused by the absorption of sunlight by (stony) materials, reduced evaporation and the emission of heat caused by human activities. The UHI effect is greatest after sunset and reported to reach up to 9°C in some cities, e.g., Rotterdam.
Significant difference is observed in air temperature in the city between blue green infrastructure and build-up areas, industrial areas, brownfields, shopping centres. The observed UHI effects in air temperature between these areas in the city ranges from 10 to 15°C.Significant difference is observed in surface kinetic temperature in the city between blue green infrastructure and build-up areas, industrial areas, brownfields, shopping centres. Satellite images allow to create spatial surface heat islands / archipelago of islands

NBS relevant to KPI	
	- Climate adaptive gardens - Extensive green roofs - Green facade with climbing plants - Face-bound greening - Urban arboretum - Trees renaturing parking - Floating gardens - Green shaded structures/shaded trees - Residential park - Green corridors

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE - Quantitative	DATA SOURCE
- Temperature		- Sensor / survey/ spatial data / satellite images /statistics

MEASUREMENT UNIT	FREQUENCY
- Celsius degree	- 1h data - 24h series - Satellite images

METHOD

1. Identify or install one or more meteorological (temperature) measurement stations within the built environment, and one measurement station outside the city that functions as a reference station.
2. Compare the hourly average air temperature measurements of the urban measurement station(s) with the station outside the city (the reference station).
3. Look for the largest temperature difference (hourly average) between urban and countryside areas during the summer months. This temperature difference is an absolute measure of the UHI effect.

Identify time of satellite images over the city area. Collect the satellite thermal images for this area for spring and summer season in the given year. Select images for the days without clouds over the area. Use the Landsat methodology and ArcMap programming for determination of average surface temperature of different land use categories in the city. Select areas with the highest average surface temperature as a problematic areas in the city with the surface UHI effects.

References

- L. Liu , Y. Zhang, Remote Sens., *Urban Heat Island Analysis Using the Landsat TM Data and ASTER Data: A Case Study in Hong Kong*, **3**, 1535-1552 (2011)
- EPA, Reducing Urban Heat Islands: Compendium of Strategies Urban Heat Island Basics, (2014)
- https://landsat.usgs.gov/using-usgs-landsat-8-product

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 3	Challenge name: UHI effect
KPI no.: 21	**KPI name: Maximum surface temperature reduction.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

The surface temperature tool can be used to model the maximum surface temperature expected in a neighbourhood, taking into account the evaporative cooling effect of the vegetation. Since the implementation of nature-based solutions will usually result in an increase in vegetation cover, it should be possible to observe a decrease in the modelled maximum surface temperature under each climate change scenario (including the baseline).
The STAR Tools are surface temperature and runoff tools for assessing the potential of green infrastructure in adapting urban areas to climate change. They are freely available at http://maps.merseyforest.org.uk/grabs/.

NBS relevant to KPI	
	- Climate adaptive gardens - Shade trees - Extensive green roofs - Urban arboretum - Floating gardens - Residential park - Green corridors - Cooling trees - Urban park - Free standing wall - Facade-bound greening - Ground-based greening - Trees renaturing parking - Green facade with climbing plants - Green shaded structures

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Temperature scenarios - Land cover scenarios - Precipitation scenarios, etc.	- Quantitative	- GIS databases - Metrological databases

MEASUREMENT UNIT	FREQUENCY
- °C	- Annually - At minimum before and after NBS implementation

METHOD

The software includes scenarios for different parameters (temperature, precipitation, and land cover, etc.). However, these scenarios were developed for a concrete area (North West England). Therefore, information must be provided to build the scenarios in other cities outside this area.

References

- URBAN GreenUP project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 3	Challenge name: UHI Effect
KPI no.: 22	**KPI name: Mean daytime temperature.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

The temperature of the air is measured in a shaded and ventilated shelter. However, such value can also be predicted using microclimatic or climatic models (Redon et al 2017) to minimize UHI-effect and hotspot mitigation (temperature reduction) or for obtain high thermal comfort.

The continuous measurements of air temperature allow to determine mean daily temperature and identify the peaks of maximum and minimum air temperature during a day/ month /season/ year.

Green urban infrastructure can significantly affect climate change adaptation by reducing air and surface temperatures with the help of shading and through increased evapotranspiration. Conversely, green urban infrastructure can also provide insulation from cold and/or shelter from wind, thereby reducing heating requirements (Cheng, Cheung, & Chu, 2010). By moderating the urban microclimate, green infrastructure can support a reduction in energy use and improved thermal comfort.

NBS relevant to KPI	- Urban arboretum - Residential park - Shaded trees

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Hourly air temperature	- Quantitative	- Sensor / survey/ spatial data from satellite images /statistics

MEASUREMENT UNIT	FREQUENCY (how often to measure this indicator?)
- Celsius degree	- 1h data - 24h average - daily peaks of air temperature – minimum, maximum - monthly average air temperature - monthly peaks of air temperature – minimum, maximum

METHOD

Thermometer equipped with solar radiation shield or thermal sensor, installed in a shaded and ventilated shelter. Hourly temperature data should be registered and statistical tools should be used for determination of daily mean air temperature as well as maximum and minimum air temperature for each day.

External data also can be used from:

- National Centre for Atmospheric Research (NCAR) & University Corporation for Atmospheric Research (UCAR). (n.d.). Weather Research and Forecasting (WRF) Model Users' Page. Retrieved from http://www2.mmm.ucar.edu/wrf/users/

- Weather Research and Forecasting model coupled to Chemistry (WRF-Chem). Retrieved from https://ruc.noaa.gov/wrf/wrf-chem/

References

- UnaLab project
- Nature4cities project
- International Journal of Remote Sensing, 25(1), 129–143. Weather Research and Forecasting Model (WRF): https://www.mmm.ucar.edu/weather-researchand-forecasting-mod

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

<table>
<tr><td>Challenge no.: 3</td><td colspan="2">Challenge name: UHI Effect</td></tr>
<tr><td>KPI no.: 23</td><td colspan="2">KPI name: Heatwave risk (day).</td></tr>
<tr><td colspan="2">Type of KPI</td><td>Scale</td></tr>
<tr><td colspan="2">☐ Descriptive
☐ Assessment/Modelled
☒ Monitoring</td><td>☒ City
☐ Neighbourhood/district
☒ Pilot/site</td></tr>
<tr><td colspan="3">Brief Description/definition of KPI

The period when in 3 following days mean air temperature is >25°C (Heatwave risk). Heatwave is characterized by number of days with air temperature >25°C.

Heatwave is a period of prolonged abnormally high air/surface temperatures relative to those normally expected. Heatwaves can be characterized by low humidity, which may exacerbate drought, or high humidity, which may exacerbate the health effects of heat-related stress such as heat exhaustion, dehydration and heatstroke. Heatwaves in Europe are associated with significant morbidity and mortality. Furthermore, climate change is expected to increase average summer temperatures and the frequency and intensity of hot days (Russo et al., 2014). In cities and urban areas, the UHI tends to exacerbate heatwave episodes.</td></tr>
<tr><td colspan="2">NBS relevant to KPI</td><td>- Climate adaptive garden
- Extensive green roofs/ smart roofs
- Intensive green roofs
- Green façade with climbing plants
- Shade trees
- Trees renaturing parking
- Living walls
- Floating garden
- Green shaded structures
- Urban park
- Colling trees
- Single line trees</td></tr>
<tr><td colspan="3">DATA AND MEASUREMENT</td></tr>
<tr><td>REQUIRED DATA

- Temperature
- Humidity -
etc.</td><td>INPUT TYPE

- Quantitative</td><td>DATA SOURCE

- Sensor / survey/
spatial satellite images data /statistics</td></tr>
<tr><td colspan="2">MEASUREMENT UNIT

- Celsius degree
- %</td><td>FREQUENCY

- 24h average air temperature and humidity</td></tr>
</table>

METHOD
Physical measurement of air temperature. Use of statistical method for determination of mean daily air temperature and check number of following days with daily mean temperature >25°C to assess of intensity of heatwave. Comparison of risk with nearby areas of similar form with low/no NBS Assessment of reduction of risk due to GI interventions, also modelled in GVal
References
- Urban GreenUP project - UNaLab project - GVal

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 3	Challenge name: UHI Effect
KPI no.: 24	KPI name: Heatwave risk (tropical nights).

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Heatwave risk – tropical nights is a period of 3 days prolonged with air temperature > 20°C and with low humidity, which may exacerbate drought, or with high humidity, which may exacerbate the health effects of heat-related stress such as heat exhaustion, dehydration and heatstroke.

NBS relevant to KPI	
	- Climate adaptive garden - Extensive green roofs/ smart roofs - Intensive green roofs - Green façade with climbing plants - Shade trees - Trees renaturing parking - Living walls - Floating garden - Green shaded structures - Urban park - Colling trees - Single line trees

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Air temperature - Humidity - Number of nights with air temperature > 20°C	- Quantitative	- Sensor measurements / surface temperature – satellite images/ spatial data /statistics

MEASUREMENT UNIT	FREQUENCY
- Celsius degree - Humidity [%]	- 1h data over the nights - 1h data over 24h

METHOD

This indicator is assessed through continuous monitoring of air temperature and humidity by the sensors, and/or estimated by applying meteorological models such as the WRF (NCAR & UCAR, n.d.; NOAA, n.d.).
Evaluation of tropical nights risk can be done by determination number of combined tropical nights (>20°C) and hot days (>35°C).
Based on continuous air temperature monitoring other statistical assessments can be provided such as:

- Number of tropical nights over the summer season
- Comparison of risk with nearby areas of similar form with low/no NBS

References

- UnaLab project
- Urban GreenUP project

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Challenge no.: 4	Challenge name: Water pollution
KPI no.: 25	**KPI name: Pollutant discharge to local waterbodies.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

In the EU, all waterbodies are classified by quality status based on guidelines set in the Water Framework Directive (WFD), Directive 2000/60/EC (European Parliament, Council of the European Union, 2000). The WFD outlines biological, physico-chemical and hydromorphological quality elements. Comparison of measured water quality parameters for a given waterbody with standard values outlined in the WFD allows classification of the status of a waterbody from high to bad. Parameters taken into account include a large number of variables including, e.g., plankton counts, aquatic flora, invertebrates, hydrological continuity and conditions, thermal conditions, oxygen conditions, salinity, nutrient conditions and prevalence of priority pollutants and other specific pollutants. Many of these parameters are waterbody specific and the determination of stress caused by a pollution source depends on the type and size of the waterbody (European Parliament, Council of the European Union, 2000).

NBS relevant to KPI	- Smart soils - Constructed wet roof - Tree trenches and bioswales - Climate adaptive gardens - Electro wetland - Sustainable drainage system (SuDS)

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE - Measurement data
- Measurement data	- Quantitative	

MEASUREMENT UNIT	FREQUENCY
- Water quality status according to WFD as determined by pollutant discharge monitoring	- Continuous

METHOD

Typical parameters to consider when assessing urban runoff water quality include faecal bacteria, Escherichia coli and Enterococcus faecalis, which measure the prevalence of faeces or wastewater.
Nutrients, including total nitrogen (Ntot), ammonium (NH4+), nitrate (NO3-) and total phosphorus (Ptot) are related to the runoff from lawns, gardens and parks, chemical discharges, or accumulated residues in streambanks or sediments released by storm surges. Oil, grease, petroleum hydrocarbons, rubber particles, asphalt dust, soot, polycyclic aromatic hydrocarbons (PAHs), as well as the metals nickel (Ni), copper (Cu), zinc (Zn), cadmium (Cd), and lead (Pb) are typical pollutants emerging from roads and parking lots

References

- UNaLab project

Challenge no.: 4	Challenge name: Water pollution
KPI no.: 26	**KPI name: Basic water quality (pH, temperature, EC, DO, flow rate).**

Type of KPI	**Scale**
☐ Descriptive ☒ Assessment/Modelled ☒ Monitoring	☒ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Basic water quality parameters include pH, temperature, electrical conductivity (EC), dissolved oxygen (DO) content and flow rate. Each of these parameters is usually quantified using a meter (i.e., via electrometry) both in the field and in samples collected in the field and transported to the laboratory for analysis.

NBS relevant to KPI	
	- Constructed wet roof - Tree trenches and bioswales - Climate adaptive gardens - Electro wetland - Sustainable drainage system (SuDS)

DATA AND MEASUREMENT

REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE** - Measurement data
- pH - Temperature - EC - DO - Flow rate	- Qualitative	

MEASUREMENT UNIT	**FREQUENCY**
- Unitless	- Continuous

METHOD

Typical parameters to consider when assessing urban runoff water quality include faecal bacteria, Escherichia coli and Enterococcus faecalis, which measure the prevalence of faeces or wastewater.
Nutrients, including total nitrogen (Ntot), ammonium ($NH4+$), nitrate ($NO3-$) and total phosphorus (Ptot) are related to the runoff from lawns, gardens and parks, chemical discharges, or accumulated residues in streambanks or sediments released by storm surges. Oil, grease, petroleum hydrocarbons, rubber particles, asphalt dust, soot, polycyclic aromatic hydrocarbons (PAHs), as well as the metals nickel (Ni), copper (Cu), zinc (Zn), cadmium (Cd), and lead (Pb) are typical pollutants emerging from roads and parking lots

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 4	Challenge name: Water pollution
KPI no.: 27	**KPI name: Eutrophication.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Eutrophication is probably the most serious environmental problem affecting water reservoirs. Excessive nutrient input (mainly nitrogen and phosphorus) lead to an overgrowth of biomass that affect water dissolved oxygen, water transparency with a negative impact on human and animal health.

NBS relevant to KPI	- Climate adaptive gardens - Smart soils - Electro wetland - Constructed wet roof - Tree trenches and - Sustainable bioswales drainage system (SuDS)

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Concentration of total nitrogen, total phosphorus, chlorophyll concentration, dissolved oxygen	- Discrete variables	- Measurements

MEASUREMENT UNIT	FREQUENCY
- mg/dm^3	- Pre and post implementation data collection

METHOD

The water eutrophication level will be evaluated by a Set Pair Analysis of 5 indices. Total nitrogen, total phosphorus, chlorophyll concentration, dissolved oxygen, will be used in a Set Pair Analysis to detect a eutrophication level.

References

- proGIreg project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 4	Challenge name: Water pollution
KPI no.: 28	**KPI name: Total Suspended Solids (TSS) content.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Total Suspended Solids (TSS) are solids in water that can be trapped by a filter. TSS can include a wide variety of material and can have adsorbed pollutants. High concentrations of suspended solids can affect the health and productivity of the aquatic life. TSS and turbidity are simple indicators of water quality. Sources of TSS include, e.g., sediment runoff from agricultural fields, logging activities, construction sites, roadways, waste discharge, or excessive algal growth. The TSS content often increases sharply during and immediately following a rainfall event. The EU Freshwater Fish Directive
(2006/44/EC) recommends ≤25 mg/L TSS for salmonid and cyprinid fish health (European Parliament, 2006), whilst the concentration of TSS in wastewater treatment plant effluents is limited to ≤35 mg/L by Wastewater Directive 91/271/EEC (European Parliament, Council of the European Union, 1991).
Total suspended solids (TSS) or turbidity (%, mg/L and total; units dependent upon measurement technique). A measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids".

NBS relevant to KPI	
	- Smart soils - Constructed wet roof - Tree trenches and bioswales - Climate adaptive gardens - Electro wetland - Sustainable drainage system (SuDS)

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- TSS or turbidity measurement data	- Quantitative and semi-quantitative	- Measurements

MEASUREMENT UNIT	FREQUENCY
- mg/L, %, ppm	- Daily, weekly, monthly or annually

METHOD

Total suspended solids (TSS) are typically quantified in the laboratory using a gravimetric process, yielding TSS measurement in units of mass per volume (e.g., mg/L or ppm). Measurement of TSS involves filtration of a water sample followed by drying and weighing of the particulates removed. Simply, this means anything that is captured by filtering the sample aliquot through a specific pore size filter. A measured volume (no more than 1 L) of sample is passed through a prepared, pre-weighed filter paper. The filter is dried at 104 ± 1°C. After drying, the filter is reweighed and the TSS is calculated.
A semi-quantitative, rapid assessment of TSS can be accomplished by evaluating sample turbidity, a measure of the relative transparency of a water sample. Turbidity measurements rely on comparison of light scattering with standard solutions (turbidity meter) or visual assessment (Secchi disk, transparency tube). Turbidity meters use a light beam with defined characteristics to provide a semiquantitative measure of the particulates present in the water, providing an integrated measure of light scattering and absorption. The measurement is provided in nephelometric turbidity units (NTU). Turbidity (in NTU) can be directly related to TSS (in mg/L) via creation of a standard curve (TSS versus turbidity) for a given location/type of fine particulate material.
• Measuring turbidity in-situ:
o Secchi disk, which is lowered into the water and the level where the disk disappears is registered. o Turbidity meter consists of a light source that illuminates a water sample and a photoelectric cell that measures the intensity of light scattered at a 90° angle by the particles in the sample. o Transparency tube is a clear, narrow plastic tube marked in units with a light and dark pattern painted on the bottom. Water is poured into the tube until the pattern disappears, and the depth is recorded.

References

- CLEVER Cities project
- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 4	Challenge name: Water pollution
KPI no.: 29	KPI name: Nitrogen and phosphorus concentration or load.

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Nutrients, including nitrogen (N) and phosphorus (P), can have significant impact on water quality, including effects on plant growth, oxygen concentration, water clarity, and sedimentation rates. Some major anthropogenic sources of nutrients are agricultural and industrial emissions, discharged wastewater and atmospheric deposition. Nitrogen and phosphorus are present in water in many different forms, or as many different chemical species. The forms of N and P that are quantified can include some or all of the following:

- Nitrogen: total N (N_{tot}), total Kjeldahl N (TKN), dissolved organic N (DON), nitrate (NO_3^-), nitrite (NO_2^-) and ammonia/ammonium (NH_3/NH_4^+)
- Phosphorus: total P (P_{tot}), acid-hydrolysable P (AHP), orthophosphate (PO_4^{3-}).

Nitrogen and phosphorus in surface water and/or groundwater (%, expressed as total annual N or P load and/or reduction of maximum annual concentration)

NBS relevant to KPI	
	- Climate adaptive gardens - Smart soils - Electro wetland - Constructed wet roof - Tree trenches and - Sustainable bioswales drainage system (SuDS)

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Measurement data of a water sample	- Quantitative	- Measurements

MEASUREMENT UNIT	FREQUENCY
- %, expressed as total annual N or P load and/or reduction of maximum annual concentration	- Daily, weekly, monthly or annually

METHOD

Different nitrogen and phosphorus species can be quantified in a water sample either in the field, using a test kit or ion selective electrode (ISE), or via laboratory analyses. Laboratory analyses can be done for multiple chemical species of N and P.
Ion selective electrodes are analogous to a pH electrode and are used in much the same way as a pH electrode (pH electrodes are essentially ion selective electrodes that are sensitive to the H+ ion) ISEs have a potential for permanent installation at a given sampling point. It is possible to program a data logger connected to an in-situ ISE to measure and record a value at a prescribed frequency. Test kits are usually used on site (in the field). Test kits typically involve the addition of chemical reagents to a water sample and yield results based on test strip colour comparison, solution colour comparison to a colour wheel or colour chart, or measurement with a photometer. The spectrophotometer measures the quantity of a chemical based on its characteristic absorption spectrum.

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 5	Challenge name: Soils
KPI no.: 30	**KPI name: Soil organic matter index.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

SOM is a crucial parameter of soil biological, chemical and physical quality. All soil properties are highly depending on this parameter (soil aggregation, soil nutrients, soil decomposers…).
This indicator is a numerical value used to ensure/improve soil organic matter content to allow long-term soil quality. This indicator is available to everyone and easy to implement. It is possible to apply the indicator in different locations. The indicator has been used in different circumstances (different soil uses) and delivered reasonable results. This indicator is capable to describe initial planning problems, like soil nutrient deficiency for plant growth, soil compaction.

NBS relevant to KPI	- Urban farming - Climate smart greenhouses - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Soil organic matter content (SOM)	- Quantitative, soil physico-chemical properties	- Measurement/Monitoring - Bibliography

MEASUREMENT UNIT	FREQUENCY
- g of organic matter per kg of soil	- In concept and detailed design phase of urban and object planning.

METHOD

- No required tool,
- No formula,
- Direct parameter.

Measuring this parameter is the best way to calculate this indicator, because urban soil properties are very heterogeneous. If it can't be measured, parameters estimation is possible thanks to the bibliography.
SOM index is given in form of a performance bar with numerical values ranked in terms to the best (1) and worst (0) scenario.

References

- Nature4Cities project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 5	Challenge name: Soils
KPI no.: 31	**KPI name: Concentration or load.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

SOM is a crucial parameter of soil biological, chemical and physical quality. All soil properties are highly depending on this parameter (soil aggregation, soil nutrients, soil decomposers)

NBS relevant to KPI	
	- Urban farming - Climate smart greenhouses - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Soil organic matter content (SOM)	- Quantitative	- Measurement data

MEASUREMENT UNIT	FREQUENCY
- g of organic matter per kg of soil	- Continuous

METHOD

This indicator is a numerical value used to ensure/Improve soil organic matter content to allow long-term soil quality. This indicator is available to everyone and easy to implement It is possible to apply the indicator in different locations. The indicator has been used in different circumstances (different soil uses) and delivered reasonable results.

References

- Nature4Cities project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 5	Challenge name: Soils
KPI no.: 32	**KPI name: Measured soil carbon content.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Accounting for C stored in soil and vegetation in an urban area can provide an indication of the condition of natural green spaces, total free surface area and total quantity of vegetation in the area examined. Measures of C storage and sequestration also provide a tangible connection to climate change mitigation, and the impacts of local land use, planning and management decision-making. It is important to note the substantial variation in C sequestration and storage capacity of different types of NBS.

NBS relevant to KPI	
	- Urban arboretum - Urban farming - Trees renaturing - Community garden parking - Climate smart greenhouses

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Site characteristics, including maps of soil type, topography and vegetation - Average soil bulk density (in kg / m3; can be measured or estimated on the basis of the soil type). Can be obtained from the municipality, department of environment, geological research	- Quantitative	- Measurement data

MEASUREMENT UNIT	FREQUENCY
- t/ha/y	- Continuous

METHOD

Total amount of carbon (tons) stored in soil per unit area and unit time (e.g., t/ha/y).
The most reliable and accurate method of determining soil C content is field sampling followed by laboratory analysis. Combustion is an accurate, commonly used analytical technique to quantify total C in soil – including both organic and inorganic soil C. Combustion analysis involves converting all forms of C in the soil to CO_2 by wet or dry combustion, then measuring evolved CO_2. Change in soil C content occurs most readily in the SOC fraction, so observed changes in total soil C content with time are most likely to represent changes to SOC content. Sampling is performed using a measuring tape (for establishment of sampling transect or grid), soil corer, and plastic bags. It may be challenging to detect small changes in soil C content in soils that contain substantial inorganic (mineral) C. A rapid field test of the soil's reactivity to acid can indicate whether it may be necessary to undertake more intensive analyses of soil samples to quantify both the organic and inorganic C fractions, rather than total (inorganic + organic) C by combustion

References

- Nature4Cities project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 5	**Challenge name: Soils**
KPI no.: 33	**KPI name: Soil carbon to nitrogen ratio.**

Type of KPI	**Scale**
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

The respective quantities of carbon and nitrogen in soil is critical to soil microbial activity and a fundamental indicator of biogeochemical cycling in ecosystems. Changes to soil C/N ratio impacts nutrient cycling in soils and the structure and function of plant communities, thereby affecting ecosystem service functions. Soils with higher C/N ratio are better able to buffer soil and water N pollution, because soils with greater C/N ratio generally exhibit slower rates of N mineralization and nitrification, and greater capacity for N immobilization (Groffman et al., 2006). The accumulation of C and N in urban green space soils is determined both by the length of time following urbanization that an area is managed as a green space and the structural composition of green space vegetation. Factors such as the presence of trees, an understory, and surface litter are key to soil C and N accumulation. Urban green space soils under tree canopies have been shown to have significantly greater soil C and N content and higher C/N ratios compared with grassed areas (Livesley et al., 2015). Soil microorganisms require C and N in a ratio of about 24:1 to support metabolic processes (USDA-NRCS, 2011).

NBS relevant to KPI	- Urban arboretum - Urban farming - Trees renaturing - Community garden parking - Climate smart greenhouses

DATA AND MEASUREMENT

REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE** - Measurement data
- Site characteristics, including maps of soil type, topography, and vegetative cover. Average soil bulk density (in kg/m3; can be measured or estimated based on soil type). Obtainable from local municipality, department of environment, geological survey.	- Quantitative	

MEASUREMENT UNIT	**FREQUENCY**
- Unitless	- Continuous

METHOD

The ratio between the total mass of carbon and the total mass of nitrogen in soil.
The most reliable and accurate method of determining soil C and N content is field sampling followed by laboratory analysis. Sampling is performed using a measuring tape (for establishment of sampling transect or grid), soil corer, and plastic bags. Soil cores should be taken to a depth of at least 0.3 m,
and up to 1.0 m depth depending on the rooting depth of local vegetation. Combustion is an accurate, commonly used analytical technique to quantify C and N in soil. A carbon-nitrogen combustion analyser can provide measures of total carbon, total organic carbon and total inorganic carbon (after sample acidification), total nitrogen, and C/N ratio.

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 5	Challenge name: Soils
KPI no.: 34	**KPI name: Soil water retention capacity.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Soils can store water in their matrix and skeleton depending on their structure, texture and mineral composition. There is an intrinsic relationship between the amount of water stored in the soil and the matric suction, which is established through the soil water retention function. This function defines field capacity and wilting point, which difference establishes the water available to plants in the soil.
Soil water retention is also related to soil strength and bridges soil hydrology with mechanics. Soils that can hold a lot of water support more plant growth and are less susceptible to leaching losses of nutrients and pesticides. All of the water held by soil is not available for plant growth. Soil water retention capacity is mainly determined by the soil texture (sand, silt, clay contents), structure (bulk density and porosity), and organic matter content. It can influence the choice of NBS as well as the stability/effectiveness of the NBS put in place to mitigate against natural hazards. In general, the higher the percentage of silt and clay sized particles, the higher the water holding capacity. The small particles (clay and silt) have a much larger surface area than the larger sand particles. This large surface area allows the soil to hold a greater quantity of water.
Soil water retention capacity it is the ability of the soil to store water under changing hydrological regimes -i.e., residual, transition and saturation.
Soil water retention (or holding) capacity is the amount of water that a given soil can hold for an intended use.

NBS relevant to KPI	
	- Smart roof - Constructed wet roof - Community gardens - Urban farming - Tree trenches and - Climate adaptive bioswales gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Moisture contents at different air pressures	- Numerical	- Measurements

MEASUREMENT UNIT	FREQUENCY
- m^3/m^3	- Periodic

METHOD

Determine water content at field capacity. Determine water content at wilting point.

Plant available water = field capacity – wilting point moisture content

Create a soil water retention curve.

References

- OPERANDUM project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 5	Challenge name: Soils
KPI no.: 35	**KPI name: Soil Available Water (SAW)**- Urban farming

Type of KPI	**Scale**
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

The SAW represents the capacity of the soil to provide water for plant uptake (Yilmaz et al. 2016; Bouzouidja et al. 2018).
The use of this indicator aims to:
- Provide water for plants growth,
- Favor plant transpiration and cooling effect.

NBS relevant to KPI

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Several input data is required. Measuring these parameters is the best way to calculate this indicator, because urban soil properties are very heterogeneous. If it can't be measured, parameters estimation is possible thanks to the bibliography. • Soil water field capacity (H_{fc}) • Soil water content at the wilting point (H_{wp}) • Soil thickness (z) • Soil bulk density (Bd) • Stone fraction content (F)	- Quantitative	- Measurement/Monitoring - Bibliography

MEASUREMENT UNIT	FREQUENCY
- mm water / cm of soil	- In concept and detailed design phase of urban and object planning

METHOD

$SWR = (H_{fc}-H_{wp}) \cdot Bd \cdot z \cdot F$

with H_{fc} is the massif water content at field capacity (in kg water/kg dry soil), H_{wp} the volumetric water content at the wilting point (m^3/m^3), Bd is the bulk density in (kg/m^3), z is the depth of soil in (m), F is the stone fraction content (in m^3 of small soil per m^3 of total soil).

References

- Nature4Cities project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 5	Challenge name: Soils
KPI no.: 36	**KPI name: Surface area of restored and/or created wetlands.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Wetlands are unique ecosystems that occur in places where the water table is close to the ground level, or where land is covered by water, either seasonally or permanently. Convention on Wetlands (Ramsar, Iran, 1971), or Ramsar Convention, defines wetlands as "… a wide variety of inland habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas such as saltmarshes, mangroves, intertidal mudflats and seagrass beds, and also coral reefs and other marine areas no deeper than six meters at low tide." Conservation and restoration of wetlands is regarded as one of the critical factors for establishing climate adaptation as part of the disaster risk reduction. Wetlands provide resilience against water-related hazards such as floods, storm surges and droughts by capturing and holding water and gradually releasing it. Peatlands enhance climate resilience by storing carbon.
Surface area of constructed and/or restored wetlands within a defined area (ha)

NBS relevant to KPI	
	- Urban arboretum - Green corridors - Floating garden - Wildlife park - Tree trenches and bioswales

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Land-use raster of the area of interest; - local records; - satellite imagery	- Quantitative	- Measurement/Monitoring - GIS databases

MEASUREMENT UNIT	FREQUENCY
- ha	- Annually

METHOD

The extent of the surface area covered by constructed and/or restored wetlands can be assessed using the land use raster data (local or EU-wide, e.g., Corine Land Cover) in GIS software that allows to examine the total area. Satellite imagery may be used for visual assessment and manual area calculation.

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 5	Challenge name: Soils
KPI no.: 37	KPI name: Erosion risk (soil loss estimate).

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Soil erosion is among the most challenging and continuous environmental problems in the world and can take form of erosion by water (usually surface runoff) or wind. The displaced soil travels away from the point of origin and can create additional risks to life and property. Soil erosion is one of the main and original risks the NBS were employed to mitigate against.
The likelihood of a site/plot of soil to lose the uppermost layer due to the agents of water, wind, etc.
Usually measured as the volume of lost soil per unit of time.

NBS relevant to KPI	- Urban arboretum - Urban farming - Trees renaturing - Community garden parking - Climate smart greenhouses

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Soil parameters, - Vegetation parameters, - Climatic parameters	- Numerical, quantitative	- Measurement/Monitoring - Databases exist for preliminary assessment

MEASUREMENT UNIT	FREQUENCY
- Volume of lost soil per unit of time	- Once as a baseline, - Sporadically thereafter throughout the life of the NBS

METHOD

(Revised) Universal Soil Loss Equation is used to calculate the soil loss per unit of time. The calculation involves consideration of soil type, climatic parameters (rainfall), and methods of soil cultivation (not necessarily NBS).
Scale of measurement: Meso (field) to macro/global (regional, continental)

References

- OPERANDUM project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 5	Challenge name: Soils
KPI no.: 38	KPI name: Polluted soils.

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

This indicator evaluates whether the project scenarios enhance the ability of a soil to resist or recover their healthy state in response to destabilizing influences.
This Indicator describes the quantity of soils in the study area, measured in hectares, used for highly polluting industries, brownfields, dross capes, mines, dumps, construction sites. It provides a quick evaluation of soil quality since the less polluted a soil is, the higher its overall quality.

NBS relevant to KPI	- Climate smart greenhouses - Wildlife park - Urban forest

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Detailed land use data	- Quantitative	- GIS Databases

MEASUREMENT UNIT	FREQUENCY
- ha	- Annually

METHOD

The final formula of Polluted Soils (PS) results as: $PS = \sum_i A_i^{PS}$

where: A_i^{PS} is the extension of the i-th polluted area (e.g., highly polluting industries, brownfields, dross capes, mines, dumps, construction sites) [ha]
The indicator is easily calculated in a GIS environment using simple GIS geoprocessing tools.

References

- PHUSICOS project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 5	Challenge name: Soils
KPI no.: 39	KPI name: Derelict land reclaimed for NBS.

Type of KPI	Scale
☒ Descriptive ☒ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Brownfield land refers to urban developed areas that are currently idle. Typically, they are sites of previous commercial or industrial activities, which might have detected or suspected pollution and soil contamination problems, hindering their future development. Redeveloping brownfields can save pristine green spaces from development as well as reclaim unused spaces into meaningful application (University of the West of England [UWE] Science Communication Unit, 2013).

NBS relevant to KPI	
	- Floating garden - Green covering shelters - Green roof (intensive or extensive) - Green corridors - Sustainable drainage system (SuDS) - Trees trenches and bioswales

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Site characteristics including maps of topography, land use maps	- Quantitative	- National, regional and local GIS databases

MEASUREMENT UNIT	FREQUENCY
- %	- Continuous

METHOD

Idle, developed areas within the community are identified and their combined surface area is calculated using maps. This is done yearly and the percentage change in the area is reported, as well as the actual area remaining.

References

- Leitat project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 5	Challenge name: Soils
KPI no.: 40	**KPI name: Hydrocarbons pollution level of soil.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Soil is contaminated when chemical substances are present in the soil in excess of their normal content and cause changes in soil properties that do not allow for normal soil use.
Hydrocarbons, the source of which are, among others crude oil and its products, i.e. gasoline, diesel oil, when they get into the soil in significant amounts, may cause its exclusion from biological activity for 10–15 years. Soil saturation with these products destroys soil and plant microorganisms and causes oxygen deficiency.
Due to the fact that the natural decomposition of these compounds in the soil would take many years, these soils should be recultivated.
The methods we use to purification soils contaminated with hydrocarbons are:

- in situ methods - without removing contaminated soil from the contaminated site, and
- ex situ methods - with the displacement of polluted soil to a place intended for its treatment or storage.

Compared to physicochemical methods or removing contaminated soil and replacing it with uncontaminated soil, a cheaper process, and also providing aesthetic value in the form of planted plants, is phytoremediation.

NBS relevant to KPI	
	- Climate smart greenhouses - Wildlife park - Urban forest

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Content of hydrocarbons in soil	- Quantitative	- Measurements

MEASUREMENT UNIT	FREQUENCY
- mg/kg dry weight	- Before and after recultivation

METHOD

The use of any recultivation methods should be preceded by an assessment of the quality of the soil in the identified hotspot and an assessment of the volume of soil that needs to be recultivated. The basic reference methodology is gas chromatography (GC) for the determination of aliphatic hydrocarbons and high performance liquid chromatography (HPLC) for the determination of polycyclic aromatic hydrocarbons (PAHs).

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 5	Challenge name: Soils
KPI no.: 41	KPI name: Heavy metal pollution levels of soil.

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Soil is contaminated when chemical substances are present in the soil in excess of their normal content and cause changes in soil properties that do not allow for normal soil use.
Environmental pollution with heavy metals is becoming an increasingly serious problem. This is mainly due to the development of industry, especially mining, communication and the increased consumption of agrochemicals in agriculture. Heavy metals are basically not biodegradable, and as a result they accumulate in soil ecosystems. Moreover, they can remain in the environment for many years, changing only the forms in which they occur. The soil, into which pollutants can penetrate from the air and water, is a particularly vulnerable element of the biosphere. Moreover, due to its physicochemical properties, soil is a medium in which pollutants stay much longer compared to the two previous environmental components.
Environmental contamination with heavy metals requires their removal from the soil. For this reason, they must be desorbed from the soil or separated from the soil solution. The presence of heavy metals in soil is a risk for several reasons: the possibility of migration and groundwater contamination; toxicity to aquatic and soil organisms; toxicity to plants, in particular to arable crops; bioaccumulation (accumulation of heavy metals in the body resulting from chronic exposure to a given metal) and biomagnification (accumulation of heavy metals in the trophic chain) in plant and animal organisms.
The methods we use to purification soils contaminated with heavy metals are:

- in situ methods - without removing contaminated soil from the contaminated site, and
- ex situ methods - with the displacement of polluted soil to a place intended for its treatment or storage.

Compared to physicochemical methods or removing contaminated soil and replacing it with uncontaminated soil, a cheaper process, and also providing aesthetic value in the form of planted plants, is phytoremediation.

NBS relevant to KPI	
	- Phyto-remediation plants - Climate smart greenhouses - Wildlife park - Urban forest

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Content of heavy metal in soil	- Quantitative	- Measurements

MEASUREMENT UNIT	FREQUENCY
- mg/kg dry weight	- Before and after recultivation

METHOD

The use of any recultivation methods should be preceded by an assessment of the quality of the soil in the identified hotspot and an assessment of the volume of soil that needs to be recultivated. The basic reference methodologies for the determination of most heavy metals are: inductively coupled plasma optical emission spectroscopy (ICP-OES), inductively coupled plasma mass spectrometry (ICP-MS) and electrothermal atomic absorption spectrometry (ETAAS) or flame atomic absorption spectrometry (FAAS). Only the determination of mercury requires the use of cold vapor atomic absorption spectroscopy (CV-AAS) or atomic absorption spectrometry with amalgamation technique (AMA).

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 5	Challenge name: Soils
KPI no.: 42	KPI name: Pesticide levels of soil.

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Soil is contaminated when chemical substances are present in the soil in excess of their normal content and cause changes in soil properties that do not allow for normal soil use.
The main source of soil contamination with pesticides is the excessive use of plant protection products in agriculture. Excessive use of pesticides can contaminate the soil and, as a consequence, the cultivated plants. Soil saturation with pesticides also destroys soil and plant microorganisms and causes oxygen deficiency.
Due to the fact that the natural decomposition of these compounds in the soil would take many years, these soils should be recultivated.
The methods we use to purification soils contaminated with pesticides are:

- in situ methods - without removing contaminated soil from the contaminated site, and
- ex situ methods - with the displacement of polluted soil to a place intended for its treatment or storage.

Compared to physicochemical methods or removing contaminated soil and replacing it with uncontaminated soil, a cheaper process, and also providing aesthetic value in the form of planted plants, is phytoremediation.

NBS relevant to KPI	
	- Climate smart greenhouses - Wildlife park - Urban forest

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Content of pesticide in soil	- Quantitative	- Measurements

MEASUREMENT UNIT	FREQUENCY
- mg/kg dry weight	- Before and after recultivation

METHOD

The use of any recultivation methods should be preceded by an assessment of the quality of the soil in the identified hotspot and an assessment of the volume of soil that needs to be recultivated. The basic reference methodology is gas chromatography (GC) with ECD detector or gas chromatography with detection by mass spectrometry (GC-MS) for the determination of organochlorine pesticides and high performance liquid chromatography (HPLC) with UV or FL detector or gas chromatography with detection by mass spectrometry (GC-MS) for the determination of nonchlorinated pesticides.

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 6	**Challenge name: Water**
KPI no.: 43	**KPI name: Infiltration capacity.**

Type of KPI	**Scale**
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Surface imperviousness is characteristic of urban areas and it is an important environmental indicator (Arnold & Gibbons, 1996; Strohbach et al., 2019). As surface imperviousness increases, the volume and velocity of surface runoff increases and there is a corresponding decrease in water infiltration. A high proportion of surfaces in urban areas are impermeable and the impermeability of surfaces in the cities is increasing as cities become more densely populated. The impermeability of urban surfaces originates from constructing buildings, roads, parking areas, etc., with materials that are not permeable to water.
Infiltration capacity (%) - change in precipitation infiltration capacity measured using ring infiltrometer & extrapolated/modelled for full unsealed area).

NBS relevant to KPI	
	- Smart roofs - Construction wet roofs - Intensive green roofs - Extensive green roofs - Climate adaptive - Tree trenches and gardens bioswales - Sustainable drainage systems (SuDS)

DATA AND MEASUREMENT

REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE**
- Soil texture and structure category - Infiltration rate of soil	- Quantitative	- Measurements

MEASUREMENT UNIT	**FREQUENCY**
- %	- Annually, and before and after NBS implementation

METHOD

When measuring water flow parameters in the field (field-saturated parameters), the measurements in the unsaturated or vadose zone (above the water table), are typically conducted using various ring infiltrometer and borehole or well permeameter methods. In the saturated zone (below the water table), water flow parameters (saturated parameters) are usually measured using auger hole methods, and at greater depths using piezometer methods.
Measurements of water flow parameters of the soil in the vadose zone using ring infiltrometers can be conducted with the following steps (Reynolds et al., 2002):

1. The cylinder is inserted 3-10 cm into the soil. The contact between the soil and the inside cylinder should be lightly tamped to prevent flow or leakage around the cylinder walls.
2. A constant depth of water is ponded inside the measuring cylinder and also inside the buffer cylinder if the concentric ring infiltrometer is used. The ponding depth is usually 5-20 cm depending on the circumstances.
3. The water infiltration rate through the measuring cylinder is measured. The infiltration rate through the buffer cylinder can also be measured if single-ring and concentric-ring infiltration rate results are compared.

Quasi-steady flow in the near-surface soil under the measuring cylinder is assumed to occur when the discharge becomes effectively constant. The field-saturated hydraulic conductivity, K_{fs}, can be calculated using the equation bellow:

$$q_s/K_{fs} = Q/(\pi a^2 K_{fs}) = [H/(C_1 d + C_2 a)] + \{1/[\alpha^*(C_1 d + C_2 a]\} + 1$$

where: q_s (LT^{-1}) is quasi-steady infiltration rate, K_{fs} (LT^{-1}) is the field-saturated hydraulic conductivity, Q(L^3T^{-1}) is the corresponding quasi-steady flow rate, a(L) is the ring radius, H(L) is the steady depth of ponded water in the ring, d(L) is the depth of ring insertion into the soil, $C_1=0.316\pi$ and $C_2=0.184\pi$ are dimensionless quasi-empirical constants that apply for d ≥3 cm and H ≥5 cm (Reynolds & Elrick, 1990; Youngs, Leeds-Harrison, & Elrick, 1995). The macroscopic capillary length, α(L^{-1}), can be estimated from soil structure and texture or measured using independent methodology. Some values for α:
Table: Soil texture-structure categories for site estimation of the parameter "α" (Reynolds et al., 2002, adapted from Elrick, Reynolds & Tan, 1989).

Soil texture and structure category	**α^* (cm^{-1})**
Compacted, structureless, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments	0.01
Soils that are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12
Coarse and gravelly sands; may also include highly structured or aggregated soils, as well as soils with large and/or numerous cracks, macropores.	0.36

The instructions for measuring infiltration of a water permeable pavement are based on the ASTM C1701/C1701M-09 (infiltration rate of in situ pervious concrete). More details are provided in the standard.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

References
- UnaLab project - Arnold, C.L., Jr., & Gibbons, C.J. (1996). Impervious surface coverage: The emergence of a key environmental indicator. Journal of the American Planning Association, 62(2), 243-258. - ASTM C1701/C1701M-09. Standard test method for infiltration rate of in place pervious concrete. - Reynolds, W.D., Elrick, D.E., & Youngs, E.G. (2002). Ring or Cylinder Infiltrometers (Vadose Zone). In J.H. Dane & G.C. Topp (Eds.), Methods of Soil Analysis. Part 4 Physical Methods. Madison, Wisconsin: Soil Science Society of America, Inc. - Strohbach, M.W., Döring, A.O., Möck, M., Sedrez, M., Mumm, O., Schneider, A.-K., … Schröder, B. (2019). The "hidden urbanization": Trends of impervious surface in low-density housing developments and resulting impacts on the water balance. Frontiers in Environmental Science, 7, 29. - Youngs, E.G., Leeds-Harrison, P.B., & Elrick, D.E. (1995). The hydraulic conductivity of low permeability wet soils used as landfill lining and capping material: analysis of pressure infiltrometer measurements. Journal of Soil Technology, 8, 153-160.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 6	Challenge name: Water
KPI no.: 44	**KPI name: Volume of water slowed down.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Volume of water slowed down entering sewer system.

NBS relevant to KPI	
	- Smart roofs - Construction wet roofs - Intensive green roofs - Extensive green roofs - Climate adaptive - Tree trenches and gardens bioswales - Sustainable drainage systems (SuDS)

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- i.e. site characteristics including maps of land cover, soil characteristic, meteorological data	- Quantitative	- Measurement data

MEASUREMENT UNIT	FREQUENCY
- m^3 of water	- Continuous

METHOD

Direct measurement of water flow pre and post intervention m^3 of water. Create local urban catchment hydrograph for demonstration sites. Model: Calculate using standard software (Excel/R)
Sensor: Water flow sensor. Discharge data for storm water (m3) from United Utilities

References

- Urban GreenUP project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 6	Challenge name: Water
KPI no.: 45	**KPI name: Rainwater or greywater use for irrigation purposes.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Rainwater and greywater have a potential to be reused for irrigation purposes if collected to a storage unit. This is especially prominent for areas exposed to drought. Domestic wastewater consists of greywater, the wastewater discharged from hand basins, showers and baths, dishwashers, and laundry machines, and blackwater from toilets. Depending on local regulations, water from the kitchen sink be regarded as greywater or blackwater. One person generates 90–120 L greywater each day depending on lifestyle, living standard, age, gender, and other factors. Greywater comprises 5080% of all domestic wastewater but contains a relatively small fraction of the total pollutant load (Antonopoulou, Kirkou, & Stasinakis, 2013; Donner et al., 2010; Li, Wichmann, & Otterpohl, 2009). Separation of domestic greywater from blackwater and on site re-use for toilet flushing or irrigation of non-edible vegetation provides an alternative water source in areas facing water shortage. On-site greywater re-use can reduce potable water use by as much as 50% (Gross, Shmueli, Ronen, & Raveh, 2007).

NBS relevant to KPI	- Smart roofs - Construction wet roofs - Intensive green roofs - Extensive green roofs - Climate adaptive Tree trenches and gardens bioswales - Sustainable drainage systems (SuDS)

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Volume of rainwater and greywater used for irrigation purposes	- Quantitative	- Measurement data

MEASUREMENT UNIT	FREQUENCY
- m^3/y	- Continuous

METHOD

Volume of rainwater or greywater used for irrigation purposes (L/y or similar unit).
Accurate accounting of rainfall capture and use for irrigation requires use of a water level sensor to measure the volume of water contained within a given rainwater storage unit at any time. If the storage unit is completely sealed and the water level can be easily recorded each time it is opened (and again after water is discharged for use), it may be possible to manually record and calculate the volume of water captured and used for irrigation purposes. An alternate solution is to equip the discharge point of the rainwater storage unit/tank with a water meter, and record the volume of water used over a specific period of time. This is well suited to applications with multiple water storage tanks and/or in situations where it may be challenging to accurately quantify water use manually. The water meter(s) may be connected to an automatic meter reading (AMR) device that enables remote communication of water usage between the water meter and a central point. It is recommended that domestic greywater is filtered (e.g., sand and/or granular activated carbon filter and/or treatment in vertical subsurface-flow wetland or reed bed, etc.) prior to use for irrigation of non-edible vegetation such as landscaping.

References

- Urban GreenUP project

Challenge no.: 6	**Challenge name: Water**
KPI no.: 46	**KPI name: Water Exploitation Index.**

Type of KPI	**Scale**
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

The Water Exploitation Index (WEI) compares the volume of water consumed each year to the available freshwater resources. More specifically, the WEI presents total annual freshwater extraction as a proportion (%) of the long-term annual average freshwater available from renewable resources. The WEI warning threshold of 20% distinguishes a water-stressed area from one not suffering water scarcity. Severe scarcity is defined as WEI >40%.
Annual total water abstraction as a proportion (%) of available long-term freshwater resources in the geographically relevant area (basin) from which the municipality obtains its water.

NBS relevant to KPI

- Climate adaptive gardens
- Smart soils
- Urban farming
- Community gardens
- Climate smart greenhouses
- Sustainable drainage systems (SuDS)

DATA AND MEASUREMENT

REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE**
- Annual volumes of water abstraction (groundwater, surface water) from a given basin or subbasin, - Information related to annual volumes of water returns, - Information about long-term renewable water resources.	- Quantitative	- Necessary information about annual volumes of water abstraction (groundwater, surface water) from a given basin or sub-basin can be obtained from records of water supply companies and city documents relating to water abstraction permits. - Wastewater treatment companies, water supply companies and municipal environment/environmental management departments are sources of information related to annual volumes of water returns. - Information about long-term renewable water resources can be obtained from local water boards, municipal departments and/or national environment agencies.

MEASUREMENT UNIT	**FREQUENCY**
- %	- Annually

METHOD

The WEI is calculated as follows (European Environment Agency [EEA], 2018):

WEI = (Volume of water abstraction/Volume of renewable freshwater resources) x 100

An advanced version of the WEI, called the WEI+, accounts for recharge of available freshwater supplies, or water return (EEA, 2018a):

WEI+ = ((Volume of water abstraction – Volume of water returns)/Volume of renewable freshwater resources) x 100

The volume of long-term renewable freshwater resources in a natural or semi-natural geographically relevant area (e.g., basin or sub-basin) is calculated as (EEA, 2018): Long term renewable freshwater resources = E_{xIn} + P – ET_a – S where E_{xIn} = external inflow, P = precipitation, ET_a = actual evapotranspiration and ΔS = change in storage (lakes and reservoirs).
The equation for renewable freshwater resources can be simplified as follows for highly-modified (i.e., not natural or semi-natural) river basins or sub-basins (EEA, 2018):

Long term renewable freshwater resources = outflow + (abstraction – return) – · S where outflow = downstream flow or discharge to sea and ΔS = change in storage (lakes and reservoirs).
Scale of measurement: Basin scale

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 7	Challenge name: Biodiversity
KPI no.: 47	**KPI name: BAF - Biotope Area Factor.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☐ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

The BAF is calculated by dividing the amount of surface area available for nature and vegetation by the total surface area considered. Each type of soil / ground cover / land use is affected a coefficient related to its potential for vegetation growth & nature implementation (e.g. sealed surface = 0; semipermeable = 0.3; green wall = 0.5; green roof = 0.7; in-ground plantations = 1).
Thresholds and goals can then be determined based on the expected performance or current land use / urban planning objectives (e.g., the City of Berlin expects BAF to be produced for each new project – the result must be between 0.3 and 0.6, depending of the project's nature).
The BAF takes values between 0 and 1. It increases with in-ground planted areas.
For this indicator, outputs can be both map-like and numerical. For the simplified assessment, that outputs will be numerical only.

NBS relevant to KPI	- Floating garden - Green covering shelters - Green roof (intensive or extensive) - Green corridors - Sustainable drainage system (SuDS) - Trees trenches and bioswales

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Land use map - Ground cover / surface materials	- Quantitative	- Geodatabase of land use / land cover - Parameters with BAF coefficients

MEASUREMENT UNIT	FREQUENCY (how often to measure this indicator?)
- %	- Once, during conception, to characterize the project - Before / after the project's implementation, to characterize it is effects on the local environment

METHOD

GIS analysis.
BAF = ecologically-effective surface areas / total land area.

References

- Nature4Cities project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 7	Challenge name: Biodiversity
KPI no.: 48	**KPI name: Percentage of protected natural areas.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Percentage of protected natural areas, restored and naturalized areas on public land in municipality.

NBS relevant to KPI	
	- Pollinator roof - Green corridors - Wildlife park - Urban forest - Single line trees

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Surface of protected natural areas, restored and naturalized areas on public land in municipality, - Surface of public land in municipality	- Quantitative	- Municipal GIS databases

MEASUREMENT UNIT	FREQUENCY
- %	- Annually

METHOD

Percentage of protected natural areas, restored and naturalized areas on public land in municipality.

References

- Leitat

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 7	Challenge name: Biodiversity
KPI no.: 49	KPI name: Percentage of tree canopy cover.

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Urban tree canopy is a measurement which encompasses the layer of leaves, branches and stems of trees that shelter the ground when viewed from above. This measurement is expressed as a percentage of ground area that is covered by tree crowns, and relates to the branching spread of the trees in an urban forest. Some urban tree canopy covers natural areas or gardens and lawns, while other canopy spreads across impervious surfaces such as roads, buildings and parking lots. Trees in general provide a large number of ecosystem services, environmental benefits that we directly experience by having trees planted throughout our city. Ecosystem services carried out by trees include:

- removal of pollutants from the air, soil and water
- release of water vapor into the atmosphere which cools the surrounding areas, mitigating the urban heat island effect
- interception of rainfall and reduction of storm water runoff (and thus, reducing the costs related to infrastructure required to manage it)
- energy savings and reduced greenhouse gas emissions due to shade provided
- carbon sequestration
- increased property values.

In addition to the contribution of these ecosystem services, trees provide other health, social, economic, and aesthetic benefits. The magnitude of ecosystem services is tied to the age, size and condition of the trees in the urban forest. Mature trees with larger crowns that are in good condition will provide more services than younger, smaller trees. As a result, a city with greater urban tree canopy cover (a larger network of trees) will experience more ecosystem services than a city with a lower canopy coverage.
Tree preservation, tree planting (with appropriate selection and placement), and improving tree health through proper tree care practices can all contribute to a sustained or enhanced urban tree canopy. In contrast, tree removal, site clearing during development, natural incidents such as fire and storms, and poor tree condition can contribute to a reduced amount of tree canopy. It is important to note that tree species planted will influence the speed of urban tree canopy increase, due to varied growth rates, mature sizes, and life spans.
Percentage of tree canopy cover within the city.

NBS relevant to KPI	- Urban forest - Green corridors - Urban arboretum - Shade trees - Trees renaturing parking

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Google Earth or other aerial imagery	- Spatial	- Google Earth

MEASUREMENT UNIT	FREQUENCY
- %	- Annually

METHOD

Percentage of tree canopy cover within the city.
i-Tree Canopy is one of possible tools. This tool is designed to allow users to easily and accurately estimate tree and other cover classes (e.g., grass, building, roads, etc.) within their city or any area they like. This tool randomly lays points (number determined by the user) onto Google Earth imagery and the user then classifies what cover class each point falls upon. The user can define any cover classes that they like and the program will show estimation results throughout the interpretation process. Point data and results can be exported for use in other programs if desired.
The accuracy of the analysis depends upon the ability of the user to correctly classify each point into its correct class. Thus the classes that are chosen for analysis must be able to be interpreted from an aerial image. As the number of points increase, the precision of the estimate will increase as the standard error of the estimate will decrease. If too few points are classified, the standard error will be too high to have any real certainty of the estimate. Another limitation of this process is that the Google imagery may be difficult to interpret in all areas due to relatively poor image resolution (e.g., image pixel size), environmental factors, or poor image quality.

References

- i-Tree Canopy https://canopy.itreetools.org/
- https://www.edmondok.gov/1533/Tree-Canopy

Challenge no.: 7	Challenge name: Biodiversity
KPI no.: 50	**KPI name: Number of native species.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

The total number of native species within a defined area (site/neighbourhood/region/city). This can compromise one or more of the following taxonomic groups (it should be specified which groups are covered):
a. Plants
b. Birds
c. Butterflies
d. Invertebrates
e. Mammals
Provides an overview of the species diversity, with distinctions able to be made across taxonomic groups if multiple groups can be covered. Defined species can also serve as an indirect "indicator" for the habitat quality.

NBS relevant to KPI	
	- Verges and space for pollination - Urban arboretum - Natural Pollination's modules - Wildlife park - Urban forest

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Survey data	- Quantitative	- Field survey

MEASUREMENT UNIT	FREQUENCY
- Number of species in a defined area	- Typically annual, but can be less frequent if resources are stretched.

METHOD

The sum for each taxonomic group is calculated using field survey. It should be clarified whether this is the exact number or an estimation.

References

- CONNECTING Nature project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 7	Challenge name: Biodiversity
KPI no.: 51	KPI name: City Biodiversity Index.

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

The definition of biodiversity is the presence of different species of different taxonomic groups. The net change in the number of species in a municipality is an indication of biological diversity loss or gain. A more comprehensive sample of the biodiversity in an area can be obtained through a census of species in different groups. Vascular plants, birds, and butterflies have been defined in the City Biodiversity Index as core taxonomic groups to be followed in all cities. On top of these, cities are encouraged to select two supplementary taxonomical groups chosen to reflect local biodiversity best. The supplementary taxonomical groups can include, e.g., bryophytes, fungi, amphibians, reptiles, fish, beetles, spiders, seagrasses or others.
The number of native species detected in the urban area, compared to a baseline number of species.

NBS relevant to KPI	
	- Urban arboretum - Green corridors - Verges and space for pollination - Pollinations walls/ vertical for pollination - Wildlife park - Urban forest - Intensive green roofs

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Data on counts of animal and plant species found on the whole urban area of interest. These can be available through municipalities, government agencies, environmental organizations, bird watch organizations or universities.	- Quantitative or semiquantitative	- Possible sources of data include agencies in charge of nature conservation / biodiversity (Wildlife Trusts, etc), city municipalities and urban planning agencies, biological records centres, nature groups, universities, etc.

MEASUREMENT UNIT	FREQUENCY
- Example units of calculation are: number/abundance of native bird species per hectare.	- Annually

METHOD

Counts of animal and plant species found on the whole urban area of interest are used. As focus in this metric is increasing biodiversity and reintroducing broader array of natural species, it can be sufficient to select a certain biotypes or areas and a selection of species for monitoring. The indicator value is the number of new native species detected in the urban area, compared to a baseline species number. The first part of the framework involves a profile of the city, then 23 indicators are proposed that comprise 3 core components: 1) native biodiversity, 2) ES provided by biodiversity, and
3) governance and management of biodiversity. This framework could be used to undertake a full CBI self-assessment. Alternatively, those indicators that directly measure biodiversity could be used, for example Indicator 3: native biodiversity in built-up areas (bird species), or Indicators 4-8 which include three 'core indicator' groups that are most surveyed worldwide – plants, birds and butterflies. Cities can select two additional taxonomic groups (for instance those where data is already held or target groups of local importance/conservation interest). The data from the first year of implementing the Index provides the baseline for future monitoring. It is recommended that application of the Index take place every 3 years to allow sufficient time for the results of biodiversity conservation efforts (e.g., NBS implementation) to materialise. Example units of calculation are: number/abundance of native bird species per hectare. The net change in number of native species from the previous survey to the most recent survey is calculated as: total increase in number of species (as a result of re-introduction or restoration efforts, new species found, etc.) minus number of species that have gone extinct.

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 7	Challenge name: Biodiversity
KPI no.: 52	KPI name: Pollinator species presence.

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

The presence of pollinating insects such as bees, hoverflies, butterflies and moths visiting flowers is indicative of pollination (ecosystem service). Increased habitat for pollinators in NBS GI may contribute to increased abundance of pollinators in the wider urban area and provide stepping stones or corridors of habitat from a source site such as an urban park to another urban GI site. Flying pollinating insects are an appropriate indicator of pollination and biodiversity in new NBS GI as these taxa are likely to be already present in source sites such as urban parks within normal foraging range of the new NBS. Flying pollinating insects are highly-mobile, and therefore, considered to have the potential to reach the NBS sites within the project monitoring period.
This environmental (biological) indicator evaluates if new GI/NBS can attract pollinators species.

NBS relevant to KPI	
	- Urban arboretum - Green corridors - Verges and space for pollination - Pollinations walls/ vertical for pollination - Wildlife park - Urban forest - Intensive green roofs

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Field surveys	- Quantitative	- Counting of species

MEASUREMENT UNIT	FREQUENCY
- No./ha or - %	- Specific surveying calendar (weekly, monthly, etc). Survey take place with the period of the flowering of the autochthonous species of each zone or area, since this determines the period in which the insects carry out their activity.

METHOD

Measures will be carried out by visual direct counting of species in a given area (limited square) and during a concrete space of time. This method will be repeated periodically in a given area.

References

- URBAN GreenUP KPI: Pollinator species increase
- URBAN GreenUP Deliverable D2.4 - Monitoring program to Valladolid. https://www.urbangreenup.eu/insights/deliverables/d2-4---monitoring-program-to-valladolid.kl
- URBAN GreenUP Deliverable D3.4 - Monitoring program to Liverpool https://www.urbangreenup.eu/insights/deliverables/d3-4---monitoring-program-to-liverpool.kl
- URBAN GreenUP Deliverable D4.4 – Monitoring program to Izmir https://www.urbangreenup.eu/insights/deliverables/d4-4--monitoring-program-to-izmir.kl
- URBAN GreenUP Deliverable D5.3: City Diagnosis and Monitoring Procedures https://www.urbangreenup.eu/insights/deliverables/d5-3-city-diagnosis-and-monitoringprocedures.kl

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 7	Challenge name: Biodiversity
KPI no.: 53	KPI name: Density and seasonal spread of floral resources for pollinators.

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Increase in density and seasonal spread of floral resources for pollinators.

NBS relevant to KPI	
	- Urban arboretum - Green corridors - Verges and space for pollination - Pollinations walls/ vertical for pollination - Wildlife park - Urban forest - Intensive green roofs

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Field surveys	- Quantitative	- Counting of species

MEASUREMENT UNIT	FREQUENCY
- % change	- Once a year, pre intervention and at 1- and 2-years post intervention

METHOD

Ecological surveys of selected taxa at NBS locations pre intervention and at 1- and 2-years post intervention.
Analysis of survey data using standard software (Excel/R).

References

URBAN GreenUP project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 7	**Challenge name: Biodiversity**
KPI no.: 54	**KPI name: Number of non-native species introduced.**

Type of KPI	**Scale**
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Proportion of non-native animal and/or plant species introduced within an area as part of a nature based solution scheme.
Non-native species are those that have been transported to regions beyond their natural range. In terms of biodiversity objectives, these species can:

- create a risk of harm if they become invasive;
- provide biodiversity benefits (e.g., complementing native species provision to extend flowering seasons for nectar and pollen collecting insects)
- reduce the number of native species within a scheme.

NBS relevant to KPI	- Compacted Pollination's modules - Wildlife park - Urban forest - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE**
- Survey data	- Quantitative	- Field survey

MEASUREMENT UNIT	**FREQUENCY**
- % of species in a defined area	- Typically, annual but can be less frequent if resources are stretched.

METHOD

Proportion is calculated based on the number of non-native species divided by the total number of species (i.e., the number of non-native species plus the total number of native species).

References

- CONNECTING Nature project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 7	Challenge name: Biodiversity
KPI no.: 55	**KPI name: Number of invasive alien species.**

Type of KPI	**Scale**
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Proportion of invasive alien species within an area.
Provides an overview of the prevalence of potentially harmful species within a defined area (site/neighbourhood/region/city).

NBS relevant to KPI	- Urban arboretum - Green corridors - Verges and space for pollination - Pollinations walls/ vertical for pollination - Wildlife park - Urban forest - Intensive green roofs

DATA AND MEASUREMENT

REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE**
- Survey data	- Quantitative	- Field survey

MEASUREMENT UNIT	**FREQUENCY**
- % of species in a defined area	- Typically annual but can be less frequent if resources are stretched.

METHOD

Proportion is calculated on the basis of the number of invasive alien species divided by the total number of species (i.e., the number of invasive alien species plus the total number of native species).

References

- CONNECTING Nature project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 7	Challenge name: Biodiversity
KPI no.: 56	**KPI name: Plant species richness.**

Type of KPI	**Scale**
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Increase in plant species richness and functional diversity as a result of NBS.

NBS relevant to KPI	- Urban arboretum - Green corridors - Verges and space for pollination - Pollinations walls/ vertical for pollination - Wildlife park - Urban forest Intensive green roofs

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Field surveys	- Quantitative	- Counting of species

MEASUREMENT UNIT	FREQUENCY
- % change	- Once a year, pre intervention and at 1- and 2-years post intervention

METHOD

Ecological surveys of selected taxa at NBS locations pre intervention and at 1- and 2-years post intervention.
Analysis of survey data using standard software (Excel/R).

References

- URBAN GreenUP project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 7	Challenge name: Biodiversity
KPI no.: 57	**KPI name: Percentage of private green areas in the city area.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

High rate of private green areas cause that city has no influence on the greens management within the city.
Definition: Percentage of private green areas in the city area.

NBS relevant to KPI	
	- Sensory garden - Climate smart greenhouses

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- GIS data - town planning department data	- Quantitative	- GIS databases - town planning department

MEASUREMENT UNIT	FREQUENCY
- % of private green areas in the city area	- Annual

METHOD

Percentage of private green areas in the city area = (Area of private green areas in the city / Total area of green areas) x 100%.

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 7	Challenge name: Biodiversity
KPI no.: 58	**KPI name: Number of veteran trees per unit area.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

In addition to the multifunctional benefits that are provided by trees, veteran trees play a crucial role in the conservation of biodiversity. An effective measure of conservation of veteran trees is the number of such trees within a unit area (e.g., Formal Urban Area).
Although not as old as ancient trees provide holes, cavities and crevices which are especially important for wildlife. In particular, trees with decay containing cavities are important habitats for many saproxylic invertebrate species. As such, targets and measures of number of veteran trees in a landscape can contribute to the biodiversity conservation objectives and strategies.
Whilst provision of nature-based solutions rarely created new veteran trees (due to long time-sales involved in veteran tree development), nature-based solutions can protect veteran trees, deliver veteranisation of young trees, or cause the loss of veteran trees. As such, this represents a valuable biodiversity indicator.

NBS relevant to KPI	
	- Wildlife park - Urban forest - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- background maps (e.g., Ordnance Survey Maps) and - ground-truthed GPS point source data to represent each individual veteran tree - satellite imagery	- Quantitative and spatial	- Satellite imagery and maps

MEASUREMENT UNIT	FREQUENCY
- % of species in a defined area	- Once a baseline spatial dataset of canopy cover has been established, it may be possible to update the regularly using satellite imagery. This is particularly to case for individual trees in urban/pasture settings. Veteran trees as part of woodland canopies would require ground truthing surveys which, due to their resource intensity, are generally carried out less frequently. Under such a scenario survey should be repeated at 5 yearly intervals or less.

METHOD

Standard veteran tree identification and mapping protocols have been developed. An example of this from the UK was developed by Treeworks (1996). This protocol supports the identification, characterisation, and mapping of veteran tree networks. The protocol is based on field survey and subsequent mapping.

References

- CONNECTING Nature project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 8	**Challenge name: Ecosystem connectivity**
KPI no.: 59	**KPI name: Proportion of natural areas within a defined urban zone.**

Type of KPI	**Scale**
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Biodiversity is the measure of biological variety in the environment, and it has an important role in functioning ecosystems services and health of environment and society. Biodiversity is an aspect of natural environment that is most directly affected by anthropogenic influence. City biodiversity is seen as an important aspect of sustainable and resilient urban development. Natural areas are defined as ecosystems, which are not significantly influenced by human actions and comprise mainly of native species in natural environments. Such environments are important in preserving biodiversity as natural areas typically harbour much larger biodiversity than urban or constructed green spaces.
Proportion of natural areas within a defined urban zone (fraction or %).

NBS relevant to KPI

- Ground-based
- Pollinator roofs greening
- Urban farming
- Floating gardens
- Community gardens
- Trees renaturing parking
- Urban forest/park
- Urban arboretum
- Green corridors/roofs
- Residential parks
- Sensory garden
- Trees trenches and bioswales
- Wildlife park
- Sustainable drainage systems (SuDS)

DATA AND MEASUREMENT

REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE**
- Data on zones in natural or naturalized condition in the urban area of interest from, e.g., government agencies, municipalities, nature groups, universities, etc.	- Quantitative	- Satellite images (e.g. Google Maps) - GIS databases

MEASUREMENT UNIT	**FREQUENCY**
- Fraction or %	- Annually

METHOD

The area can be calculated using mapping tools, including satellite images from Google Maps. Calculate the share of the sum of natural and naturalized areas to the total area to get the indicator value. Natural areas include forests, swamps, streams, lakes, etc., but exclude parks and green infrastructure. Re-naturalized areas can be included.

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 8	Challenge name: Ecosystem connectivity
KPI no.: 60	**KPI name: Public green space distribution.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Public greenspace in cities contributes to quality of life in terms of environmental services and social and psychological services. Public greenspace distribution can therefore be an important factor for making a city sustainable. Decisions on where to create greenspace/NBS should be based on criteria related to maximizing the equitability of distribution, focusing on areas lacking greenspace and in areas where ES valuation identifies greatest benefit/need.

Data on public greenspace distribution generated in these ways can be used to:

- Quantify the benefits of a nature-based solution project in terms of improving the distribution of public greenspace;
- Support the planning of new nature-based solution greenspace initiatives;
- Underpin other indicators that require an understanding of greenspace distribution as a foundation (e.g., green space provision and availability).

Measure of the distribution of public greenspace (total surface or per capita) and categories (i.e., street trees, residential gardens, school green areas, parks) using more applied and participatory approaches as an index to increase quality/quantity of green/blue existing, restored and new NBS with a high degree of multifunctionality (informed by ES Valuation e.g., includes cultural ES value, needs of residents, socio-economics etc.) and adapted to the type of urban area (e.g., size of urban area/landscape structure).

NBS relevant to KPI	
	- Community gardens - Urban farming - Ground-based greening

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Required data will depend on selected methods, for further details on applied and earth observation/remote sensing metrics refer to Connecting Nature Indicator Metrics Reviews Env23_Applied and Env23_RS.	- Data input types will be dependent on selected methods, for further details on applied or earth observation/remote sensing metrics refer to Connecting Nature Indicator Metrics Reviews Env23_Applied and Env23_RS.	- Data source will depend on selected methods

MEASUREMENT UNIT	FREQUENCY
- Total surface or per capita	- Data collection frequency will be dependent on selected methods, for further details on applied or earth observation/remote sensing metrics refer to Connecting Nature Indicator Metrics Reviews Env23_Applied and Env23_RS.

METHOD

A variety of methods exist from applied/public participation techniques through to earth observation/remote sensing approaches. For further details on measurement tools and metrics, including those adopted by past and current EU research and innovation projects, refer to Connecting Nature Indicator Metrics Reviews Env23_Applied and Env23_RS.

References

- Connecting Nature project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 8	Challenge name: Ecosystem connectivity
KPI no.: 61	**KPI name: Community Garden area.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Community garden area provide active interaction with nature and opportunities for social cohesion (a measure of per capita garden area per target distance). Community gardens deliver a social function.

NBS relevant to KPI	
	- Green corridors - Urban rooftop farming - Sensory garden - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Satellite/map data	- Quantitative	- Satellite/map data

MEASUREMENT UNIT	FREQUENCY
- m2 per capita	- Annually

METHOD

A method based on mapping and GIS modelling of the accessibility of a community garden.

References

- Connecting Nature project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 8	Challenge name: Ecosystem connectivity
KPI no.: 62	KPI name: Ratio of open spaces to build form.

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Brownfield land refers to urban developed areas that are currently idle. Typically, they are sites of previous commercial or industrial activities, which might have detected or suspected pollution and soil contamination problems, hindering their future development. Redeveloping brownfields can safe pristine green spaces from development as well as reclaim unused spaces into meaningful application (University of the West of England [UWE] Science Communication Unit, 2013).

NBS relevant to KPI	
	- Floating garden - Green covering shelters - Green roof (intensive or extensive) - Green corridors - Sustainable drainage system (SuDS) - Trees trenches and bioswales

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Percentage of brownfield sites redeveloped to be used each year - Absolute area of identified remaining brownfield sites	- Quantitative	- Percentage of brownfield sites redeveloped to be used each year - Absolute area of identified remaining brownfield sites

MEASUREMENT UNIT	FREQUENCY
- Reclamation of contaminated land (brownfields), expressed as total area, area per capita or % of contaminated area reclaimed	- Annually

METHOD

The metric for brownfield reclamation is the proportion of brownfield redeveloped each year into use, and the absolute area of identified brownfield remaining. The indicator is simple and easy to calculate and provides a measure that can be easily followed. The definition and classification of areas as brownfield is not rigorously defined, and thus comparison between areas and countries can be misleading without closer case studies.

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 8	Challenge name: Ecosystem connectivity
KPI no.: 63	**KPI name: Benefits provided pre and post interventions.**

Type of KPI	Scale
☒ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Assessment of typology, functionality and benefits provided pre and post interventions.

NBS relevant to KPI	
	- Floating garden - Green covering shelters - Green roof (intensive or extensive) - Green corridors - Sustainable drainage system (SuDS) - Trees trenches and bioswales - Community gardens - Urban farming

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- GIS maps - Surveys	- Quantitative - Qualitative	- GIS maps - Surveys

MEASUREMENT UNIT	FREQUENCY
- m or km of each type of NBS - Likert scale measures (e.g. very poor to excellent) - Frequency count statistics	- Before and after introducing NBS

METHOD

GIS mapping to identify the type and functionality of NBS in each site.
Surveys examining engagement with NBS, perceptions, quality of life, and types of use of NBS will also be used to define benefits and functionality of NBS pre- and post-interventions.
Social Survey - Calculated with questionnaire and standard software (Excel or SPSS).

References

- Urban GreenUP project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 8	Challenge name: Ecosystem connectivity
KPI no.: 64	**KPI name: Edge density of Green Urban Areas (GUAs).**

Type of KPI	**Scale**
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Within cities, green areas may not be equally distributed. An uneven distribution of GUAs prevents equal accessibility for all city dwellers, focuses benefits from exposure on fewer city elements (neighbourhoods, streets, buildings or houses) and prevents connectivity of all the available green spaces in the ecological network.
The edge density provides an indication of the distribution of GUAs. A high edge density in a city indicates a relatively high number of green areas that border residential, commercial, and industrial or other public buildings. Consequently, a higher value for the indicator may be due to a long boundary length, i.e., more small patches.
This measure provides a proxy for the equal or non-equal distribution of green urban areas in the city. Increasing the green area and distributing it more evenly is an effective measure in reducing the undesired effects of clustered urban green areas.
Relationship between green area boundaries (edges) and all the other elements present in the city.
The total length of the edges is compared with the city's urban area (m/ha)

NBS relevant to KPI	
	- Floating garden - Green covering shelters - Green roof (intensive or extensive) - Green corridors - Sustainable drainage system (SuDS) - Trees trenches and bioswales

DATA AND MEASUREMENT

REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE**
- Copernicus Urban Atlas (or any land use data set)	- Quantitative and spatial	- Copernicus Land Monitoring Service with public access

MEASUREMENT UNIT	**FREQUENCY**
- m/ha	- Every 6 years. Currently available for 2006, 2012 and 2018.

METHOD

Green urban areas are based on several classes (11230, 11240, 14100, 14200, 20000, 30000) of the Urban Atlas data, which contain substantial green spaces (the two least dense residential classes with a sealing degree < 30 %, urban parks, sports and leisure facilities, forest, seminatural and agriculture). It is computed for the core city as defined by Eurostat/Urban Audit.
The indicator is based on the edge density metric. Length of the green urban area perimeter (in metres) is divided by the urban area (in hectares).
Minimum mapping unit 0.25 ha is required. Note: In 2020, the Copernicus Urban Atlas data was used and hence the MMU was improved to 0.25 ha.

References

- Indicators for urban green infrastructure (EEA)

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 8	Challenge name: Ecosystem connectivity
KPI no.: 65	**KPI name: Distribution of blue space.**

Type of KPI	**Scale**
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Measuring blue space change in urban areas can provide an index representing the degree of nature conservation, and improving public health and quality of life, as they are directly related to the natural water circulation, environmental purification and the green/blue network. More green and blue space also reduces vulnerability to extreme weather events like urban heat islands and flooding by heavy rainfall. Blue space area can be used as an indicator of these environmental, social and economic benefits.
In addition to ground-truth mapping, in order to characterise urban blue infrastructure and assess changes of different blue space types over varying time periods different remote sensing techniques and GIS can be used. The most common use of RS data is for the purpose of greenness identification.
Many of these metrics are equally applicable to blue spaces.
Data on blue space area collected in these ways can be used to:

- Quantify the distribution of blue space across target areas;
- Support the equitable distribution of blue space through urban planning for environmental, social and economic benefits;
- Provide underpinning data for other indicators such as ecosystem service mapping, stormwater management, biodiversity mapping, etc.

Measure change in blue space (ponds, rivers, lakes) in urban area (%, hectares or ha/100km) due to NBS based on more applied and participatory methods.

NBS relevant to KPI	
	- Wildlife park - Pollinator roofs - Sensory garden - Floating gardens - Trees renaturing - Urban arboretum parking - Urban forest/park - Residential parks - Green corridors/roofs - Sustainable drainage systems (SuDS) - Trees trenches and bioswales

DATA AND MEASUREMENT

REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE**
- Required data will depend on selected methods, for further details on applied and earth observation/remote sensing metrics refer to Connecting Nature Indicator Metrics Reviews Env23_Applied and Env23_RS.	- Data input types will be dependent on selected methods, for further details on applied or earth observation/remote sensing metrics refer to Connecting Nature Indicator Metrics Reviews Env23_Applied and Env23_RS.	- Data source will depend on selected methods

MEASUREMENT UNIT	**FREQUENCY**
- %, hectares or ha/100km	- Data collection frequency will be dependent on selected methods, for further details on applied or earth observation/remote sensing metrics refer to Connecting Nature Indicator Metrics Reviews Env23_Applied and Env23_RS.

METHOD

A variety of methods exist from applied/public participation techniques through to earth observation/remote sensing approaches. For further details on measurement tools and metrics, including those adopted by past and current EU research and innovation projects can be found in: Connecting Nature Indicator Metrics Reviews Env56_Applied and Env56_RS.

References

- Connecting Nature project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

<table>
<tr><td>Challenge no.: 8</td><td colspan="2">Challenge name: Ecosystem connectivity</td></tr>
<tr><td>KPI no.: 66</td><td colspan="2">KPI name: Effective green infrastructure at the urban-rural interface.</td></tr>
<tr><td colspan="2">Type of KPI</td><td>Scale</td></tr>
<tr><td colspan="2">☐ Descriptive
☒ Assessment/Modelled
☐ Monitoring</td><td>☒ City
☒ Neighbourhood/district
☐ Pilot/site</td></tr>
<tr><td colspan="3">Brief Description/definition of KPI

Green infrastructure at the fringes of cities performs similar ecosystem services to that in inner urban areas, though direct benefits from urban-rural interactions are highlighted. Green spaces in the peri urban area may improve air quality and mitigate climate change. A well-connected network of green elements, which form ventilation channels, facilitates the circulation of fresher and cleaner air from the periphery into the city. The vegetated ventilation network may reduce traffic emissions, mitigate noise and provide a cooling effect.
Open areas at the urban fringe may favor species richness. These natural and semi-natural areas generally host a diversity of landscapes, as they are dynamic locations surrounded by a variety of land uses. Moreover, GI elements may be used to join urban areas with the neighbouring countryside. This improved connectivity may support the functioning of ecosystems, both urban and rural, mitigating the negative effects of the built environment.
Moreover, the urban-rural interface forms a vital recreational and cultural pool for urban society that is equally connected to nature and the countryside.
Percentage of potential green infrastructure on the peri urban area.</td></tr>
<tr><td colspan="2">NBS relevant to KPI</td><td>- Wildlife park - Pollinator roofs
- Sensory garden - Floating gardens
- Trees renaturing - Urban arboretum parking
- Urban forest/park - Residential parks
- Green corridors/roofs - Sustainable drainage systems (SuDS) - Trees trenches and bioswales</td></tr>
</table>

<table>
<tr><td colspan="3">DATA AND MEASUREMENT</td></tr>
<tr><td>REQUIRED DATA

- Copernicus Urban Atlas (or any land use data set)</td><td>INPUT TYPE

- Quantitative and spatial</td><td>DATA SOURCE

- Copernicus Land Monitoring Service with public access</td></tr>
</table>

MEASUREMENT UNIT	FREQUENCY
- %	- Every 6 years (2000, 2006, 2012, 2018).

<table>
<tr><td>METHOD</td></tr>
<tr><td>The delineation of potential green infrastructure in the peri urban area is based on a proximity analysis of selected Corine land cover classes associated with green infrastructure (EEA, 2006; EEA, 2014).
The proximity analysis follows the Corilis methodology (EEA, 2006). This method uses the gridded structure of the data to measure the potential or influence of a given land cover type in the area around the place where it is found, using a weighting distance function. The approach assumes that the influence of a given land parcel on its surroundings declines with increasing distance. Thus, the methods can be used to produce scaled maps with cell values ranging from 0 to 100 to show the degree of influence that the distribution of a stock of a given cover type has on its neighbourhood. Intensity maps are generated after weighting values of neighbouring cells.
In order to be as restrictive as possible, the spatial smoothing is applied to a radius of 1 km, which means that all neighbouring green infrastructure elements within a distance of 1 km will be considered to influencing on each point of the territory. Several previous tests revealed that the selected threshold to represent the green potentiality is to be set on a minimum of 70%.
Note: In 2020, the Copernicus Urban Atlas data was used and hence the minimum mapping unit was improved to 0.25 ha.</td></tr>
<tr><td>References</td></tr>
<tr><td>- Indicators for urban green infrastructure (EEA)</td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 8	Challenge name: Ecosystem connectivity
KPI no.: 67	**KPI name: Total vegetation cover.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Total vegetation cover is the percentage of soil which is covered by green vegetation.

NBS relevant to KPI	
	- Floating garden - Green covering shelters - Green roof (intensive or extensive) - Green corridors - Trees trenches and bioswales

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- GIS/Project Data	- Quantitative	- GIS/Project Data

MEASUREMENT UNIT	FREQUENCY
- %	- Annually

METHOD

Soil covered by assemblage of plant species and the ground, without specific reference to particular taxa, life forms, structure, spatial extent, or any other specific botanical or geographic characteristics (GIS).

References

- PHUSICOS project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 9	Challenge name: Gender
KPI no.: 68	KPI name: Involvement of citizens from traditionally underrepresented groups.

Type of KPI	Scale
☒ Descriptive ☐ Assessment/Modelled ☐ Monitoring	☐ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

The indicator is showing the extent to which the NBS project has led to the increased participation by groups of people who are typically not well represented in the society. Among these groups the following are under consideration: women and girls, children, refugees, internally displaced persons, stateless persons, national minorities, indigenous people, migrant workers, disabled persons, elderly persons, differently gendered people (LGBTQ+). The performance of a particular NBS project is meant with regard to the participation of vulnerable or traditionally under-represented groups.

NBS relevant to KPI	- Green corridors - Urban rooftop farming - Sensory garden - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Information used to evaluate the performance of a particular NBS project with regard to the participation of vulnerable or traditionally underrepresented groups. Interviews during the project	- Qualitative	- Survey

MEASUREMENT UNIT	FREQUENCY
- 1-5 scores	- Before and after implementation of NBS

METHOD

The indicator is of qualitative character. Can be measured in a five-point scale. Participation of groups not well represented in a society is measured in a scale from: 1 – the project has not increased participation of these groups,
2 – the project has achieved a little in terms of increasing participation of these groups,
3 – the project has somewhat increased the level of participation of these groups,
4 - the project has significantly increased the level of participation of these groups,5 – the project has caused huge improve the level of participation of these groups.
The assessment of this scale can be made basing on the documentation of the project of NBS including description of various kinds of forms of public involvement in the process of the NBS implementation.

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 9	Challenge name: Gender
KPI no.: 69	**KPI name: REC-Recognition.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Recognition: how has attention been given to a diversity of voices and/or a diversity of participants in the process around this NBS? What can we know about the diversity of those affected by this particular NBS?
In the process from designing an intervention (NBS) until after its
implementation and maintenance, questions about recognition of diversity refer to the acknowledgement of diverse needs and ambitions, with particular attention to vulnerable groups that are prone to exclusion (e.g. migrants, women, children, elderly, people with disabilities, people suffering from deprivation). Put the other way around, a lack of recognition of diverse needs undermines the quality of the participatory process and undermines possibilities for a fair distribution.

NBS relevant to KPI	
	- Green corridors - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Data on diversity of backgrounds, needs, perspectives, types of knowledge and related understandings of NBS among all stakeholders	- Qualitative	- meeting with stakeholders, public consultations

MEASUREMENT UNIT	FREQUENCY
- n/a	- Annually

METHOD

Unit of analysis can be the individual and individual perspectives; or social groups; socially shared accounts/discourses. In evaluating the process of realizing an NBS: address to what extent a diversity of voices, perspectives, needs and social groups that affect and/or are affected by this process and its outcome, have been involved. Particular attention to be paid to vulnerable groups (e.g. children, migrants, women, lowly educated groups, etc.). In assessing the impact of an NBS, addressing how it affects (caters for the needs of) these diverse groups of stakeholders and social groups or individuals.

References

- Nature4cities 600 project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 9	Challenge name: Gender
KPI no.: 70	**KPI name: Consciousness of citizenship.**

Type of KPI	Scale
☒ Descriptive ☐ Assessment/Modelled ☐ Monitoring	☐ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

The indicator shows the performance of NBS project in increasing of the consciousness of citizenship. The consciousness of citizenship is meant as being aware of how the community functions and understanding the individual's role in the community. As such, consciousness of citizenship contributes to a sense of community.
Conscious citizenship is developed by creating the conditions to expand awareness of social, global and environmental conditions while being empowered to assume personal responsibility, by engaging in, committing to and initiating positive impact, to ultimately improve life and living on the planet. A conscious global citizen "sees" the interconnection of one's own actions and the consequences of these and strives towards a higher purpose of creating harmonious and optimal living. Therefore, NBS project can contribute to increasing of consciousness of citizenship.

NBS relevant to KPI	
	- Green corridors - Urban rooftop farming - Sensory garden - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Information used to evaluate the performance of a particular NBS project with regard to increasing the consciousness of citizenship. Interviews during the project	- Qualitative	- Survey

MEASUREMENT UNIT	FREQUENCY
- 1-5 scores	- Before and after implementation of NBS

METHOD

The indicator is of qualitative character.
Can be measured in a five-point scale. The level of increase of consciousness of citizenship is measured in a scale from:

No increase – 1 – 2 – 3 – 4 – 5 – 6 – 7 – High increase

1. None: The NBS project has made no effort to increase civic consciousness.
2. Little: The NBS project has made a small effort to increase civic consciousness.
3. Somewhat: The NBS project has developed some initiatives to increase civic consciousness.
4. Significant: The NBS project has executed several activities to increase civic consciousness.
5. High: Increasing civic consciousness was (one of) the main goals of the NBS project and substantial effort has been made to enhance civic consciousness.

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 10	Challenge name: Age vulnerability
KPI no.: 71	**KPI name: Prevalence of attention deficit/ hyperactivity disorder (ADHD).**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Attention Deficit/Hyperactivity Disorder (ADHD) is the most commonly diagnosed behavioural disorder in children (Taylor and Kuo, 2011). A series of studies have documented reductions of symptoms of ADHD in children when they perform activities in green outdoor environments, independent of age, gender, income groups, community types or geographic regions (Kuo & Taylor, 2004). A walk of barely 20 minutes in a park holds more significant effects than a downtown or neighbourhood walk (Taylor & Kuo, 2011). Furthermore, children with ADHD who play regularly in green play settings were found to have milder symptoms than children who play in built outdoor and indoor settings (Taylor & Kuo, 2011). Authors report that only relatively open green spaces have this effect (Taylor & Kuo, 2011).

NBS relevant to KPI	- Sensory gardens - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- NBS characteristics for each city/site, nature of activities one can get involved into while engaging with nature, opportunities for play and physical exercise, etc. - Surveys results	- Quantitative	- Questionnaire - Surveys - Observation results - Research results - Surveys results

MEASUREMENT UNIT	FREQUENCY
- %	- After NBS implementation and aligned with timing of study design

METHOD

Strengths and Difficulties Questionnaires (SDQ, Goodman, 1997) is a behavioural screening questionnaire used to generate separate scores for conduct problems, emotional symptoms, and hyperactivity (Goodman, 1997). The SDQ asks about 25 attributes, 10 of which would generally be thought of as strengths, 14 of which would generally be thought of as difficulties, and one of which —" gets on better with adults than with other children"—is neutral. The 25 SDQ items are divided between 5 scales of 5 items each, namely Hyperactivity Scale, Emotional Symptoms Scale, Conduct Problems Scale, Peer Problems Scale, Prosocial Scale (See Goodman, 1997, p. 582 – items scoring).

Strengths and Difficulties Questionnaires (SDQ, Goodman, 1997)

Instruction: For each item (/.../), please mark the box for Not True, Somewhat True or Certainly True. It would help us if you answered all items as best you can even if you are not absolutely certain, or the item seems daft! Please give your answers on the basis of the child's behaviour over the last six months or this school year.

Questions: Considerate of other people's feelings / Restless, overactive. cannot stay still for long / Often complains of headaches, stomach-aches or sickness / Shares readily with other children (treats, toys, pencils, etc.) / Often has temper tantrums or hot tempers / Rather solitary, tends to play alone / Generally obedient, usually does what adults request / Many worries, often seems worried / Helpful if someone is hurt, upset or feeling ill / Constantly fidgeting or squirming / Has at least one good friend / Often fights with other children or bullies them / Often unhappy, downhearted or tearful / Generally liked by other children / Easily distracted, concentration wanders / Nervous or clingy in new situations, easily loses confidence / Kind to younger children / Often lies or cheats / Picked on or bullied by other children / Often volunteers to help others (parents, teachers, other children) / Thinks things out before acting / Steals from home, school or elsewhere / Gets on better with adults than with other children / Many fears, easily scared / Sees tasks through to the end. good attention span

References

- CONNECTING Nature project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 10	Challenge name: Age vulnerability	
KPI no.: 72	**KPI name: Quality of life for elderly people.**	

Type of KPI	**Scale**
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☐ City ☒ Neighbourhood/district ☐ Pilot/site
Brief Description/definition of KPI The indicator relates to the effects of NBS in form of satisfaction of elderly people resulting from positive perception of nature provided by NBS. It is also increased quality of life and well-being.	
NBS relevant to KPI	- Sensory gardens - Urban farming - Community gardens

DATA AND MEASUREMENT		
REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE**
- Periodic surveys	- Quantitative	- Surveys

MEASUREMENT UNIT	**FREQUENCY**
- % of satisfaction - Subjective rating on both aspects from 1 to 10	- After implementation of NBS

METHOD
Number of seniors using green area. Level of satisfaction. Both aspects measured by rating from 1 to 10.
References
- Urban GreenUP project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 11	Challenge name: Socio-economic
KPI no.: 73	**KPI name: Community involvement in planning.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Public participation in NBS project can concern several steps such as: creation, implementation, and management. It encompasses various forms and opportunities for citizens, nongovernmental organizations, businesses, and other stakeholders to take part in the whole process of NBS project. Citizens and other stakeholders' involvement in NBS process can serve as an example of an open transparent process and can influence other decision-making processes in a municipality. Public involvement is an indispensable element required in projects concerning various aspects of sustainable development planning and management.

NBS relevant to KPI	
	- Green corridors - Urban rooftop farming - Sensory garden - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Periodic surveys, Information on public participation processes during the planning phase of NBS project	- Qualitative	- Surveys

MEASUREMENT UNIT	FREQUENCY
- % of satisfaction - Subjective rating from 1 to 5	- Annually; at minimum, before and after NBS implementation

METHOD

A five-point Likert scale based on the ladder of citizen participation (Arnstein, 1969) can be used to assess the success of community involvement in NBS planning qualitatively. The Likert scale follows Arnstein's ladder from non-participation (1) through degrees of tokenism (2-3) to citizen empowerment via partnership (4) or citizen control (5):

No involvement — 1 — 2 — 3 — 4 — 5 — High involvement

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 11	Challenge name: Socio-economic
KPI no.: 74	**KPI name: Diversity of stakeholders involved.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

In co-design, co-implement and co-management of nature based solutions various stakeholders should participate on equal basis. Therefore five key audiences to be targeted as part of a coproduction process (Carayannis et al. 2012; Figure 2): 1) Education system (e.g. academia, higher education, schools, kindergartens); 2) Economic system (e.g. industry(ies), firms, services, banks, entrepreneurs); 3) Political system (e.g. national/local governments, policymakers, law makers, politicians); 4) Civil society and media (e.g. local communities, community groups, NGO's, mainstream and local media, environmental media); 5) Natural environments of society (e.g. NBS experts from NGO's, policy makers, political bodies, experts and opinion leaders on NBS).

NBS relevant to KPI	- Green corridors - Urban rooftop farming - Sensory garden - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Timesheets for each meeting/activity per participatory process	- Quantitative	- Surveys; Timesheets from meetings

MEASUREMENT UNIT	FREQUENCY
- %	- Every six months after each meeting to reflect on diversity

METHOD

At the beginning of the meetings organized during a coproduction/participatory process, stakeholders should be invited to sign a timesheet. The Indicator will be equal to the whole number of stakeholders involved during these meetings. In a second step, the stakeholders are categorised based on the role/position they took in the process. There are two options to categorise the diversity of stakeholders. The numbers per category are added up and the proportion of each group is calculated

References

- CONNECTING Nature project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 11	Challenge name: Socio-economic
KPI no.: 75	**KPI name: Investment cost for NBS (construction and equipment).**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Total of investment costs in €
- construction
- equipment
- other

NBS relevant to KPI	
	- Floating gardens - Wildlife park - Residential park - Urban park - Sensory garden - Urban forest - Green corridors

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Accounting record of beneficiaries	- Quantitative	- Accounting record of beneficiaries

MEASUREMENT UNIT	FREQUENCY
- EUR	- After completion of the investment

METHOD

Total of investment costs in €
- construction
- equipment
- other

References

- Ksenia project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 11	Challenge name: Socio-economic
KPI no.: 76	**KPI name: Perceptions of citizens on urban nature – Green spaces quality.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Perceptions of citizens on urban nature - Green spaces quality.

NBS relevant to KPI	- Climate adaptive garden - Green corridors - Green covering shelters - Urban park - Green shaded structures - Urban forest - Single line trees - Cooling trees - Green bus stop with selected plant species

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Answers from social surveys	- Quantitative - Qualitative	- Social Survey

MEASUREMENT UNIT	FREQUENCY
- Unitless	- Annually

METHOD

Qualitative and quantitative measures of awareness of NBS (and its social, economic, and ecological values). Plus, satisfaction survey of NBS investment and changes in environmental quality. Social Survey - Calculated with questionnaire and standard software (Excel or SPSS).

References

- Urban GreenUP project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

<table>
<tr><td>Challenge no.: 11</td><td colspan="2">Challenge name: Socio-economic</td></tr>
<tr><td>KPI no.: 8</td><td colspan="2">KPI name: Areas with high unemployment rate.</td></tr>
<tr><td colspan="2">Type of KPI</td><td>Scale</td></tr>
<tr><td colspan="2">☐ Descriptive
☒ Assessment/Modelled
☐ Monitoring</td><td>☒ City
☐ Neighbourhood/district
☐ Pilot/site</td></tr>
<tr><td colspan="3">Brief Description/definition of KPI Areas with high unemployment rate.</td></tr>
<tr><td colspan="2">NBS relevant to KPI</td><td>- Intensive green roof
- Urban farming</td></tr>
</table>

DATA AND MEASUREMENT		
REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE**
- Number of unemployment people - Areas	- Quantitative	- Labor Office

MEASUREMENT UNIT	FREQUENCY
- Number of unemployment people/area	- Annually

METHOD

The method consists in collecting data from the city office regarding the number of unemployed people and data about the district in which they live. These data will make it possible to determine areas with high unemployment rate.

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 11	Challenge name: Socio- economic
KPI no.: 78	KPI name: Children involved in environmental educational activities.

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

According to social-ecological theory, personal, environmental and social factors influence children's behaviour. Behaviour change requires environments and policies that support healthful and ecological choices, strong social norms and social support for healthful and ecological choices as well as motivation and education of Individuals to make those choices (Sallis et al. 2008). Sustainability education may include initiatives related to recycling, schoolyard habitat, rainwater harvesting and management, nutrition and health, waste reduction, etc. School learning gardens provide an opportunity to engage schoolchildren in practical tasks of food growing, which can stimulate children's curiosity and interest and deepen environmental participation (Williams and Brown 2012). Additionally, research shows that school gardening and active learning has positive impacts on academic achievements of schoolchildren (Wells et al. 2015).

NBS relevant to KPI	- Sensory gardens - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Data from observation - Number of school hours - Number of pupils and school results - Teachers impressions	- Quantitative - Qualitative	- Questionnaire - Surveys - Observation results

MEASUREMENT UNIT	FREQUENCY
- Unitless	- Once in the pre-intervention phase, once during the implementation, once after the intervention and the annually

METHOD

Scale of measurement: School
Children involved in environmental educational activities

1. Number of school hours spent on teaching about rainwater management and in preparing the information board

2. Number of pupils gaining an increased knowledge on plants, gardening, nature and sustainability due to a thematic inclusion in their curriculum, cumulated over project period (n)

3. Change in knowledge about natural cycles in pupils participating in aquaponic project in comparison to those who were not involved (better result in test in %).

Measurement procedure:

1. Observing the integration of the topic in education, curriculum and interviews.

2. Observations, fieldwork: counting, photographing, checklist.

3. Counting and comparing in regular intervals, the achievements in class tests are compared.

References

- CLEVER Cities project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 11	Challenge name: Socio-economic
KPI no.: 79	**KPI name: Citizen's awareness regarding urban nature ecosystem services.**

Type of KPI	Scale
☒ Descriptive ☐ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Awareness of environmental issues is a critical first step in creating support for environmental projects and programs. The extent to which a project has used opportunities to Increase citizen's awareness of urban nature and ecosystem services and educate urban citizens about sustainability and the environment.

NBS relevant to KPI	- Floating gardens - Wildlife park - Residential park - Urban park - Sensory garden - Urban forest - Green corridors

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Answers from surveys - Information about opportunities to increase citizens awareness of NBS and ecosystem services	- Qualitative	- Survey

MEASUREMENT UNIT	FREQUENCY
- Unitless	- Annually; at minimum, before and after NBS implementation

METHOD

The extent to which a project exploits opportunities to increase citizens' awareness of NBS and ecosystem services, or to more generally educate citizens about sustainability and the environment, can be evaluated using a five-point Likert scale (Bosch et al., 2017):

Not at all 1-2-3-4-5- Very much

1. Not at all: opportunities to increase environmental awareness were not taken into account in the project communication.

2. Poor: opportunities to increase environmental awareness were slightly taken into account in the project communication.

3. Somewhat: opportunities to, increase environmental awareness were somewhat taken into account in the project communication, at key moments in the project there was attention for this issue.

4. Good: opportunities to increase environmental awareness were sufficiently taken into account in the project communication; the project utilized many possibilities to address this issue in their communications.

5. Excellent: opportunities to increase environmental awareness were taken into account in the project communication; the project utilized every possibility to address this issue in both online and offline communications.

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 12	Challenge name: Cultural racial
KPI no.: 80	**KPI name: Access to cultural facilities.**
Type of KPI	**Scale**
☒ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☐ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Access to cultural facilities is an average journey time for residents on foot or average distance to cultural centres

NBS relevant to KPI	- Green bus stop with selected plant species

DATA AND MEASUREMENT		
REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE**
- Statistical data from municipality - Data from inventory of municipality - etc.	- Qualitative - Quantitative	- Statistical data from municipality - Questionnaire data

MEASUREMENT UNIT	**FREQUENCY**
- Distance in minutes - etc.	- Twice: before and after NBS implementation

METHOD
Statistical data from municipality; questionnaire data
References
- Urban GreenUP project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 12	Challenge name: Cultural racial
KPI no.: 81	KPI name: Number of new activities in the tourism sector in the study area.

Type of KPI	Scale
☒ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Some NBS projects could promote a new touristic development of rural and mountainous area in
many different ways: by creating a new qualified natural attraction (a riverside, a green infrastructure, a new sport trial in natural context), increasing accessibility to and/or connecting existing cultural heritage sites or landscape viewpoints. This could promote new activities in tourism sector (e.g., B&B, restaurants, café, and touristic guides).

This indicator is equal to the number of new activities in the tourism sector in the study area and gives information about the dynamism of tourism sector in the study area before the project will be implemented.

NBS relevant to KPI	
	- Intensive green roofs - Extensive green roofs - Wildlife park - Urban forest - Moss wall - Sensory garden

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Number of new activities - Data on new enterprises by categories of economic activities	- Quantitative	- Statistical Institute, Chamber of Commerce

MEASUREMENT UNIT	FREQUENCY
- Number - etc.	- Annual data

METHOD

The indicator could be also estimated in the Design Scenario, using a probabilistic scale (e.g., Likert Scale). It also will be assessed in a Long Term Scenario, considering data made available some years after NBS/Grey/Hybrid solutions have been implemented, computing the number of new activities in the tourism sector in the study area.

In the Baseline Scenario, the indicator can be calculated consulting data on new enterprises, counting the number of new activities related to tourism sector in the study area. In the Design Scenario, the indicator can be assessed adopting a five-point Likert item with categories "Very Poor", "Poor", "Average", "Good", and "Very Good to evaluate the likelihood of occurring the creation of new activities related to tourism sector in the study area. In the Long Term Scenario, the indicator will be calculated consulting data on new enterprises, counting the number of new activities related to tourism sector activities related to tourism sector in the study area.

References

- Likert Scale Definition, Examples and Analysis By Dr. Saul McLeod, published 2008, updated 2019

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 12	Challenge name: Cultural racial
KPI no.: 82	**KPI name: Number of visitors per day number that is seen as fully or partially connected to the NBS.**

Type of KPI	Scale
☒ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Many EU countries rely on tourism as a major contributor to the economy. Area improvements brought about by NBS implementation may provide increased incentives for visitors to the area, thereby increasing the number and amount spent by tourists.

NBS relevant to KPI	- Green bus stop with climbing plants

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Mean no. visitors/day per year to NBS area	- Quantitative	- Municipality or local statistics Chamber of Comers

MEASUREMENT UNIT	FREQUENCY
- Number of visitors to NBS area	- Annual data

METHOD

The increase (or decrease) in number of visitors per day that is seen as fully or partially connected to the NBS at a local or international level. Local or municipal monitoring of visitors.

References

- CONNECTING Nature project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 13	Challenge name: Health
KPI no.: 83	KPI name: Morbidity, Mortality and Years of Life Lost due to poor air quality.

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Air pollution has been related to numerous adverse health effects, typically expressed in several morbidity and mortality endpoints (see Costa et al., 2014). In particular, an increasing amount of epidemiological and clinical studies observes that exposure to air pollution is associated with increased risk of heart disease, myocardial infarction and stroke as well as lung cancer (e.g., Costa et al., 2014). While the impact of these health effects may appear low at the individual level, the overall public-health burden is sizable as the entire population is exposed (Pascal et al., 2011).

NBS relevant to KPI	
	- Green corridors - Moss wall - Urban park/forest - Urban arboretum - Residential park - Wildlife park - Green covering - Trees renaturing shelters parking - Green bus stop with selected plant- species

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- involved pollutants and their air concentration levels - health indicators analyzed in terms of morbidity and mortality - affected age group - exposure time	- Quantitative	- Central Statistical Office - Data from air pollution measurement stations

MEASUREMENT UNIT	FREQUENCY
- No. of years / No./y	- Daily, weekly, monthly or annually

METHOD

Reduction in years of life (y) due to premature mortality in comparison with standard life expectancy (Morbidity): Long-term (annual) incidence of chronic bronchitis due to poor air quality calculated using atmospheric NO_2 and PM_{10} data (Mortality): Long-term (annual) incidence of mortality due to poor air quality calculated using atmospheric $PM_{2.5}$, PM_{10}, O_3 and NO_2 data.

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 13	Challenge name: Health
KPI no.: 84	KPI name: Proportion of population exposed to ambient air pollution.

Type of KPI	Scale
☒ Descriptive ☒ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Proportion of population exposed to ambient air pollution in excess of threshold values during the preceding 12 months.

Air pollution has been related to numerous adverse health effects, typically expressed in several morbidity and mortality endpoints (see Costa et al., 2014). In particular, an increasing amount of epidemiological and clinical studies observes that exposure to air pollution is associated with increased risk of heart disease, myocardial infarction and stroke as well as lung cancer (e.g., Costa et al., 2014). While the impact of these health effects may appear low at the individual level, the overall public-health burden is sizable as the entire population is exposed (Pascal et al., 2011).
According to this the percentage of population exposed to ambient air pollution standards during the year is very important parameter

NBS relevant to KPI	
	- Urban arboretum - Urban forest - Green roof - Moss wall - Green corridors - Hedge

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Spatial distribution of population density - Spatial distribution of annual air pollutant concentrations - Spatial distribution of annual air pollution index	- Qualitative, - Quantitative	- Population/air quality monitoring/ spatial data / local or regional statistics

MEASUREMENT UNIT	FREQUENCY
- Population density inhabitant/m^2 or grid - annual air pollutant (PM2,5,PM10, SO_2, NO_2, CO,O_3) concentrations [μg/m^3] in grid - Air quality index in used scale or in descriptive form - % of population exposed to air pollution excess of annual air quality standards	- Annual data for population density and air pollutant concentrations - 1h air quality index

METHOD

To obtain quantitative value of this indicator it is necessary to collect statistic data on number of inhabitants and area from local administration (pilot, district, city), then using GIS system create the map on the spatial distribution of population in the investigated area (pilot, district, city) and calculate number of inhabitants per area (pilot, district, city).

For calculation of annual air pollutant concentrations, it is necessary to obtain measured data from local/regional authority responsible for air pollution monitoring. Administrative bodies also produce the maps with spatial distribution of annual air pollutant concentrations with the marked areas of exceedance an annual air quality standards.

Using GIS methods imposition, the maps of spatial distribution of population and spatial distribution of annual air pollutant concentrations the number of population exposed to air pollution excess of annual air quality standards can be calculated as well as % of population exposed to air pollution excess of annual air quality standards.

References

- Leitat project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 13	Challenge name: Health
KPI no.: 85	KPI name: Exposure to noise pollution.

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Percentage of the population exposed to average day- evening- night noise levels (Lden)>55 dB (A). Prolonged exposure to noise, such as the environmental noise pollution caused by road, rail and airport traffic, industry, construction, and other outdoor activities, can lead to significant physical and mental health effects.
Environmental noise pollution is any disturbing noise that interferes with or harms humans or wildlife. The LDEN indicator has been defined several years ago by a European expert group, in order to compare different noise situations all over European cities (noise maps of people exposed to sound pollution) through the use of a single, common and harmonized indicator. Despite the assumptions and limitations of such energetic descriptors, the LDEN indicator is now stabilized and generalized. The LDEN is a daily equivalent sound pressure level (T=00h-24h), with a 0dB(A) penalty increase for the Day period (T=6h-18h), a 5dB(A) penalty increase for the Evening period (T=18h-22h) and a 10dB(A) penalty increase for the Night period (T=22h-6h).

NBS relevant to KPI	
	- Green walls - Green facade with climbing plants - Green noise barriers - Facade-bound greening - Green-based greening - Free standing living walss

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Population density/distribution - Noise level measurements (Lden) or modelled numerical prediction of noise distribution - Wind speed measurements	- Qualitative, - Quantitative	- In situ noise level measurements/modelled numerical predictions Lden / spatial data on noise level distribution /statistics on population/ Noise Reduction Action Plan

MEASUREMENT UNIT	FREQUENCY
- Decibels with A ponderation: dB(A) Lden - m/sec.	- Twice; once before the implementation of the nature-based solutions and once after.

METHOD

Measurements of noise level can be provided by integrating sonometer, either professional, low-cost or even smartphone http://noise-planet.org/noisecapture.html.
Measurements need acoustic acquisition (in dB(A)) on hourly periods (with typically 1 sec sampling rate), gathered on 3 periods (Day, Evening, Night) and next aggregated on 24h.

Simulated LDEN (numerical predictions) can be done using noise prediction software, e.g., opensource tool "NoiseModelling" http://noise-planet.org/noisemodelling.html

Obtain data on noise level from measurements in situ or from numerical modelling of noise propagation to environment should be compare with the data on number of inhabitants in neighbourhood/district and calculation of number of inhabitants exposed to noise as well as percentage exposed inhabitant to total number of inhabitants should be done.

References

- ISO 2018
- Urban GreenUP project
- Leitat project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 13	Challenge name: Health
KPI no.: 86	**KPI name: Distribution of public green space – total surface or per capita.**

Type of KPI	**Scale**
☒ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

This is indicator showing availability of public green spaces for inhabitants, what has serious consequences for the psychological well-being of individuals and influence on assessment of the quality of life. Availability green space in neighbourhood due to many investigations show positive impact on health and comfort of life. It influents also on frequency of visits to and time spent in different types of green and blue spaces, separately for spring-summer and autumn-winter. Visual access to green space and short-term looking at green spaces could have mental health benefits such as reducing stress, restoring attention, and improving mood.

NBS relevant to KPI	
	- Ground-based - Pollinator roofs greening - Urban farming - Floating gardens - Community gardens - Trees renaturing parking - Urban forest/park - Urban arboretum - Green - Residential parks corridors/roofs - Sensory garden - Trees trenches and bioswales - Wildlife park - Sustainable drainage systems (SuDS)

DATA AND MEASUREMENT

REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE**
- Surface of public green spaces in neighbourhood/district, - Total area of pilot/district/city - Population of pilot/district/city - Green corridor distance,	- Qualitative - Quantitative	- Urban Atlas /administrative spatial data /statistics/ questionnaire data

MEASUREMENT UNIT	**FREQUENCY**
- m^2 or ha - Distance in meters - Total number of inhabitants - Surface of green spaces/ capita	- Twice: before and after NBS implementation

METHOD

Indicator is calculated with Geographic Information Systems (GIS).
Area of influence of the specific actions (façade, noise barrier, etc.), calculated in a buffer to be determined, for example, 50 meters around the NBS.
Divide total surface between inhabitants.

References

- Local Agenda 21 of Valladolid - Sustainability indicators

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 13	Challenge name: Health
KPI no.: 87	KPI name: Animal species potentially at risk

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☐ City ☐ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

This indicator assesses the potential animal species exposed to risk and their protection.

NBS relevant to KPI	- Climate adaptative gardens - Urban park - Wildlife park - Urban forest

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Density of species - Extension of habitats	- Quantitative	- Literature data of density of species - GIS maps - Data from the Corine Land Cover Project

MEASUREMENT UNIT	FREQUENCY
- Nr/ha	- Annually

METHOD

The final formula of Domestic and Wild Fauna at Risk (DWFR), for each species and habitat type k results as:

$$DWFR = \frac{\sum i \sum j \delta_i \cdot h_j + L}{A}$$

Where:
δ_i is the density of the i-th specie living in the habitats in the study area exposed to risk [nr/ha]
h is the extension of the j-th habitat in the study area exposed to risk [ha]
L is the number of head of livestock living in the study area exposed to risk [nr]
A is the extension of the study area [ha]

References

- PHUSICOS project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 13	Challenge name: Health
KPI no.: 88	**KPI name: General wellbeing and happiness.**

Type of KPI	Scale
☒ Descriptive ☐ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Unpolluted natural environment has a significant (positive) impact on physical and mental wellbeing, which in turn could affect happiness; 3. natural environments might increase happiness by facilitating and encouraging - for practical, cultural and/or psychological reasons - behaviours that are physically and mentally beneficial, including physical exercise, recreation and social interaction.

Cross-disciplinary literature operates with a variety of concepts to delineate general wellbeing (WB) and happiness, such as (subjective) wellbeing (SWB), happiness, life satisfaction (LS), experienced utility, and quality of life (Larson, Jennings , & Coutier, 2016; MacKerron & Mourato, 2013). Cervinka, Röderer, and Hefler (2012).

Mackerron and Maurato (2013) distinguish three categories of SWB: evaluative SWB, in which people are asked for global assessments of their lives for example, their satisfaction with life as a whole eudemonic SWB, based on reports concerning flourishing, purpose and meaning in life , and the realization of one's potential, and hedonic or experienced SWB, based on reports of mood, affect or emotion, and representing the Utilitarian view of wellbeing as pleasure and pain.

NBS relevant to KPI	
	- Sensory gardens - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Data (answers) from questionnaire, surveys - NBS characteristics for each city/site, nature of activities one can get involved into while engaging with nature, opportunities for social interaction and for physical exercise	- Quantitative	- Questionnaire, surveys

MEASUREMENT UNIT	FREQUENCY
- Unitless	- After NBS implementation or aligned with timing of targeted (especially long-term) objectives.

METHOD

Scale of measurement: Satisfaction with Life

Instructions: Below are five statements with which you may agree or disagree. Using the 1-7 scale below, indicate your agreement with each item by placing the appropriate number on the line preceding that item. Please be open and honest in your responding. The 7-point scale is: strongly disagree, 2-disagree, 3-slightly disagree, 4-neither agree nor disagree, 5-slightly agree, 6-agree, 7strongly agree.

1. In most ways my life is close to my ideal.

2. The conditions of my life are excellent.

3. I am satisfied with my life.

4. So far I have gotten the important things I want in life.

5. If I could live my life over, I would change almost nothing.

References

- Connecting Nature project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 14	Challenge name: Housing
KPI no.: 89	**KPI name: Change in mean or median land and property value.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Change in mean or median land and property prices.

NBS relevant to KPI	- Trees renaturing parking - Green corridors - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Social Survey - Calculated with questionnaire and standard software (Excel or SPSS)	- Quantitative	- Data from questionnaire

MEASUREMENT UNIT	FREQUENCY
- EUR	- After completion of the investment

METHOD

Change in house/rental prices in NBS intervention areas using area assessment from property market data.

References

- Urban GreenUP project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 14	Challenge name: Housing
KPI no.: 90	KPI name: Perception of property betterment.

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

KPI is presenting the consumption benefits in form of perception of property betterment and visual amenity enhancement resulting from NBS.

NBS relevant to KPI	- Trees renaturing parking - Green corridors - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Social Survey – based on questionnaire	- Quantitative	- Data from questionnaire

MEASUREMENT UNIT	FREQUENCY
- %	- After completion of the investment

METHOD

Survey of the consumers perception measured in a scale:
low — 1 — 2 — 3 — 4 — 5 — High

References

- Urban GreenUP project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

<table>
<tr><td>Challenge no.: 14</td><td colspan="2">Challenge name: Housing</td></tr>
<tr><td>KPI no.: 91</td><td colspan="2">KPI name: GEN – Gentrification.</td></tr>
<tr><td colspan="2">Type of KPI</td><td>Scale</td></tr>
<tr><td colspan="2">☒ Descriptive
☐ Assessment/Modelled
☐ Monitoring</td><td>☐ City
☒ Neighbourhood/district
☒ Pilot/site</td></tr>
<tr><td colspan="3">Brief Description/definition of KPI

KPI is presenting the level of gentrification of an area in neighbourhood of NBS location. It is needed to extract the impact of a particular NBS on the gentrification, another words how much NBS contributes to the gentrification process.</td></tr>
<tr><td colspan="2">NBS relevant to KPI</td><td>- Green corridors - Urban farming
- Community gardens</td></tr>
</table>

<table>
<tr><td colspan="3">DATA AND MEASUREMENT</td></tr>
<tr><td>REQUIRED DATA

- Data on socio-demographic changes; economic and other trends (e.g. in real estate developments; land prices; housing developments)</td><td>INPUT TYPE

- Quantitative</td><td>DATA SOURCE

- Data on inequalities before, during and after the NBS intervention.</td></tr>
<tr><td>MEASUREMENT UNIT

- Descriptive</td><td colspan="2">FREQUENCY

- Before, during and after the NBS intervention.</td></tr>
</table>

<table>
<tr><td>METHOD</td></tr>
<tr><td>Desk/document-study
- Data collecting and analysis procedures like interviews, surveys, focus groups or group discussion reports; storytelling, diaries; (participant) observation;
- workshops and/or other participatory methods to collect peoples' accounts and corresponding methods of analysis. - GIS and mapping</td></tr>
<tr><td>References</td></tr>
<tr><td>- Nature4cities 622 project</td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 14	Challenge name: Housing
KPI no.: 92	**KPI name: Share of individual types of buildings in the total city area.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Share of individual types of buildings in the total city area.

NBS relevant to KPI	- Facade-bound greening - Sensory garden - Ground-bound greening - Community gardens - Free standing living wall - Climate smart greenhouses - Urban rooftop farming - Natural Pollination modules

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Data on the share of individual types of buildings in the total area of the city	- Quantitative	- Department of: architecture and construction, spatial planning and urban planning - Central statistical office

MEASUREMENT UNIT	FREQUENCY
- High number outbound commuters/area	- Annually

METHOD

The method consists for collecting statistical data of individual types of buildings in the total city area in departments with such data, and then calculating the percentage in specific area.

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 14	Challenge name: Housing
KPI no.: 93	**KPI name: Population mobility**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

For the purpose of this project we will consider population mobility to be:

The % of people whose last move was in the past one year, two years and five years.

NBS relevant to KPI	
	- Urban arboretum - Urban park - Residential park - Sensory garden - Green corridors - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Answers from questionnaires, surveys	- Quantitative	- Questionnaires - Surveys

MEASUREMENT UNIT	FREQUENCY
- Number of people - % of people	- Twice in life of project: before implementation and after implementation

METHOD

The method consists of collecting data by filling out the questionnaires, surveys. Respondents will answer the question: when was the last time that they moved and reason form moving. The survey includes % of people who moved one, two or five years ago.

References

- proGIreg project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 15	Challenge name: Jobs
KPI no.: 94	KPI name: Establishment of new businesses in the area surrounding NBS.

Type of KPI	Scale
☒ Descriptive ☐ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Urban regeneration can lead to improvement in the economic, physical, and social conditions of an area that has witnessed negative changes (Tallon, 2013). As such, it can include aspects such as development of business, housing, and a positive change on the community level (Tyler, Warnock, Provins, & Lanz, 2013). Nature-based solutions also provide a ground for 'Green businesses' to flourish (Organisation for Economic Co-operation and Development [OECD], 2013).

NBS relevant to KPI	- Trees renaturing parking - Green corridors - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Local database of new businesses	- Qualitative	- Local database

MEASUREMENT UNIT	FREQUENCY
- Unitless	- Continuous

METHOD

Calculation of the decrease in the amount of water used in irrigation, per green surface (NBS). Irrigations can be measured by models and by sensors

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 15	Challenge name: Jobs
KPI no.: 95	KPI name: Proportion of ground floor surface of buildings within a specified distance (300 m) from NBS used for commercial or public purposes

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☐ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

The atmosphere of a neighbourhood and its overall liveability are influenced by the use of ground floor spaces for commercial and public purposes. The availability of amenities not only enhances the consumer experience, but also contributes to successful retail and commerce by supporting small businesses and retailers (Arlington Economic Development, 2014). Residential and office buildings generally have the most potential for increased use of ground floor space.

NBS relevant to KPI	
	- Trees renaturing parking - Green corridors - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Data about ground floor space usage can be obtained from administrative documents and/or from interviews with the department for urban planning within the local municipality	- Quantitative	- Local database of new businesses, national statistical databases

MEASUREMENT UNIT	FREQUENCY
- %	- Continuous

METHOD

Proportion of ground floor surface of buildings within a specified distance (300 m) from NBS of at least 0.5 ha that is used for commercial or public purposes, expressed as percentage of total ground floor surface This metric is calculated as: (Ground floor space for commercial or public use (m2) / Total ground floor space (m2)) x 100.

This indicator may be limited to a defined urban area within a specific linear distance of 300 m from NBS of at least 0.5 ha in size (e.g., for consistency with Green space accessibility indicator), but may be extended to a greater linear distance in the case of large-scale NBS.

References

- UNaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 13	Challenge name: Jobs
KPI no.: 96	**KPI name: Changes in mean house prices/ rental markets.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Changes in mean house prices/ rental markets and their relationship between high quality green spaces and NBS and increased real estate values.

NBS relevant to KPI	
	- Trees renaturing parking - Green corridors - Urban farming - Community gardens

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- City official data - Real estate market data	- Quantitative	- Municipal Office - Real estate market

MEASUREMENT UNIT	FREQUENCY
- Change prices	- Before and after intervention of NBS

METHOD

The change in house/rental prices in NBS Intervention areas will be measured primarily using secondary analysis of property market data (assessments n Zoopla or similar). A full database of property market value will be collected prior to the interventions, and then monitored for a period of 2 years afterward, then analysed to determine if significant change in property values near the interventions has occurred. This will focus on changes in average rental or sale prices for apartments and houses within a 100 metre radius of the NBS interventions, a standard measure of used in such studies. This data will also be complemented by GI-Val calculations.

References

- URBAN GreenUp project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 15	Challenge name: Jobs
KPI no.: 97	**KPI name: Areas with high number inbound commuters/parking lots.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Areas with high number inbound commuters/parking lots.

NBS relevant to KPI	
	- Shade trees - Cooling trees - Green covering shelters - Green shaded - Trees renaturing structures parking

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Number of inbound commuters - Data from public transport companies - Answers from questionnaire, surveys	- Quantitative	- Public Transport Companies - Questionnaire, surveys

MEASUREMENT UNIT	FREQUENCY
- Number of inbound commuters	- Annually

METHOD

The method consists for collecting statistical data of people commuting to work by public transport and supplementing the data with a questionnaire survey to determine the number of people commuting to work by other means of transport, e.g. by cars.

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 15	Challenge name: Jobs
KPI no.: 98	KPI name: Areas with high number outbound commuters/ sleeping city issues.

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Areas with high number outbound commuters/ sleeping city issues.

NBS relevant to KPI	- Urban arboretum - Sensory garden - Residential park - Urban rooftop farming

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Data from public transport companies - Answers from questionnaire, surveys	- Quantitative	- Public Transport Companies - Questionnaire, surveys

MEASUREMENT UNIT	FREQUENCY
- High number outbound commuters/area	- Annually

METHOD

The method consists for collecting statistical data of number outbound commuters travellers by public transport and supplementing the data with a questionnaire survey to determine the number of outbound people commuting to work by other means of transport, e.g. by cars.

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 16	Challenge name: Crime
KPI no.: 99	**KPI name: CC-CRIME COUNTS.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Identifies different types of manmade events so as to control the occurrences of these events. Throughout time information can be used to monitor the changes in the number and types of events occurring at the NBS context. This information can feed into the decision-making process of the NBS governors.

NBS relevant to KPI	- Green corridors

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Average number of events per locality	- Quantitative	- Police data

MEASUREMENT UNIT	FREQUENCY
- Number of events	- Annual data

METHOD

It is a measurement method based on the number of events.

References

- Nature4cities 664 project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 16	Challenge name: Crime
KPI no.: 100	**KPI name: Crime reduction.**

Type of KPI	Scale
☐ Descriptive ☐ Assessment/Modelled ☒ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Crime reduction, through police reports and local authority data, is concerned with diminishing the number of criminal events and the consequences of crime.

NBS relevant to KPI	- Green corridors

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Average number of events	- Quantitative	- Police reports - Local authority data

MEASUREMENT UNIT	FREQUENCY
- Number of crimes per year	- Annual data

METHOD

Crime will be assessed around the location of the NBS (with 300m buffer) to assess whether increased landscaping has an impact in criminal behaviour. Based on police reports and local authority data for comparing the number of crimes over the years.

References

- Urban GreenUP project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 16	Challenge name: Crime
KPI no.: 101	**KPI name: PCFS – Percentage of citizens feeling safe.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

PCFS – Percentage of citizens feeling safe. To assess the perception of citizens safety.

NBS relevant to KPI	- Green corridors

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Answers from surveys, questionnaires	- Quantitative	- Questionnaires, surveys

MEASUREMENT UNIT	FREQUENCY
- %	- Annually

METHOD

Percentage of citizens feeling safe is assessed on the basis of questionnaires completed by residents.

Number of people answering that feel safe or very safe with respect to the total number of replies to the query.

References

- URBAN GreenUp project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 17	Challenge name: Mobility
KPI no.: 102	**KPI name: Proportion of road network dedicated to pedestrians and/or bicyclists.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Increase in pedestrian and bicycle traffic is regarded beneficial for its economic, environmental, health and life quality effects. Availability of pedestrian paths and bicycle lanes can decrease the dependency on automobile ownership and use and related costs, free space from automobile traffic and congestion, reduce air pollution, increase physical activity and related health benefits and improve social activity and interaction within communities.

NBS relevant to KPI	
	- Green corridors - Sensory garden - Single line trees

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Length of pedestrian and/or bicycling paths (e.g., from a map), - Length of the entire road network.	- Quantitative	- Spatial data

MEASUREMENT UNIT	FREQUENCY
- % of network	- Annual

METHOD

The proportion of road network dedicated to pedestrians and/or bicyclists is calculated as the total pedestrian/bicycle path length measured as a percentage of the total road network in the whole urban community in question. The pedestrian/bicycle paths are roads or lanes designated and marked for use by pedestrians and/or bicycles. The calculation can be performed from a map with adequate markings of path types and lengths, from which pedestrian/bicycle paths are summed. Pedestrian paths and bicycle routes can be considered together or separately, depending on the specific metric desired.

References

- UnaLab project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 17	Challenge name: Mobility
KPI no.: 103	KPI name: Increase in walking and cycling in and around areas of interventions.

Type of KPI	Scale
☒ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☒ Neighbourhood/district ☒ Pilot/site

Brief Description/definition of KPI

Increase in walking and cycling in and around areas of interventions.

NBS relevant to KPI	
	- Green corridors - Sensory garden - Single line trees

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Surveys results - GIS data	- Qualitative - Quantitative	- Surveys - Spatial data

MEASUREMENT UNIT	FREQUENCY
- % increase in use (hours, days, weeks) and changes in behaviour of use derived from participant responses	- Annual

METHOD

Surveys of local residents, users and businesses of their perceived and actual use of NBS for walking, cycling and other activities pre and post-investment (no Sensor / footfall sensor).
GIS to calculate changing use patterns.

References

- URBAN GreenUP project

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 17	Challenge name: Mobility
KPI no.: 104	**KPI name: Number of common bicycles available for public/number of inhabitants.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Number of common bicycles available for public/number of inhabitants.

NBS relevant to KPI	- Green corridors - Sensory garden - Single line trees

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Data of number of common bicycles available for public - Data of number of inhabitants	- Quantitative	- Department of: architecture and construction, spatial planning and urban planning - Central Statistical Office

MEASUREMENT UNIT	FREQUENCY
- Number of common bicycles available for public/number of inhabitants	- Annually

METHOD

The method consists on collecting data of the number of shared bicycles available to the public and number of inhabitants' data, and then determining the ratio of the number of shared bicycles to residents.

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 17	Challenge name: Mobility
KPI no.: 105	**KPI name: Length of public transport lines /km2 of the city area.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Length of public transport lines /km2 of the city area.

NBS relevant to KPI	- Green bus stop with selected plant species

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Length of public transport lines /km2 of the city area	- Quantitative	- Public Transport Company - Central statistical office

MEASUREMENT UNIT	FREQUENCY
- Length of public transport lines /km2 of the city area	- Annually

METHOD

The method consists on collecting data of the length of public transport lines per square kilometre of the city area.

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 17	Challenge name: Mobility
KPI no.: 106	**KPI name: Number of parking lots/number of inhabitants.**

Type of KPI	**Scale**
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI

Number of parking lots/number of inhabitants.

NBS relevant to KPI	- Shade trees - Trees renaturing parking - Green covering shelters - Green shaded structures - Cooling trees

DATA AND MEASUREMENT

REQUIRED DATA	**INPUT TYPE**	**DATA SOURCE**
- Number of parking lots - Number of inhabitants	- Quantitative	- Parking Management Department - Central Statistical Office - Spatial Planning Department

MEASUREMENT UNIT	**FREQUENCY**
- Number of parking lots per number of inhabitants	- Annually

METHOD

The method consists on collecting data of number of parking lots per number of inhabitants.

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818

Challenge no.: 17	Challenge name: Mobility
KPI no.: 107	**KPI name: Number of cars/ 1000 inhabitants.**

Type of KPI	Scale
☐ Descriptive ☒ Assessment/Modelled ☐ Monitoring	☒ City ☐ Neighbourhood/district ☐ Pilot/site

Brief Description/definition of KPI Number of cars/ 1000 inhabitants.

NBS relevant to KPI	
	- Green corridors - Single line trees

DATA AND MEASUREMENT

REQUIRED DATA	INPUT TYPE	DATA SOURCE
- Number of cars - Number of inhabitants	- Quantitative	- Parking Management Department - Central Statistical Office - Spatial Planning Department

MEASUREMENT UNIT	FREQUENCY
- Number of cars per 1000 inhabitants	- Annually

METHOD

The method consists on collecting data of number of cars per 1000 inhabitants.

References

- IETU

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101003818