URBAN GreenUP

D5.1: Technical KPIs Definition

WP 5 , T 5.1

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Authors: Jesús Ortuño (GMV), José Fermoso (CARTIF)

URBAN GreenUP

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Technical References

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[1] PU = Public

PP = Restricted to other programme participants (including the Commission Services)

RE = Restricted to a group specified by the consortium (including the Commission Services)

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Versions

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Table of Content

List of Tables

List of Figures

0 Executive summary

This deliverable defines a set of KPIs (key Performance Indicators) that will be used to assess the methodology defined in Work Package 1 (WP1): renaturing city methodology and also in each demonstration city diagnosis and baseline being developed (WP2, Valladolid; WP3, Liverpool; WP4, Izmir), where the projected NBS (Nature Based Solutions) are related to both a challenge (below) and to KPIs.

In this document the methodology shall be approached by defining the main challenges and goals that will draw directly from the Eklipse Mechanism; a self-sustained mechanism under the umbrella of the European Union's Horizon 2020.

The KPIs are based on the Eklipse mechanism framework, where a robust set of KPIs shall be selected and established by challenges that relate to NBS. These challenges are:

- Climate mitigation & adaptation
- Water Management
- Coastal Resilience
- Green Space Management
- Air Quality
- Urban Regeneration
- Participatory Planning and Governance
- Social Justice and Social Cohesion
- Public Health and Well-being
- Potential of economic opportunities and green jobs
- Other challenge/s

This document will provide a detailed definition of calculation formulas and indices in order to measure and evaluate the accuracy and quality of the Key Performance Indicators.

1 Introduction

This deliverable comes from the task 5.1 "Technical KPIs definition" which was described in the proposal agreement (H2020-SCC-2016-2017, 730426-2) document as:

> *"According to methodology detailed in WP1, each city diagnostics will cover the dimensions of infrastructure and environment, man-made and natural ones that provide critical services regarding climate and water resilience.*
>
> *In this sense, specific goals will be agreed to assess climate change related effects –e.g. heat islands, river floods, sea level rise-. Given those goals, this task will define a wide range of Key Performance Indicators –e.g. noise, pollution, humidity, day and night temperature, river water levels, water quality, soil quality, soil salinity, etc.- and associated technical methods to measure them so that cities gets different alternatives and thus implementation possibilities.*
>
> *Among the foreseen technical methods, it will be contemplated in-situ, UAV-based and space-based sensors. Existing monitoring frameworks for urban ecology and resilience will be analysed as applicable background (i.e. European Green City Index, European Green Capital Award, EEA SOER indicators, etc.)."*

The requirements expected from this deliverable are to describe and clearly define the KPIs. As specified in the proposal, the methodology of the project will be defined through the development of WP1 and each participant city will use their diagnosis and baseline evaluation to guide them in selecting a robust set of monitoring procedures and KPIs that will help them to evaluate the impact of the NBS.

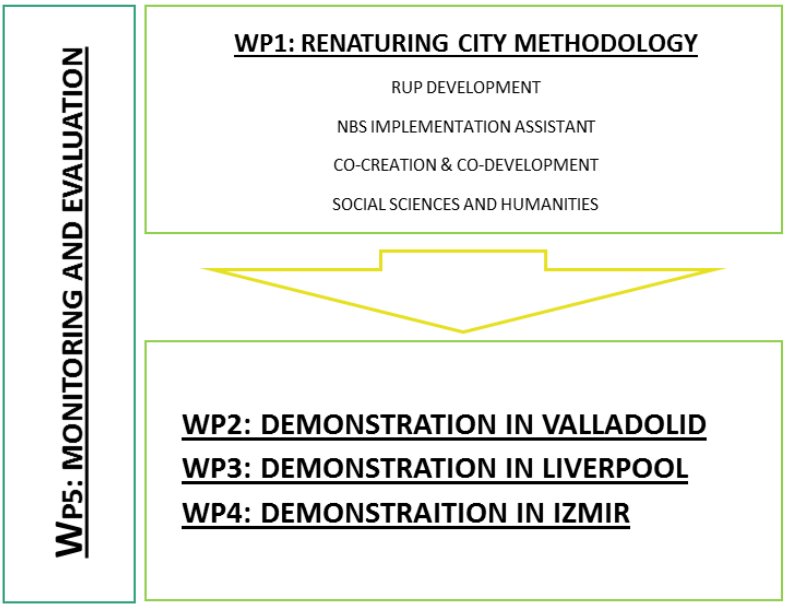

Figure 1-1: Work Plan relation scheme of WP1 to WP5.

1.1 Scope of the task

The aim of this document is to present the Urban GreenUP project KPIs and a methodological approach that will be followed at later stages of the project.

The Technical KPIs can be utilized by:

- Demo Cities and municipal administrations, enabling them to develop strategies based on the progress of the NBS.
- City residents and non –profit citizen organizations enabling them to understand the development and the baseline of the city.
- Follower cities, in order to learn from the use and application of the NBS and the improvement on the cities.
- Other professionals, e.g. urban planning, geographers, architects and landscape professionals.

The intention of the KPIs is to list a robust set of indicators that will evaluate the progress and the application of the NBS at each of the demo cities. It is desirable that each city can quantify continuously according with each goal for KPIs and Challenge.

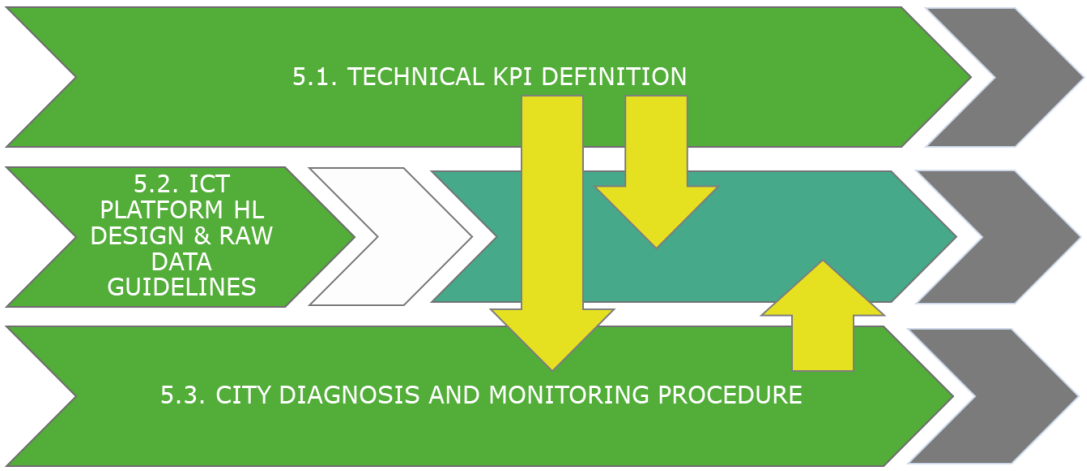

Figure 1-2: Interoperability amid the WP5.

This task is probably the most structural one of the WP5, and as shown in the previous graphic, Task 5.1, will provide information that will feed other actions of WP5 and also inform Task 5.2 and 5.3. In the case of task 5.2, the KPIs will be the indicators that are to be displayed on the ICT platform that the project includes as part of the tools for the project monitoring and evaluation. The ICT platform is specified in task 5.2 where the guidelines for the raw data and the technical specification at high level are exposed.

1.2 Structure of the document

This document is organized as follows:

- Chapter 1: Introduction. Aims to introduce the project, the scope of it and the structure of the document.
- Chapter 2: Project overview. In this section the aim is to give a general picture of the project, the WP and a description of the place that this document takes within the Working Packages.
- Chapter 3: Key Performance Indicators summary where it is explained the selection process for the KPIs, and the concept of *Core KPIs*.
- Chapter 4: Is the main part of the document here the KPIs are defined and the information by city and method planned is given.

2 Project overview

Currently, 54% of the world's population live in towns and cities, and this is projected to increase to nearly 70% by the middle of the century[2]. Therefore, the creation and maintenance of sustainable urban environments is vital.

In fact, the European Environmental Action Programme[3] states that by 2020: *"…a majority of cities in the Union are implementing policies for sustainable urban planning and design…*" and that the Commission should develop: *"…a set of criteria to assess the environmental performance of cities, taking into account economic, social and territorial impacts"*.

While the conservation and sustainable development community considers Nature-Based Solutions (NBS) to be a strong method of addressing climate change and its associated challenges in urban environments, there is still a tendency to implement mainly traditional engineering and architectural solutions. Normally, authorities promote changes in patterns of mobility, expansions of cities or major infrastructure projects to combat floods and other effects of climate change.

NBS can improve air quality, minimize heatwaves, act as carbon stores, and help mitigate climate change, reduce flooding disasters, facilitate adaptation to climate change and be an important habitat for wildlife. Furthermore, they can also provide a multitude of benefits that impact on human health, lifestyle and well-being[4] Worldwide[5] [6], and at EU level[7] [8].

In line with those statements, in 2008 the EC launched the Annual European Green Capital Award (EGCA)[9], which recognizes and rewards cities efforts. Moreover, the EC is currently working on the definition of an urban environment self-assessment tool that will be used by cities, as a basis for assessing their environmental performance and aiming to find innovative ways to meet urban environmental and sustainability policy targets[10].

[2] United Nations. World Urbanization Prospects: The 2014 Reviion, Highlights (ST/ESA/ SER.A/352). (2014).

[3] http://ec.europa.eu/environment/action-programme/ [Accessed 31/08/2016]

[4] Final Report of the Horizon 2020 Expert Group on "Nature-Based Solutions and Re-naturing Cities" (2015).

[5] IUCN. Ecosystem Based Adaptation: Knowledge Gaps in Making an Economic Case for Investing in NBS for CC. (April 2015).

[6] Green Infrastructure: Sustainable Solutions in 11 Cities across the United States. Columbia University Water Centre (April 2014).

[7] EEA Technical report Nª 2/2014. Spatial analysis of Green infrastructure in Europe. ISSN 1725-2237

[8] EEA Technical report Nº12/2015. Exploring nature-based solutions. ISSN 1725-2237

[9] http://ec.europa.eu/environment/europeangreencapital/[Accessed 31/08/2016]

[10] http://ec.europa.eu/environment/urban/tool.htm[Accessed 31/08/2016]

Despite these initiatives, there is currently a lack of tools in cities' administration to evaluate improvements in the environmental problems of cities using NBS. In addition, plans and actions involving green areas of the city are kept separate from the urban development plans and the key issue is that existing guidelines usually do not usually incorporate NBS as an option to fight against and adapt to climate change.

In order to address in depth the aforementioned needs and demonstrate the potential of the NBS to contribute to the main cities' challenges, Urban GreenUP aims to produce a tailored methodology: 1) To support the co-development of Renaturing Urban Plans (RUPs) focused on climate change mitigation and adaptation and efficient water management, and; 2) to assist in the implementation of NBS in an effective way.

NBS classification and parametrization will be addressed (WP1) and some resources to support decision-making will be established. A large scale and fully replicable demonstration action of NBS accompanied by innovative business models will provide evidence about the benefits of NBS contributing to the creation of new market opportunities for European companies, and fostering citizen insight and awareness about environmental problems. The three European cities that deliver the demos as front runners (Valladolid, Liverpool and Izmir), and the other set of two European cities that will act as followers to strengthen the replication potential of the results (Ludwigsburg and Mantova) together with three non-European cities (Medellin, Chengdu and Quy Nhon) will allow for the identification of market opportunities for European companies and foster a European leadership in NBS implementation at a global level.

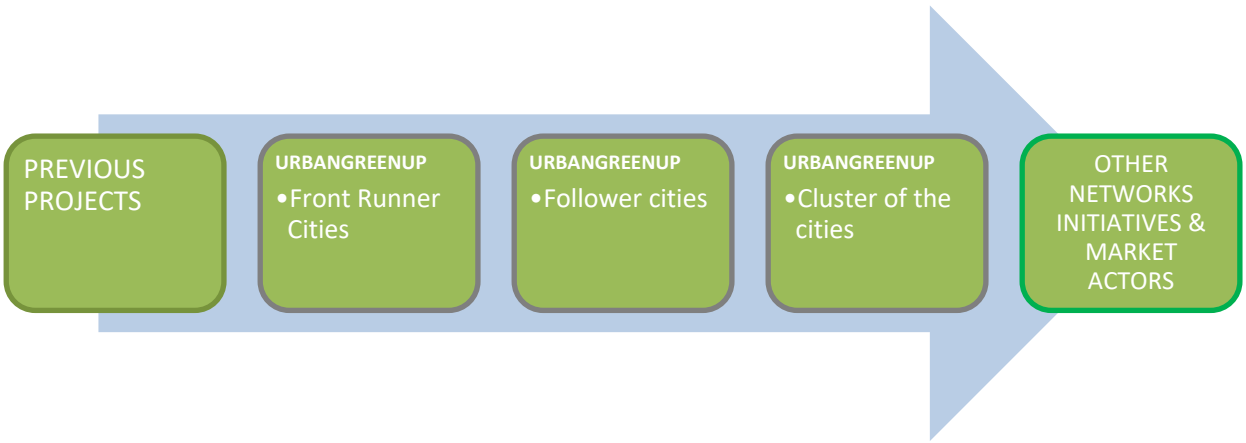

Figure 2-1 Growth of impact and market uptake of UrbanGreenUP

URBAN GreenUP aims at the creation of a Renaturing Methodology as a specific part of the Sustainable Urban Plan focused to Climate Change Mitigation (CCM) and water resilience on the basis of NBS implementation. WP1 is devoted to achieve these targets following a concept based on co-creation and social acceptance strategies. The use of Social Sciences and Humanities will be strongly embedded. The core of the work plan is the set of demonstration work packages (WP2-Valladolid, WP3-Liverpool and WP4-Izmir). Each front-runner city has planned their specific actions following similar schemes (baseline assessment, green urbanization, water

interventions, singular green infrastructures and non-technical actions) but will integrate specificities in order to properly manage all the foreseen interventions.

Several partners will act in a cross-cutting way, coordinating common actions. Each demonstration WP is led by the front-runner cities (Valladolid, Liverpool and Izmir). WP5 is dedicated to establishing the monitoring and evaluation strategy, while WP6 is focussed on deploying a deep replication strategy together with coaching, mentoring and staff exchange actions among follower cities (Mantua and Ludwigsburg in Europe, and Medellin, Chengdu and Quy Nhon outside Europe) and also between front-runner cities. WP6 will examine city clusters to foster replicability and link with other projects.

WP7 addresses tasks related with the exploitation and market deployment of the results, deploying the exploitation strategy, analysing the most promising business cases for NBS and renaturing implementation, fostering the leadership of European companies in the implementation of NBS to fight against climate change and improving the water management and use both in Europe and outside Europe. (For this ambitious challenge, three cities; two in Asia and one in South America are full members of the consortium acting as followers. As previously mentioned, these follower cities are Medellin, Chengdu and Quy Nhon). Finally WP8 aims at the deployment of a strong communication and dissemination strategy and WP9 is committed to the coordination actions.

WP5 is fully devoted to monitoring and assessment of the results, and will use information from the diagnosis, challenges identification, and definition of baselines and selection of the main Key Performance Indicators (KPIs). As can be seen in 1.3.1, section C, a rigorous set of KPIs will be selected, from the more technical to those related with social acceptance assessment and economic analysis. There is where this document seeks to establish a robust set of indicators that will interrogate the project and the NBS to be assessed; learning from it and then effectively using the results for successful replication.

2.1 Methodology

Since the main project targets are climate change mitigation and efficient water management, URBAN GreenUP will deliver a systematic strategy to reach high level of impacts by means of the use of the NBS.

URBAN GreenUP will develop an integrated methodology to support urban planning of NBS as a powerful strategy to fight against climate change and improve the capabilities of the cities to manage the use of water and associated risks.

URBAN GreenUP introduces the concept of Renaturing Urban Planning (RUP), which integrates urban planning aspects directly with NBS to achieve Sustainable Urban Planning. In parallel, URBAN GreenUP will deliver a procedure to support the direct implementation of one or a set of NBSs in a specific area of the city to address specific challenges in a more effective way.

Public authorities are considered, in principle, the main final users of this methodology, but URBAN GreenUP is going to address the process of planning and implementation of NBS as a complex problem, in which social aspects must be considered as one of the main issues? (according to previous experiences of the cities in the consortium), economic issues are going to be addressed from the point of view of the market, fostering the creation of good business cases to solve the general lack of budget within public administration. To achieve good outcomes, a co-creation approach will be adopted from the very beginning in the definition of the methodologies; from the definition and design of the technical solutions to the final assessment. Specific tasks have already been included in the project work plan for it, following the current strategies of the cities to engage citizens in the transformation of the city and planned other innovative strategies to achieve the involvement of relevant stakeholders, as local companies, academia, representatives of the industrial and commercial sectors, etc. So, conducted by the cities, an ambitious strategy of stakeholder engagement in the planning and implementation process of city renaturing will be put in place, ensuring the maximum level of acceptability and adequacy of the final results.

In addition to the co-creation process to be established, the project will deploy strategies to understand public perceptions and values of NBS before, during, and after implementation. Since social acceptance is important and there is a need to save money and achieve better outcomes, URBAN GreenUP will use existing resources to analyse these aspects. Partners with expertise in social sciences will collect and analyse information to extract conclusions and formulate recommendations to improve the process in an iterative way, in order to find a way to achieve expected impacts with a high level of social engagement, in parallel to the creation of an innovative business scenario for NBS.

The result of the method deployment will be thus twofold, on one side a RUP, fully integrated in the urban planning and land use planning, and secondly the specification of a set of NBS to mitigate one or several climate change challenges, ready to the tendering process. Both results, as mentioned previously, will be reached with a high degree of stakeholder's ownership which will ensure a more ambitious impact on planning and a more effective implementation of the NBS.

URBAN GreenUP methodology will be developed as a modular procedure. In order to achieve a usable method, a step-by-step procedure has been already proposed (should be refined during the project, but establishes the foundation of the methodology in order to detect the development needs). Figure 2.2 shows both procedures, the first one will obtain as results the RUP and the second one will achieve a tender specification document. White blocks are the steps, yellow ones are modules to be developed and green blocks are the final deliverables. Blue blocks are sets of blocks that have a joint meaning, as the RUP or decision-making tool.

The RUP development procedure consists of deploying six stages, supported by several modules. These stages are the following: 1) Diagnosis, problems and challenges identification; 2) Calculation of the city baseline; 3) Identification of boundaries and barriers; 4) Classification of city areas; 5) Definition of the basic NBS (and associated scenarios of integration) to be

implemented according the challenges identified, and; 6) Pre-assessment of the impacts on the basis of predefined KPIs.

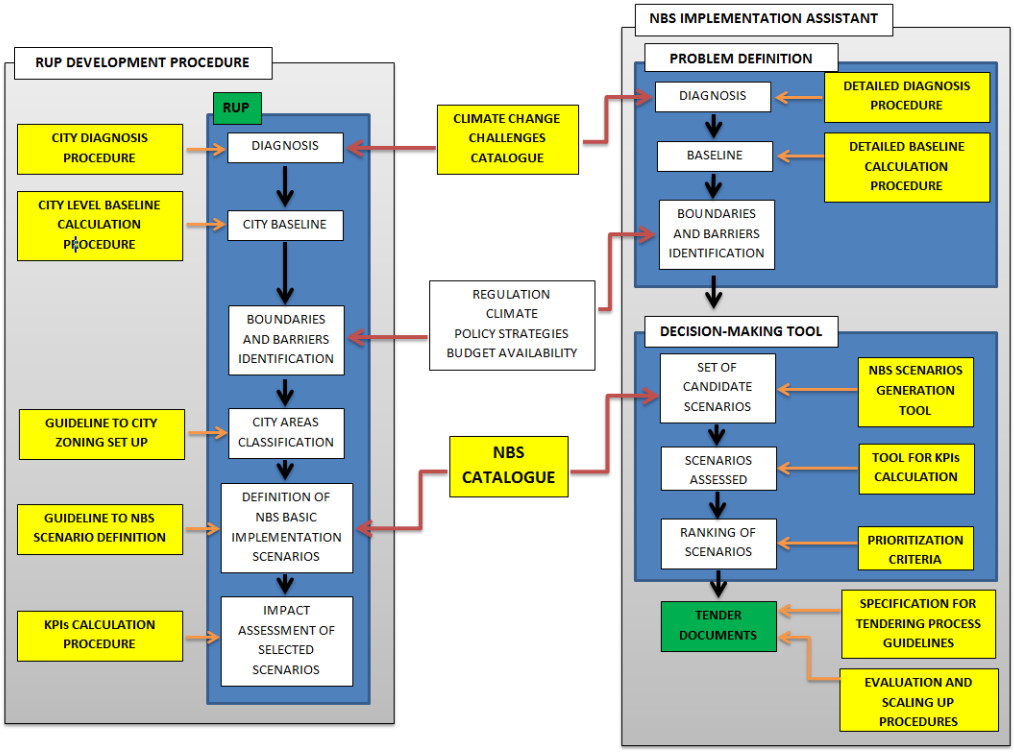

Figure 2-2 Block Diagram of the URBAN GreenUP methodology

The NBS implementation assistant will support the implementation of one or a set of integrated NBS to solve specific problems in a well-defined area of the city. It consists of seven stages:

1) Diagnosis, problems and challenges identification, detailed for the selected area;
2) Calculation of the city baseline;
3) Identification of boundaries and barriers (technical, economical and mainly social and economic);
4) Definition of the set of candidate scenarios of NBS implementation;
5) Calculation of the main KPIs for each scenario;
6) Establishment, on the basis of some prioritization criteria, of a ranking of scenarios to facilitate the decision making, and;
7) Delivering of the tender documents, with the main detailed specifications, evaluation and scaling up procedures.

In order to achieve a suitable deployment of these stages, several modules will be developed. These modules will be conceived in a standard way, with fully open specification and easily expandable. Two of the modules are conceived as a database of knowledge: the climate change challenges catalogue (including water challenges) and the NBS catalogue. Both of them are the core of the methodology, supporting both the RUP development and the NBS implementation.

- The NBS catalogue will include existing information about NBS, technical, economic and social aspects, in a standard way to be used in a systematic procedure of planning or decision-making.
- The societal challenge catalogue[11] will classify in a standard way the main city challenges related with climate change and water resilience to be used also in a systematic procedure of planning or decision-making.

In a second level, some of the modules are conceived as procedures and guidelines: City diagnosis procedure (general and detailed), City level and detailed baseline calculation procedure, Guideline to city zoning, Guideline to NBS scenario definition, KPIs calculation procedure, Specification of tendering process guideline and Evaluation and scaling up procedures.

Finally, the decision-making module will be developed as a tool. At least a spreadsheet based on Excel or similar will be developed to support three tools: NBS scenarios generation tool, KPI calculation tool and Prioritization criteria tool.

The RUP methodology will be composed integrating all the modules, and it will be validated following a rigorous procedure to guarantee their applicability and usability. Two steps of validation will be established: 1) the project partners will undertake a full validation of each of the main modules separately and 2) subsequent validation will be carried out by external stakeholders.

URBAN GreenUP will monitor and evaluate the effectiveness of the project actions and interventions as compared to the baseline situation, the objectives, and expected results. Sound and robust monitoring and evaluation protocols will be developed and will include a full methodology that will allow the collection of future data after the end of the project.

The European Commission actively seeks to boost the development of a set of KPIs to clarify the Smart City concept, as becomes evident in the Strategic Implementation Plan of the European Innovation Partnership on Smart Cities and Communities.

Moreover, current KPIs on cities are collected in the ISO 37120: "*Sustainable development of communities-Indicators for city services and quality of life*". The dimensions of those are categorized as: Information and Communication Technology, Environmental sustainability (air quality, CO2 emissions, energy, indoor pollution, water, soil, noise), Productivity (capital investment, employment, inflation, trade, savings, export/import, etc.), Quality of Life (Education, Health, Safety/security public place, convenience and comfort), Equity and social inclusion (inequity of income/consumption, social and gender inequity of access to service and infrastructure, openness and public participation, governance), and Physical infrastructure (piped water, sewage systems, electricity, waste management, health infrastructure, transport,

[11] Previously titled climate change mitigation catalogue.

etc.[12] A next step on ISO standards on cities, refers to the ISO 37121 "*Resilient cities*"[13] suggesting indicators that consider risk and vulnerability (unemployment, informal settlements, homelessness, access to water, to electricity…), institutional & response capacity (physicians, emergency response, etc.) and outcomes (disaster-related, deaths, life expectancy, property crimes, etc.). However, there is no specific mention for KPIs related to NBS and the interaction with social science and humanities and/or co-creation concepts. New NBS´s KPIs will be defined in order to measure the benefits of these nature solutions on and their interaction with KPIs collected in the current Standards and literature. Definition of new Social Science and Humanities KPIs to consider other aspects not covered yet such as the interaction of the sociology and human behaviour with the NBS and co-creation approach to RUP. New above-mentioned and existing KPIs will be integrated in the URBAN GreenUP's Methodology to consider the co-creation and co-design indicators value in performance of NBS as a decision-making parameter for measuring RUP success implementation.

The results of the monitoring program will be gathered by the front-runner cities in order to embed the mechanisms in the ICT Urban Platform to enable the collection of the necessary data and information.

In this regard, a comprehensive data collection approach will be defined in order to coordinate and supervise the collection of the information. Information from the subthemes (i.e. energy, pollution, temperature, humidity…) will be gathered and stored automatically. This information will be completed with specific data from other actions of the project (i.e. social awareness, citizen engagement, and economic performance). At least 2 years of a full dataset will be considered for the reporting period after the implementation of the actions in each demonstration area and front-runner. Finally, the evaluation procedure will be deployed in order to evaluate the performance of the actions and interventions of the project and to estimate the impact of the activities.

[12] http://www.itu.int/en/ITU-T/focusgroups/ssc/Pages/default.aspx

[13] http://resilientcities2015.iclei.org/fileadmin/RC2015/files/pptx/Opening_Plenary_Lynch.pdf

3 Key Performance Indicators Overview

3.1 Current Status

Present KPIs on cities are collected in the ISO 37120: "*Sustainable development of communities-Indicators for city services and quality of life"* and, as a next step on ISO standards on cities, refers to the ISO 37121 "*Resilient cities*".

However, there is a lack of some specific KPIs for NBS and others related to the interaction of NBS with social science and humanities and/or co-creation concepts. URBAN GreenUP's first step in this sense will be the definition of a complete set of KPIs and its integration in URBAN GreenUP´s Methodology (WP1) to consider all related indicators, co-creation and co-design ones included as a decision-making parameter.

Some specific indicators (Table 3-1) have been used in the design and demo actions selection to predict its impact and try to optimize the investments required during the proposal phase preparation and define the Project budget requirements.

Category	Description
Citizens (year)	Citizens who interact with the new G.I.
CO2 eq. Emissions Avoided (tCO2 p/year)	CO2eq emissions avoided (tCO2eq p/year) considering a life cycle approach and modelling the environmental impacts regard to indirect savings.
New Green Surface (m2)	New green surfaces at soil level.
I Green Corridor (km)	Length of new sections considered as green corridor, bike lanes, tree series, etc.
New Trees (unit)	Number of new trees planted.
Shadow Surface (m2)	Vertical shadow of structures and trees.
CO2 Sink (tCO2 p/year)	Choice of plant species for preliminary estimations have been realized following the "Guide to estimate carbon dioxide absorptions Spanish Office of Climate Change. Ministry of agriculture, Feeding-stuffs and Environment.
Drainage Surface (m2)	New surfaces with drainage capacity (SUDS includes its area of influence).
Captured/Treated Water (m3/year)	Estimated from the annual rainfall regime in each city.
Water for Irrigation Saved (m3)	Estimated value for a conventional public garden in each city except Liverpool with no irrigation necessities.
Water Storage Capacity (m3)	Design value.
Water for Irrigation Produced (m3/year)	Design value.
Avoided Fertilizers (kg/year)	Estimated value for a conventional public garden in each city.
Soil Health Improvement	Countless category.
Maximum Temperature Reduction (ºC)	Design value from in situ studies and literature.
Average Temperature Reduction (ºC)	Design value from in situ studies and literature.
Modulation of Relative Humidity	Design value from in situ studies and literature.
NOX Reduction (kg/year)	Design value from in situ studies and literature.
dB Reduction	Design value.
Biodiversity Enhancement	Relative increment taking into account baseline values.
Citizen Well-being Increase	Relative increment taking into account baseline values.
Increase Pollinator Habitat/Activity	Relative increment taking into account baseline values.
Citizen GI Awareness	Relative increment taking into account baseline values.

Table 1: Impact categories description

In order to define an effective approach for monitoring and impact assessment, UrbanGreenUP followed the Eklipse Knowledge and Learning Mechanism, another Horizon2020 project that focus on biodiversity and ecosystem services. With Eklipse among other methodologies, a set of KPIs were selected by taking into account the demo actions regarding the impact categories

shown in the above table and then scaffold through Eklipse challenges and indicators. The aim was focused into show how the proposed demo actions and selected NBS will tackle the mentioned challenges that each city is and will facing now and the upcoming years.

The idea was to let each city have autonomy during the selection process and decide which indicator will be more suitable to face each of their challenges. Therefore, each city selected from the main list the ones that shall give information on how the NBS to implement will perform. Annexed at the end of the document can be found a List of Technical KPIs per city, it displays a complete list distributed by challenges and the indicators that each city selected.

One of the findings during the selection of KPIs per city was the need of a framework on with work in parallel with other tasks in the working package (Task 5.2 and Task 5.3) and don't get stuck while organically feed each of the tasks to be able to provide the information according to schedule. Thus, was decided to create a set of KPIs that aimed to be wide ranging and to have at list one per challenge.

3.2 Core KPIs

From the KPIs mentioned before, a core set of KPIs were selected, these are specified in a summary below. These KPIs are preliminary and still need to be finalised in collaboration with the EC and other Horizon 2020 projects that focused on NBS as well as UrbanGreenUP does.

From the challenges based on Eklipse, the Challenge 3 (Coastal Resilience) was not selected as core KPIs because not all cities aim to tackle this challenge with the use of NBS or it is an inland city. The aim for the KPIs core is in the first instance to find a common ground.

CH	Nº	TYPE OF INDICATOR	KPI DEFINITION
Challenge 1	1	Environmental, Chemical	**Tonnes of carbon removed or stored per unit area per unit time (ton CO2/Ha) (ton CO2/year). Total amount of carbon stored in vegetation (ton)**
	2	Environmental, Physical	**Decrease in mean or peak daytime local temperatures (°C)**
	3		**Heatwave risks (number of combined tropical nights (>20 °C) and hot days (>35 °C)**
	4	Others	**Use of *Star tools* to calculate projected maximum surface temperature reduction (°C)**
Challenge 2	5	Physical indicators	**Run-off coefficient in relation to precipitation quantities (mm/%)**
	6		**Absorption capacity of green surfaces, bioretention structures and single trees (m3/m2) (m3/tree)**
	7		**Temperature reduction in urban areas (°C, % of energy reduction for cooling)**
	8		**Areas (Ha) and population (inhab) exposed to flooding**
	9	Chemical indicators (water quality)	**Drinking water provision (m3 ha-1year-1)**
	10		**Water for irrigations purposes (m3 ha-1year-1)**
	11	Economic indicators (benefits)	**Volume of water removed from water treatment system**
	12		**Volume of water slowed down entering sewer system**
Challenge 4	13	Social indicators (benefits)	**Accessibility (measured as distance or time) of urban green spaces for population (Tamosiunas et al., 2014).**
	14		**Weighted recreation opportunities provided by Urban Green Infrastructure (Derkzen et al. 2015)**
	15	Environmental (biological)	**Production of food (ton/Ha/year)**
	16		**Increased connectivity to existing GI**
	17		**Pollinator species increase (number)**

Challenge 5	18	Environmental (chemical)	**Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted) concentration recorded ug/m3**
	19		**Trends in emissions NOX, SOX**
	20	Economic	**Monetary values: value of air pollution reduction; total monetary value of urban forests including air quality, run-off mitigation, energy savings, and increase in property values. use of GI val to calculate the value of air quality improvements**
	21	Social (physiological)	**Number of deaths from air, water and soil pollution and contamination (proposed indicator for SDG target 3.9)**
	22		**Air quality parameters NOx, VOC, PM etc**
Ch 6	23	Urban green indicators (environmental, biological)	**Accessibility: distribution, configuration, and diversity of green space and land use changes (multi-scale ;). - Green spaces quantity**
	24	Socio-cultural indicators	**Savings in energy use due to improved GI**
Ch 7	25	Social	**Perceptions of citizens on urban nature - Green spaces quality**
Ch 8	26	Social Cohesion	**Green intelligence awareness.**
Challenge 9	27	Psychological indicators (Relaxation and restoration, sense of place, exploratory behaviour, socializing).	**Noise reduction rates applied to UGI within a defined road buffer dB(A) m-2 vegetation unit**
	28	Health indicators related to ecosystem service provision (Buffering of noise and air pollution, reduced heat, exposure to microflora).	**Increase in walking and cycling in and around areas of interventions**
Ch 10	29	Economic	**Number of jobs created; gross value added**

Table 2: Core KPI, selected from Eklipse Mechanism

4 Technical KPI definition by city and method

This Chapter aims to show the indicators selected per city or cities and to be a summary of the methodology that has been proposed to follow. This Chapter is the main part of the deliverable, it's the very important part that will help building the monitoring procedures for the project itself. This part is particularly important for all the partners because it will be common ground in a learning process in order to compare how cities are or will be calculating their indicators and see if some of the procedures could help to improve their owns or to provide positive feedback to create a learning framework that will serve the project.

4.1 CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION

<table>
<tr><th colspan="3">CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION</th></tr>
<tr><th>TYPE OF INDICATOR</th><th>KPI DEFINITION</th><th>RELATED NBS</th></tr>
<tr><td rowspan="3">Environmental, chemical</td><td>Tonnes of carbon removed or stored per unit area per unit time
(ton CO2/Ha)</td><td rowspan="3">▪ Vertical and horizontal green infrastructure
▪ Tree related actions
▪ SUDS /raingarden
▪ Urban carbon sink
▪ Vertical green interventions
▪ New green cycle lane and re-naturing existing bike lanes: green cycle lane; green resting areas; cycle-pedestrian green paths</td></tr>
<tr><td>(ton CO2/year)</td></tr>
<tr><td>Total amount of carbon stored in vegetation (ton)</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>Cities</th></tr>
<tr><td>CO2eq emissions avoided (CLA)</td><td>(ton CO2/Ha) (ton CO2/year) (ton)</td><td>Valladolid
Izmir</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>No sensor</td><td>• IPCC 2013 GWP 2010a methodology. "Considering a life cycle approach and modelling the environmental impacts regard to indirect savings".
• Commercial Software SimaPro.</td><td>Standard Emissions factor in line with the IPCC principles.
- Commercial Software SimaPro®
- http://www.covenantofmayors.eu/about/signatories_en.html?city_id=2748&seap</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td>GI Val</td><td>(KG CO2/year)</td><td>Liverpool</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>No sensor</td><td>Modelled using GIVal</td><td>-</td></tr>
</table>

CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental, chemical	**Comparison with calculations of carbon consumption of equivalent non-NBS actions (e.g. through Life Cycle Assessment).**	TBD
Measured method	**KPI Unit**	**City**
TBD	(ton CO2)	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	TBD	N/A

CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental, chemical	**Increased opportunity for species movement in response to climate change as a result of NBS**	▪ Vertical and horizontal green infrastructure ▪ Tree related actions ▪ Pollinator verges and spaces ▪ Urban carbon sink
Measured method	**KPI Unit**	**City**
Use of Condatis model to quantify increased long-distance range-shift potential for selected taxa as a result of GI interventions.	% change	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Modelled using Condatis	N/A

CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental, chemical	**Economic value of carbon sequestration by vegetation as a result of NBS over 25 years**	▪ Vertical and horizontal green infrastructure ▪ Tree related actions ▪ SUDS /raingarden ▪ Urban carbon sink
Measured method	**KPI Unit**	**City**
Modelled using GIVal to calculate the projected economic value of carbon stored in vegetation as a result of NBS over 25 years. Input data: project delivery records	(Euro)	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Modelled using GIVal	UK Treasury economic values for carbon sequestration

CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic	**Measurements of gross and net carbon sequestration of urban trees based on calculation of the biomass of each measured tree (i-Tree Eco model), translated into avoided social costs of CO2 emissions (USD t-1 carbon).**	▪ Trees in the New green corridor
Measured method	**KPI Unit**	**City**
1)Determine the above-ground weight of the tree (multiply the diameter of the trunk and the height, and 120 per cent); 2)Determine the dry weight of the tree (on average 72.5 per cent of the total weight); 3) Determine the weight of carbon in the tree (50% of the tree's total volume)	(ton CO2/Ha) (ton CO2/year) (ton)	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	By formula	TBD

<table>
<tr><th colspan="3">CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION</th></tr>
<tr><th>TYPE OF INDICATOR</th><th>KPI DEFINITION</th><th>RELATED NBS</th></tr>
<tr><td rowspan="2">Environmental, Physical (Temperature reduction)</td><td>Decrease in mean daytime local temperatures (°C)</td><td rowspan="2">▪ Tree related actions
▪ Vertical green interventions: Green noise barriers; Green vertical mobile garden; Green façade</td></tr>
<tr><td>Decrease in peak daytime local temperatures (°C)</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td>Measurement of temperature with a thermometer (local weather station network or Thermometer of URBAN GreenUP). Maximum, minimum, average.</td><td>˚C</td><td>Valladolid
Izmir</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>Calculate the temperature variation (increase - decrease). Evolution of temperature graph. Comparison with the historical daily average temperature.</td><td>Spanish State Meteorological Agency.
Data from RCCAVA.</td><td>https://datosclima.es/Aemet2013/Tempestad2013.php
www.valladolid.es/es/rccava</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td>Use of sensors to measure and compare air temperature ˚C at GI locations and control sites (without GI) pre and post GI intervention</td><td>˚C</td><td>Liverpool</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>Air temperature sensor</td><td>Calculated using standard software (Excel)</td><td>N/A</td></tr>
</table>

CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental, Physical (Temperature reduction)	**Measures of human comfort e.g. ENVIMET PET — Personal Equivalent Temperature, or PMV — Predicted Mean Vote.**	-
Measured method	**KPI Unit**	**City**
Monitoring the thermostat data for indoor places and surveys with occupants	˚C	Izmir
Sensor	**Calculi**	**External data source/ Website**
Measures of human comfort e.g. ENVIMET PET — Personal Equivalent Temperature, or PMV — Predicted Mean Vote.	Measured	TBD

CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental, Physical (Temperature reduction)	**3 days >25C day (Heatwave risk UK metric)** **3 days >18C night (Heatwave risk UK metric)**	▪ Tree related actions;
Measured method	**KPI Unit**	**City**
Physical measurement of air temperature. Assessment of reduction of risk due to GI interventions, also modelled in GVal	˚C number of days/relative risk	Liverpool
Sensor	**Calculi**	**External data source/ Website**
Air temperature sensor	Comparison of risk with nearby areas of similar form with low/no NBS	Additional source:UK Met Office

CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental, Physical (Temperature reduction)	**Heatwave risks (number of combined tropical nights (>20 °C) and hot days (>35 °C)**	▪ Vertical green interventions: ▪ Green noise barriers; ▪ Green vertical mobile garden; ▪ Green façade
Measured method	**KPI Unit**	**City**
Measurement of temperature with a thermometer (local weather station network or Thermometer of URBAN GreenUP).Maximum, minimum, average.	(nº days) (°C)	Valladolid Izmir
Sensor	**Calculi**	**External data source/ Website**
Wireless Network of T and RH sensors	Calculate number of tropical nights (>20 °C) and hot days (>35 °C) monthly. Evolution of temperature graph. Comparison with the historical daily average temperature.	Spanish State Meteorological Agency. Data from RCCAVA. https://datosclima.es/Aemet2013/Tempestad2013.php www.valladolid.es/es/rccava Air temperature sensors, network of RH sensors, *in situ* thermal sensors. thermal sensor via drone or satellite

CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Others	**Increased opportunity for species movement in response to climate change as a result of NBS**	▪ Tree related actions ▪ Urban Carbon sink ▪ Horizontal green interventions ▪ pollinator verges and spaces
Measured method	**KPI Unit**	**City**
Use of Condatis model to quantify increased long-distance range-shift potential for selected taxa as a result of GI interventions.	% change	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Modelled using Condatis	N/A

CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Others	**Use of GI Val to calculate carbon savings from GI providing shade, shelter, reduction in water treatment etc.**	▪ Tree related actions
Measured method	**KPI Unit**	**City**
Modelled using GI Val to calculate projected Carbon savings (energy savings) from reduced building energy consumption as a result of NBS over 25 years.	KG/C per year	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Modelled using GI Val	-

CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Others	**Use of *Star tools* to calculate projected maximum surface temperature reduction (°C)**	▪ Tree related actions ▪ Urban Carbon sink ▪ Horizontal green interventions
Measured method	**KPI Unit**	**City**
Use of STAR Tools to model projected maximum surface temperature reduction on warmest summer days as a result of GI tree interventions under different temperature scenarios. Input data: project delivery records.	˚C	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Modelled using STAR Tools	-

CHALLENGE 1: CLIMATE MITIGATION & ADAPTATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Others (Energy and carbon savings from reduced)	**kWh/y and t C/y saved.**	▪ Tree related actions;
Measured method	**KPI Unit**	**City**
IPCC, USEPA and CORINAIR will be calculated based on the measured consumption data and greenhouse gas emission factors taken from IPCC, USEPA and CORINAIR	(kWh/y) and (C/y)	Izmir
Sensor	**Calculi**	**External data source/ Website**
Energy sensors	Measured, by formula	TBD

4.2 CHALLENGE 2: WATER MANAGEMENT

CHALLENGE 2: WATER MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Chemical and Economic Indicators	**Economic benefit of reduction of storm water to be treated in public sewerage system (€) (Deng et al., 2013; Soares et al., 2011; Xiao and McPherson, 2002)**	Smarts soils as substrate tree related actions SUDS and raingardens Horizontal GI
Measured method	**KPI Unit**	**City**
Calculated cost savings (m3 stormwater x cost disposal/m3) Measure by applying discharge cost/m3 stormwater at baseline and then post intervention.	Euro (€)	Liverpool
Sensor	**Calculi**	**External data source/ Website**
Water flow sensor or United Utilities water flow data	Calculate using standard software (Excel/R)	Discharge cost of stormwater/m3 for treatment purposes from United Utilities included in GIVal

CHALLENGE 2: WATER MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Chemical and Economic Indicators	**Volume of water removed from water treatment system**	Smarts soils as substrate SUDS and raingardens Tree related actions GI horizontal, Floodable park.
Measured method	**KPI Unit**	**City**
Direct measurement of water flow pre and post intervention. Create local urban catchment hydrograph for demonstration site	m3 of water	Liverpool Izmir
Sensor	**Calculi**	**External data source/ Website**
Sensor	Model projected savings (Euro) using GI Val	Discharge data for storm water (m3) from United Utilities Izmir TBD

CHALLENGE 2: WATER MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Water Quality	**Nutrient abatement, abatement of pollutants (%, nutrient load, heavy metals).**	SUDS /Raingarden Green filter area Natural waste water treatment Smart soils
Measured method	**KPI Unit**	**City**
% change in key water quality indicators (specify which) between baseline measurement and years 1 and 2 post intervention.	% change	Liverpool
Sensor	**Calculi**	**External data source/ Website**
Sensor	Calculate using standard software (Excel/R)	United Utilities water quality data available

CHALLENGE 2: WATER MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Physical indicators	**Soil water storage capacity (mm)**	Tree related actions; SUDS; Natural Wastewater Treatment Plan; Rain Gardens; Floodable park; Green Parking pavement
Measured method	**KPI Unit**	**City**
Measurement with sensors	mm	Izmir
Sensor	**Calculi**	**External data source/ Website**
Various	Measurement by various sensors	TBD

CHALLENGE 2: WATER MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Physical indicators	**Drinking water provision (m3 ha-1year-1)**	Tree related actions; SUDS; NWTP; Rain Gardens; Floodable park; Green Parking pavements; Electro wetland
Measured method	**KPI Unit**	**City**
TBD	(m3/ha/year)	Izmir
Sensor	**Calculi**	**External data source/ Website**
TBD	TBD	TBD

CHALLENGE 2: WATER MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Water Quality	**Water for irrigations purposes (m3 ha-1year-1)**	Horizontal green interventions: Green covering shelter; Green roof; Green shady structures
Measured method	**KPI Unit**	**City**
Calculation of the decrease in the amount of water used in irrigation, per green surface (NBS)	(m3/ha/year)	Valladolid Izmir
Sensor	**Calculi**	**External data source/ Website**
Flowmeter in supply pipe	TBD	Parks and gardens Department (Valladolid city council) www.valladolid.es
		TBD

<table>
<tr><th colspan="3">CHALLENGE 2: WATER MANAGEMENT</th></tr>
<tr><th>TYPE OF INDICATOR</th><th>KPI DEFINITION</th><th>RELATED NBS</th></tr>
<tr><td>Economic indicators (benefits)</td><td>Volume of water slowed down entering sewer system</td><td>Tree related actions; SUDS; horizontal GI
Tree related actions
SUDS /Raingarden
Horizontal green interventions</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td>Direct measurement of water flow pre and post intervention</td><td rowspan="2">m3 of water</td><td rowspan="2">Liverpool
Izmir</td></tr>
<tr><td>Create local urban catchment hydrograph for demonstration sites</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>Water flow sensor</td><td>Calculate using standard software (Excel/R)</td><td>Discharge data for storm water (m3) from United Utilities</td></tr>
<tr><td>TBD</td><td>TBD</td><td>TBD</td></tr>
</table>

CHALLENGE 2: WATER MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Physical indicators	**Run-off coefficient in relation to precipitation quantities (mm/%)**	▪ Vertical and horizontal green infrastructure ▪ Horizontal green interventions: green covering shelter; green roof; green shady structures tree related actions ▪ SUDS /raingarden ▪ Urban carbon sink ▪ Green Parking pavements
Measured method	**KPI Unit**	**City**
Not defined	(mm/%)	Valladolid
Sensor	**Calculi**	**External data source/ Website**
Flowmeter in drain pipe	-	Spanish State Meteorological Agency. Data from RCCAVA. https://datosclima.es/Aemet2013/Tempestad2013.php www.valladolid.es/es/rccava
Measured method	**KPI Unit**	**City**
Use of Star Tools to model projected reduction in surface water run-off in the demo areas as a result of NBS under various precipitation scenarios	volume/%/run-off co-efficient	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Modelled using STAR Tools	-
Measured method	**KPI Unit**	**City**
TBD	(mm/%)	Izmir
Sensor	**Calculi**	**External data source/ Website**
TBD	TBD	TBD

CHALLENGE 2: WATER MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Physical indicators	**Absorption capacity of green surfaces, bio-retention structures and single trees (m3/m2) (m3/tree)**	New green cycle lane and re-naturing existing bike lanes: Green cycle lane; Green resting areas; Cycle-pedestrian green paths
Measured method	**KPI Unit**	**City**
Water absorption Absorption capacity of green surfaces, bioretention structures and single trees (m3/m2) (m3/tree)	(m3/m2) (m3/tree)	Valladolid Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Armson, D., Stringer, P., & Ennos, A. R. (2013). The effect of street trees and amenity grass on urban surface water runoff in Manchester, UK. Urban Forestry and Urban Greening, 12(3), 282–286.	Spanish State Meteorological Agency. https://datosclima.es/Aemet2013/Tempestad2013.php TBD

CHALLENGE 2: WATER MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Physical indicators	**Temperature reduction in urban areas (°C, % of energy reduction for cooling)**	Tree related actions; SUDS; Natural Wastewater Treatment Plan; Rain Gardens; Floodable park; Green Parking pavements
Measured method	**KPI Unit**	**City**
Measurement of temperature with a thermometer (local weather station network or Thermometer of URBAN GreenUP). Maximum, minimum, average.	(°C, % of energy reduction for cooling)	Izmir
Sensor	**Calculi**	**External data source/ Website**
Thermal sensor	Measured	TBD

4.3 CHALLENGE 3: COASTAL RESILIENCE

CHALLENGE 3: COASTAL RESILIENCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Physical indicators	**Shoreline characteristics and erosion protection**	▪ Green pavements
Measured method	**KPI Unit**	**City**
Ecological surveys of selected taxa at NBS locations pre-intervention and at 1 and 2 years post intervention	various measurement values	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor, GIS	Analysis of survey data using standard software	TBD

CHALLENGE 3: COASTAL RESILIENCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Physical indicators	**Flooding characteristics**	▪ Green pavements ▪ SUDS
Measured method	**KPI Unit**	**City**
Statistical data from municipality	# of events	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor, GIS	Data from inventory of municipality	TBD

CHALLENGE 3: COASTAL RESILIENCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic indicators	**Avoided damage costs**	TBD
Measured method	**KPI Unit**	**City**
TBD	TBD	Izmir
Sensor	**Calculi**	**External data source/ Website**
TBD	TBD	TBD

CHALLENGE 3: COASTAL RESILIENCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic indicators	**Changes in property value**	TBD
Measured method	**KPI Unit**	**City**
TBD	€	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	N/A	TBD

CHALLENGE 3: COASTAL RESILIENCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social and educational indicators	**Recreation and public access**	Engagement Portal
Measured method	**KPI Unit**	**City**
Statistical data from municipality	#	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor, GIS	Data from inventory of municipality	TBD

CHALLENGE 3: COASTAL RESILIENCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social and educational indicators	**Number of students benefiting from education and research about coastal resilience/amenity**	Engagement Portal
Measured method	**KPI Unit**	**City**
Statistical data from municipality	Nº	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	Data from inventory of municipality	TBD

CHALLENGE 3: COASTAL RESILIENCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Biological Indicators	**Estimates of species, individuals and habitats distribution**	Green pavements
Measured method	**KPI Unit**	**City**
Statistical data and inventory	Nº of species	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	Data from inventory of municipality	TBD

CHALLENGE 3: COASTAL RESILIENCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Biological Indicators	**Invasive and planted species**	Green pavements
Measured method	**KPI Unit**	**City**
Statistical data and inventory	Nº of species	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	Data from inventory of municipality	TBD

CHALLENGE 3: COASTAL RESILIENCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Biological Indicators	**Algal bloom**	Green pavements
Measured method	**KPI Unit**	**City**
Physical measurements, TBD	Nº of events	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	N/A	TBD

4.4 CHALLENGE 4: GREEN SPACE MANAGEMENT

CHALLENGE 4: GREEN SPACE MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (biological)	**Increase in density and seasonal spread of floral resources for pollinators**	SUDS /Raingarden Horizontal green interventions vertical green interventions Pollinator verges and spaces
Measured method	**KPI Unit**	**City**
Ecological surveys of selected taxa at NBS locations pre intervention and at 1 and 2 years post intervention	% change	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Analysis of survey data using standard software (Excel/R)	N/A

CHALLENGE 4: GREEN SPACE MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (biological)	**Increase in Insectivore (e.g. bat) abundance and use of corridors for movement as a result of NBS**	▪ SUDS /Raingarden ▪ Horizontal green interventions ▪ Vertical green interventions ▪ Pollinator verges and spaces
Measured method	**KPI Unit**	**City**
Bat survey transects including NBS locations pre-intervention and at 1 and 2 years post intervention; using Bat logger M real-time, full spectrum detector to record bat species echolocation calls.	% change	Liverpool
Sensor	**Calculi**	**External data source/ Website**
Bat detector	Software package for analysis of bat echolocation call data. Analysis of survey data using GIS and standard software (Excel/R)	N/A

CHALLENGE 4: GREEN SPACE MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (biological)	**Increase in plant species richness and functional diversity as a result of NBS**	SUDS /Raingarden Horizontal green interventions vertical green interventions Pollinator verges and spaces
Measured method	**KPI Unit**	**City**
Ecological surveys of selected taxa at NBS locations pre-intervention and at 1 and 2 years post intervention	% change	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Analysis of survey data using standard software (Excel/R)	N/A

CHALLENGE 4: GREEN SPACE MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (biological)	**Increased connectivity to existing GI**	New green cycle lane and re-naturing existing bike lanes: Green cycle lane; Green resting areas; Cycle-pedestrian green paths
Measured method	**KPI Unit**	**City**
Calculation of the cycle lane distance that has been increased by the green corridor, with respect to the total bike lane.	(m) (%)	Valladolid
Sensor	**Calculi**	**External data source/ Website**
No sensor	Calculated with Geographic Information Systems (GIS)	Mobility. Valladolid City Council www.valladolid.es
Measured method	**KPI Unit**	**City**
Use of GIS to calculate % change in GI parameters (including maximum distance between areas of GI; extent and type of GI within each demo area; distance from existing large urban GI e.g. parks) before vs after GI interventions. Input data: Project delivery records; OS Map datasets; high resolution imagery pre and post intervention	(m) (%)	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	GIS Analysis	N/A

CHALLENGE 4: GREEN SPACE MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (biological)	**Perceptions of connectivity and mobility**	New green cycle lane and re-naturing existing bike lanes: Green cycle lane; Green resting areas; Cycle-pedestrian green paths. Green cycle lane; Tree related actions;
Measured method	**KPI Unit**	**City**
Smartphone application: Periodic surveys can be performed via the smartphone application	Subjective rating on both aspects from 1 to 10	Valladolid
Use of the green corridor satisfaction degree.	(% satisfaction)	
Sensor	**Calculi**	**External data source/ Website**
Smartphone: Satisfaction data collected by URBAN GreenUP Mobile App.	Surveys: Identify Social perception, wellbeing	Local Agenda 21 of Valladolid - Sustainability indicators

CHALLENGE 4: GREEN SPACE MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (biological)	**Production of food (ton/Ha/year)**	Urban farming promotion: Urban orchard; Community composting; Small-scale urban livestock
Measured method	**KPI Unit**	**City**
Production of food in urban orchards (agriculture, eggs, etc.)	(ton/Ha/year)	Valladolid
Sensor	**Calculi**	**External data source/ Website**
Weighing machine	Measurement of the amount of food produced	Ecological orchards of Valladolid (2016-2017)

<table>
<tr><th colspan="3">CHALLENGE 4: GREEN SPACE MANAGEMENT</th></tr>
<tr><th>TYPE OF INDICATOR</th><th>KPI DEFINITION</th><th>RELATED NBS</th></tr>
<tr><td>Environmental (biological)</td><td>Pollinator species increase (number)</td><td>▪ SUDS /Raingarden
▪ Horizontal green interventions
▪ vertical green interventions
▪ Pollinator verges and spaces</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td rowspan="2">Ecological surveys of selected taxa at NBS pre-intervention and year 1 and 2 post intervention. Comparison of pollinator species richness/abundance/seasonal spread at NBS pre and post intervention</td><td>Species count data</td><td rowspan="2">Liverpool</td></tr>
<tr><td>% change</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>No sensor</td><td>Analysis of survey data using standard software (Excel/R)</td><td></td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td>Not defined Methodology and data collection in coming months.</td><td>Not defined</td><td>Valladolid</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>-</td><td>-</td><td>-</td></tr>
</table>

CHALLENGE 4: GREEN SPACE MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (biological)	**Quality of life for elderly people**	New green cycle lane and re-naturing existing bike lanes: Green cycle lane; Green resting areas; Cycle-pedestrian green paths
Measured method	**KPI Unit**	**City**
Seniors who use green corridor. Satisfaction.	(senior users) (% satisfaction)	Valladolid
Smartphone application: Periodic surveys can be performed via the smartphone application	Subjective rating on both aspects from 1 to 10	
Sensor	**Calculi**	**External data source/ Website**
Smartphone: Satisfaction data collected by URBAN GreenUP Mobile App.	Surverys: Identify Social perception, wellbeing	Local Agenda 21 of Valladolid - Sustainability indicators www.valladolidagendalocal21.es

CHALLENGE 4: GREEN SPACE MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (biological)	**Sustainability of green areas**	New green cycle lane and re-naturing existing bike lanes: Green cycle lane; Green resting areas; Cycle-pedestrian green paths
Measured method	**KPI Unit**	**City**
Subscriptions to the bicycle loan system of Valladolid (Vallabici)	(annual subscriptions)	Valladolid
Calculation of the number of users of the bike lane.	(nº users)	
Sensor	**Calculi**	**External data source/ Website**
No sensor	N/A	Comprehensive Urban, Sustainable and Safe Mobility Plan for the City of Valladolid (PIMUSSVA). Vallabici: www.pimussva.es http://usualbike.com/vallabici/

CHALLENGE 4: GREEN SPACE MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social indicators (benefits)	**Recreational** (number of visitors, number of recreational activities) **or cultural** (number of cultural events, people involved, children in educational activities) value (Kabisch and Haase, 2014)	Green cycle lane; Tree related actions; New Green Corridor
Measured method	**KPI Unit**	**City**
Number of events and participants	Nº	Izmir
Sensor	**Calculi**	**External data source/ Website**
RFID or ZigBee sensors	Measurement by various sensors	TBD

CHALLENGE 4: GREEN SPACE MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social indicators (benefits)	**Accessibility of urban green spaces for population (measured as distance or time, Tamosiunas et al., 2014).**	New green cycle lane and re-naturing existing bike lanes: Green cycle lane; Green resting areas; Cycle-pedestrian green paths. Vertical green interventions. Horizontal green interventions. Urban farming promotion: Urban orchard; Community composting; Small-scale urban livestock. Educational activities: Educational paths (A, C); Urban farming educational activities Tree related actions for Liverpool
Measured method	**KPI Unit**	**City**
Calculation of the shortest distance (linear) between the population in the NBS (line type), and the NBS location centroid. Results obtained in distance (m) and time (min). Tool: Geographic Information Systems.	(m) (min)	Valladolid Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Calculated with Geographic Information Systems (GIS)	Local Agenda 21 of Valladolid - Sustainability indicators.
Measured method	**KPI Unit**	**City**
GIS analysis of distance of NBS site from home, schools, and businesses. Land use cover will also be analysed in GIS to show what each area is comprised of, what different NBS are located within each site, and what socio-economic amenities can be identified. (links to recreation opportunities)	m2/km2	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No Sensor	Calculated with Geographic Information Systems (GIS)	N/A

CHALLENGE 4: GREEN SPACE MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social indicators (benefits)	**Accessibility to public parks, gardens and play-grounds (more than 50 ha) - (inhabitants within 10 km from a park)**	▪ Green cycle lane ▪ Tree related actions ▪ New Green Corridor
Measured method	**KPI Unit**	**City**
Calculation of the shortest distance (linear) between the population in the NBS area of influence, and the NBS location centroid. Results obtained in distance (m) and time (min). Tool: Geographic Information Systems.	(m) (min)	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Calculated with Geographic Information Systems (GIS)	TBD

CHALLENGE 4: GREEN SPACE MANAGEMENT		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social indicators (benefits)	**Accessibility to public parks gardens and play-grounds (between 10 ha and 50 ha) - (inhabitants within 1 km from a park)**	▪ Green cycle lane ▪ Tree related actions ▪ New Green Corridor
Measured method	**KPI Unit**	**City**
Calculation of the shortest distance (linear) between the population in the NBS area of influence, and the NBS location centroid. Results obtained in distance (m) and time (min). Tool: Geographic Information Systems.	(m) (min)	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Calculated with Geographic Information Systems (GIS)	TBD

<table>
<tr><th colspan="3">CHALLENGE 4: GREEN SPACE MANAGEMENT</th></tr>
<tr><th>TYPE OF INDICATOR</th><th>KPI DEFINITION</th><th>RELATED NBS</th></tr>
<tr><td>Social indicators (benefits)</td><td>Distribution of public green space – total surface or per capita.</td><td>New green cycle lane and re-naturing existing bike lanes: Green cycle lane; Green resting areas; Cycle-pedestrian green paths
Vertical green interventions: Green noise barriers; Green vertical mobile garden; Green façade
Horizontal green interventions: Green covering shelter; Green roof; Green shady structures</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td rowspan="2">Green corridor distance, calculated with GIS (cycle lane). 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.</td><td>(m2/capita)</td><td rowspan="2">Valladolid
Izmir</td></tr>
<tr><td>(km _{cycle lane}/capita)</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>No sensor</td><td>Calculated with Geographic Information Systems (GIS)</td><td>Local Agenda 21 of Valladolid - Sustainability indicators</td></tr>
</table>

<table>
<tr><th colspan="3">CHALLENGE 4: GREEN SPACE MANAGEMENT</th></tr>
<tr><th>TYPE OF INDICATOR</th><th>KPI DEFINITION</th><th>RELATED NBS</th></tr>
<tr><td>Social indicators (benefits)</td><td>Weighted recreation opportunities provided by Urban Green Infrastructure (Derkzen et al. 2015)</td><td>Tree related actions; Green cycle lane/pedestrian route/road traffic junction improvements
Urban farming promotion: Urban orchard; Community composting; Small-scale urban livestock
Educational activities: Educational paths (A, C); Urban farming educational activities</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td rowspan="3">Green corridor distance (km).
Users.
Satisfaction.
Cycle lane = green corridor distance (m).
Number of people who use green corridor (nº users).
Being valued for recreation, social interaction, education and supporting healthy living (satisfaction)</td><td>(km)</td><td rowspan="3">Valladolid</td></tr>
<tr><td>(nº users)</td></tr>
<tr><td>(% satisfaction)</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>No sensor.
Satisfaction data collected by URBAN GreenUP Mobile App.</td><td>Surface calculated with Geographical Information Systems (GIS)</td><td>http://www.valladolidagendalocal21.es/</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td rowspan="2">Baseline and post-intervention measurements of engagement with NBS through walking and cycling, Types of activity undertaken in/with NBS (other than walking and cycling), frequency of interaction with NBS. Reported as frequency count data (interactions/week)</td><td>(number of visitors, number of recreational activities)</td><td rowspan="2">Liverpool</td></tr>
<tr><td>(Number of cultural events, people involved, children in educational activities) value Kabiisch and Haase 2014)</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>No sensor</td><td>Social Survey - Calculated with questionnaire and standard software (Excel or SPSS)</td><td>N/A</td></tr>
</table>

4.5 CHALLENGE 5: AIR QUALITY

<table>
<tr><th colspan="3">CHALLENGE 5: AIR QUALITY</th></tr>
<tr><th>TYPE OF INDICATOR</th><th>KPI DEFINITION</th><th>RELATED NBS</th></tr>
<tr><td>Environmental (chemical)</td><td>Air quality parameters NOx, VOC, PM etc.</td><td>New green cycle lane and re-naturing existing bike lanes: Green cycle lane; Green resting areas; Cycle-pedestrian green paths
Vertical green interventions: Green noise barriers; Green vertical mobile garden; Green façade
Horizontal green interventions: Green covering shelter; Green roof; Green shady structures</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td rowspan="6">Emissions avoided due to bicycle use: PM2.5, PM10, SO2, NO, NO2, CO, O3, Benzene (C6H6), Toluene, MP-Xylene, Ethyl-Benzene, O-Xylene: Data value by hour and day (24 / day). Quality air index (ICA): Daily value.</td><td>(kg CO2/km car)</td><td rowspan="6">Valladolid</td></tr>
<tr><td>O3 (µg/m³) Benzene (µg/m³)</td></tr>
<tr><td>Toluene (µg/m³) MP-Xylene</td></tr>
<tr><td>(µg/m³) Ethyl-Benzene (µg/m³)</td></tr>
<tr><td>O-Xylene (µg/m³)</td></tr>
<tr><td>Quality air index (ICA)</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>Valladolid air quality network (5 stations)</td><td>Evolution of air quality value graph.</td><td>Valladolid City Council Air Pollution Control Network (RCCAVA)</td></tr>
</table>

CHALLENGE 5: AIR QUALITY		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (chemical)	**Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted) concentration recorded ug/m3**	Tree related actions Green cycle lane/pedestrian route/road traffic junction improvements Vertical green interventions: Green noise barriers; Green vertical mobile garden; Green façade; green filter area Horizontal green interventions: Green covering shelter; Green roof; Green shady structures Biofilter
Measured method	**KPI Unit**	**City**
Air Pollution Control Network (RCCAVA) data Air quality measurement of the stations local network. Data value by hour and day (24 / day)	(µg/m3) PM2.5 (µg/m3) PM10	Valladolid
Sensor	**Calculi**	**External data source/ Website**
Valladolid air quality network (5 stations)	Evolution of air quality value graph.	Valladolid City Council Air Pollution Control Network (RCCAVA)
Measured method	**KPI Unit**	**City**
Air quality sensor (tons or equiv) / filter deposition (tbc) Compare levels of PM2.5 and PM10 at NBS locations and control sites (without GI)	(µg/m3) PM2.5 (µg/m3) PM10	Liverpool
Sensor	**Calculi**	**External data source/ Website**
Sensor	Analysed using standard software (Excel/R)	

CHALLENGE 5: AIR QUALITY		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (chemical)	**Mean levels of exposure to ambient air pollution (population weighted) (proposed indicator for SDG target 3.9)**	Biofilter
Measured method	**KPI Unit**	**City**
Biofilter measurement in-situ, real implementation will be held in one of the tunnels of Valladolid	(inhab.) (kg CO2/km car)	Valladolid
Sensor	**Calculi**	**External data source/ Website**
Air Quality Parameters sensor	Air Quality sensor value, data measurement compared before/after BioFilter installation	City available data according to the Air Quality Value (average data)

CHALLENGE 5: AIR QUALITY		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental, Economic and Social (physiological)	**Number of deaths from air, water and soil pollution and contamination (proposed indicator for SDG target 3.9)**	▪ Horizontal green interventions ▪ Tree related actions Smart soils, Green filter área, vertical Green interventions
Measured method	**KPI Unit**	**City**
Deaths from various sources related to air quality are measured by the government and publicly available.	Nº of deaths	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No Sensor	Externally calculated by Public Health England	Public Health England https://www.gov.uk/guidance/phe-data-and-analysis-tools

CHALLENGE 5: AIR QUALITY		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (chemical)	**Trends in emissions NOX, SOX**	▪ Tree related actions ▪ Green cycle lane/pedestrian route/road traffic junction improvements ▪ Vertical green interventions: Green noise barriers; Green vertical mobile garden; Green façade, green filter area ▪ Horizontal green interventions: Green covering shelter; Green roof; Green shady structures ▪ Biofilter
Measured method	**KPI Unit**	**City**
Air quality measurement of the stations local network. Data value by hour and day (24 / day)	(µg/m3) SO2 (µg/m3) NO (µg/m3) NO2	Valladolid
Sensor	**Calculi**	**External data source/ Website**
Valladolid air quality network (5 stations)	Evolution of air quality value graph.	Valladolid City Council Air Pollution Control Network (RCCAVA) http://www.valladolid.es/es/rccava/datos-red
Measured method	**KPI Unit**	**City**
Diffusion tubes Compare levels of SO_2, NO and NO_2 at NBS locations and control sites (without GI)	(µg/m3) SO_2 (µg/m3) NO (µg/m3) NO_2	Liverpool
Sensor	**Calculi**	**External data source/ Website**
Air Quality Parameters sensor	Air Quality sensor value, data measurement compared before/after BioFilter installation	City available data according to the Air Quality Value (average data)

CHALLENGE 5: AIR QUALITY		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (chemical)	**Non-spatial indicators of gross quantities: annual amount of pollutants captured by vegetation** (Bottalico et al., 2016).	Green cycle lane; Tree related actions; Smarts soils as substrate; Urban garden bio-filter; Vertical green interventions; Horizontal green interventions
Measured method	**KPI Unit**	**City**
Annual measurements via air quality measurement sensors / Calculation by formulas	kg pollutant / year	Izmir
Sensor	**Calculi**	**External data source/ Website**
Air quality sensors	Measured	TBD

CHALLENGE 5: AIR QUALITY		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (chemical)	**Non-spatial indicators of net quantities: net air quality improvement** (pollutants produced – pollutants captured + GHG emissions from maintenance activities) (Baró et al., 2014).	Green cycle lane; Tree related actions; Smarts soils as substrate; Urban garden bio-filter; Vertical green interventions; Horizontal green interventions
Measured method	**KPI Unit**	**City**
Annual measurements via air quality measurement sensors	kg pollutant / year	Izmir
Sensor	**Calculi**	**External data source/ Website**
Air quality sensors	Measured	TBD

CHALLENGE 5: AIR QUALITY		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (chemical)	**Spatial indicators: pollutant fluxes per m2 per year** (Manes et al., 2016; Tallis et al., 2011).	Green cycle lane; Tree related actions; Smarts soils as substrate; Urban garden bio-filter; Vertical green interventions; Horizontal green interventions
Measured method	**KPI Unit**	**City**
Air quality measurements; IPCC, USEPA and CORINAIR, CO2 emissions will be calculated. The other pollutants such as PM10, SO2, NOx and ozone will be measured/collected from a stationary Air Quality Measurement Station located in Çiğli and a mobile station belongs to Izmir Metropolitan Municipality. Then the improvement in air quality and pollutant fluxes in urban level will be determined	kg pollutant / year	Izmir
Sensor	**Calculi**	**External data source/ Website**
Air quality sensors	Measured	TBD http://aqicn.org/city/izmir/

CHALLENGE 5: AIR QUALITY		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental (chemical)	**Non-spatial indicators of shares: share of emissions (air pollutants) captured/sequestered by vegetation** (Baró et al., 2014).	Green cycle lane; Tree related actions; Smarts soils as substrate; Urban garden bio-filter; Vertical green interventions; Horizontal green interventions
Measured method	**KPI Unit**	**City**
Annual measurements via air quality measurement sensors / Calculation by formulas	kg pollutant / year	Izmir
Sensor	**Calculi**	**External data source/ Website**
Air quality sensors	Measured	TBD

CHALLENGE 5: AIR QUALITY		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social (physiological)	**Number of deaths from air, water and soil pollution and contamination (proposed indicator for SDG target 3.9)**	▪ Vertical and horizontal green infrastructure ▪ Tree related actions ▪ Smarts soils as substrate ▪ Biofilter
Measured method	**KPI Unit**	**City**
Public health statistics. Deaths from various sources related to air quality are measured by the government and publicly available.	No. of deaths	Valladolid
Sensor	**Calculi**	**External data source/ Website**
No Sensor	Externally calculated by Public Health	City available data according to the Air Quality Value (average data)http://www.valladolid.es/es/rccava/contaminantes
Measured method	**KPI Unit**	**City**
Public health statistics. Deaths from various sources related to air quality are measured by the government and publicly available.	Nº. of deaths	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No Sensor	Externally calculated by Public Health England	Public Health England

CHALLENGE 5: AIR QUALITY		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social (physiological)	**Air quality parameters NOx, VOC, PM etc.**	Biofilter
Measured method	**KPI Unit**	**City**
Air Quality Improvement Gathered Biofilter measurement in-situ, real implementation will be held in one of the tunnels of Valladolid	(µg/m3) SO2 (µg/m3) NO (µg/m3) NO2	Valladolid
Sensor	**Calculi**	**External data source/ Website**
Air Quality Parameters sensor	Air Quality sensor value, data measurement compared before/after BioFilter installation	City available data according to the Air Quality Value (average data)

CHALLENGE 5: AIR QUALITY		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic (Monetary values)	**Value of air pollution reduction** **Total monetary value of urban forests including air quality** **Run-off mitigation** **Energy savings** **Increase in property values.**	▪ Tree related actions ▪ vertical green interventions ▪ Smarts soils as substrate ▪ green filter area ▪ Biofilter
Measured method	**KPI Unit**	**City**
Cost Calculation to define the over cost BioFilter Prices comparison to the prices of the state of the art Solutions	Euro	Valladolid
Sensor	**Calculi**	**External data source/ Website**
No sensor	-	-
Measured method	**KPI Unit**	**City**
Modelled using GIVal and data from city air quality monitoring and publicly available data on monetary value relating to air pollution reduction, energy use, and property values.	Euro	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Calculated with GIVal and standard software (Excel or SPSS)	Public Health England
Measured method	**KPI Unit**	**City**
TBD	Euro	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	TBD	TBD

4.6 CHALLENGE 6: URBAN REGENERATION

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Socio-cultural indicators	**Assessment of typology, functionality and benefits provided pre and post interventions**	Tree related actions SUDS /Raingarden Urban Carbon sink Pollinator verges and spaces Green filter area Green cycle lane/pedestrian route/road traffic junction improvements Non-technical actions Natural waste water treatment New green cycle lane and re-naturing existing bike lanes: Vertical and Horizontal green interventions.
Measured method	**KPI Unit**	**City**
Increase in the bike lane distance by green corridor: New cycle lane (km)+ existing cycle lane (km)	(% increased km cycle lane)	Valladolid
m2 developed in the project + existing green m2.	(m2) (m2/capita)	
Sensor	**Calculi**	**External data source/ Website**
No sensor	Calculated with Geographic Information Systems (GIS)	Local Agenda 21 of Valladolid - Sustainability indicators
Measured method	**KPI Unit**	**City**
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.	m or km of each type of NBS,	Liverpool
	Likert scale measures (e.g. very poor to excellent)	
	Frequency count statistics	
Sensor	**Calculi**	**External data source/ Website**
No sensor	Social Survey - Calculated with questionnaire and standard software (Excel or SPSS)	N/A

<table>
<tr><th colspan="3">CHALLENGE 6: URBAN REGENERATION</th></tr>
<tr><th>TYPE OF INDICATOR</th><th>KPI DEFINITION</th><th>RELATED NBS</th></tr>
<tr><td>Socio-cultural indicators</td><td>Savings in energy use due to improved GI</td><td>Tree related actions
SUDS /Raingarden
Urban Carbon sink
Pollinator verges and spaces
Green filter area
Green cycle lane/pedestrian route/road traffic junction improvements
Non-technical actions
Natural waste water treatment
New green cycle lane and re-naturing existing bike lanes: Vertical and Horizontal green interventions.</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td rowspan="2">Diesel consumption saved by the use of the bicycle in the green corridor. It will be calculated by a conversion factor of the average fuel consumption of a vehicle.</td><td>(l diesel)</td><td rowspan="3">Valladolid</td></tr>
<tr><td>(savings l diesel)</td></tr>
<tr><td>Electricity measurement for the expenses in air conditioning and heating.</td><td>(KWh/m2)</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>No sensor</td><td>Decrease in diesel consumption due to the NBS (vehicle vs bicycle)</td><td>Mobility. Valladolid City Council</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td>Buildings retrofitted with NBS will be surveyed prior to and post investment to calculate changing costs of energy</td><td>Savings in £/€</td><td>Liverpool</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>No Sensor</td><td>Social Survey - Calculated with questionnaire and standard software (Excel or SPSS)</td><td>N/A</td></tr>
</table>

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Socio-cultural indicators	**Conservation of built heritage resources: percentage of built from retained for culture.**	TBD
Measured method	**KPI Unit**	**City**
TBD	TBD	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	N/A	TBD

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Socio-cultural indicators	**Land dedicated to pedestrians: percentage of road network**	Green Route
Measured method	**KPI Unit**	**City**
Statistical data from municipality	%	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	Data from inventory of municipality	TBD

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Socio-cultural indicators	**Public transport links: walking distance to nearest facilities.**	Green Route
Measured method	**KPI Unit**	**City**
Statistical data from municipality	m	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	Data from inventory of municipality	TBD

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Socio-cultural indicators	**Access to open space: average journey time for residents/employees by foot or average distance to sports centre, recreation area, or green space**	▪ Green cycle lane ▪ Green route ▪ New green corridor
Measured method	**KPI Unit**	**City**
Statistical data from municipality	Various measurement values TBD	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	Data from inventory of municipality	TBD

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Socio-cultural indicators	**Access to cultural facilities: average journey time for residents on foot or average distance to cultural centre**	▪ Green cycle lane ▪ Green route ▪ New green corridor
Measured method	**KPI Unit**	**City**
Statistical data from municipality	min	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	Data from inventory of municipality	TBD

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Socio-cultural indicators	**Level of devices contributing to the safety of users in the neighbourhood: lighting of common areas, access control, presence of technical, or specialized staff, etc.**	▪ Green cycle lane ▪ Green route ▪ New green corridor
Measured method	**KPI Unit**	**City**
Statistical data from municipality	%	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	Data from inventory of municipality	TBD

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental, biological (Urban green indicators)	**Accessibility: distribution, configuration, and diversity of green space and land use changes (multi-scale ;). - Green spaces quantity**	Tree related actions New green cycle lane and re-naturing existing bike lanes: Green cycle lane; Green resting areas; Urban orchard; Community composting; Small-scale urban livestock
Measured method	**KPI Unit**	**City**
Distance of road (traffic) substituted by cycle lanes.	(km cycle/km road)	Valladolid
Convert brownfield to green areas in urban regeneration projects (non-used land) - Analysis of land use change.	(m2)	
Level of satisfaction obtained by the NBS (wellbeing).	(% satisfaction)	
Sensor	**Calculi**	**External data source/ Website**
-	Surface calculated with Geographical Information Systems (GIS)	Valladolid City Council General Urban Planning (PGOU) Local Agenda 21 of Valladolid
Measured method	**KPI Unit**	**City**
GIS mapping will be used to identify the composition and diversity of NBS in each site. Analysis of distance to/accessibility of NBS from homes, schools, and places of business	Distance from NBS % land cover of different NBS weighted accessibility (good, moderate, poor)	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Calculated with Geographic Information Systems (GIS)	N/A
Measured method	**KPI Unit**	**City**
Connectivity of green spaces were quantified on the basis of land use/cover maps using Area and Edge Metrics (CA-class area, PLAND-percentage of landscape, GY¬RATE_AM-area weighted mean radius of gyration, AREA_MN-patch area distribution), Aggregation metrics (NP-number of patches, CONNECT-Connectance index.	(nº species) (% satisfaction)	Izmir
Sensor	**Calculi**	**External data source/ Website**
WorldView2 satellite images	Image Analysis	TBD

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental, biological (Urban green indicators)	**Assessment of typology, functionality and benefits provided pre and post interventions**	Vertical and horizontal green infrastructure, horizontal GI, tree related actions, SUDS and raingardens, pollinator verges and spaces, Green cycle lanes, urban carbon sink Green filter areas, natural waste water treatment, non-technical intervention
Measured method	**KPI Unit**	**City**
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.	m or km of each type of NBS	Liverpool
	Likert scale measures (e.g. very poor to excellent)	
	frequency count statistics	
Sensor	**Calculi**	**External data source/ Website**
No sensor	Social Survey - Calculated with questionnaire and standard software (Excel or SPSS)	N/A

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Environmental, biological (Urban green indicators)	**Urban green: Index of biodiversity, provision and demand of ecosystem services.**	Pollinator / Urban farming
Measured method	**KPI Unit**	**City**
The formula for calculating Simpson's index is: Where N = the total number of all organisms and n = the numbers of individuals of each individual species. The scale ranges from 0 to 1 where 1 represents low biodiversity	Nº species	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	The Simpson's index: $D = \frac{\sum n(n-1)}{N(N-1)}$	N/A

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Urban green indicators (environmental, biological)	**Ecological connectivity**	▪ Vertical and horizontal green infrastructure ▪ Tree related actions ▪ Vertical green interventions
Measured method	**KPI Unit**	**City**
Functional connectivity among GI patches in the city network for focal species. Ecological surveys of selected taxa at NBS and existing GI (including large urban parks) pre-intervention and in years 1 and 2 post intervention. Evaluating similarity of pollinator species composition among GI patches (NBS and existing GI) and the importance of variables including spatial arrangement of GI in the urban matrix.	Relative similarity	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Using GIS and software package R	N/A
Measured method	**KPI Unit**	**City**
connectivity of green spaces were quantified on the basis of land use/cover maps using Area and Edge Metrics (CA-class area, PLAND-percentage of landscape, GY¬RATE_AM-area weighted mean radius of gyration, AREA_MN-patch area distribution), Aggregation metrics (NP-number of patches, CONNECT-Connectance index	Various measurements values	Izmir
Sensor	**Calculi**	**External data source/ Website**
WorldView2 satellite images		

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Building efficiency and environmental design	**Reclamation of building materials: percentage reclaimed from existing buildings**	TBD
Measured method	**KPI Unit**	**City**
TBD	TBD	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	N/A	TBD

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Building efficiency and environmental design	**Energy efficiency: building materials/construction methods based on points awarded according to energy efficiency checklist**	TBD
Measured method	**KPI Unit**	**City**
will be calculated based on the measured consumption data and greenhouse gas emission factors taken from IPCC, USEPA and CORINAIR	kWh	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	Measured	TBD

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Building efficiency and environmental design	**Incorporation of environmental design: percentage of total building stock**	TBD
Measured method	**KPI Unit**	**City**
Statistical data from municipality	Nº of buildings	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Data from inventory of municipality	TBD

CHALLENGE 6: URBAN REGENERATION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Building efficiency and environmental design	**Land devoted to roads: percentage of site area occupied by roads**	TBD
Measured method	**KPI Unit**	**City**
Statistical data from municipality	m2	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	Data from inventory of municipality	TBD

4.7 CHALLENGE 7: PARTICIPATORY PLANNING AND GOVERNANCE

CHALLENGE 7: PARTICIPATORY PLANNING AND GOVERNANCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social	**Citizen participation in the development and delivery of interventions**	Vertical and horizontal green infrastructure; tree related actions; horizontal green interventions
Measured method	**KPI Unit**	**City**
Quantitative and qualitative data on the number of actors/stakeholders delivering NBS, support for stakeholders delivering NBS, and wider citizen participation in the development and delivery of NBS.	Frequency counts (organisations and individuals) and Likert scale measures	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No Sensor	Social Survey - Calculated with questionnaire and standard software (Excel or SPSS); Interviews and Participant Observation (analysis with Nvivo)	N/A

CHALLENGE 7: PARTICIPATORY PLANNING AND GOVERNANCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social	**Perceptions of citizens on urban nature - Green spaces quality**	Vertical and horizontal green infrastructure; tree related actions ; promotion of NBS at citizen scale: Engagement Portal for citizen; Promotion of ecological reasoning and intelligent; Single desk for RUP deployment; City mentoring strategy (Staff Exchange activities)
Measured method	**KPI Unit**	**City**
Periodic surveys can be performed via the smartphone application. The % of satisfaction can be determined with the number of participants above a threshold	% of satisfaction can be determined by users over a threshold	Valladolid
Sensor	**Calculi**	**External data source/ Website**
Smartphone	N/A	Local Agenda 21 of Valladolid - Sustainability indicators
Measured method	**KPI Unit**	**Cities**
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	Reported perception of NBS and value to social, economic and ecological landscape	Liverpool Izmir
Sensor	**Calculi**	**External data source/ Website**
No Sensor	Social Survey - Calculated with questionnaire and standard software (Excel or SPSS)	N/A

CHALLENGE 7: PARTICIPATORY PLANNING AND GOVERNANCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social	**Openness of participatory processes** (Frantzeskaki and Kabisch, 2016; Luyet et al., 2012; Uittenbroek et al., 2013)	Vertical green interventions; non-technical actions
Measured method	**KPI Unit**	**City**
Statistical data from municipality	%	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	Data from inventory of municipality	TBD

CHALLENGE 7: PARTICIPATORY PLANNING AND GOVERNANCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social	**Legitimacy of knowledge in participatory processes** (Frantzeskaki and Kabisch, 2016; Luyet et al., 2012)	Vertical green interventions; non-technical actions
Measured method	**KPI Unit**	**City**
Survey	%	Izmir
Sensor	**Calculi**	**External data source/ Website**
no sensor	Analysis of survey data using standard software	TBD

CHALLENGE 7: PARTICIPATORY PLANNING AND GOVERNANCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social	**Social learning concerning urban ecosystems and their functions/services** (Colding and Barthel, 2013)	Vertical green interventions; non-technical actions
Measured method	**KPI Unit**	**City**
Survey	%	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Analysis of survey data using standard software	TBD

CHALLENGE 7: PARTICIPATORY PLANNING AND GOVERNANCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social	**Policy learning concerning adapting policies and strategic plans by integrating ecosystem services and possibly their valuation** (Crowe et al., 2016; Uittenbroek et al., 2013; Vandergert et al., 2015)	Vertical green interventions; non-technical actions
Measured method	**KPI Unit**	**City**
Survey	%	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Analysis of survey data using standard software	TBD

CHALLENGE 7: PARTICIPATORY PLANNING AND GOVERNANCE		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social	**Social values for urban ecosystems and biodiversity** (Brown and Fagerholm, 2014; Kenter et al., 2015; Polat and Akay, 2015; Raymond et al., 2014, 2009; Scholte et al., 2015)	Vertical green interventions; non-technical actions
Measured method	**KPI Unit**	**City**
Survey	various measurement values TBD	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Analysis of survey data using standard software	TBD

4.8 CHALLENGE 8: SOCIAL JUSTICE AND SOCIAL COHESION

CHALLENGE 8: SOCIAL JUSTICE AND SOCIAL COHESION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social cohesion	**Structural aspects: indicators of family and friendship ties; participation in organised associations; integration into the wider community** (Cozens and Love, 2015; Stafford et al., 2003)	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
Survey and statistical data	Various measurement values	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Data from inventory of municipality	TBD

CHALLENGE 8: SOCIAL JUSTICE AND SOCIAL COHESION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social cohesion	**Cognitive aspects: indicators of trust, attachment to neighbourhood, practical help, tolerance and respect** (Mihaylov and Perkins, 2014; Uzzell et al., 2002)	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
Survey and statistical data	Various measurement values	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Analysis of survey data using standard software	TBD

CHALLENGE 8: SOCIAL JUSTICE AND SOCIAL COHESION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social Justice	**Access to financial resources, including indicators of income per capita in a given neighbourhood, or urban area** (Klasen, 2008)	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
Survey and statistical data	Various measurement values	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Data from inventory of municipality	TBD

CHALLENGE 8: SOCIAL JUSTICE AND SOCIAL COHESION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social Justice	**Bodily integrity - Being able to move freely from place to place; to be secure against violent assault, including indicators of crime by time of day** (Felson and Poulsen, 2003)	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
Statistical data from municipality	Nº of events	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Data from inventory of municipality	TBD

CHALLENGE 8: SOCIAL JUSTICE AND SOCIAL COHESION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social Justice	**Senses, imagination and thought: being able to use the senses, to imagine, think, and reason about the environment, informed by indicators of levels of literacy, mathematics and science knowledge** (Chen and Luoh, 2010; Elliott et al., 2001).	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
Survey	Various measurement values	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Analysis of survey data using standard software	TBD

CHALLENGE 8: SOCIAL JUSTICE AND SOCIAL COHESION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social Justice	**Emotions: being able to have attachments to things and people outside ourselves; to love those who love and care for us, including indicators of place attachment, empathy and love** (Lawrence et al., 2004; Manzo and Devine-Wright, 2014; Perkins et al., 2010; Raymond et al., 2010)	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
Survey and statistical data	Various measurement values	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Analysis of survey data using standard software	TBD

CHALLENGE 8: SOCIAL JUSTICE AND SOCIAL COHESION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social Justice	**Being able to participate effectively in political choices that govern one's life, including indicators on level and quality of public participation in environmental management** (Reed, 2008; Reed et al., 2009).	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
Survey	%	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Analysis of survey data using standard software	TBD

CHALLENGE 8: SOCIAL JUSTICE AND SOCIAL COHESION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social Justice	**Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities**	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
Survey and statistical data	%	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Data from inventory of municipality	TBD

CHALLENGE 8: SOCIAL JUSTICE AND SOCIAL COHESION		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Social justice (Informed by the capability framework of social justice: Comim et al., 2008; Nussbaum, 2011; Sen, 2005)	**Crime reduction through police reports and local authority data**	▪ Vertical and horizontal green infrastructure ▪ Tree related actions ▪ SUDS /raingarden ▪ Horizontal green interventions ▪ Vertical green interventions ▪ Pollinator verges and spaces ▪ Non-technical actions
Measured method	**KPI Unit**	**City**
Crime will be assessed around the location of the NBS (with 300m buffer) to assess whether increased landscaping has an impact in criminal behaviour	No of crimes per annum	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No Sensor	Externally by police and additionally by use of LCC CONFIRM data on environmental crime e.g. littering, graffiti, damage to trees etc.	Merseyside police statistics and LCC CONFIRM database reports

<table>
<tr><th colspan="3">CHALLENGE 8: SOCIAL JUSTICE AND SOCIAL COHESION</th></tr>
<tr><th>TYPE OF INDICATOR</th><th>KPI DEFINITION</th><th>RELATED NBS</th></tr>
<tr><td>Social cohesion</td><td>Green intelligence awareness</td><td>▪ Vertical and horizontal green infrastructure
▪ Tree related actions
▪ SUDS /raingarden
▪ Pollinator verges and spaces
▪ Educational activities: educational paths (a, c); urban farming educational activities
▪ Non-technical actions;</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td rowspan="2">Number of environmental education actions carried out. Number of people attending. Dissemination activities can be performed through the smartphone application itself, and the smartphone can measure both participation and the level of completion in the education activities</td><td>(nº educ. actions)</td><td rowspan="2">Valladolid</td></tr>
<tr><td>(inhab attended)</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>Smartphone</td><td>N/A</td><td>Ecological orchards of Valladolid (2016-2017)</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td>Awareness of the benefits and values of NBS to individuals and communities will be examined using social survey methods exploring use, valuation and barriers to use</td><td>Reported awareness and engagement with NBS from survey respondents</td><td>Liverpool</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>No Sensor</td><td>Social Survey - Calculated with questionnaire and standard software (Excel or SPSS)</td><td>N/A</td></tr>
</table>

4.9 CHALLENGE 9: PUBLIC HEALTH AND WELL-BEING

<table>
<tr><th colspan="3">CHALLENGE 9: PUBLIC HEALTH AND WELL-BEING</th></tr>
<tr><th>TYPE OF INDICATOR</th><th>KPI DEFINITION</th><th>RELATED NBS</th></tr>
<tr><td>Health indicators related to ecosystem service provision (Buffering of noise and air pollution, reduced heat, exposure to microflora)</td><td>Increase in walking and cycling in and around areas of interventions</td><td>Green cycle lane; Vertical green interventions; Horizontal green interventions; Floodable park</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td rowspan="2">Using the smartphone application we can promote walking and cycling at the intervention sites, and also measure its use by using the GPS or other types of validation (QR code reading)
Subscriptions to the bicycle loan system of Valladolid (Vallabici)
Calculation of the number of users of the bike lane.</td><td>(annual subscriptions)</td><td rowspan="2">Valladolid</td></tr>
<tr><td>(nº users)</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>No sensor</td><td>N/A</td><td>• Comprehensive Urban, Sustainable and Safe Mobility Plan for the City of Valladolid (PIMUSSVA).
• Vallabici.</td></tr>
<tr><th>Measured method</th><th>KPI Unit</th><th>City</th></tr>
<tr><td>Survey of local residents, users and businesses of their perceived and actual use of NBS for walking, cycling and other activities pre and post-investment.</td><td>% increase in use (hours, days, weeks) and changes in behaviour of use derived from participant responses</td><td>Liverpool</td></tr>
<tr><th>Sensor</th><th>Calculi</th><th>External data source/ Website</th></tr>
<tr><td>No Sensor / footfall sensor</td><td>Social survey / GIS to calculate changing use patterns</td><td>N/A</td></tr>
</table>

CHALLENGE 9: PUBLIC HEALTH AND WELL-BEING		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Psychological indicators (Relaxation and restoration, sense of place, exploratory behaviour, socializing)	**Noise reduction rates applied to UGI within a defined road buffer dB(A) m-2 vegetation unit**	Vertical green interventions: Green noise barriers; Green vertical mobile garden; Green façade
Measured method	**KPI Unit**	**City**
Noise measurements with sound level meter. Analysis of the evolution of the noise level. Decrease in noise level due to NBS. Noise model.	(dB(A))	Valladolid
Sensor	**Calculi**	**External data source/ Website**
Sound level meter (manual)	Noise measurements plan for the NBS	Valladolid City Council Air Pollution Control Network (RCCAVA). Strategic Noise Map (Ministry of Environment, MAPAMA). Municipal Plan against Noise Pollution of Valladolid.

CHALLENGE 9: PUBLIC HEALTH AND WELL-BEING		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Health indicators related to ecosystem service provision (Buffering of noise and air pollution, reduced heat, exposure to microflora)	**Perceptions of health and quality of life**	▪ SUDS /Raingarden ▪ Horizontal green interventions ▪ Vertical green interventions ▪ Green cycle lane/pedestrian route/road traffic junction improvements
Measured method	**KPI Unit**	**City**
Survey of local residents to understand perceptions of general, physical, and mental health, as well as general, individual, and communal well-being	Likert scale units (e.g. very poor to excellent)	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Social Survey - Calculated with questionnaire and standard software (Excel or SPSS)	N/A

CHALLENGE 9: PUBLIC HEALTH AND WELL-BEING		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Health indicators related to ecosystem service provision (Buffering of noise and air pollution, reduced heat, exposure to microflora)	**Reduced autoimmune diseases and allergies (potentially)** (Kuo, 2015).	▪ Vertical green interventions
Measured method	**KPI Unit**	**City**
Statistical data from municipality and health facilities	Nº of events	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Data from inventory of municipality	TBD

CHALLENGE 9: PUBLIC HEALTH AND WELL-BEING		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Health indicators related to ecosystem service provision (Buffering of noise and air pollution, reduced heat, exposure to microflora)	**Reduced cardiovascular morbidity and mortality** (Tamosiunas et al., 2014).	TBD
Measured method	**KPI Unit**	**City**
		Izmir
Sensor	**Calculi**	**External data source/ Website**

CHALLENGE 9: PUBLIC HEALTH AND WELL-BEING		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Health indicators related to ecosystem service provision (Buffering of noise and air pollution, reduced heat, exposure to microflora)	**Green space of min. 2 ha within 300m percentage of green space** (Maas et al., 2006; Vries et al., 2003), (Kabisch and Haase, 2014; van den Berg et al., 2010).	TBD
Measured method	**KPI Unit**	**City**
NDVI, Imagery, Statistical data from the municipality	Min/%	Izmir
Sensor	**Calculi**	**External data source/ Website**
TBD	GIS software. Data from inventory of municipality	TBD

4.10 CHALLENGE 10: POTENTIAL OF ECONOMIC OPPORTUNITIES AND GREEN JOBS

CHALLENGE 10: POTENTIAL OF ECONOMIC OPPORTUNITIES AND GREEN JOBS		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic	**Change in mean or median land and property prices** (Forestry Commission, 2005)	▪ Tree related actions ▪ SUDS /Raingarden ▪ Green filter area ▪ Non-technical actions ▪ Natural waste water treatment
Measured method	**KPI Unit**	**City**
Change in house/rental prices in NBS intervention areas using area assessment from property market data and/or Hedonic pricing	Euro (€)	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Social Survey - Calculated with questionnaire and standard software (Excel or SPSS)	N/A
Measured method	**KPI Unit**	**City**
Statistical data and survey	%	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Change in prices	TBD

CHALLENGE 10: POTENTIAL OF ECONOMIC OPPORTUNITIES AND GREEN JOBS		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic	**Net additional positive outcomes into employment** (Tyler et al., 2013)	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
TBD	TBD	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	TBD	TBD

CHALLENGE 10: POTENTIAL OF ECONOMIC OPPORTUNITIES AND GREEN JOBS		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic	**Increased returns of business rates** **New businesses attracted and additional business rates**	▪ Tree related actions ▪ SUDS /Raingarden ▪ Green filter area ▪ Non-technical actions ▪ Natural waste water treatment
Measured method	**KPI Unit**	**City**
Change in revenue from businesses in the NBS intervention areas, as self-reported in surveys	Euro(€)	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No sensor	Social Survey - Calculated with questionnaire and standard software (Excel or SPSS)	N/A
Measured method	**KPI Unit**	**City**
Opening of shops, new businesses, in the environment of the NBS.	nº new business/year	Valladolid Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	New shops / businesses opening evolution.	Data from Opening Licenses Department (Valladolid City council; Izmir TBD)

CHALLENGE 10: POTENTIAL OF ECONOMIC OPPORTUNITIES AND GREEN JOBS		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic	**Number of subsidies or tax reductions applied for (private) NBS measures** (Meulen et al., 2013).	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
TBD	TBD	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	TBD	TBD

CHALLENGE 10: POTENTIAL OF ECONOMIC OPPORTUNITIES AND GREEN JOBS		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic	**Resource efficiency in the urban system** (CO2 emissions per capita, CO2 emissions for transportation per capita, etc.) (OECD, 2013)	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
Measurements from emission sources; emission factors from IPCC	ton CO2	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	TBD	TBD

CHALLENGE 10: POTENTIAL OF ECONOMIC OPPORTUNITIES AND GREEN JOBS		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic	**Public-sector cost per net additional job** (Tyler et al., 2013)	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
TBD	TBD	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	TBD	TBD

CHALLENGE 10: POTENTIAL OF ECONOMIC OPPORTUNITIES AND GREEN JOBS		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic	**Net additional jobs in the green sector enabled by NBS projects.** (Tyler et al., 2013)	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
Number of new jobs created related to NBS (gardening, maintenance, etc.). Increase in the property value or land value in the NBS area	nº jobs €	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	Number of employees (maintenance, parks and gardens) Property value / Land value evolution	TBD

CHALLENGE 10: POTENTIAL OF ECONOMIC OPPORTUNITIES AND GREEN JOBS		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic	**Gross value added per employees based on full-time equivalent jobs in the green sector** (Tyler et al., 2013)	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
TBD	TBD	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	TBD	TBD

CHALLENGE 10: POTENTIAL OF ECONOMIC OPPORTUNITIES AND GREEN JOBS		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic	**Number of jobs created; gross value added/job creation, increased footfall and spend in the areas of interventions if appropriate**	Vertical green interventions. Horizontal green interventions. Urban farming promotion: Urban orchard; Community composting; Small-scale urban livestock Sponsoring activities; Support to citizen project of NBS Non-technical actions Natural waste water treatment
Measured method	**KPI Unit**	**City**
Number of new jobs created related to NBS (gardening, maintenance, etc).	(nº jobs)	Valladolid Izmir
Increase in the property value or land value in the NBS area.	(€/m2)	
Number of people who find a job and leave the urban orchard.	(nº jobs or nº users)	
Compost production (t/year) and sales (€).	(kg/year) (€/year)	
Sensor	**Calculi**	**External data source/ Website**
No sensor	• Number of employees (maintenance, parks and gardens). • Property value / Land value evolution.	Valladolid city council Human Resources Department (Environment > Parks and Gardens). VIVA - Land and Housing Municipal Society of Valladolid. Izmir. TBD
Measured method	**KPI Unit**	**City**
Change in number of jobs located in areas in NBS investment and reporting and changes in income/composition of company post-investment.	Nº of jobs created. Economic increase (€) in business returns	Liverpool
Sensor	**Calculi**	**External data source/ Website**
No Sensor	Social Survey - Calculated with questionnaire and standard software (Excel or SPSS)	N/A

CHALLENGE 10: POTENTIAL OF ECONOMIC OPPORTUNITIES AND GREEN JOBS		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic	**Production benefit: earnings uplift arising from skills enhancement in the design and implementation of NBS** (Tyler et al., 2013)	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
TBD	TBD	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	TBD	TBD

CHALLENGE 10: POTENTIAL OF ECONOMIC OPPORTUNITIES AND GREEN JOBS		
TYPE OF INDICATOR	**KPI DEFINITION**	**RELATED NBS**
Economic	**Consumption benefits: property betterment and visual amenity enhancement resulting from NBS**. (Tyler et al., 2013)	▪ Non-technical actions
Measured method	**KPI Unit**	**City**
TBD	TBD	Izmir
Sensor	**Calculi**	**External data source/ Website**
No sensor	TBD	TBD

5 Conclusions

First of all would be worth to highlight what this document really is, this document is a basic approach to technical KPI and their definition. This is a living document that the content of it shall be improved during the upcoming months and throughout the evolution of the project itself. In this particular document, the type of indicators are exposed, following by a short definition of the KPIs and their relation to certain NBS. Also, the technical part, the calculation procedures and the method of measurement were sketched as well along the pages above. Each city compromised to follow this stepping stone and following deliverables shall scaffold on the knowledge built here. Nevertheless, this deliverable came out with an early approach to calculation procedures and sensors to be used and the plausible available data sources that will be further defined in future deliverables. This deliverable is a preliminary statement.

If we characterise this deliverable as preliminary would be an asset to consider this document as well as a provisional approach that it's expected to suffer modifications along the years of the project.

All the indicators that were shown and specially those selected per city were aimed to provide information about the current knowledge per city in order to identify deficits and advantages per city. With the idea to point out where the advantages in other demo cities can help and assist, if possible, to each deficit area of knowledge per city and draw some know-how to their own profit and benefit from the project in a global perspective. That was planned from the begging and that was identified as one of the key parts of the selection of indicators and the sharing process of the methodology.

In conclusion, the Technical and also non-Technical KPIs definitions here are a key part in order to create a robust set of monitoring procedures along the project. Consequently, the work related here has to be acknowledged as first and necessary steps to achieve that goal. The awareness raised here and the importance of the selection of the indicators provided a demarcation of themselves that constructed the common ground in which a learning process through the WP was kicked-off in terms of indicators facing NBS not only citywide but in a global approach due the difference between cities and NBS. That is a challenge ahead for the WP and also for the project that it is more than important to walk it thoughtfully lengthways.

ANNEX: Urban GreenUP Technical KPIs table

CHALLENGES	TYPE OF INDICATORS	KPI	VALLADOLID	LIVERPOOL	IZMIR	CORE KPIS
CHALLENGE 1: Climate mitigation & adaptation	Environmental, Chemical	Tonnes of carbon removed or stored per unit area per unit time (Zheng et al., 2013), total amount of carbon (tonnes) stored in vegetation (Davies et al., 2011).				
		Comparison with calculations of carbon consumption of equivalent non-NBS actions (e.g. Through Life Cycle Assessment).				
		Increased opportunity for species movement in response to climate change as a result of NBS				
		Economic value of carbon sequestration by vegetation as a result of NBS over 25 years				
		Allometric forest models of carbon sequestration, developed using proxy data obtained from Lidar data (Giannico et al., 2016).				
		Growth rates derived from Forest Inventory Analysis (Zheng et al., 2013).				
		Other metrics				
	Economic	Measurements of gross and net carbon sequestration of urban trees based on calculation of the biomass of each measured tree (i-Tree Eco model), translated into avoided social costs of CO2 emissions (USD t-1 carbon).				
	Environmental, Physical	Decrease in mean or peak daytime local temperatures (oc) (Demuzere et al., 2014).				
		Measures of human comfort e.g. ENVIMET PET — Personal Equivalent Temperature, or PMV — Predicted Mean Vote.				
		Heatwave risks (number of combined tropical nights (>20oc) and hot days (>35oc) following Fischer, Schär, 2010, cited by Baró et al. (2015).				
		Kwh/y and t C/y saved.				
		Final energy consumption				
		Final Energy use/capita				
	Other	Increased opportunity for species movement in response to climate change as a result of NBS				

		Use of Star tools to calculate projected maximum surface temperature reduction				
		Physical measurement of temperature in the demo sites				
		Use of GI Val to calculate carbon savings from GI providing shade, shelter, reduction in water treatment etc				
CHALLENGE 2: Water Management	**Physical indicators**	Run-off coefficient in relation to precipitation quantities (mm/%) (Armson et al., 2013; Getter et al., 2007; Iacob et al., 2014; Scharf et al., 2012)				
		Flood peak reduction (Iacob et al., 2014), Increase in time to peak (Iacob et al., 2014) (%).				
		Reduction of drought risk (probability).				
		Increasing ground water availability, (depth to groundwater) (Feyen and Gorelick, 2004).				
		Absorption capacity of green surfaces, bioretention structures and single trees (Armson et al., 2013; Davis et al., 2009)				
		Increased evapotranspiration measured/modelled (Litvak and Pataki, 2016).				
		Temperature reduction in urban areas (°C, % of energy reduction for cooling) (Demuzere et al., 2014).				
		Soil water storage capacity (mm)				
		Soil water infiltration capacity (cm)				
		Water retention capacity by vegetation and soil (ton km-2)				
		Intercepted rainfall (m3 year-1)				
		Share of green areas in zones in danger of floods (%)				
		Population exposed to flood risk (% per unit area)				
		Areas (ha) and population exposed to flooding				
	Chemical indicators (water quality)	Nutrient abatement, abatement of pollutants (%, nutrient load, heavy metals).				
		Increase of ground water quality (nutrient load, heavy metals).				
		Water Quality Index for Biodiversity				
		Drinking water provision (m3 ha-1year-1)				
		Water for irrigations purposes (m3 ha-1year-1)				

	Economic indicators (benefits)	Economic benefit of reduction of stormwater to be treated in public sewerage system (€) (Deng et al., 2013; Soares et al., 2011; Xiao and mcpherson, 2002)				
		Reduction of inundation risk for critical urban infrastructures (probability) (Pregnolato et al., 2016)				
		Stage-damage curves relating depth and velocity of water to material damages (€) (de Moel et al., 2015).				
		Volume of water removed from water treatment system				
		Volume of water slowed down entering sewer system				
CHALLENGE 3: Coastal Resilience	**Physical indicators** (Fagherazzi, 2014; Gedan et al., 2011; Grabowski et al., 2012; Stark et al., 2016).	Shoreline characteristics and erosion protection				
		Soil, temperature, drainage				
		Flooding characteristics				
	Economic indicators (Gedan et al., 2011; Narayan et al., 2016; Shuster and Doerr, 2015).	Avoided damage costs				
		Changes in property value				
	Social and education indicators (Piwowarczyk et al., 2013; Schuster & Doerr, 2015).	Recreation and public access				
		Number of students benefiting from education and research about coastal resilience/amenity				
	Biological indicators (Bell, 1997; Yepsen et al., 2016).	Estimates of species, individuals and habitats distribution				
		Invasive and planted species				
		Algal bloom				
	Chemical indicators (Grabowksi et al., 2012; Yepsen et al., 2016).	Concentration of nutrients				
		Salinity, ph				
	Social indicators (benefits)	Distribution of public green space – total surface or per capita (Badiu et al.,				

CHALLENGE 4: Green Space Management		2016; Gómez-Baggethun and Barton, 2013; La Rosa et al., 2016).				
		Accessibility (measured as distance or time) of urban green spaces for population (Tamosiunas et al., 2014).				
		Recreational (number of visitors, number of recreational activities) or cultural (number of cultural events, people involved, and children in educational activities) value (Kabisch and Haase, 2014).				
		Percentage of people living within 300 m of green urban areas of any size in inner city				
		Accessibility15 to public parks, gardens and play-grounds (more than 50 ha) - (inhabitants within 10 km from a park)				
		Accessibility to public parks gardens and play-grounds (between 10 ha and 50 ha) - (inhabitants within 1 km from a park)				
		Accessibility to public parks gardens and play-grounds (between 2.5 ha and 10 ha) - (inhabitants within 500 m from a park)				
		Accessibility to public parks gardens and play-ground (between 0.75 ha and 2.5 ha or smaller but important green spaces) - (inhabitants within 250 m from a park).				
		Weighted recreation opportunities provided by Urban Green Infrastructure (Derkzen et al. 2015)				
		Nature based recreation opportunities (includes Natura 2000; includes bathing water quality) (dimensionless) (Zulian et al. 2013)				
		Proximity of green infrastructure to green travel routes (km)				
		Green related social service provided to population (dimensionless) (Secco and Zulian 2008)				
		Accessibility of parks from schools (number of public parks and gardens within a defined distance from a school)				
	Environmental (biological)	Increase in plant species richness and functional diversity as a result of NBS				
		Increase in Insectivore (e.g. bat) abundance and use of corridors for movement as a result of NBS				
		Increase in density and seasonal spread of floral resources for pollinators				

		Changes in the pattern of structural and functional connectivity (Iojă et al., 2014).				
		Species richness and composition in respect to indigenous vegetation and local/national biodiversity targets (Cohen et al., 2012; Krasny et al., 2013).				
		Forest area as a proportion of total land area				
		Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type				
		Biodiversity habitat index				
		Trends in land degradation (proposed for SDG target 15.3)				
		Number and total area of designated sites of local (city) biodiversity importance within the city (habitat/species management areas)				
		Number and total area of Natura 2000 sites that are located in the city or nearby (i.e. Within 10 km)				
		Production of food (ton ha-1 year-1)				
		Sustainability of green areas				
		Quality of life for elderly people				
		Increased connectivity to existing GI				
		Pollinator species increase				
		Perceptions of connectivity and mobility				
CHALLENGE 5: Air Quality	**Environmental (chemical)**	Non-spatial indicators of gross quantities: annual amount of pollutants captured by vegetation (Bottalico et al., 2016).				
		Non-spatial indicators of net quantities: net air quality improvement (pollutants produced – pollutants captured + GHG emissions from maintenance activities) (Baró et al., 2014).				
		Non-spatial indicators of shares: share of emissions (air pollutants) captured/sequestered by vegetation (Baró et al., 2014).				
		Spatial indicators: pollutant fluxes per m2 per year (Manes et al., 2016; Tallis et al., 2011).				
		Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted) oncentration recorded ug/m3				

		Trends in emissions NOX, SOX				
		Trends in CFC emissions (chlorofluorocarbons (cfcs) in ODP				
		Mean levels of exposure to ambient air pollution (population weighted) (proposed indicator for SDG target 3.9)				
		Pollutants removed by vegetation (in leaves, stems and roots) (kg ha-1 year-1)				
	Economic	Monetary values: value of air pollution reduction (Manes et al., 2016); total monetary value of urban forests including air quality, run-off mitigation, energy savings, and increase in property values (Soares et al., 2011). Use of GI val to calculate the value of air quality improvements				
	Social (physiological)	Other indicators: health impact indicators such as premature deaths and hospital admissions averted per year (Tiwary et al., 2009).				
		Number of deaths from air, water and soil pollution and contamination (proposed indicator for SDG target 3.9)				
		Number of deaths, missing persons and persons affected by disaster per 100,000 people				
		Air quality parameters Nox, VOC, PM etc				
CHALLENGE 6: Urban Regeneration	**Urban green indicators (environmental, biological)**	Urban green: Index of biodiversity, provision and demand of ecosystem services.				
		Ecological connectivity (Pino and Marull, 2012).				
		Accessibility (Schipperijn et al., 2010): distribution, configuration, and diversity of green space and land use changes (multi-scale; Goddard et al., 2010).				
		Ratio of open spaces to build-form.				
		Reclamation of contaminated land: percentage of contaminated area reclaimed.				
	Building efficiency and environmental design indicators	Reclamation of building materials: percentage reclaimed from existing buildings.				
		Energy efficiency: building materials/construction methods based on points awarded according to energy efficiency checklist.				
		Incorporation of environmental design: percentage of total building stock.				

		Land devoted to roads: percentage of site area occupied by roads.				
	Socio-cultural indicators	Conservation of built heritage resources: percentage of built from retained for culture.				
		Land dedicated to pedestrians: percentage of road network.				
		Public transport links: walking distance to nearest facilities.				
		Access to open space: average journey time for residents/employees by foot or average distance to sports centre, recreation area, or green space.				
		Access to cultural facilities: average journey time for residents on foot or average distance to cultural centre.				
		Access to housing: affordability and choice.				
		Level of devices contributing to the safety of users in the neighbourhood: lighting of common areas, access control, presence of technical, or specialized staff, etc.				
		Assessment of typology, functionality and benefits provided pre and post interventions				
		Savings in energy use due to improved GI				
CHALLENGE 7: Participatory Planning and Governance	**Social**	Openness of participatory processes (Frantzeskaki and Kabisch, 2016; Luyet et al., 2012; Uittenbroek et al., 2013).				
		Legitimacy of knowledge in participatory processes (Frantzeskaki and Kabisch, 2016; Luyet et al., 2012).				
		Social learning concerning urban ecosystems and their functions/services (Colding and Barthel, 2013).				
		Policy learning concerning adapting policies and strategic plans by integrating ecosystem services and possibly their valuation (Crowe et al., 2016; Uittenbroek et al., 2013; Vandergert et al., 2015).				
		Perceptions of citizens on urban nature (Buchel and Frantzeskaki, 2015; Colding and Barthel, 2013; Gerstenberg and Hofmann, 2016; Scholte et al., 2015; Vierikko and Niemelä, 2016).				
		Social values for urban ecosystems and biodiversity (Brown and Fagerholm, 2014; Kenter et al., 2015; Polat and Akay, 2015; Raymond et al., 2014, 2009; Scholte et al., 2015).				
		Citizen participation in the development and delivery of interventions				

CHALLENGE 8: Social Justice and Social Cohesion	**Social justice,** informed by the capability framework of social justice (Comim et al., 2008; Nussbaum, 2011; Sen, 2005).	Access to financial resources, including indicators of income per capita in a given neighbourhood, or urban area (Klasen, 2008).				
		Bodily integrity - Being able to move freely from place to place; to be secure against violent assault, including indicators of crime by time of day (Felson and Poulsen, 2003).				
		Senses, imagination and thought: being able to use the senses, to imagine, think, and reason about the environment, informed by indicators of levels of literacy, mathematics and science knowledge (Chen and Luoh, 2010; Elliott et al., 2001).				
		Emotions: being able to have attachments to things and people outside ourselves; to love those who love and care for us, including indicators of place attachment, empathy and love (Lawrence et al., 2004; Manzo and Devine-Wright, 2014; Perkins et al., 2010; Raymond et al., 2010).				
		Being able to participate effectively in political choices that govern one's life, including indicators on level and quality of public participation in environmental management (Reed, 2008; Reed et al., 2009).				
		Crime reduction through police reports and local authority data				
		11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities				
	Social cohesion	Structural aspects: indicators of family and friendship ties; participation in organised associations; integration into the wider community (Cozens and Love, 2015; Stafford et al., 2003).				
		Cognitive aspects: indicators of trust, attachment to neighbourhood, practical help, tolerance and respect (Mihaylov and Perkins, 2014; Uzzell et al., 2002).				
		Green intelligence awareness				
	Psychological indicators (Relaxation and	Noise reduction rates applied to UGI within a defined road buffer db(A) m-2 vegetation unit (Derkzen et al. 2015)				

CHALLENGE 9: Public Health and Well-being	restoration, sense of place, exploratory behaviour, socializing).	Reduction in chronic stress and stress-related diseases measured through repeated salivary cortisol sampling (Roe et al., 2013; Ward Thompson et al., 2012) and hair cortisol (Honold et al., 2016); use cortisol slope and average cortisol levels as an indicator of chronic stress.				
		Cognitive and social development in children: indicators related to improvement in behavioural development and symptoms of attentiondeficit/hyperactivity disorder (ADHD) related to green space use; questionnaire indicators on sociodemographic and household characteristics, the time spent playing in green and blue spaces, ADHD symptom criteria, such as emotional symptoms, inattention, conduct problems, hyperactivity/inattention, and peer relationship problems; and a strengths subscale for prosocial behaviour (Amoly et al., 2014).				
		Mental health changes measured through Mental Well-being scales asking participants how they have felt over the previous four weeks in relation to a number of items (e.g., feeling relaxed, feeling useful), with responses rated on a 5-point scale from “none of the time” to “all of the time” (Roe et al., 2013).				
	Health indicators related to physical activity (Sports and leisure activities including e.g. walking, cycling).	Number and share of people being physically active (min. 30 min 3 times per week).				
		Reduced percentage of obese people and children; reduced overall mortality and increased lifespan.				
		Reduced number of cardiovascular morbidity and mortality events (Tamosiunas et al., 2014).				
	Health indicators related to ecosystem service provision (Buffering of noise and air pollution, reduced heat, exposure to microflora).	Reduced autoimmune diseases and allergies (potentially) (Kuo, 2015).				
		Reduced cardiovascular morbidity and mortality (Tamosiunas et al., 2014).				
		GIS related indicators: NDVI, proximity measures (green space of min. 2 ha within 300m, (Maas et al., 2006; Vries et al., 2003)), percentage of green space (Kabisch and Haase, 2014; van den Berg et al., 2010).				
		Perceptions of health and quality of life				

		Measurement of wellbeing of people in the area, employees and visitors				
		Increase in walking and cycling in and around areas of interventions				
CHALLENGE 10: Potential of economic opportunities and green jobs	**Economic**	Number of subsidies or tax reductions applied for (private) NBS measures (Meulen et al., 2013).				
		Number of jobs created (Forestry Commission, 2005); gross value added (Forestry Commission, 2005).				
		Change in mean or median land and property prices (Forestry Commission, 2005).				
		New businesses attracted and additional business rates (Eftec, 2013).				
		Resource efficiency in the urban system (CO_2 emissions per capita, CO_2 emissions for transportation per capita, etc.) (OECD, 2013).				
		Public-sector cost per net additional job (Tyler et al., 2013).				
		Net additional positive outcomes into employment (Tyler et al., 2013).				
		Net additional jobs (Tyler et al., 2013) in the green sector enabled by NBS projects.				
		Gross value added per employees based on full-time equivalent jobs (Tyler et al., 2013) in the green sector.				
		Production benefit: earnings uplift arising from skills enhancement (Tyler et al., 2013) in the design and implementation of NBS.				
		Consumption benefits: property betterment and visual amenity enhancement (Tyler et al., 2013) resulting from NBS.				
		Job creation, increased footfall and spend in the areas of interventions if appropriate				
	TOTAL NUMBER OF KPIs	**151**	**28**	**35**	**75**	**29**

Table 3. Urban GreenUP Technical KPIs table.