URBAN GreenUP

D5.6: Technical KPIs definition

WP 5 , T 5.3

Date of document

15th March 2023

Authors: 15 (GMV), 1 (CAR), 2 (VAL), 7 (LIV), 8 (CFT), 9 (UOL), 10 (IZM), 11 (DEM), 12 (EGE), 13 (IZT), 14 (BIT)

URBAN GreenUP

SCC-02-2016-2017

Innovation Action – GRANT AGREEMENT No. 730426

Technical References

Project Acronym	**URBAN GreenUP**
Project Title	New Strategy for Re-Naturing Cities through Nature-Based Solutions – URBAN GreenUP
Project Coordinator	Raúl Sánchez Fundación CARTIF rausan@cartif.es
Project Duration	1 June 2017 – 31 May 2022 (60 Months)

Deliverable No.	D5.3
Dissemination Level	PU/PP/RE/CO[1]
Work Package	WP 5 - Monitoring and evaluation
Task	T 5.3 – City Diagnosis and Monitoring Procedures
Lead beneficiary	15 (GMV)
Contributing beneficiary(ies)	1 (CAR), 2 (VAL), 7 (LIV), 8 (CFT), 9 (UOL), 10 (IZM), 11 (DEM), 12 (EGE), 13 (IZT), 14 (BIT)
Due date of deliverable	31 May 2023
Actual submission date	15 March 2023

[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)

CO = Confidential, only for members of the consortium (including the Commission Services)

Versions

Version	Person	Partner	Date
V0	Contribution from all partners in previous documents and reports	CAR, VAL, LIV, CFT, UOL, IZM, DEM, EGE, IZT, BIT	-
V0.1	Jesús Ortuño	GMV	30 August 2017
V1	Jesús Ortuño	GMV	1 September 2017
V1.1	Jesús Ortuño	GMV	20 September 2017
V1.2	Jesús Ortuño	GMV	27 November 2017
V2	José Fermoso	CAR	28 November 2017
V2.1	Sarah Clement	UOL	28 November 2017
V3	Juliet Staples	LIV	28 November 2017
Interim I version	Jesús Ortuño	GMV	29 November 2017
Interim I version comments addressed	Jesús Ortuño	GMV	2 February 2018
Interim II version		All partners involved	January 2019
Final version draft	Jesús Ortuño	GMV	December 2022
Final version	Jesús Ortuño	GMV	15 march 2023
Final version comments addressed	Jesús Ortuño	GMV	1 June 2023

Table of Content

List of Tables

List of Figures

0 Executive summary

This document represents the culmination of the UrbanGreenUP H2020 project monitoring indicators summary. Providing a comprehensive record of The Key Performance Indicators (KPIs) and their associated monitoring program. Over the course of the project, two iterations of the document have been delivered, incorporating feedback and insights from stakeholders, partners, and experts. This final version signifies the completion of the project and the establishment of a robust framework for monitoring and evaluating the project's objectives.

Building upon the Eklipse mechanism framework, the KPIs outlined in this document have been carefully tailored to meet the specific requirements of the participating cities and draw upon the expertise of all project partners. These indicators serve as quantifiable measures to assess the performance and impact of the UrbanGreenUP initiatives, ensuring transparency and accountability in achieving the project's objectives.

This final version of the document includes a detailed description of each KPI and its methodology for calculation. By providing this comprehensive information, stakeholders and future researchers will have access to a standardized approach for evaluating similar urban sustainability projects. The KPIs cover a wide range of dimensions, including environmental, social, and economic aspects, allowing for a holistic understanding of the project's outcomes.

Throughout the project, the monitoring program has been instrumental in tracking progress, identifying areas for improvement, and informing decision-making processes. By aligning the KPIs with the project's goals and targets, the monitoring program has provided valuable insights into the effectiveness of the implemented interventions, enabling adjustments and optimization as needed.

The UrbanGreenUP H2020 project has made significant strides in promoting sustainable urban development and improving the quality of life in participating cities. The utilization of these KPIs and the monitoring program has facilitated evidence-based decision-making, fostering the adoption of innovative solutions and the replication of successful practices in other urban contexts.

As this final version of the document marks the end of the UrbanGreenUP project, it also represents the beginning of a new chapter. The insights gained and the methodologies established through this project will serve as valuable resources for future urban sustainability initiatives. The legacy of the UrbanGreenUP project lies not only in the tangible outcomes achieved but also in the knowledge and experience gained, which will continue to shape and inspire sustainable urban development for years to come.

1 Introduction

This report presents the technical definition of Key Performance Indicators (KPIs) for a Horizon 2020 UrbanGreenUP project on Nature-Based Solutions (NBS). The project aimed to develop and implement NBS in urban environments to improve resilience, sustainability, and liveability. The KPIs presented in this report are the result of a six-year project involving experts from various fields, including urban planning, environmental science, and engineering.

The purpose of this report is to summarize all the indicators calculated during the project and explain the methodology behind each of them. The report aims to contribute to the knowledge regarding NBS and KPIs for future projects, city administrations, urban planners, and citizens interested in sustainable urban development.

The methodology behind each KPI is explained in detail in this report, including the data sources, calculation methods, and limitations. The KPIs were developed to be clear, easily understandable, and replicable in other contexts. By using these KPIs, city administrations and urban planners can assess the effectiveness of NBS in achieving sustainability goals and make informed decisions about future projects.

Overall, this report aims to provide a comprehensive overview of the KPIs used during the project and their methodology. It is hoped that this report will contribute to the knowledge and understanding of NBS and KPIs and support the implementation of sustainable urban development projects in the future.

1.1 General Principles of Survey Design and Sampling

1.1.1 Survey Design: Before After Control Impact (BACI)

BACI survey design aims to separate the effects of an intervention (impacts) from those of other spatial and temporal variables. An impact site is where a specified impact from the intervention (NBS) is expected to occur. A control site is selected as a location similar - ideally identical - to the impact site pre-intervention, which is expected not to be affected by the intervention. The control site should be located at a sufficient distance from the paired impact site to minimise the likelihood of observations not being independent. As baseline conditions (e.g. ecological community, windspeed, pollutant levels) of the impact and control sites selected are unlikely to be identical, sampling both impact and control sites pre-intervention as well as post-intervention can identify and account for other variables, providing a more robust survey approach. For most biophysical variables in this monitoring program, we will pair Liverpool NBS sites (impact site) to control sites located within the same demo area, similar to the pre-intervention NBS site. NBS (impact) sites and control sites will be sampled during the year pre-intervention (September 2018-2019) to provide a baseline and post-intervention.

1.1.2 Temporal and Spatial scale

Monitoring design should be at an appropriate temporal and spatial scale to detect change in the indicators selected. For example, considering the metric *observed pollinator-flower visits* as an indicator of change in number of pollinator species using an NBS as foraging habitat post-intervention: sampling should be carried out at both impact and control sites over sufficient time to account for natural population fluctuations. Depending on the environmental parameter selected, a series of control sites may be placed at different radii from the intervention to assess the scale of the impact. For example, additional control sites can be located at increasing intervals from roadside impact and control sites to inform the scale at which an NBS green infrastructure intervention impacts NO_2 levels originating from vehicle emissions.

1.1.3 Causation and inference

Replicated experiment with randomized assignment of the treatment (intervention and control) is not practicable for most studies of environmental impact. In this study the NBS (intervention) site locations are subject to existing constraints including urban infrastructure. BACI is therefore selected as the most robust approach to survey design to evaluate impact of an intervention. Causation of impact by the intervention cannot be established by this method as the influence of non-identified confounding variables cannot be ruled out. Impact from the intervention can be inferred by significant difference in measured values for an environmental parameter between samples from the impact site post-intervention, and samples from pre-intervention impact and control as well as post-intervention control sites. The scale at which the impacts of the intervention are relevant should be stated.

1.1.4 Limitations

Known limitations of the study/monitoring method should be stated so that the reader can interpret the results within the context of these constraints. For example;

- Potentially confounding variables for which the study has been unable to account (such as possible differences in land management between impact and control sites)
- Sub-optimal survey conditions or missing surveys/data
- The assumptions underlying a model used to quantify environmental impact or economic benefit

1.1.5 Sample size and statistical analysis

The power of statistical tests increases with the number of sampling units. Monitoring design should incorporate enough sampling units to generate data with sufficient statistical power to enable the rejection of the null hypothesis of no difference pre- and post-intervention in the environmental parameter selected.

1.1.6 Selection of indicator species

Robust empirical evidence should underpin the selection of indicator species to infer an ecosystem function or service, or the presence of a group of species. The size of the sampling areas (study sites) should be appropriate to the ecology of the focal taxon.

1.1.7 Stratification

Stratification starts by partitioning a study area into blocks of similar habitat (which in total represent the population of interest within the study site). For example, identifying each of the floral resources' strata within an otherwise urban grey study site. Sampling is then organised within each of the blocks, and an assumption may be made that the results can be extrapolated to the rest of a given block.

1.1.8 Sample replication in ecological survey

As a complete census of a study site for a focal taxon is generally not practicable in ecological survey, a random sampling method should be determined with sufficient samples to be representative of the community sampled. For example, construction of a diversity curve to evaluate at what point diversity index values level off as sample numbers rise, can indicate of level of sampling effort required to represent the diversity of the community sampled. Samples should spaced from each other as much as practicable in order to be independent. Random sampling will be employed where feasible, but some of our surveys take a systematic sample along a transect route, and practical accessibility has also influenced survey locations – for more details see the individual protocols in each section below.

1.1.9 General References

- Block *et al.* 2001. Design and Implementation of Monitoring Studies to Evaluate the Success of Ecological Restoration on Wildlife. Restoration Ecology 9
- Dytham, C. 2011. Choosing and Using Statistics, 3rd edition. Wiley-Blackwell
- MaGurran, A.E. 1988. Ecological Diversity and Its Measurement. University Press, Cambridge

2 URBANGREENUP'S KPIs

2.1 CLIMATE MITIGATION & ADAPTATION

2.1.1 Ton CO_2 CARBON REMOVED

In this section is contemplated two indicators:

- CO_2 removed per Ha.
- CO_2 removed per year.

Urban vegetation plays a vital role in offsetting atmospheric CO_2 by acting as a sink and storing carbon. Carbon sinks can be at the city or urban regional level, with urban green areas having local importance as carbon sinks. However, urban parks can also function as carbon sources due to their management and use producing more CO_2 emissions than their carbon sequestration capacity.

RATIONALE

Urban vegetation has an important role in offsetting CO_2 concentration by acting as a sink for atmospheric CO_2 via photosynthesis and by storing carbon through the growth process[2].

A proportion of the CO_2 that is sent into the atmosphere is reabsorbed. The concentration of the gas would otherwise increase exponentially and would undoubtedly be irreversible. Natural systems are responsible for part of this absorption. They have a limited capacity which can also change the effects of climate change or how different ecosystems are used. Most natural systems have stored carbon, and the amount that is stored at any given time is called a carbon reservoir or carbon stock. If the amount in this system naturally increases over time, then it is described as a sink, which helps reduce the concentration of CO_2 the atmosphere. This process is called carbon sequestration. However, if the amount of carbon in the system declines, this is a CO_2 emission source[3].

Carbon sinks can be addressed at two spatial scales: within the city and at the urban regional level. Within a city park, green areas and tree plantings can function as carbon sinks, although urban vegetation only sequestrates a small part of annual CO_2 emissions of a city. In fact, urban parks can function as carbon sources because management and the use of parks produce multiple amounts of CO_2 emissions compared to the carbon sequestration capacity of a green area. Although urban carbon sinks do not necessarily have a significant impact on the global

[2] Gratani L. et al. Carbon sequestration of four urban parks in Rome. Urban Forestry & Urban Greening 19 (2016) 184–193.

[3] CLIMATE CHANGE IN CATALONIA Executive summary of the Third Report on Climate Change in Catalonia, ISBN 978-84-9965-317-4 (2017).

carbon balance, urban green areas can have local importance as carbon sinks[4]. This KPI is selected by Izmir and Valladolid.

RELATED NBS

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.

METHODOLOGY

This KPI can be estimated as carbon sequestration and it is defined as the process of increasing the carbon content of a reservoir or pool other than the atmosphere. When plants grow, they capture CO_2 from the atmosphere therefore the choice of plant species for urban areas may be set out considering their own air amelioration capability. Maximizing the net sequestration of carbon through species selection and management practices will be the aim.

In this KPI, total amount of carbon (tonnes) stored in vegetation will be calculated and used to assess the impact of the NBS. This KPI includes the measurement and calculation of area of new woodland created to complete the study.

In the case of Izmir demo, based on different land covers, different formulas are employed for calculating the amount of carbon stored in vegetation at the level of the related demo sites. The carbon storage capacity of the existing land covers are calculated separately based on the methods and formulas employed by Rowntree and Nowak, 1991[5] [5]. It is executed in the scale of demo sites (kg/year) before the interventions and will be executed again using the same formulas and equations after NBSs are implemented in order to make a before and after comparison (kg/year).

DATA SAMPLING

Datasets should be identified to know:

- Area of new woodland created
- Type of species
- Number of species

Different data sources will be consulted to estimate this KPI, mainly the Spanish National Forest Inventory (SNFI) and the Spanish Forest Map. The selection of species present at these inventories will be prioritised.

---

[4] Niemelä J. et al. Using the ecosystem services approach for better planning and conservation of urban green spaces: a Finland case study. Biodiversity and October 2010, Volume 19, Issue 11, pp 3225–3243.

[5] Rowntree and Nowak, 1991; Vleeshouwers and Verhagen, 2002; Bandarnayake et al., 2003; Tratalos et al., 2007; Townsend-Small and Czimczik, 2010; Davies et al., 2011; Beaumont et al., 2014.

DATA PROCESSING

KPI calculation will be based on CO_2 removals per planted specimen, to subsequently apply this data to the entire project, depending on the number of specimens expected at the end of the period of project development.

Plant structure in each technology will be analysed regarding type of plant species and total number of species. The choice of plant species for each action shall be specific set out within the project development, considering their own air amelioration capability[6] [4].

Total t CO_2, removed thanks to each NBS detailed before shall be calculated as follows:

$$\frac{tCO_{2,removed}}{yr * ha} = \left[\frac{tCO_{2,sequestred}}{specie * n_{years}}\right]_{[4]} * n_{years} * \frac{Number_{species} \text{to be planted within the NBS}}{\text{Total ha of species}}$$

RESULTS

- ton CO_2/year
- ton CO_2/year * ha

The amount of carbon stored in biomass (leaves, stems, trunk, roots, and soil organic matter) to assess the tonnes of carbon removed or stored per unit area per unit time shall be obtained at the end of the process for this KPI.

2.1.2 CARBON STORED by soil & vegetation

RATIONALE

Vegetation sequesters and stores carbon from the atmosphere, thus helping to mitigate climate change. GI-Val tool 1.7 can be used to estimate the amount of carbon sequestered by trees as they grow, and tool 1.8 can estimate the amount of carbon sequestered as a result of various other land use changes.

Tool 1.7 is based upon the Forestry Commission's Woodland Carbon Code Calculators and Lookup Tables (West, 2018). It distinguishes between broadleaf and coniferous trees, using sycamore/ash/birch of yield class 4 at 2.5m spacing as a proxy for the former and Sitka spruce of yield class 12 at 2.0m spacing as a proxy for the latter, as per the Small Project Carbon Calculator. It also distinguishes between thinned and non-thinned planting, and takes into account the varying levels of sequestration as the trees mature. The total is reduced by 20% to account for the model precision level and by 15% to represent the possibility that the trees are removed within the 50-year modelling period.

Tool 1.8 is based upon De Deyn et al (2010) and Dawson & Smith (2007). It estimates the carbon sequestration resulting from three types of land cover change:

[6] Guide to estimate carbon dioxide absorptions (in Spanish) Spanish Office of Climate Change. Ministry of Agriculture, Food and Environment

- Land converted from improved grassland or other land use to semi-natural grassland
- Land converted from arable to wetland
- Land converted from grassland to wetland

METHOD

The areas of each type of new vegetation planted will be entered into GI-Val (Appendix 1)[7].

2.1.3 CARBON SEQUESTRATION

This KPI will be modelled using GI-Val to calculate the projected economic value of carbon stored in vegetation as a result of NBS over 25 years. The input data will be primarily project delivery records.

RATIONALE

Vegetation sequesters and stores carbon from the atmosphere, thus helping to mitigate climate change. GI-Val tool 1.7 can be used to estimate the amount of carbon sequestered by trees as they grow, and tool 1.8 can estimate the amount of carbon sequestered as a result of various other land use changes. For more information, see 'Total amount of carbon stored in vegetation' (above).

The monetary value of the benefits to society of carbon sequestration can be estimated. The UK Government Department for Business, Energy & Industrial Strategy regularly publishes such estimates (Department for Business, Energy & Industrial Strategy, 2018). These are used by GI-Val to relate a monetary value to its sequestration estimate, discounted over time as appropriate.

METHOD

The areas of each type of new vegetation planted will be entered into GI-Val[8]. The discounting period will be adjusted to 25 years.

2.1.4 TEMPERATURE DECREASE

RATIONALE

Green urban infrastructure can play a role in climate change adaptation through reducing air and surface temperature by providing shading and enhancing evapotranspiration, which leads to two benefits: improved thermal comfort and reduced energy use. We address the thermal comfort and reduced energy benefits via physical indicators such as ambient temperature, turbulent fluxes, and energy savings.

[7] https://www.merseyforest.org.uk/services/gi-val/

[8] https://www.merseyforest.org.uk/services/gi-val/

In this KPI, mean and peak daytime local temperatures will be calculated and used to assess the impact of the NBS. This KPI includes the measurement and calculation of mean and daytime local relative humidity to complete the study.

NBS TYPES

Green Shady structures, shade tree, cooling trees, green façade, and green parking pavements.

METHOD: BACI (BEFORE, AFTER, CONTROL, IMPACT)

Measure air temperature and relative humidity at sampling points at a range of radii from NBS locations both pre- and post-intervention. Compare these data to measurements taken at equivalent locations on equivalent stretches of street without those NBS at a similar time of day on the same dates or continuously.

Field measurements will be done at the micro scale by using fixed sensors placed on site in representative locations and regularly measuring variables of interest. The meteorological data gathered from demo sites before and after the application will be compared and the impacts of the NBS on demo sites will be evaluated.

As a previous work, temporal series of temperature and relative humidity will be studied in order to define peak times and values and mean values of historical data (at night and daytime) for the city in the *Red de Control de la Contaminación Atmosférica del Ayuntamiento de Valladolid* (RCCAVA) areas (According its characteristics). This study will serve to stablish a general baseline for the city. On the other hand, RCCAVA measurements will be used as additional references of non-intervention areas.

NULL HYPOTHESIS

There is no difference in air temperatures and relative humidity between samples in stretches of street where green shady structures, street trees/green walls, etc. are present, and samples or measurements taken in stretches of streets without the NBS.

MONITORING EQUIPMENT

Wireless samplers to hang from streetlamps or other urban furniture without carrying out works (low weight and low visual impact).

MEASUREMENTS

Air temperature and relative humidity, wind velocity and direction will be measured and recorded hourly (at least).

UNIT OF MEASUREMENT

Temperature in ºC and Relative Humidity in % and wind velocity in m/s

CALIBRATION / VERIFICATION

Calibration at laboratory.

STUDY SITES

a) Stretches of street where street shady structures or tree/green wall interventions are proposed (intervention study sites) selected at random from qualifying intervention locations (random stratified sampling); and
b) A matching number of locations along equivalent stretches of street (street of similar width and with comparable building heights to intervention site and **orientation**) where street tree/green wall interventions are not proposed (**control study sites**). Control sites should be a sufficient distance away from intervention sites for the observations made to be considered independent from the effects of NBS.

NUMBER OF SAMPLES

At each study site and control site, a set of sensors will be installed at fixed height (between 1.5m, human height, and 3.5m, height to avoid vandalism) in different locations (same number in right and left side of the street) and avoiding estrange elements which can modify air conditions like exhaust part of an air conditioning or a shop door. This range of sampling point distances from proposed NBS reflects the scale at which measurable impacts are predicted relative to the size of street tree/green wall interventions proposed for Liverpool.

SAMPLING METHOD

Both intervention and matched control study sites should be monitor with the same schema during the same time (although with a lower number of sensor points). Each fixed sampling location at a study site should be sampled hourly (at least) for a year pre-intervention (September 2018 to August 2019), and for two years following intervention (spring 2020 to spring 2022).

DATA PROCESSING

Calculation of dairy, weekly, monthly and annual mean levels (night and day) of temperature and relative humidity at each stretch. Comparison of mean values for NBS intervention and control sample locations will be done at each study site before and after of the interventions.

Calculations for comparison purposes must be done using comparable periods of time before and after the interventions (i.e. if measurement period before of the intervention goes from nov18-oct19, measurement period must be from nov19-oct21 at least and processing can be done for either years or yearly).

SPATIAL ANALYSIS

QGIS is the GIS software proposed to be used, due to it is an open source and multiplatform software and it is distributed under Creative Commons Attribution-Share Alike 3.0 licence (CC BY-SA). We recommend to use the last long-term release repository, most stable (QGIS 2.18

latest stable version or QGIS 3 early release[9]). Data processing involved in this KPI can be done with the standard version and the standard toolbox.

RESULTS

The calculated values will be compared qualitatively and quantitatively for the periods before and after the interventions in the NBS and reference sections. Quantitative assessment will be done by using the following expression:

$$\textbf{Temperature impact} = \left(\frac{NBS\ Temp.average\ after\ intervent. - NBS\ Expected\ Temp.average\ after\ intervent.}{NBS\ Expected\ Temp.average\ after\ intervent.}\right) \times 100$$

Where *temperatures average after intervent.* Is the average value of measurements after interventions and *Expected temperature value after intervent.* (But supposing that interventions had not been done) is:

$$\textbf{Temperature Expected average after intervent.} = \left(\frac{Ref.Temp.average\ after\ intervent.}{Ref.Temp.average\ before\ intervent.}\right) \times NBS\ Temp.average\ before\ intervent.$$

Positive or null temperature impact values indicate negative or no impact of the NBS on average temperatures for that implementation. A negative value indicates a positive impact of that NBS on temperatures (and/or humidity, same procedure).

REFERENCES

- EKLIPSE Report.
- Demuzere et al., 2014. Mitigating and adapting to climate change: Multi-functional and multi-scale assessment of green urban infrastructure. Journal of Environmental Management 146, 107-115
- Yu, C., Hien, W., 2006. Thermal benefits of city parks. Energy Build. 38 (2), 105-120.
- V.T. Ca, T. Asaeda, E.M. Abu, Reductions in air conditioning energy caused by a nearby park, Energy and Buildings 29 (1998) 83–92.

[9] Accessed: 18 Jun. 18

2.1.5 TEMPERATURE REDUCTION (PROJECTION)

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

The STAR Tools underlying models were used by The University of Manchester in the ASCCUE project where they were applied to Greater Manchester (Gill, 2006; Gill et al, 2007). They had previously been developed and used in Merseyside (Whitford et al, 2001). As part of the GRaBS project the surface temperature model was also used in Catania, Italy (Cuvato & Ianni, 2011). The surface temperature model was developed from an urban climate model used in Kuala Lumpur, Malaysia (Tso et al, 1991; 1990).

The following maps are an example of how the outputs from the surface temperature tool can be used. In Urban GreenUP, however, the areas of interest will likely be much smaller, and since the model is not well suited to very small areas, the number of subdivisions is likely to be much smaller as well.

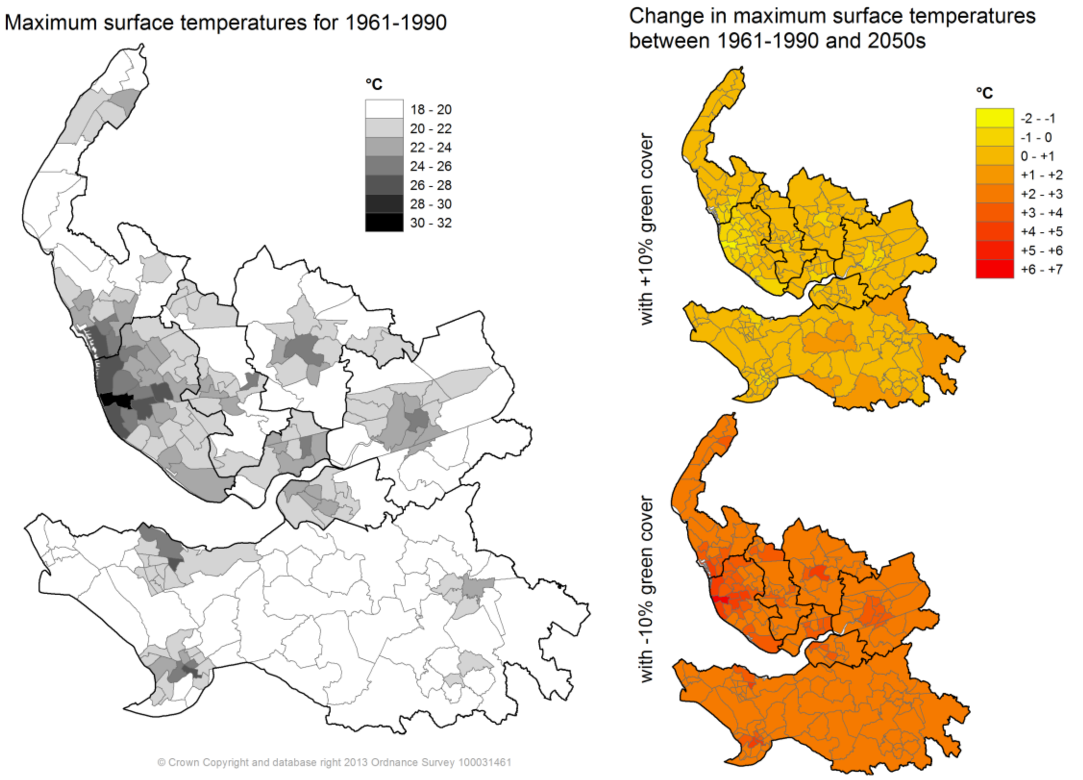


Figure 2.1: Example of a representation into a map of the KPI-13

METHOD

In the case of the Liverpool demo the sub-demo areas will be divided into study areas where groups of interventions have been made, and for each study area the pre- and post-intervention land cover will be calculated. The primary inputs for these calculations will be Ordnance Survey's MasterMap[10] and the landscape architects' drawings. The default temperature scenarios and other parameters will be used, as these are appropriate to North West England. Valladolid and Izmir demo shall adapt the methodology to their specific case.

2.1.6 HUMAN COMFORT

RATIONALE/INTRODUCTION

Climate change is often discussed in terms of changes in air temperature, cloud, wind, etc. However, in order to evaluate its impact on people's thermal perception and wellbeing, it is definitely necessary to analyse their combined effect (Mayer, H. and Höppe, P., 1987). Human thermal comfort can be defined as a condition of mind that shows satisfaction with the surrounding environment. High temperatures and humidity naturally result in discomfort sensations and dissatisfaction (Abdel-Ghany et al., 2013).

The degree of human or thermal comfort that people experience in open and green spaces is one of the key factors, especially in areas with extreme climatic conditions. There is a wide range of indexes in the literature on this matter, such as THI, PE, TS, PMV, PET, mPET and COMFA (Matzarakis et al., 1999, Ruiz & Correa, 2014, Xuea and Xiao, 2016).

The main goal of this KPI is to calculate outdoor thermal comfort after measuring micro-climate conditions in Demo Sites before and after implementation of the NBS.

NBS TYPES

Green shady structures, green covering shelters, shade and cooling trees, cool and green pavements.

METHOD BACI (BEFORE, AFTER, CONTROL, IMPACT)

A common adaptation measure to decrease radiation fluxes and outdoor temperatures is to increase shadow surfaces by plantations and/or shelters (Figure 2-12) The reduction of the surface temperatures on the shaded grounds can further decrease turbulent and convective heat transport and thus contribute to achieving decrease in outdoor thermal discomfort (Shashua-Bar et al., 2011; Spronken-Smith and Oke, 1999).

[10] https://www.ordnancesurvey.co.uk/business-and-government/products/mastermap-products.html

Figure 2.2 Green covering shelters.

To be able to obtain the above-mentioned effects on the parking lots at Sub Demo A (Vilayetler Evi and Sasalı Natural Life Park Parking Lots) where there is no shadow area, green covering shelters will be constructed with a total area of 1 450 m².

The method is composed of two parts;

(1) Air and surface temperature, relative humidity will be measured under the shelters and unsheltered parking lots in-situ (sensors and thermal cameras) and aerial sensors by drone and/or satellite (measured for KPI 7),

(2) The collected data will be processed using the RayMan model (Matzarakis et al., 2007; 2010) in order to calculate outdoor thermal comfort indexes such as the Predicted Mean Vote (PMV), the Physiological Equivalent Temperature (PET) and the new Standard Effective Temperature (SET*). The PET is derived from the human energy balance and is preferable to other thermal comfort indexes such as Predicted Mean Vote (PMV) because of its unit (°C).

MEASUREMENTS

Air temperature, relative humidity, wind velocity and direction (at selected locations) will be measured and recorded hourly (at least) on of the five days on which temperatures are forecast to be highest during that month.

If there is safety or working environment restrictions exists for study sites, then these measurements will be taken once every four weeks over the summer months (May- September) at multiple pre-determined (fixed) points at each NBS study site selected for this type of monitoring and at paired control study sites. Temperature measurements at each study site will be taken between 12.00 and 17.00 hours and few nights hour measurements on one of the five days on which temperatures are forecast to be highest during that month.

UNIT OF MEASUREMENT

Temperature in °C, relative humidity in % and wind velocity m/s

CALIBRATION / VERIFICATION

Calibration/verification at laboratory.

STUDY SITES

Figure 2.3 Study Sites

a) Measurements under the shelters and unsheltered parking lots in-situ (sensors and thermal cameras) and aerial sensors by drone and/or satellite.
b) A matching number of locations along equivalent stretches of NBS locations where without any intervention (**control study sites**). Control sites should be a sufficient distance away from intervention sites for the observations made to be considered independent from the effects of NBS.

NUMBER OF STUDY SITES

Two parking lots, one in a highly urbanised area, the other one in a sub-urban area, are selected as study sites.

DATA SAMPLING

Both intervention and matched control study sites will be monitored with the same schema during the same time (although with a lower number of sensor points). Each fixed sampling location at a study site will be sampled hourly (at least) for a year pre-intervention (September 2018 to August 2019), and for two years following intervention (spring 2020 to spring 2022).

DATA PROCESSING

Calculation of daily, weekly, monthly, and annual mean levels (night and day) of temperature and relative humidity at each stretch. Comparison of mean values for NBS intervention and control sample locations will be done at each study site before and after the interventions.

RESULTS

Table 2-1 shows the ranges of the most common thermal comfort indexes PMV and PET (Mayer and Matzarakis, 1997).

The PET index assesses thermal comfort by considering thermal-hygric conditions, radiation and wind data, the human metabolic heat exchange rate and other individual-related parameters (e.g., age, gender, and clothing), allowing a comprehensive assessment of the effectiveness of the adaptation measures. The RayMan Pro version 2.1 software (Matzarakis at al., 2010) will be used to calculate PET values from the measured data. This software is well suited for determining microclimatic changes in different urban structures, as it calculates the radiation fluxes of different surfaces and their changes (Gulyas et al., 2006).

PMV (-)	PET (°C)	Thermal Sensation	Grade of Physiological Stress
		PET<4 Very cold 4<PET<8 Cold 8<PET<13 Cool 13<PET<18 Slightly cool 18<PET<23 Comfortable 23<PET<29 Slightly warm 29<PET<35 Warm 35<PET<41 Hot PET>41 Very hot	Extreme cold stress Strong cold stress Moderate cold stress Slight cold stress No thermal stress Slight heat stress Moderate heat stress Strong heat stress Extreme heat stress
-3.5	4		
-2.5	8		
-1.5	13		
-0.5	18		
0.5	23		
1.5	29		
2.5	35		
3.5	41		

Table 2-1 Ranges of the thermal indexes predicted mean vote (PMV) and physiological equivalent temperature (PET) (Source: Mayer and Matzarakis, 1997).

The PET index is based on the Munich Energy Balance Model for Individuals (MEMI), which models the thermal conditions of the human body in a physiologically relevant way (Equation 1) (Höppe, 1999; Matzarakis and Amelung, 2008).

$$M + W + R + C + E_D + E_{Re} + E_{Sw} + S = 0$$

Where, M is the *metabolic rate* (internal energy production), W is the *physical work output*, R is the *net radiation of the body*, C is the *convective heat flow*, E_D is the *latent heat flow to evaporate water diffusing through the skin* (imperceptible perspiration), E_{Re} is the *sum of heat flows for heating and humidifying the inspired air*, E_{Sw} is the *heat flow due to evaporation of sweat*, and S is the *storage heat flow for heating or cooling the body mass*. The individual terms in this equation have positive signs if they result in an energy gain for the body and negative signs in the case of an energy loss (M is always positive; W, E_D and E_{Sw} are always negative). The unit of all heat flows is in Watt (Matzarakis at al., 2007).

The calculation of PET includes the following steps (Matzarakis and Amelung, 2008):

- Calculation of the thermal conditions of the body with MEMI for a given combination of meteorological parameters.
- Insertion of the calculated values for mean skin temperature and core temperature into the model MEMI and solving the energy balance equation system for the air temperature T_a (with v = 0.1 m/s, P_v = 12 kPa and $T_{mrt} = T_a$).

Where, P_v vapor is the *pressure of the air*.

2.1.7 HEATWAVE RISK

This indicator considers the number of combined tropical nights and hot days per city. Physical measurements of air temperature shall be performed. Comparison of risk with nearby areas of similar form with low/no NBS.

Considering different metrics per city, in the case of Liverpool (53°25’00”N 3°00’00”O), the metrics to follow are:

- 3 days >25Cº at day
- 3 days >18Cº at night

And in Valladolid (41°39’07”N 4°43’43”O) and Izmir (38°26’00”N 27°09’00”E) demonstrations the metrics are:

- 3 days >35Cº at day
- 3 days >20Cº at night

The unit proposed are ˚C per number of days and nights. An assessment of reduction of risk due to GI interventions, also modelled in GI-Val.

SENSOR

Air temperature sensor and external data source UK –Met office–

RELATED NBS

Tree related actions, Vertical green interventions, Green noise barriers, Green vertical mobile garden, and Green facade.

RATIONALE

Urban heat island (UHI) effect refers to the increased temperatures of urban areas compared to surrounding rural areas under a range of meteorological conditions. Temperatures of sealed urban surfaces such as roads and pavements can be significantly higher than air temperature due to the higher capacity of construction materials to absorb and retain heat, releasing it during the night. The UHI effect can exacerbate summer heatwave conditions, with a detrimental effect on human health. Vegetation is well known to mitigate the effects of UHI through the process of evaporative cooling; where leaf stomata open at periods of intense heat to release moisture into the air. Trees additionally contribute to reducing temperatures by providing shade, making public space and travelling routes more comfortable for people on summer days when temperatures in urban areas are high. We propose to a) evaluate the local impact of a number of individual NBS on air and surface temperatures and, b) assess the potential impact of NBS on heatwave risk at the sub-demo scale by modelling using GI-Val.

NBS TYPES

Green shady structures, Shade Trees, Cooling trees, Green Façade, and Green parking pavements.

MONITORING METHOD

1. **Air temperature measurement**

Physical air temperature measurements at GI locations and control sites without GI pre- and post-intervention can be obtained using a portable anemometer or standard outdoor thermometer. This is a cheap and simple method suitable for monitoring multiple fixed survey points over time.

2. **Surface temperature**

Thermal imaging camera to capture surface temperatures at GI locations and control sites without GI pre- and post-intervention. Thermograms should be taken under consistent emissivity settings and displayed using a consistent temperature scale. Relative contribution of different urban surfaces to the UHI effect may be inferred from difference in surface temperatures during hottest summer days. This is a relatively simple method suitable for comparing surface temperatures at multiple fixed survey points over time.

3. **Reference data: air temperature**
   - A continuous air temperature data logger will be installed in each of the sub-demo areas to provide background data for air temperature in the shade.
   - Air temperature data from the nearest Meteorological Office weather station.

DATA PROCESSING

Calculation of the number of tropical nights and heatwaves monthly (summertime) and yearly assessing hourly mean values of temperature at each stretch. Comparison of mean values for NBS intervention and control sample locations will be done at each study site.

DATA ANALYSIS

1. **Evaluate the local impact** of individual NBS by comparing *a)* air temperatures and *b)* surface temperatures on hottest summer days at fixed sampling points at each NBS site selected for monitoring with those recorded at equivalent fixed sampling points at its matched control site; both pre- and post-NBS intervention. Temperature measurements at sampling points for each NBS should be taken on the same date and at similar times of day as measurements for its matched control site. Compare temperature values measured at NBS and matched control sites to background data for the same date and time from the nearest continuous temperature data logger (one situated in each sub-demo area), and to local Meteorological Office weather station temperature data.
2. **Evaluate impact of NBS at a sub-demo** or city-scale by using a model (STAR Tools) to estimate reduction in peak summer temperatures. Input: pre-intervention proportion of green space in the demo area and post-intervention increase in proportion of green space. The output of the model will be the predicted reduction in peak summer temperatures in the demo area modelled. From the modelled output, the potential

impact of NBS on hypothetical heatwave conditions in the demo area modelled can be inferred.

The STAR Tools are surface temperature and runoff tools for assessing the potential of green infrastructure in adapting urban areas to climate change. They were created by The Mersey Forest and The University of Manchester, and can be found at https://maps.merseyforest.org.uk/grabs

REFERENCES

- EKLIPSE Report.
- Demuzere et al., 2014. Mitigating and adapting to climate change: Multi-functional and multi-scale assessment of green urban infrastructure. Journal of Environmental Management 146, 107-115
- Yu, C., Hien, W., 2006. Thermal benefits of city parks. Energy Build. 38 (2), 105-120.
- V.T. Ca, T. Asaeda, E.M. Abu, Reductions in air conditioning energy caused by a nearby park, Energy and Buildings 29 (1998) 83–92.
- Baró, F. et al., 2015. Mismatches between ecosystem services supply and demand in urban areas: A quantitative assessment in five European cities. Ecological Indicators 55 (2015) 146–158.
- Fischer, E.M., Schär, C., 2010. Consistent geographical patterns of changes in high-impact European heatwaves. Nat. Geosci. 3, 398–403.

2.1.8 kWh savings per year

RATIONALE/INTRODUCTION

Climate change can cause overheating in city centers, especially through the "heat island effect". Green urban infrastructure can play a role in climate change adaptation through reducing air and surface temperature by providing shading and enhancing evapo-transpiration, which leads to energy and carbon savings from reduced building energy consumption especially in summer (Akbari, 2002). On the other hand, insulating effect of plants reduces heating energy consumption and associated carbon emissions in winter (Alexandri and Jones, 2008; Zinzi and Agnoli, 2011).

NBSs in Izmir do not have any building level interventions such as green roof and green façade. Green shady structures will be implemented in parking lots, which has no connection with buildings. Therefore, energy and carbon savings from reduced building energy consumption will be obtained using a dynamic building energy performance software, Design Builder (v.4.7) (Design Builder, 2018). The buildings in NBS locations will be classified such as residential, commercial, etc. and one example from each class will be modelled. The models will be simulated by air temperature and relative humidity, and surface temperature values which will be obtained from KPI-7 "Decrease in mean or peak daytime local temperatures (°C)". The difference between energy consumption values of pre- and post-intervention will give energy savings. Then, corresponding carbon savings from reduced energy consumption will be calculated by conversion factors given by the Building Energy Performance Regulation (BEP, 2017). Finally, the study would be extended to all buildings at NBS locations.

NBS TYPES

Green shady structures, green covering shelters, shade and cooling trees, cool and green pavements.

METHOD

The methodology consists of measurements, modelling and simulations. The steps of the methodology are:

1. Collecting air temperature and relative humidity, and surface temperature data (measured for KPI 7) from NBS locations both pre- and post-intervention,
2. Classifying the buildings at NBS locations and modelling one building for each class,
3. Simulating the building models to obtain energy consumption values,
4. Converting the energy consumption values to primary energy consumption value using conversion factors provided by the Building Energy Performance Regulation (BEP, 2017),
5. Converting the energy consumption values into CO_2 by means of conversions factors provided by the Building Energy Performance Regulation (BEP, 2017),
6. Obtaining energy and carbon savings by comparing pre- and post-intervention primary energy consumptions and CO_2 emissions at NBS locations,
7. Extending the study to all buildings at NBS locations.

If modelling will not be possible, as Plan B, a city specific heat gain/loss correlation (mean) will be obtained from the literature. Based on the decrease in air temperature by interventions, decrease in energy consumption will be calculated by this correlation. Finally, corresponding carbon savings from reduced energy consumption will be calculated.

SENSOR/SOFTWARE

Design Builder (v.4.7) (Design Builder, 2018) software will be used to model the buildings and simulate the model to obtain energy consumption data based on measured air temperature and relative humidity, and surface temperature data for KPI 7.

MEASUREMENTS

The models will be simulated by air temperature and relative humidity, and surface temperature values which will be measured at KPI-7 "Decrease in mean or peak daytime local temperatures (°C)".

STUDY SITES

Karşıyaka Metropolitan District which is a highly urbanised area will be the study site. The measurements will be conducted at Vilayetler Evi parking lot and surroundings. Decrease in temperature because of the interventions in the Demo Site, will be used to calculate the energy savings in the District.

RESULTS

Energy consumption outputs of the model will be compared for the periods before and after the interventions in the NBS and reference sections. Corresponding carbon savings from reduced energy consumption will be calculated. The study would be extended to all buildings at NBS locations.

Results can be displayed throughout maps and/or tables.

2.1.9 t C/y savings per year

Derived from previous methodology.

2.1.10 SPECIES MOVEMENT

RATIONALE

Distribution of many species in response to climate change may shift north, or to higher altitudes, to take advantage of newly suitable habitat as temperatures warm and existing habitat becomes unsuitable. The presence of sufficient blocks or corridors of suitable habitat to provide routes along which species can move is therefore key to maintaining populations under changing climate. Modelling habitat resources for movement and dispersal of species under different scenarios is of increasing importance for ecological network assessment and planning. The Condatis software developed by the University of Liverpool (Hodgson *et al.* 2012) is designed to model a multigenerational wave of species movement through a landscape. Using Condatis this KPI will measure whether GI NBS have provided increased opportunity for species movement in response to climate change.

METHOD

Use of the Condatis model to quantify increased (% change) long-distance range-shift potential for selected taxa because of GI interventions.

BASELINE HABITAT INPUT DATA

Baseline habitat flow maps show the relative importance of three habitat types, (intensively and less intensively managed grassland and trees) and identify potential bottlenecks for species movement in the three demo areas and wider Liverpool area. Bottleneck view highlights habitat links that currently constrain connectivity (represented by darker coloured lines), which is also where habitat restoration could make a big difference. The baseline habitat flow maps were produced in 2017 using the Condatis model (University of Liverpool) with habitat data (200m rasters) created from OS Master map Green infrastructure typology (Master Map Topography Layer and Greenspace Layer) and tree canopy data from BlueSky's National Tree Map. Polygons classified as intensively managed grassland included land use classifications: general amenity space, green roof, institutional grounds, outdoor sports facility, park or public garden and private domestic garden. Polygons classified as less intensively managed grassland included land use classifications: grassland, heathland, moorland or scrubland, cemetery, churchyard or burial ground and derelict land. Species dispersal distances were set as 1km and 2km. Source and target locations were selected to represent species movement from south to north through the Liverpool area [Appendix **D3.2** Mersey Forest].

POST-INTERVENTION HABITAT INPUT DATA

Use existing 2017 Condatis maps referred to above [**D3.2** Mersey Forest] (or updated maps to reflect any update in OS MasterMap Topography/Greenspace Layers/Bluesky National Tree Map) to represent baseline pre-intervention habitat in the demo areas. From project records detailing the extent, location and type of intervention, shapefiles/cells will be created and added to the model to represent the extent and type of new NBS GI habitat post-intervention.

CALCULATION OF % CHANGE IN LONG-DISTANCE RANGE-SHIFT POTENTIAL PRE- AND POST-INTERVENTION

The Condatis model will be used to test whether the new NBS GI habitat patches have increased the connectivity value of existing habitat networks across the Liverpool area. Calculate the improvement in speed (the overall conductance of the whole landscape) post-intervention. Quantify the impact on flow made by a new habitat cell/cluster of cells (NBS GI) in each demo area by obtaining flow values for each new habitat cell pre- and post-intervention. Express difference in flow speed values as a percentage change value. (Note where there was no habitat pre-intervention the flow will be zero).

TECHNICAL SPECIFICATIONS

Condatis is a user-friendly, open source program, which is available to anyone. It is released under the GNU General Public Licence version 3 with one additional permitted term: http://download.condatis.org.uk/Condatis_License.html The Condatis software runs on Windows and Unix-like operating systems such as Mac OS X and Linux. Condatis is written in Python 2.7. Author: David W. Wallis and Jenny A. Hodgson

- Title: Condatis; software to assist with the planning of habitat restoration
- Version: [0.6.0.]
- URL: www.condatis.org.uk

REFERENCE

- Hodgson, J.A., Thomas, C.D., Dytham, C.,Travis, J.M.J. and Cornell, S.J. (2012) The speed of range shifts in fragmented landscapes. PLoS ONE 710
- Hodgson, J.A., Wallis, D.W., Krishna, R. & Cornell, S.J. (2016) How to manipulate landscapes to improve the potential for range expansion. *Methods in Ecology and Evolution,* **7,** 1558-1566. http://dx.doi.org/10.1111/2041-210X.12614
- **Habitat Map data sources**
  - OS Mastermap Topography and Greenspace Layers[11]
  - Digimap[12]
  - Bluesky National Tree Map[13]

[11] https://www.ordnancesurvey.co.uk/business-and-government/products/mastermap-products.html

[12] http://digimap.edina.ac.uk/

[13] https://www.blueskymapshop.com/products/national-tree-map

2.2 WATER MANAGEMENT

2.2.1 RUN-OFF COEFFICIENT

In Valladolid demo, the KPI will be calculated based in a hydraulic model.

In the case of Liverpool, the use of Star Tools will be considered to model projected reduction in surface water run-off in demo areas because of NBS under various precipitation scenarios.

The metrics will be run off coefficient in terms of water volume or percentage (%).

RATIONALE

The STAR Tools are surface temperature and runoff tools for assessing the potential of green infrastructure in adapting urban areas to climate change. They are freely available at http://maps.merseyforest.org.uk/grabs/. The surface runoff tool can be used to model the volume and percentage of rainfall that will be converted to runoff in a neighbourhood, considering the various effects of the vegetation (interception, infiltration and storage). Since the implementation of nature-based solutions will usually result in an increase in vegetation cover, we should be able to see a decrease in the modelled surface water runoff under each precipitation scenario (including the baseline).

The STAR Tools underlying models were used by The University of Manchester in the ASCCUE project[14] where they were applied to Greater Manchester (Gill, 2006; Gill et al, 2007). They had previously been developed and used in Merseyside (Whitford et al, 2001). The surface runoff model is based upon the US Soil Conservation Service approach (Soil Conservation Service, 1972).

RELATED NBS

SUDs, Natural Wastewater Treatment Plan, Rain Gardens, Floodable Park, Green Parking pavements.

SENSOR/SOFTWARE

No sensor is required. Data are acquired by statistic and rainfall and soil available information in each intervention. The runoff reduction will be compared before and after the installation of the NBS to know if the intervention has influenced the study area. Spreadsheet software can be required.

METHODOLOGY

This is an estimated KPI using a cost-effective hydrologic model based on the Soil Conservation Service Curve Number (SCS-CN) method (*NRCS, 1986*).

The SCS-CN model can estimate the volume of runoff reduction by urban green spaces in each of the different sites where NBS´s will be allocated. The SCS-CN method has been used for a

[14] https://www.mui.manchester.ac.uk/cure/research/projects/past-projects/asccue/

wide range of watershed areas, ranging from 0.25 ha to 1000 km^2, applied to various climatic zones and functions well both in natural or urban areas. *(Boughton, 1989; Ebrahimian et al., 2012; El-Hames, 2012; Baker and Miller, 2013).*

This model is based on empirical studies of ungauged watersheds to estimate runoff from rainfall events (*NRCS, 1986*). Minimal input data are needed to simulate direct surface runoff. Specifically, the calculations require only rainfall abstraction, without considering other complex factors such as groundwater recharge and baseflow (*Yao et al., 2015*).

Three parameters are used to calculate surface runoff: rainfall depth, initial abstraction of the rainfall, and the potential maximum storage of the soil (*Boughton, 1989*).

Daily rainfall data from each intervention site are needed to calculate runoff. In case of the interventions developed in Spain, rainfall data can be obtained from the *AEMET* Service.

In the case of Liverpool, the approach will be focused in the sub-demo areas and will be divided into study areas where groups of interventions have been made, and for each study area the pre- and post-intervention land cover will be calculated. The primary inputs for these calculations will be Ordnance Survey's MasterMap[15] and the landscape architects' drawings. The hydrological soil types will be derived from data from the National Soil Resources Institute at Cranfield University[16]. The default precipitation scenarios and other parameters will be used, as these are appropriate to Northwest England.

RUNOFF REDUCTION CALCULATION

Since the reduction of surface runoff is achieved by replacing fully impervious surfaces with urban green spaces, two variables have been defined to evaluate the potential hydrologic benefits of runoff reduction: the total amount of runoff reduction due to urban green spaces (ΔV) and the runoff reduction coefficient (Cr).

- **DV**, as defined by *Zhang et al., 2012*, is used to represent differences in total runoff reduction volume and characterize the general benefit provided by URBAN GreenUP interventions in terms of reducing rainfall-runoff.

- **Cr** is like the runoff coefficient (runoff depth/rainfall depth) (*Weng, 2001; Costa et al., 2003*) and is generated by dividing DV by the total amount of rainfall in a specific area. Unlike DV, Cr represents differences in runoff reduction efficiency.

2.2.2 WATER SLOWED DOWN FROM SEWER SYSTEM

This KPI is principally based on investigating rate change in runoff production at field or plot scale. The parameters under principal investigation are discharge (m^3 sec^{-1}) and flow velocity (m

[15] https://www.ordnancesurvey.co.uk/business-and-government/products/mastermap-products.html

[16] www.landis.org.uk/data/index.cfm

sec^{-1}), which when plotted on a storm-hydrograph, ought to demonstrate the following changes between the baseline and post GI scenario:

1. An increased lag-time (L), the time of peak rainfall to peak discharge and,
2. Reduced peak discharge (Q_p)

KPI SCOPE

Evapotranspiration (ET) (mm sec^{-1}) and interception rates will not be directly observed under this KPI, through various processes, both are implicit in reducing inflow rates into sewers. ET represent system losses of groundwater, potentially lowering wetted fringe and water table that is hypothesised to reduce soil moisture and increase infiltration – a useful GI service if permeable paving is installed.[17]

KPI METHOD

I) Source local tipping bucket rainfall data (P), from Liverpool University weather observatory, scale P rates to study site area.

II) Determine inflow and outflow points to a given locality of GI interventions, established from surface water flood mapping (Environment Agency RoSWFM/JFLOW[18]) and overland flow routing model[19]

III) Apportion percentage inflow and outflow to the boundary of the plot or field-scale site under investigation.

IV) At the area of largest or principal inflow and outflow, install a gauging station, with one or more mid-point gauging stations along the overland flow-pathway and proposed GI corridor, to augment boundary observations, creating a longitudinal chain of continuous discharge observation.

V) Conduct continuous discharge monitoring through the baseline and post-intervention scenario to tests the effects of GI on increased lag-time and reduced $Q_{p.}$

APPARATUS

Open Pipe

I) V-notch gauging station weir with stilling well and spot discharge measurement to establish stage-discharge relationship, and therefore continuous discharge, extrapolated from 5-minute water-level (stage).

II) Non-contact flow measurement – Particle Image Velocity [20]and infa-red height sensors to continually monitor height and velocity, over a known cross-sectional area. Together these observations can combine to create a continuous discharge data-series.

[17] Hankin B, Craigen I, Chappell NA et al. (2016) Strategic Investigation of Natural Flood Management in Cumbria. Jeremy Benn Associates, Skipton, UK. See http://naturalcourse.co.uk/uploads/2017/04/2016s4667-Rivers-Trust-Life-IP-NFM-Opportunities-Technical-Report-v8.0.pdf (accessed 02/02/2018).

[18] https://www.gov.uk/government/publications/flood-risk-maps-for-surface-water-how-to-use-the-map

[19] http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst-toolbox/stream-order.htm

[20] http://meetingorganizer.copernicus.org/EGU2015/EGU2015-8582.pdf

Closed Pipe

i) Ultrasonic Flow Meters, see example here: http://www.rshydro.co.uk/liquid-pipe-flowmeters/

RELATED NBS

Tree related actions; SUDs; horizontal GI, Tree related actions, SuDs /Raingarden, Horizontal green interventions, natural flood management techniques.

2.2.3 NUTRIENT ABATEMENT (Chemical Oxygen Demand, COD)

INTRODUCTION

"Nutrient abatement, abatement of pollutants" is included in the *Challenge 2. Water management.* Some NBS related to water management, such as the NTWP and the Electrowetlands, are designed for the removal of organic compounds and nutrients from the wastewater. The treatment of wastewater by means of green solutions supposes the discharge of low loads of organic matter, nutrients, and other pollutants (such as heavy metals or emerging contaminants) to the environment. Therefore, the safety discharge to the environment or later reuse for different purposes (such as irrigation of green areas) is ensured.

This KPI aims at determining the organic matter, nutrients, and other pollutants removal in the NBS. For that purpose, the concentration of the specific contaminants to be monitored are determined both in the influent (raw wastewater) and the final effluent of the NBS. The reduction observed in the concentration is the abatement reached in the monitored system. This KPI involves sampling and analytical determinations in a lab.

In the European Union, the urban wastewater treatment is regulated through the Directive 91/271/EEC. This Directive concerns the urban wastewater "collection, treatment and discharge of urban wastewater and the treatment and discharge of waste water from certain industrial sectors". It aims "to protect the environment from adverse effects of wastewater discharges from cities and "certain industrial sectors".

Parameters	Concentration	Minimum percentage of reduction (¹)	Reference method of measurement
Biochemical oxygen demand (BOD5 at 20 °C) without nitrification (²)	25 mg/l O_2	70-90 40 under Article 4 (2)	Homogenized, unfiltered, undecanted sample. Determination of dissolved oxygen before and after five-day incubation at 20 °C ± 1 °C, in complete darkness. Addition of a nitrification inhibitor
Chemical oxygen demand (COD)	125 mg/l O_2	75	Homogenized, unfiltered, undecanted sample Potassium dichromate
Total suspended solids	35 mg/l (³) 35 under Article 4 (2) (more than 10 000 p.e.) 60 under Article 4 (2) (2 000-10 000 p.e.)	90 (³) 90 under Article 4 (2) (more than 10 000 p.e.) 70 under Article 4 (2) (2 000-10 000 p.e.)	— Filtering of a representative sample through a 0,45 µm filter membrane. Drying at 105 °C and weighing — Centrifuging of a representative sample (for at least five mins with mean acceleration of 2 800 to 3 200 g), drying at 105 °C and weighing

(¹) Reduction in relation to the load of the influent.
(²) The parameter can be replaced by another parameter : total organic carbon (TOC) or total oxygen demand (TOD) if a relationship can be established between BOD5 and the substitute parameter.
(³) This requirement is optional.

Analyses concerning discharges from lagooning shall be carried out on filtered samples ; however, the concentration of total suspended solids in unfiltered water samples shall not exceed 150 mg/l.

Table 2.2: Requirements for discharges from urban waste water treatment plants subject to Articles 4 and 5 of the Directive. The values for concentration or for the percentage of reduction shall apply.

Parameters	Concentration	Minimum percentage of reduction (¹)	Reference method of measurement
Total phosphorus	2 mg/l P (10 000 - 100 000 p. e.) 1 mg/l P (more than 100 000 p. e.)	80	Molecular absorption spectrophotometry
Total nitrogen (²)	15 mg/l N (10 000 - 100 000 p. e.) 10 mg/l N (more than 100 000 p. e.) (³)	70-80	Molecular absorption spectrophotometry

(¹) Reduction in relation to the load of the influent.
(²) Total nitrogen means : the sum of total Kjeldahl-nitrogen (organic N + NH_3), nitrate (NO_3)-nitrogen and nitrite (NO_2)-nitrogen.
(³) Alternatively, the daily average must not exceed 20 mg/l N. This requirement refers to a water temperature of 12° C or more during the operation of the biological reactor of the waste water treatment plant. As a substitute for the condition concerning the temperature, it is possible to apply a limited time of operation, which takes into account the regional climatic conditions. This alternative applies if it can be shown that paragraph 1 of Annex I.D is fulfilled.

Table 2.3: Requirements for discharges from urban wastewater treatment plants to sensitive areas which are subject to eutrophication as identified in Annex ILA (a). One or both parameters may be applied depending on the local situation. The values for concentration or for the percentage of reduction shall

Locally the limits to wastewater treatment and discharge are imposed by the River Basin Authority (Duero River Basin Authority in the case of Valladolid) who may adopt directly the values in tables 1 and 2 (in case declared sensitive areas) or establish more restrictive ones.

NBS TYPES

1. Natural wastewater treatment	Wastewater treatment plant based on the combination of natural treatment systems, such as constructed wetlands and ponds, following the concept of waterharmonica. The flowsheet can be completed by sand filtration and chlorination (disinfection) for the later water reuse. These systems provide more than just simple purification, because while treating the water, they are also regulating temperature and providing valuable habitats for biodiversity.
2. Electrowetland	An Electrowetland is a natural wastewater treatment system that generates electricity from the oxidation of the organic matter. It is based on a conventional Horizontal Subsurface Flow Constructed Wetland (HSSF CW) in which electrodes are introduced. Therefore, it consists on a planted and permanently flooded gravel basin in which wastewater flows horizontally from one side to the other of the system crossing the electrode layer.

Table 2-4. NBS types that applies to the KPI

METHOD

This KPIs is calculated from measured data using a methodology defined by URBAN GreenUP Project.

BACI (BEFORE, AFTER, CONTROL, IMPACT)

Pollutants abatement in the related NBS are determined through the comparison of the concentration of the targeted pollutant in the influent and effluent of the system (NTWP or electrowetland). This KPI implies the sampling of water and later analysis in a lab. Sensors for continuous water quality monitoring are considered complementary.

NULL HYPOTHESIS

NBS proposed do not remove from municipal wastewater any of the contaminants considered for this KPI and therefore there is no nutrient abatement. Also, if treated wastewater does not fulfil the legislation limits established in the Urban Wastewater Treatment Directive (91/271/EC) (Tables 1 and 2) or the ones imposed by the River Basin Authority.

ANALYSIS: WATER QUALITY PARAMETERS

To analyse the pollutant abatement, samples at the influent and effluent of the NBS (NTWP and Electrowetland) will be taken and analysed by Aquavall (Municipal Public Entity in charge of water supply and wastewater treatment in Valladolid city).

MEASUREMENTS AND UNITS OF MEASUREMENT

The pollutants to be monitored will be, at least, the parameters listed in the authorisation for wastewater discharge from the River Basin Authority. Commonly, the monitoring parameters are the ones in table 3.

Temperature (ºC)
Dissolved oxygen (mg L^{-1})
pH
Conductivity (µS cm^{-1})
Biochemical Oxygen Demand in 5 days, BOD5(mg O_2 L^{-1})
Chemical Oxygen demand, COD (mg O_2 L^{-1})
Suspended solids, SS (mg L^{-1})
Total Nitrogen, TN (mg N L^{-1})
Ammonium, N- NH4 (mg N L^{-1})
Total Phosphorous, TP (mg P L^{-1})
Chloride (mgCl^- L^{-1})
Grease & fats (mg L^{-1})

Table 2-5 Common monitoring parameters for the determination of the efficiency of wastewater treatment plants

Temperature, dissolved oxygen, pH and conductivity are commonly measured in situ by individual sensors or a multiparameter probe. The monitoring of these parameters shall be punctual or continuous (depending on the budget available for the acquisition of sensors and probes and the later maintenance).

The rest parameters will be determined in the lab using standard methods. However, in recent years, on site probes for the determination of some of the parameters listed in table 3 have been deployed in the market (i.e, probes for nitrates, ammonia, suspended solids). Their implementation allows the continuous monitoring of the water quality but might suppose an increase in the capital and running costs of the NBS.

Other pollutants, such as heavy metals or emerging contaminants, shall also be determined if required in the authorisation of wastewater discharge issued by the River Basin Authority.

CALIBRATION / VERIFICATION

Water quality laboratory personnel will calibrate and verify equipment and probes used to quantify the above defined parameters over time according to each manufacturer specifications.

MEASUREMENT SITES

Flow-proportional or time-based 24-hour samples shall be collected at the same well-defined point in the outlet and if necessary, in the inlet of the treatment plant in order to monitor compliance with the requirements for discharged waste water laid down in the UWWTD 91/271/EEC.

Figure 2.4. Example of an automatic sampler Sigma 900 HACH.

Good international laboratory practices aiming at minimizing the degradation of samples between collection and analysis shall be applied.

NUMBER OF SAMPLES

Following the indications of Annex I of the UWWTD 91/271/EEC, the minimum annual number of samples shall be determined according to the size of the treatment plant and be collected at regular intervals during the year:

- 2000 to 9999 p.e.: 12 samples during the first year. Four samples in subsequent years, if it can be shown that the water during the first year complies with the provisions of the Directive; if one sample of the four fails, 12 samples must be taken in the year that follows.
- 10 000 to 49 999 p.e.: 12 samples.
- 50 000 p.e. or over: 24 samples.

DATA

Data sampling
The analytic results are gathered in a lab work sheet. In case on site probes are installed in the NBS, data can be recorded through a datalogger.

Data processing
The efficiency of the NBS in the abatement of organic matter, nutrients and other pollutants (heavy metals or emerging contaminants) can be expressed as a percentage (% removed) or mass reduction (kg/day).

$$\%\, removed = \frac{C_i - C_e}{C_i} \times 100$$

C_i = concentration in the influent (mg/l)

C_e= concentration in the effluent (mg/l)

$$mass\ reduction\ \left(\frac{Kg}{day}\right) = (C_i \times Qi) - (C_e \times Qe)$$

Qi= inflow rate (m^3/day)

Qe= outflow rate (m^3/day)

Note: normally, Qi and Qe are considered equal (water losses in the system might be considered negligible)

RESULTS

% removed; mass reduction (kg/day)

REFERENCES

- Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment

2.2.4 NUTRIENT ABATEMENT (BOD)

Previous section

2.2.5 NUTRIENT ABATEMENT (Total Solids, TSS)

Previous section

2.2.6 WATER REMOVED FROM THE WATER TREATMENT

RATIONALE

Green infrastructure can prevent rainfall from entering the water treatment system by allowing it to soak into the soil or to evaporate back into the air. GI-Val tool 2.1 can be used to model the volume and percentage of rainfall that is affected in these ways, and to put a monetary value on part of the benefit: the energy and carbon emission savings.

In the case of Valladolid, storm water, domestic sewage and industrial wastewater are collected through a combined sewers system which transports all the wastewater to a sewage treatment plant. The wastewater treatment plant (WWTP) of Valladolid has a treatment capacity for 570,000 population equivalent (future extension up to 750,000 pe) and a maximum flow rate 3 m^3/s. The foreseen reduction in the surface runoff by the implementation of the different NBS in Valladolid city will reduce the total volume of wastewater collected though the sewers system and, therefore, the volume of water to be treated at the WWTP. Thus, will suppose an important economic savings.

MEASURED METHOD

Direct measurement of water flow pre and post intervention. Create local urban catchment hydrograph for demonstration site. Model projected savings (Euro) using GI-Val. Discharge data for storm water (m^3) from United Utilities.

RELATED NBS

Smarts soils as substrate, SUDS and raingardens, tree related actions, GI horizontal, Floodable Park.

METHOD

There are two options here: either directly measure changes in flow, convert them to changes to the runoff volume/percentage, enter them into GI-Val[21], or use GI-Val solely to estimate the monetary value; or model the changes to the runoff volume/percentage in GI-Val as well, thus reducing the need for direct measurements and their conversion.

If the second option is pursued, the sub-demo areas will be divided into study areas where groups of interventions have been made, and for each study area the pre- and post-intervention land cover will be calculated. In the specific case of Liverpool demo the primary inputs for these calculations will be Ordnance Survey's MasterMap[22] and the landscape architects' drawings. The hydrological soil types will be derived from data from the National Soil Resources Institute at Cranfield University[23]. Precipitation data will be sourced from the Met Office[24].

In the case of Valladolid, the volume of water retained by the NBS will be estimated through KPI 16 and 20. Then, this volume of water (m^3/ year; m^3/month), which is not diverted to the sewer system, will be multiplied by the annual costs of water treatment (€/m^3 of wastewater treated). The actual costs of the water treatment will be provided by AQUAVALL (the public company which manages the urban water cycle in Valladolid).

2.2.7 SAVINGS IN TREATMENT OF STORMWATER

Derived from previous indicator described in 2.2.6

2.2.8 RUNOFF ESTIMATION OF BIOSWALES IN BIOBOULEVARD

INTRODUCTION

This KPI measures capacity information of grassed swale systems by calculating the runoff volume in İzmir case. This calculation is also important for dimensioning the scale of bio-swale systems in bio-boulevard since this area is known by its high groundwater level and in winter times, İzmir has recent heavy rains that cause flood actions in areas where soil has a heavy structure as our study area.

NBS TYPES

This KPI is related to NBS involving bio-boulevard and grassed swales and water retention pounds around bio-boulevard.

---

[21] https://www.merseyforest.org.uk/services/gi-val/

[22] https://www.ordnancesurvey.co.uk/business-and-government/products/mastermap-products.html

[23] www.landis.org.uk/data/index.cfm

[24] http://www.metoffice.gov.uk/hadobs/hadukp/data/download.html

METHOD

A GIS based analysis will be made to predict runoff by using the most common method called The Runoff Curve Number (CN), developed for ungauged basins to calculate runoff from rainfall data by USDA NRCS (United States Department of Agriculture Natural Resources Conservation Service) formerly known as the Soil Conservation Service (SCS). The method is used worldwide to predict runoff based on the amount of impervious area, soil group, land cover type, hydrological condition, and antecedent runoff (USDA NRCS, 1986).

MEASUREMENTS

Runoff depth, runoff volume, bio-swale dimensions

UNIT OF MEASUREMENT

Runoff depth: mm

Runoff volume: m^3

Bio-swale dimensions: m^2

STUDY SITES

In İzmir, study sites will be along the bio-boulevard (Sub-demo B) area that is located in Çiğli-Sasalı region.

DATA PROCESSING

ArcMap 10.3 is the GIS software proposed to be used in İzmir. Calculations for baseline values were carried out based on satellite images using GIS techniques. Land cover information is taken on site by visits. Noted down invasive *Eucalyptus* species and native herbaceous plant cover is the dominant vegetation covering app. 80% of the NBS area which is currently abandoned to its own natural dynamics. The needed soil information is provided by in-situ soil analysis. Precipitation values are estimated based on a 10-year return period with a 24-hour duration rainfall data for İzmir city.

RESULTS, REPORT FORMAT

Results can be displayed throughout maps and/or tables.

2.3 GREEN SPACE MANAGEMENT

2.3.1 GREEN SPACE DISTRIBUTION (m2/capita)

INTRODUCTION

This indicator is included in the list of indicators for Challenge 4. Green Space Management. This social indicator evaluates the increases of public green spaces in terms of total surface or per capita.

Urban green infrastructures are key part of the sustainable development in our cities. They can provide important Ecosystem Services in them, including provisioning, regulating, supporting and cultural services. The total surface of green areas needs to be relativized in terms of total area or per capita, in order to compare results with other cities or to observe the evolution within the same city.

A survey carried out in 2017 by the AEPJPs for 54 spanish cities found the average value of public green space by the total surface were 3.4%. This survey also evaluates the public green space in terms of total surface per capita, and the average value for this were 12.46 m^2/hab. However, this and other study (Badui et al, 2016) proved the great variability that these indicators have between cities. The values given by the World Health Organization are also variable, since it sets the minimum green area per inhabitant at 9 m^2/hab and the ideal value at 50 m^2/hab.

NBS TYPES

This KPI can evaluate NBS involving horizontal green infrastructures, such as new green cycle lane and re-naturing existing bike lanes: green cycle lane; Green resting areas; Cycle-pedestrian green paths, etc.

CODE	ACTION	SUB-DEMO	CATHEGORY	SUB-CATHEGORY
VAc1	New green cycle lane and re-naturing existing bike lanes	A	Re-naturing Urbanization	Green route
VAc2	Planting 1,000 trees	A	Re-naturing Urbanization	Arboreal interventions
VAc3	Tree shady places (500 trees)	A	Re-naturing Urbanization	Arboreal interventions
VAc4	Shade and cooling trees (600 trees)	B	Re-naturing Urbanization	Arboreal interventions
VAc5	Re-naturing parking trees (250)	C1	Re-naturing Urbanization	Arboreal interventions

VAc7	Urban Carbon Sink	C3	Re-naturing Urbanization	Carbon capture
VAc26	Electro wetland	B	Singular GI	Horizontal GI
VAc27	Green Covering Shelter	B	Singular GI	Horizontal GI
VAc28	Green Roof	B	Singular GI	Horizontal GI
VAc29	Green Shady Structures	B	Singular GI	Horizontal GI

Table 2-6 : List of NBS Types that can be measurable with this KPI

METHOD

This KPI can be measured throughout specific software, such as GIS software and spreadsheet software. Results can be displayed throughout maps and/or tables.

This KPI can be considered for the entire municipality of Valladolid, giving a single resulting value for each study campaign. However, a neighbourhood level study is recommended since it can be useful for detecting deficit areas.

SENSOR/SOFTWARE

Data are acquired by statistic and GIS processing, so no sensor is required.

Spatial Analysis software is required. QGIS is the GIS software proposed to be used, due to it is an open source and multiplatform software and it is distributed under Creative Commons Attribution-Share Alike 3.0 licence (CC BY-SA). We recommend using the last long-term release repository, most stable (QGIS 2.18 is currently the last one). Data processing involved in this KPI can be done with the standard version and the standard toolbox.

Spreadsheet software is required.

DATA SAMPLING

Datasets are provided by Valladolid City Council. All Datasets need to follow INSPIRE principles. An appropriated Coordinate Reference Systems must be defined for each location (city). The image below shows the recommended CRS for Valladolid location.

This is considered as a very stable KPI, so frequency could be the same as city council's demographic statistics, therefore, annual. To set the starting situation a preliminary study is also needed.

The required and recommended inputs for the calculation of this KPI are shown in the following table.

VARIABLE	DESCRIPTION	UNIT	SOURCE TYPE	NOTES
Green infraestructures surface	Green infrastructures cartography	m^2	Shapefile – Polygon	Required study data for this KPI. This dataset can also require an ID value.
City surface	Official City Boundaries cartography	m^2	Shapefile – Polygon	Required data for this KPI. This dataset can also require an ID value.
City population	Official City Boundaries cartography	number of inhabitants	Shapefile – Polygon	Required data for this KPI. This dataset can also require an ID value.
Neighborhood surface	Official Neighborhood	m^2	Shapefile – Polygon	Optional data for this KPI. This dataset can also require an ID value.

	Boundaries cartography			
Neighborhood population	Official Neighborhood Boundaries cartography	number of inhabitants	Shapefile – Polygon	Optional data for this KPI. This dataset can also require an ID value.

Table 2-7 : List of NBS Types that can be measurable with this KPI

DATA PROCESSING

Data processing using QGIS has been designed to obtain one KPI value by neighbourhood.

The first step consists in obtain a shapefile in which each GI is associated to its neighbourhood location throughout the tool **Join attributes by location**. As a result, a new shapefile is obtained, with an attribute table associated containing a mixed of both attribute tables entries. To obtain a unique **green areas surface** value for each **neighbourhood**, a **Single Part to multipart** tool can be used. Then the total surface can be calculated by the **Field Calculator** tool using the *$area* function.

The table below shows the properties of the new variable obtained.

VARIABLE	DESCRIPTION	UNIT	SOURCE TYPE	NOTES
Green areas surface by neighborhood	Green infrastructures joined by location cartography	m^2	Shapefile – Polygon	Derived variable obtained by GIS processing. This variable must be recalculated after the join.

Two new fields must be calculated using Field Calculator tool, which represent the total green area in terms of total surface or per capita.

DESCRIPTION	UNIT	SOURCE TYPE	NOTES
Green area surface by neighborhood / Neighborhood surface	% (m^2/m^2)	Shapefile – Polygon	Derived variable obtained by GIS processing.
Green area surface by neighborhood / Neighborhood inhabitants	m^2/hab	Shapefile – Polygon	Derived variable obtained by GIS processing.

Overall statistics can also be calculated by a QGIS tool called **Basic statistics for numeric fields** (based on KPI_052). Te result of this tool is a table (not GIS data), with resume figures of both terms of the KPI, including minimum and maximum values, range, mean and median value, standard deviation and coefficient of variation.

The next picture shows the algorithm for this described process.

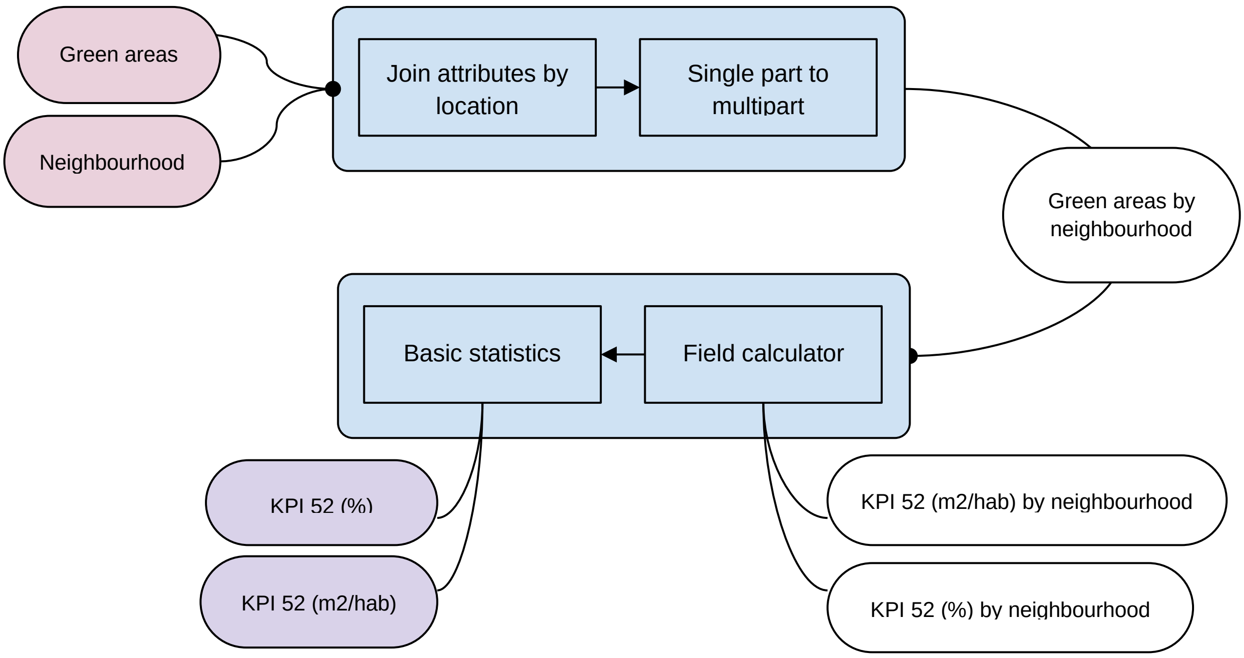


Figure 2.5: KPI algorithim dataflow scheme

RESULTS

Two final figures are obtained at the end of the process for this KPI. One of them shows the distribution of green areas surface in terms of total surface (%), and the other shows the distribution of green areas surface in terms of inhabitants (m^2/hab.).

In addition, a very simple map is proposed to show the KPI results by each neighbourhood. Resume statistics can be displayed also in this map.

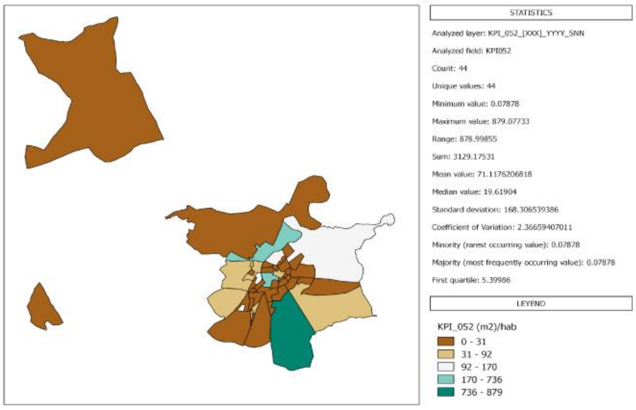


Figure 2.6: Example of the representation of the idicator

REFERENCES

- QGIS 2.18 – Userguide. https://www.qgis.org/en/site/
- Spatial Reference - Howard Butler, Christopher Schmidt, Dane Springmeyer, and Josh Livni http://spatialreference.org/
- Inspire Knowledge Base - https://inspire.ec.europa.eu/
- Raymond, C.M., Berry, P., Breil, M., Nita, M.R., Kabisch, N., de Bel, M., Enzi, V., Frantzeskaki, N., Geneletti, D., Cardinaletti, M., Lovinger, L., Basnou, C., Monteiro, A., Robrecht, H., Sgrigna, G., Munari, L. and Calfapietra, C. (2017) An Impact Evaluation Framework to Support Planning and Evaluation of Nature-based Solutions Projects. Report prepared by the EKLIPSE Expert Working Group on Nature-based Solutions to Promote Climate Resilience in Urban Areas. Centre for Ecology & Hydrology, Wallingford, United Kingdom
- Badiu, D.L., Iojă, C.I., Pătroescu, M., Breuste, J., Artmann, M., Niță, M.R., Grădinaru, S.R., Hossu, C.A., Onose, D.A., 2016. Is urban green space per capita a valuable target to achieve cities' sustainability goals? Romania as a case study. Ecol. Indic. 70, 53–66. doi:10.1016/j.ecolind.2016.05.044
- ANÁLISIS DE LA CONSERVACIÓN DE LA INFRAESTRUCTURA VERDE URBANA EN ESPAÑA 2015 Junio 2017 Asociación Española de Parques y Jardines Públicos

2.3.2 GREEN SPACE DISTRIBUTION (km cycle lane/capita)

Described in Previous section

2.3.3 GREEN SPACE ACCESSIBILITY

Calculation of the shortest distance (linear) between the population in the NBS (line type), and the NBS location centroid. This social indicator evaluates the accessibility of urban green spaces for population in terms of total distance or time.

RELATED NBS

This KPI affects NBS involving green infrastructures, either horizontal or vertical, such as:

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

TOOL/SENSOR

This KPI can be measured throughout specific software, such as GIS software and spreadsheet software. QGIS is the GIS software proposed to be used, due to it being an open source and multiplatform software and it is distributed under Creative Commons Attribution-Share Alike 3.0 licence (CC BY-SA).

METHOD

Data processing using QGIS has been designed to obtain one KPI value for the whole city. In addition, a neighbourhood level study is also recommended to find deficient areas.

The first step is obtaining a shape file in which each Entryway is linked to its nearest GI, throughout the tool Distance to the nearest hub. As a result, a new shapefile is obtained with an attribute field containing the measured distance in meters.

To obtain this KPI in terms of time, Field calculator tool can be used. A conversion factor must be set to measure a pedestrian walking speed. Bosina et al (2017) sets the average for pedestrian speed walking in Spain were 1.59 m/s, which means 95.4 m/min. So, the distance value in minutes can be obtained dividing by this value.

VARIABLE	DESCRIPTION	UNIT	SOURCE TYPE	NOTES
Distance to nearest GI.	Entryways linked to its nearest Green infrastructures (line).	m	Shapefile – Polyline	Derived variable obtained by GIS processing.
Time to nearest GI.	Entryways linked to its nearest Green infrastructures (line).	min	Shapefile – Polyline	Derived variable obtained by GIS processing.

Table 2.8: Table with properties of the new variable obtained

Overall statistics can also be calculated by a QGIS tool called Basic statistics for numeric fields. The result of this tool is a table (not GIS data), with resume figures of both terms of the KPI, including minimum and maximum values, range, mean and median value, standard deviation and coefficient of variation.

VARIABLE	DESCRIPTION	UNIT	SOURCE TYPE	NOTES
KPI 053 (1)	Accessibility (measured as distance) of urban green spaces for population.	m	table	Derived variable obtained by GIS processing.

KPI 053 (2)	Accessibility (measured as time) of urban green spaces for population.	min	table	Derived variable obtained by GIS processing.

Table 2.9: Inputs provided for the KPIs calculation

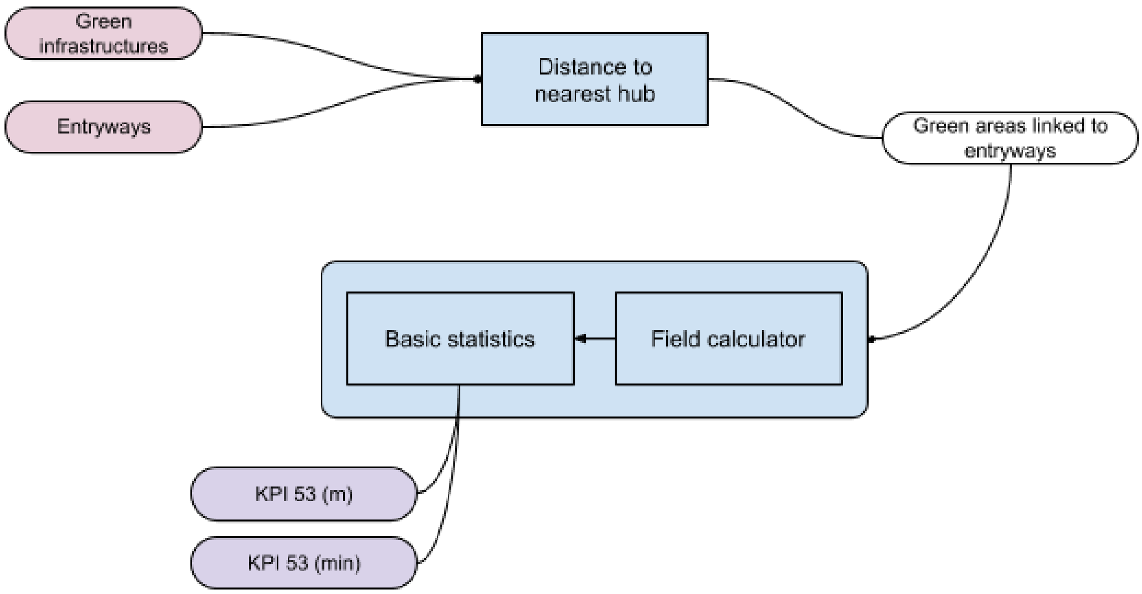


Figure 2.7 Algorithm for this described process

RESULTS

Two final figures are obtained at the end of the process for this KPI. One of them shows the accessibility for green areas in terms of total distance (m), and the other shows the accessibility for green areas in terms of total time (min).

Tamosiunas et al (2014) classifies the accessibility to green parks using a tertiles method. As a result, they obtained 3 categories showed in the table below. A tertiles distribution is also proposed to use in this case.

CATEGORY	HIGH	MODERATE	LOW
Distance	≤347.8 m	347.81–629.6 m	≥629.61 m

Table 2.10: Tamosiunas et al (2014) classification of the accessibility to green parks

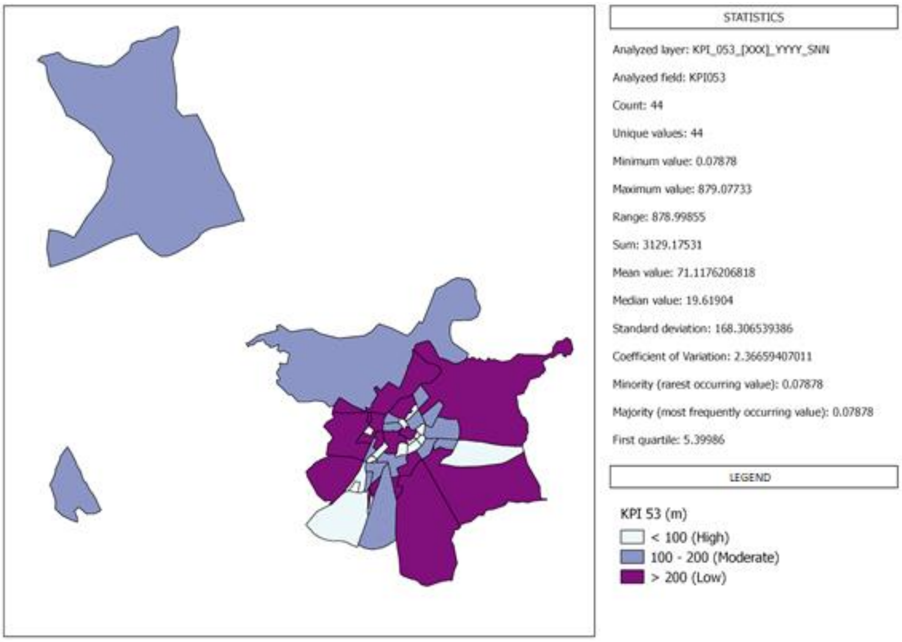


Figure 2.8: Example of classification in a map

REFERENCES

- QGIS 3 – Userguide. https://www.qgis.org/en/site/
- Spatial Reference - Howard Butler, Christopher Schmidt, Dane Springmeyer, and Josh Livni http://spatialreference.org/
- Inspire Knowledge Base - https://inspire.ec.europa.eu/
- Tamosiunas, A., Grazuleviciene, R., Luksiene, D., Dedele, A., Reklaitiene, R., Baceviciene, M., Venclovene, J., Bernotiene, G., Radisauskas, R., Malinauskiene, V., Milinaviciene, E., Bobak, M., Peasey, A., Nieuwenhuijsen, M.J., 2014. Accessibility and use of urban green spaces, and cardiovascular health: Findings from a Kaunas cohort study. Environ. Heal. 13, 20. doi:10.1186/1476-069X-13-20
- Raymond, C.M., Berry, P., Breil, M., Nita, M.R., Kabisch, N., de Bel, M., Enzi, V., Frantzeskaki, N., Geneletti, D., Cardinaletti, M., Lovinger, L., Basnou, C., Monteiro, A., Robrecht, H., Sgrigna, G., Munari, L. and Calfapietra, C. (2017) An Impact Evaluation Framework to Support Planning and Evaluation of Nature-based Solutions Projects. Report prepared by the EKLIPSE Expert Working Group on Nature-based Solutions to Promote Climate Resilience in Urban Areas. Centre for Ecology & Hydrology, Wallingford, United Kingdom

2.3.4 GREEN INFRASTRUCTURE CONNECTIVITY

This indicator is included in the list of indicators for Challenge 4. Green Space Management. This environmental (biological) indicator evaluates the increases of connectivity related to existing green infrastructures.

In Liverpool demo case, the calculation of the cycle lane distance that has been increased by the green corridor, with respect to the total bike lane. 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. GIS Analysis (m) (%)

RELATED NBS

New green cycle lane and re-naturing existing bike lanes: Green cycle lane; Green resting areas; Cycle-pedestrian green paths.

CODE	ACTION	SUB-DEMO	CATHEGORY	SUB-CATHEGORY
VAc1	New green cycle lane and re-naturing existing bike lanes	A	Re-naturing Urbanization	Green route
VAc2	Planting 1,000 trees	A	Re-naturing Urbanization	Arboreal interventions
VAc3	Tree shady places (500 trees)	A	Re-naturing Urbanization	Arboreal interventions
VAc4	Shade and cooling trees (600 trees)	B	Re-naturing Urbanization	Arboreal interventions
VAc5	Re-naturing parking trees (250)	C1	Re-naturing Urbanization	Arboreal interventions
VAc6	Installation of 3 Green Resting Areas	A	Re-naturing Urbanization	Resting areas
VAc7	Urban Carbon Sink	C3	Re-naturing Urbanization	Carbon capture
VAc15	Cycle-pedestrian green paths	A	Singular GI	Cycle-pedestrian infrastructure
VAc22	Green noise barriers	A	Singular GI	Vertical GI
VAc23	Green noise barriers	B	Singular GI	Vertical GI
VAc24	Green Vertical mobile garden	B	Singular GI	Vertical GI
VAc25	Green Façade	B	Singular GI	Vertical GI
VAc26	Electro wetland	B	Singular GI	Horizontal GI
VAc27	Green Covering Shelter	B	Singular GI	Horizontal GI
VAc28	Green Roof	B	Singular GI	Horizontal GI
VAc29	Green Shady Structures	B	Singular GI	Horizontal GI

Table 2.11: complete list of NBS Types that can be measurable with this KPI

RATIONALE

The extent and spatial arrangement of accessible green space within each sub-demo area may have an important influence on public health and wellbeing; as well as having the potential to increase biodiversity. Vegetated areas provide cooling on hot days through evapotranspiration; and trees reduce radiant heat by shading, making public space and travelling routes more comfortable for people on days when temperatures in urban areas are high. This KPI will focus on public accessible greenspace, therefore residential gardens will not be considered here.

METHOD

Typology map data representing areas of GI both before and after NBS GI interventions will be analysed using a Geographic Information System (GIS) to calculate change in each sub-demo area in *a)* the proportion of the sub-demo area represented by GI, *b)* distance between areas of GI, and *c)* the number of street trees

BASELINE HABITAT INPUT DATA

In the case of Liverpool, a baseline GI typology maps [Figure 38, D3.2 Mersey Forest] were produced in 2017 using OS Mastermap Green infrastructure typology (MasterMap Topography Layer and Greenspace Layer) and tree canopy data from Bluesky's National Tree Map. If the Mersey Forest maps are updated to reflect any update in OS MasterMap Topography/Greenspace Layers/Bluesky National Tree Map before interventions start in the demo areas this updated version will be used.

POST-INTERVENTION HABITAT INPUT DATA

From project delivery records detailing the extent, location and type of each GI intervention, shapefiles will be created and added to the baseline typology map to create a new map layer representing the extent and type of new NBS GI habitat post-intervention.

CALCULATIONS

Use of GIS to calculate % change in the following parameters in each sub-demo area following NBS GI interventions:

1. The extent of accessible GI. Calculate the proportion of the sub-demo area occupied by GI (select all GI types in typology layer except residential gardens) pre- and post- GI interventions.
2. The distance between each accessible GI patch and its nearest accessible GI neighbour within the sub-demo area. If *d* is the nearest-neighbour (Euclidean) distance from accessible GI patch *i* to accessible GI patch *j*; calculate the mean nearest-neighbour distance over all patches, both pre- and post-intervention (FRAGSTATS, 2015)
3. The distance to the nearest accessible green infrastructure everywhere (for every raster cell) calculated using a raster nearest neighbour approach
4. the number of street trees

HABITAT MAP DATA SOURCES

For example in Liverpool:

- OS Mastermap Topography and Greenspace Layers[25][26]
- Bluesky National Tree Map[27]

SPATIAL ANALYSIS SOFTWARE

QGIS is free, open source software. The current version is QGIS 2.18.16 'Las Palmas' and was released on 19.01.2018. QGIS is available[28] on Windows, MacOS X, Linux and Android... QGIS 2.18 user guide is available at the same page[29].

CALCULATION OF LANDSCAPE METRICS IN QGIS

QGIS Landscape Ecology Plugin LecoS[30] is based on metrics taken from FRAGSTATS[31] for calculation of landscape metrics using raster and vector layers.

REFERENCES AND SOURCES OF FURTHER INFORMATION

- D3.2 Baseline Document for Liverpool 2017. Urban Green UP Project Deliverable
- FRAGSTATS, 2015 McGarigal, K. fragstats.help.4.2.pdf
- http://www.umass.edu/landeco/research/fragstats/fragstats.html
- LecoS2.0.7 http://plugins.qgis.org/plugins/LecoS/
- QGIS Development Team 2013. QGIS Geographic Information System. Open Source Geospatial Foundation. URL http://qgis.osgeo.org

2.3.5 RECREATIONAL VALUE

INTRODUCTION

Kabisch and Haase (2014), define this KPI as recreational (number of visitors, number of recreational activities) or cultural (number of cultural events, people involved, children in educational activities) value.

The KPI “Green intelligence awareness” refers to the number of educational activities related to a NBS; “Recreational or cultural value” intends to apply a different approach. Therefore, this KPI estimates the number of people who interact with a NBS, for cultural, recreational or educational purposes.

NBS TYPES

[25] https://www.ordnancesurvey.co.uk/business-and-government/products/mastermap-products.html
[26] http://digimap.edina.ac.uk/
[27] https://www.blueskymapshop.com/products/national-tree-map
[28] https://www.qgis.org/en/site/forusers/download.html#
[29] https://docs.qgis.org/2.18/en/docs/user_manual/
[30] http://plugins.qgis.org/plugins/LecoS/
[31] http://www.umass.edu/landeco/research/fragstats/fragstats.html.

Non-technical interventions: Educational activities: Educational paths (A, C); Urban farming educational activities.

METHODOLOGY

Quantify the visitors and the number of people participating in the recreational activities per year, related to a NBS:

- Number of people who use urban orchards (nº users).
- Number of visitors: connections between beacons and URBAN GreenUP Mobile APP.
- Number of participants in guided tours.
- Number of participants in educational meetings: courses, conferences, lectures, workshops, seminars, and symposia.
- Number of participants i competition activities.

SENSOR/SOFTWARE

URBAN GreenUP Mobile App

DATA SAMPLING

No sensor.

Number of visitors' data is collected by URBAN GreenUP Mobile App.

DATA PROCESSING

Sum of the numbers of users, visitors and participants of events related to a NBS during a year.

RESULTS

Number of people per year

REFERENCES

- Questionnaires applied to the population for the recreational and cultural benefits of green spaces (Kabisch and Haase, 2014).

2.3.6 GREEN AREAS SUSTAINABILITY

INTRODUCTION

Urban green solutions and spaces have to be designed and appropriately managed taking into account the high impacts on the ecological systems and communities.

Among others, they can improve the quality of the life of the neighbours, re-store ecosystems, mitigate the effects of the climate change and promote a healthy and environmentally friendly way to live, reducing the harmful impacts in the present and the future, during all its lifetime.

Sustainability concept integrates social, economic, cultural and environmental aspects. So that, sustainable development of green spaces can be defined ""as a state that in a particular time and space, an urban green system can achieve self-stability; in addition, sustainable development of green space provides the ecosystem service functions needed to protect the environment as well as meeting the needs for sustainable development of society and the economy.” (Article: Research on the Sustainable Development of Green-Space in Beijing Using the Dynamic Systems Model Fangzheng Li 1,2, Yinan Sun 1,2, Xiong Li 1,2,*, Xinhua Hao 3, Wanyi Li 1,2, Yun Qian 1,2, Haimeng Liu 4 and Haiyan Sun 1)

NBS TYPES

Sustainability of green areas indicator applies to the following NBS: Green cycle lane; Tree related actions; Vertical and horizontal interventions; NWTP

METHODOLOGY

Sustainability is a wide concept, so the definition of a calculation method is not easy and can be very cumbersome and complicated. Therefore, a simplified method based on a score table, has been defined to have an evaluation approach of the impact of the different Nature Based Solutions (NBS).

The method evaluates different aspects (requisites) organized in three different topics:

1) Impact on ecosystem: the ecological context where a project is placed and developed.
2) Construction and OPERATION: the impact of the execution of the works to implement the NBS and the impact through the life due to the use.
3) Impact on society: improvement of the quality of the community life.

A score table has to be completed, by checking the items that the project meet: a comparison between the state before and after the implementation of the NBS have to be done, in order to assess if the project fulfils the condition of the requisite. Some of the requisites have a KPI related which can help to evaluate the level of fulfilment.

One check means ten points earned, so considering that each topic has 10 items, a maximum of 100 points can be achieved per category, and a maximum of 300 points in total.

ECOSYSTEM				
	Requisite	Yes	No	Points (10 or 0)
	Develop degraded sites			
	Air quality improvement (KPI: Air quality parameters: NOx, VOC, PM, etc.			
	Reduction of noise pollution (KPI: Noise reduction rates			
	Reduction of light pollution			
	Water use reduction for landscape irrigation (KPI: Water for irrigations purposes			
	Reduction of pollution into water (KPI: Nutrient abatement, abatement of pollutants			
	On-site precipitation management (KPI: Run-off coefficient in relation to precipitation quantities (KPI: Reduction of drought risk (probability). (KPI: Absorption capacity of green surfaces, bioretention structures and single trees			
	Restore aquatic ecosystems			

	Use native plants			
	Restore animal habitats of populations of species			
CONSTRUTION / OPERATION				
	Requisite	Yes	No	Points (10 or 0)
	Integrative design process engaging users and stakeholders			
	Conservation of landscapes features			
	Conservation of buildings and structures			
	Use recycled content materials			
	Use regional materials			
	Energy use reduction (improvement of energy efficiency) (KPI: Energy and carbon savings from reduced building energy consumption (KPI: Savings in energy use due to improved GI.			
	Generation or use of renewable energy			
	Reduction of heat island effect (KPI: Decrease in mean or peak daytime local temperatures (KPI: Temperature reduction in urban areas			
	Sustainable maintenance planned			
SOCIETY				
	Requisite	Yes	No	Points (10 or 0)
	Educational and interpretive elements on site			
	Educational activities planned (KPI: Green intelligence awareness			
	Improvement of sustainable mobility (KPI: Encuestas Agenda21 sobre uso bicicleta			
	Improvement of connectivity (KPI: Increased connectivity to existing GI			
	Tourism impact			
	Production of food (KPI: Production of food			
	Aumento actividad física ciudadanos (paseo, bici) (KPI: Quality of life for elderly people (KPI: Increase in walking and cycling in and around areas of interventions			
	Improvement of social connection			
	Creation of new jobs (KPI: Number of jobs created; gross value added.			
	Satisfacción general (KPI: Assessment of typology, functionality and benefits provided pre and post interventions. (APP			
			TOTAL POINTS =	

Table 2.12: Questionnaire

RESULTS

The total number of points achieved has to be divided per 3, in order to have a percentage value (de 0% a 100%). Also, four levels have been defined according to the following scale:

Category	Very good	Good	Bad	Very bad
Percentage	65-100	40-65	20-40	0-20

Table 2.13: Scale of KPI's percentage value.

2.3.7 FOOD PRODUCTION

Production of food in urban orchards (agriculture, eggs, etc.). Measurement of the amount of food produced. The production of food will be measured by tones/Ha per year.

RELATED NBS

Urban farming promotion: Urban orchard; Community composting; Small-scale urban livestock

METHODOLOGY

Measurement of the amount of food produced. If it cannot be measured, an estimate of the amount generated will be made.

Users will be asked directly using surveys.

MONITORING EQUIPMENT / SOFTWARE

Online surveys.

DATA PROCESSING

Sum of the KG per user in yearly bases.

RESULTS

Kg/Ha year: Kg produced per Ha of the orchard yearly.

REFERENCES

- Ecological orchards of Valladolid (2016-2017)[32]

2.3.8 POLLINATOR SPECIES INCREASE

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. Analysis of survey data using standard software (Excel/R).

RELATED NBS

SuDs /Raingarden; Horizontal green interventions; Vertical green interventions; Pollinator verges and spaces Pollinator (houses) modules.

[32] http://www.valladolid.es/es/actualidad/noticias/huertos-ecologicos-2016-2017

In the case of Izmir, the pollinator study has been conducted at two locations determined in Karşıyaka-Mavişehir and Çiğli- Sasalı regions. The study has been carried out two days in every month in each locality for 6 months from March to August 2018. These localities were determined on the basis of NBSs where pollinator species are aimed to be observed and recorded (please see Report 4.2). Sample areas with a 10 X 10 m stable quadrat are determined in the localities and observations of pollination have been executed to record the species of insects (species count) that visit plant species throughout the day. Simultaneously, microclimatic variables (air temperature and wind speed) of the observation areas (using by data logger) have been recorded. In the locality in Karşıyaka-Mavişehir, majority of the plant cover is composed of exotic shrubs and trees, and there is not much plant diversity based on the initial observations. Therefore, a 10 x 10 m stable quadrat serves our purpose very well to represent the entire area. Other study area in the Sasali region is treated in a similar fashion in terms of quadrat size and observation intervals. It is a semi-natural area that contains native annuals and some invasive Eucalyptus trees. In addition to these observations in 10 x 10 m quadrat, since flying pollinating insects are highly mobile, in the vicinity of the quadrats, additional one-day/month observation has been made in the monitoring period. It is hoped that at the end of the observation period, two different insect lists will be prepared per locality.

The same procedure will be repeated after the NBSs are implemented in the project area to see if there is an increase in number of pollinator insects visiting NBS. All the observations are being photographed as well.

RATIONALE: POLLINATORS AS ECOLOGICAL INDICATORS

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

NBS TYPE

Monitoring focus for this KPI will be NBS sites with herbaceous or shrub vegetation including floral resources (not trees). The NBS types proposed in this category are: pollinator verges and spaces, pollinator walls, SUDs (including rain garden) and pollinator roofs. For example, in the case of Liverpool the NBS types proposed in this category are:

Sub-demo A (Baltic)

- Pollinator verges
- Pollinator walls vertical
- SUDs (Rain garden)

Sub-demo B (BID)

- Pollinator roofs
- Pollinator walls vertical
- Moving gardens

Sub-demo C (Jericho)

- Pollinator verges
- Pollinator walls vertical
- SUDs (open water)

STUDY SITES

(i) Pollinator NBS sites with herbaceous vegetation (i.e., Not tree interventions);
(ii) Paired control sites within the same demo area and of a similar size to NBS match site;
(iii) Matching number of randomly selected UGI sites (with public access) within each demo area;
(iv) Matching number of homogenous areas of herbaceous vegetation in large source sites (with public access - parks etc.) Within or close to each demo site.

NUMBER OF STUDY SITES

In the case of Liverpool demo, for each of the three Liverpool demo areas the following study sites will be selected:

- Pollinator NBS GI - depending on the spatial arrangement and design of NBS within the demo sites: either 2 study sites (each with 3x 1x1m pollinator samples) or 3 study sites (each with 2x 1x1m pollinator samples) tbc when NBS locations, size, number and type are confirmed.

- For each pollinator NBS study site selected for monitoring; a control study site will also be selected.

SIZE OF SAMPLING UNIT (LIVERPOOL SPECIFIC)

1x1m quadrats are selected as appropriate to observe and record flower visits by pollinating insects. In the case of green walls, a 1x1m area will be selected estimated using ground measurements (with the centre of the plot at head height if possible, or if the entire wall is above head height, sampled using binoculars). The position of the plot along the length of the wall will be determined by random number.

NUMBER OF SAMPLES

An equal number of random samples should be carried out for each study site, although study site size may vary. Comparing sites of continuous homogenous vegetation and sites with scattered floral resources (the floral element of an urban 'mosaic' community)

In a study site comprised mainly of impermeable surfaces no herbaceous vegetation or only scattered flowering plants (e.g. pre-intervention NBS and control sites) where the total area (m^2) of vegetation supporting floral resources is lower than the area required to support the total number of 1x1m pollinator samples required per site; each of the scattered areas of flowering plants will be sampled using 1x1m quadrats, after which additional samples without vegetation - up to the total number of samples required per site - will be recorded as zero pollinator-flower visits.

- **Repeated sampling & detectability of focal taxon**

Each study site will be sampled (with sample locations selected at random on each occasion to ensure observations are independent) once every 4 weeks between May and September (selected as an optimal seasonal time window for recording pollinator foraging activity) over three years (pre-intervention 2018; plus 2 years post-intervention). Pollinator observations will be carried out between 10 and 4pm, in appropriate weather conditions (see below) for detecting pollinator visits to floral resources.

LOCATION OF SAMPLES

Sampling locations will be selected at random at every visit. To select random location, in advance of the survey a 1m grid produced in QGIS will be overlaid on a map of each study site and random numbers for x and y co-ordinates used to determine location of the required number of pollinator 1x1m quadrats. The co-ordinates generated from the random selection process will be located at the study site using Garmin e-trex GPS (to a 3m accuracy limit of the e-trex device). If there are no open flowers at the point selected at random, then the surveyor should walk to the nearest flower seen and place the quadrat there.

- **Floral resources samples**

For each study site, a nectar index will be obtained by sampling at random (using random walk with distance and direction determined by random numbers from each pollinator quadrat location) 5x the number of pollinator plots sampled at the study site. Count the number of flowers open in a 1x1m quadrat.

- **Pollinator samples**

At each plot vegetation, variables below will be recorded and pollinator visits to flowers within the plot will then be observed for a continuous period of 15 minutes. The observer should stand in a position that does not shade the plot. Close focus binoculars will be used, together with compact close focus camera to aid species ID. Collecting containers/net may be used to aid insect ID if necessary but all pollinators will be released immediately at the study site.

- **Weather conditions**

National Pollinator Monitoring Scheme guidance: pollinator observation count surveys should be carried out when the weather is warm and dry. If the sky is clear (less than half cloud) the minimum temperature for a count is 13°C. If the sky is cloudy (half cloud or more) the minimum temperature for a count is 15°C. (www.ceh.ac.uk/our-science/projects/pollinator-monitoring)

EQUIPMENT

In the case of Liverpool demo, the equipment to be used shall be: Garmin e-trex GPS, compass, lightweight 1x1m quadrat, binoculars, camera, ID guides, and temperature logger.

VARIABLES TO BE RECORDED AT EACH POLLINATOR SAMPLING PLOT (1X1M)

- Date
- Time
- Temperature (air and surface)
- Weather e.g. full sun, breeze, overcast etc.
- Aspect – if sloped or vertical
- List of each plant species and estimated abundance % cover
- Substrate type
- Number of flowers open (nectar source/pollen source)
- % plot shaded
- % plot bare ground
- Number of visits by pollinating insects – landing on an open flower: record taxonomic group of each pollinating insect, to species level where possible. Alternatively, higher level pollinator groups can be used: bumblebees, solitary bees, hoverflies, butterflies, moths.
- Plant species of flower visited by each pollinating insect recorded
- Photograph of insect or plant species if required for ID.

NOTE

It is possible that the same insect may be recorded more than once if it leaves and returns to the plot during sampling).

ADDITIONAL INFORMATION REQUIRED

- Locations and design of NBS
- Selection of control/UGI and source sites (once NBS locations and design known)
- Access permissions – particularly to pollinator roof and control roof

2.3.9 PLANT SPECIES INCREASE

Related methodology descripted in previous section (2.3.8.)

2.3.10 FLORAL RESOURCES INCREASE

Related methodology descripted in previous section (2.3.8.)

2.3.11 INSECTIVORE INCREASE

Related methodology descripted in previous section (2.3.8.)

2.4 AIR QUALITY

2.4.1 ANNUAL MEAN LEVELS OF FINE PM2.5 PARTICULES

RATIONALE

Road transport and construction operations are identified as major sources of air pollutants in cities. Airborne particulate matter is associated with harmful effects on human cardiovascular and respiratory health. Particles ≤ 10 microns (PM10), and particularly the finer particles ≤ 2.5 microns (PM2.5) associated with road transport vehicles, are of concern due to their small size; (a micron, or micrometre = one-millionth of a meter: 0.001 millimetre). Green walls (or screens) in urban streets may act as barriers to direct dispersal of pollutants from combustion engine vehicles to pedestrian areas. Particulates may be deposited on the leaf surface of trees or taken up into the leaf surface wax layer, reducing atmospheric particulate concentrations. Monitoring of air quality parameters is complex; involving many potentially interacting variables. Variation in weather conditions; prevailing wind direction and speed; tree species, density, location and structure; and the configuration of built urban infrastructure are among factors which may affect the trajectory and rate of dispersal of particulate pollutants. We aim to compare outdoor air concentrations of PM10 and PM2.5 at child and adult head heights at locations with and without street trees or green walls to evaluate whether these NBS are associated with reduced local concentrations of airborne PM10 and PM2.5.

NBS TYPES

Street trees and green walls (or screens), Urban Garden BioFilter, Urban Trees including: Planting and renewal of urban trees; Shade Trees; Cooling trees; Trees re-naturing parking and Arboreal areas around urban areas, Green Façade, Green shady structures, Green fences.

METHOD BACI (BEFORE, AFTER, CONTROL, IMPACT)

Measure air concentrations of PM2.5 and PM10 at sampling points at a range of radii from NBS street tree/green wall locations both pre- and post-intervention. Compare these data to measurements taken at equivalent locations on equivalent stretches of road without street trees/green wall at a similar time of day on the same dates.

NULL HYPOTHESIS

There is no difference in concentrations of PM2.5 or PM10 between samples in stretches of road where street trees/green walls are present, and samples taken in stretches of road without street trees/green walls.

MONITORING EQUIPMENT

A portable photometric sampler designed to measure ambient PM2.5 and PM10 concentrations: for example, the Aeroqual Series 500 Portable PM Monitor. A laser and optical sensor are fitted to the sensor head of the monitor to measure light scattered from particles passing through a laser beam. The scattered light is transformed to electrical signals to provide mass measurements of PM2.5 and PM10. (https://www.aeroqual.com/product/portable-particulate-monitor). Data stored on the device can be downloaded later to a PC using the USB cable and software provided with the monitor.

MEASUREMENTS

Concentrations of airborne particulate matter are measured by recording PM mass per cubic metre of air.

UNIT OF MEASUREMENT

Micrograms (mcg) per cubic metre, $\mu g\ m^{-3}$. (Microgram (µg) One-millionth of a gram; a milligram (mg) = 1000 micrograms).

CALIBRATION

Comparison of the readings from the portable PM monitor against those from the static PM monitoring equipment at the Liverpool local government AQ monitoring station at Speke to inform reliability of measurements[33].

STUDY SITES

a) Stretches of road where street tree/green wall interventions are proposed (intervention study sites) selected at random from qualifying intervention locations (random stratified sampling); and

b) A matching number of locations along equivalent stretches of road (road of similar width and with comparable building heights to intervention site) where street tree/green wall interventions are not proposed (control study sites). Control sites should be a sufficient distance away from street tree/green wall intervention sites for the observations made to be considered independent from the effects of street trees/green walls.

NUMBER OF SAMPLES

At each study site and control site, depending on the width between road and street buildings, a sample will be taken at pre-determined locations:

a) at the roadside,

[33] http://www.airqualityengland.co.uk/local-authority/?la_id=183

b) 3-5m from the road (where street trees/green walls have been installed the NBS should be situated between this sampling point and the road)

c) 6-10m from the road; with additional measurements at intervals at greater distances from the road for study sites where urban infrastructure constraints allow. This range of sampling point distances from proposed NBS reflects the scale at which measurable impacts are predicted relative to the size of street tree/green wall interventions proposed for Liverpool.

SAMPLING METHOD

Both intervention and matched control study sites should be sampled on the same occasion during each round of samples (i.e. an intervention site and matched control should be sampled on the same date and at as close a time of day as possible). Each pre-determined sampling location at a study site should be repeat sampled every 4 weeks for a year pre-intervention (September 2018 to August 2019), and for two years following intervention (spring 2020 to spring 2022). At each sampling point two readings should be taken: at heights estimated to represent ***a)*** child and ***b)*** adult head heights.

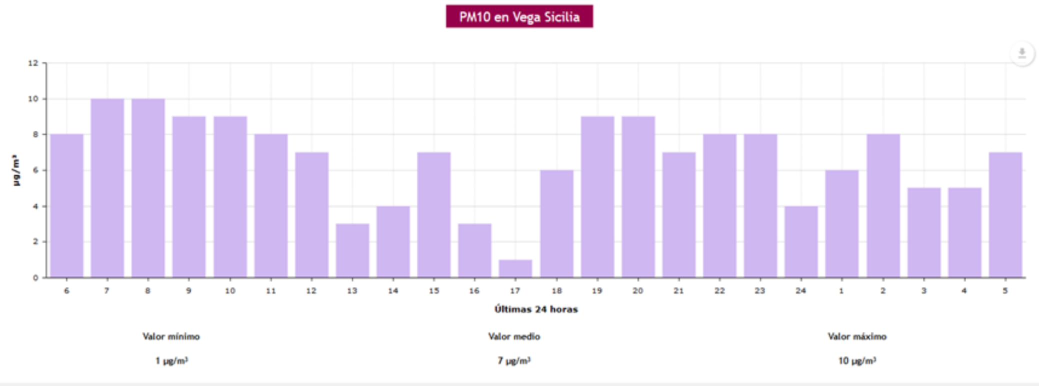


Figure 2.9. Example of data sampling by hour. Source: Valladolid City Council

DATA PROCESSING

Calculation of annual and monthly mean levels of NO_2, O_3, PM10 and PM2.5 at each station location.

There are three main types of stations for city domains (excepting industrial sites that are no considered for this KPI).

- Road traffic
- Urban background
- Peri-urban background

According to this classification, it can be obtained average values for road traffic areas, urban areas, and peri-urban areas. Then, using a GIS software, a model of the city can be built that classifies all locations/streets/areas of the city in those categories.

DATA ANALYSIS

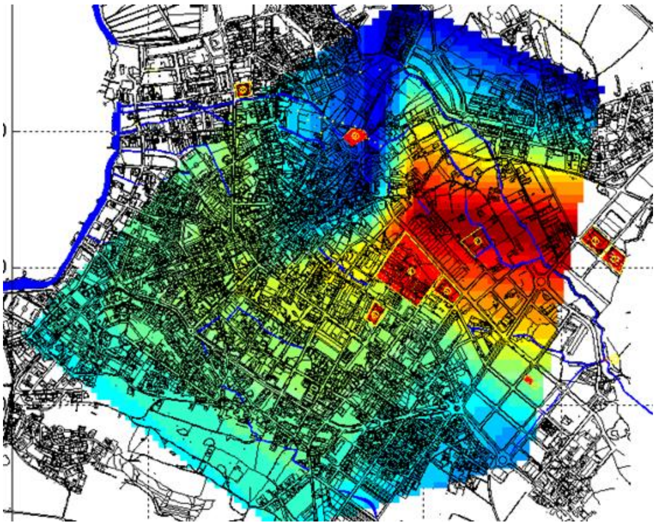
Data to be downloaded to PC from Aeroqual PM monitor using bundled software and exported to Excel (xlsx or csv file). Calculation of annual mean levels of PM10 and PM2.5 at each sampling location. Comparison of annual mean values for NBS intervention and control sample locations at each study site.

SPATIAL ANALYSIS SOFTWARE

QGIS is the GIS software proposed to be used, due to it is an open source and multiplatform software and it is distributed under Creative Commons Attribution-Share Alike 3.0 licence (CC BY-SA). We recommend to use the last long-term release repository, most stable (QGIS 2.18 is currently the last one and QGIS 3). Data processing involved in this KPI can be done with the standard version and the standard toolbox.

RESULTS

The main result of this KPI is a city map where can be shown air quality average levels for the city. This outcome can be used to define population exposition levels and to highlight buildings used by vulnerable groups such as schools or residences for the elderly.



REFERENCES

- AQEG (2005) Particulate Matter in the UK: Summary. Defra, London.
- Baró, F., Haase, D., Gómez-Baggethun, E., Frantzeskaki, N., 2015. Mismatches between ecosystem services supply and demand in urban areas: A quantitative assessment in five European cities. Ecol. Indic. 55, 146–158. doi:10.1016/j.ecolind.2015.03.013.
- Bealey, W.J., McDonald, a G., Nemitz, E., Donovan, R., Dragosits, U., Duffy, T.R., Fowler, D., 2007. Estimating the reduction of urban PM10 concentrations by trees within an environmental information system for planners. J. Environ. Manage. 85, 44–58. doi:10.1016/j.jenvman.2006.07.007
- Bottalico, F., Chirici, G., Giannetti, F., De Marco, A., Nocentini, S., Paoletti, E., Salbitano, F., Sanesi, G., Serenelli, C., Travaglini, D., 2016. Air pollution removal by green infrastructures and urban forests in the city of Florence. Agric. Agric. Sci. Procedia 8, 243–251. doi:10.1016/j.aaspro.2016.02.099.

- Dover JW. 2015. Green Infrastructure: incorporating plants and enhancing biodiversity in buildings and urban environments. Routledge
- Grote et al., 2016. Functional traits of urban trees: air pollution mitigation potential. Front Ecol Environ 2016; doi:10.1002/fee.1426.
- Hitchens et al. 2000 Concentration of submicrometre particles from vehicle emissions near a major road. Atmospheric Environment 34
- Janhäll, S. 2015. Review on urban vegetation and particle air pollution – deposition and dispersion. Atmospheric Environment, 105, pp.130-137.
- Jin, S., Guo, J., Wheeler, S., Kan, L. and Shenguan, C. 2014. Evaluation of impacts of trees on PM2.5 dispersion in urban streets. Atmospheric Environment 99 277-287
- Mullaney, J., Lucke, T., Trueman, S.J., 2015. A review of benefits and challenges in growing street trees in paved urban environments. Landscape Urban Plan. 134, 157–166. doi:10.1016/j.landurbplan.2014.10.013.
- SDG indicator 3.9.1 https://unstats.un.org/sdgs/metadata/files/Metadata-03-09-01.pdf
- SDG indicator 11.6.2. https://unstats.un.org/sdgs/metadata/files/Metadata-11-06-02.pdf
- https://www.valladolid.es/es/rccava/rccava
- https://qgis.org/en/site/

2.4.2 ANNUAL MEAN LEVELS OF FINE PM10 PARTICULES

Described above.

2.4.3 NOx TRENDS

RATIONALE

It is estimated that in the UK air pollution reduces overall life expectancy by seven to eight months, with estimated annual health costs of up to £20 billion. The impacts are higher on the most vulnerable, including lifelong impact on children.

The predominant source of NO_x in Britain is road transport and it is thought that half of emissions in Europe originate from this source; certainly the highest concentrations of NO_2 are generally found close to busy roads in urban areas In keeping with other local authorities across England and Wales, Liverpool and the wider city region is close to failing to meet the European Union (EU) air quality standard for Nitrogen Dioxide (NO_2) which is measured as an annual mean of 40µg/m^3. High levels of NO_2 have a health impact on the local population, in particular those suffering from existing heart related conditions, asthma, and Chronic Obstructive Pulmonary Disease. Whilst air pollution from NO_2 cannot be said to be the single direct causal effect upon hospital emissions, it does contribute. NO_2 pollution levels within the Liverpool City region follow a similar pattern with most NO_x emissions being road transport related. Commercial, industrial, and domestic sources also make a small contribution to background.

The main source of SO_2 is fossil fuel combustion. And SO_x emissions in the UK have decreased substantially since 1992, due to reductions in the use of coal, gas, and oil, and also to reductions in the sulphur content of fuel oils and DERV (diesel fuel used for road vehicles). The decrease in emissions over time is the continuation of an on-going trend partly due to the decline of the UK's heavy industry. Although the city has made great strides in reducing levels of sulfur dioxide over recent years it remains an important atmospheric pollutant.

We aim to compare outdoor air concentrations of NO_x and SO_x according to the established practices currently operated by Liverpool City Council to ensure that data remains comparable to our historical citywide baseline. We intend to mount the diffusion tubes on street furniture owned by the city council such as lamp posts or other street furniture at a monitoring height of roughly 3m or 10 feet.

The height of the diffusion tube placement is a little higher than adult head height but is necessary in a public place to reduce unauthorised removal of tubes and disruption to the experiment. The diffusion tubes will remain in situ for a month and then be removed and replaced. Usually, two people are required to remove and replace tubes and a litter picker can be used to retrieve and replace tubes. Retrieved diffusion tubes will be sent away for analysis. At present the analysis is carried out for existing city air quality diffusion tubes by a laboratory called Gradko who use an analytical method of 20% TEA in water.

It is proposed that diffusion tube analysis for the URBAN GreenUP project will also be carried out by the same laboratory to provide consistency in comparability of data collected historically and elsewhere across the city.

NBS TYPES

Street trees and green walls (or screens), improved highway improvements

METHOD BACI (BEFORE, AFTER, CONTROL, IMPACT)

Measure air concentrations of NO_x and SO_x at identified sampling points close to planned nature-based interventions and highway improvement schemes both pre- and post-intervention. Compare this data for differences and also compare this data to historical city wide data and trends.

NULL HYPOTHESIS

There is no difference in concentrations of NO_x and SO_x between sampling locations with or without nature-based ort highway interventions.

MONITORING EQUIPMENT

Diffusion tubes designed to measure dissolved gaseous emissions of NO_x and SO_x will be used throughout the study. Diffusion tubes are a type of passive sampler; that is, they absorb the pollutant to be monitored directly from the surrounding air and need no power supply. Passive samplers are easy to use and relatively inexpensive, so they can be deployed in large numbers over a wide area, giving good spatial coverage. This has made them a popular choice for Local Authorities, who often use diffusive samplers to complement more expensive automatic monitoring techniques, or at locations where it would not be feasible to install an automatic monitor.

It should be noted that diffusion tubes have two limitations. Firstly, they are an *indicative* monitoring technique. Whilst ideal for screening surveys, or for identifying locations where NO_2 concentrations are highest, they do not provide the same level of accuracy as automatic monitoring techniques. Secondly, as the exposure period is typically several weeks, the results cannot be compared with air quality standards and objectives based on shorter averaging periods such as hourly means. Diffusion tube samplers operate on the principle of molecular diffusion, with molecules of a gas diffusing from a region of high concentration (open end of the sampler) to a region of low concentration (absorbent end of the sampler). Their use is recognised by DEFRA.

MEASUREMENTS

Concentrations of NO_x and SO_x (units) will be provided following laboratory analysis.

CALIBRATION

Comparison of the readings from the diffusion tubes for NO_x and SO_x can be compared against those from the static PM monitoring equipment at the Liverpool local government AQ monitoring station at Speke to inform reliability of measurements (http://www.airqualityengland.co.uk/local-authority/?la_id=183). Analysis at the same laboratory, using the same techniques for the city's existing diffusion tubes will help to ensure consistency and comparability between historical and citywide air quality data.

STUDY SITES

a) At suitable locations tbc in the Baltic corridor.
b) At suitable locations tbc in the Business Improvement District in the city centre
c) At suitable locations tbc in the Jericho Lane/Otterspool corridor.

Control sampling will be considered for some key sites according to the available budget. There are 88 diffusion tubes across the city at 86 locations, which are prepared and analysed by Gradko (2017).

NUMBER OF STUDY SITES

There are 3 sub demo areas but the number of individual study sites within each of the sub demo areas has yet to be determined and will be guided by the final position of the Nature Based Solutions.

NUMBER OF SAMPLES

It is estimated that the budget could potentially allow for something in the region of 100 diffusion tubes; spread across the 3 demo areas, 2 different air quality parameters over a 3 year period. The location and nature of the various NBS interventions will however dictate the final positioning and type of diffusion tube and they will not necessarily be spread equally between the demo areas or the different air quality parameters being recorded. An option exists to consider some limited replication at key sites and to utilise any current data from existing diffusion tube sampling at appropriate locations. Budget costs dedicated to other essential monitoring equipment will determine the final number of diffusion tube sampling locations that can be supported throughout the duration of the project.

SAMPLING METHOD

Both intervention and the control study site should be sampled on the same occasion. Each fixed sampling location at a study site should be sampled every month for a year pre-intervention (September 2018 to August 2019), and for two years following intervention (spring 2020 to spring 2022).

DATA ANALYSIS

Data analysis will be carried out by a third party to enable calculation of NO_x and SO_x at each location. Data can be compared with available historical data across the city.

REFERENCES

- AEA (2008) Diffusion Tubes for Ambient NO2 Monitoring: Practical Guidance for Laboratories and Users. Produced on behalf of Defra. *ED48673043,* AEA/ENV/R/2504 – Issue 1a.
- APSE (Association Public Service Excellence): Briefing 17-34 September 2017. Air quality plan for nitrogen dioxide (NO2) in UK (2017)
- DEFRA4 (2017) Air Quality Plan for tackling roadside nitrogen dioxide concentrations in Liverpool Urban Area (UK0006) July 2017. 2017 Zone plans. Document UK0006.
- Gradko (2017) Nitrogen Dioxide Diffusion Tubes. Shop. [Online] <http://www.gradko.com/store/environmental-store/no2-tube-analysis.shtml> Accessed on 23/07/18.
- Horan, Melody Louise (2016/17). An Investigation Into How Urban Trees Impact Air Quality Within Central and South Liverpool. Dissertation submitted as partial fulfilment for the degree of M.Sc. in Environmental Science, School of Environmental Sciences. University of Liverpool.

2.4.4 NOx TRENDS (Biofilter)

Additional description related mainly for the Urban Garden Biofilter, that in future can be used for other NBS to be installed in outdoor pipes to capture pollutants.

RELATED NBS

Urban Garden BioFilter.

METHOD

This KPI is calculated from measured data using a methodology defined by URBAN GreenUP Project.

BACI (BEFORE, AFTER, CONTROL, IMPACT)

Measure air concentrations of NO_2, PM2.5 and PM10 at sampling points at a range of radii from NBS location both pre- and post-intervention. Compare these data to measurements taken at equivalent locations on equivalent stretches of street without NBS at a similar time of day on the same dates.

NULL HYPOTHESIS

There is no difference in concentrations of NO_2, PM2.5 or PM10 between samples in stretches of road where street trees/green walls are present, and samples taken in stretches of road without street trees/green walls.

MEASUREMENTS

Concentrations of NO_2 and airborne particulate matter are measured by recording PM mass per cubic metre of air (PM2.5 and PM10).

UNIT OF MEASUREMENT

PM - Micrograms (mcg) per cubic metre, µg/m^3. (Microgram (µg) One-millionth of a gram; a milligram (mg) = 1000 micrograms).

NO_2 – ppb (parts per billion). Parts per billion (ppb) is the number of units of mass of a contaminant per 1000 million units of total mass.

NUMBER OF SAMPLES

Continuous monitoring in the selected points each ten minutes.

DATA SAMPLING

Continuous monitoring in the selected points each ten minutes.

Figure 2.10. Data example of the KPI

DATA PROCESSING

Calculation of (weekly, monthly and/or yearly) mean levels of NO_2, PM10 and PM2.5 at each sampling location as the average value of the all the measurements done before and after of the interventions. Comparison of mean values for NBS intervention and control sample locations in the implementation area.

Data comparison before and after of the intervention using the reference to assess possible meteorological or other factors influence.

RESULTS

The calculated values will be compared qualitatively and quantitatively for the periods before and after the interventions in the NBS and reference sections.

2.4.5 SOx TRENDS

Described above.

2.4.6 O3 TRENDS

INTRODUCTION / RATIONALE

Air pollution consists of many pollutants, among other particulate matter. These particles can penetrate deeply into the respiratory tract and therefore constitute a risk for health by increasing mortality from respiratory infections and diseases, lung cancer, and selected cardiovascular diseases. The mean annual concentration of fine suspended particles of less than 2.5 microns in diameters (PM2.5) is a common measure of air pollution. The mean is a population-weighted average for urban population in a country and is expressed in micrograms per cubic meter [µg/m3]. Other important pollutants are ozone and NO_X. This indicator can be calculated using the different pollutants depending on the data availability and problems caused by each pollutant (according to maximum levels reached in extreme events). This indicator has been defined using the SDG indicators numbers 3.9.1 and 11.6.2 as references but adapting it to be used at urban scale. This KPI is useful to assess the level of population exposed to low air quality levels in the city and the importance of this challenge for the city. Further analysis could be developed using public health or hospital admission data to correlate the importance or green infrastructure on air quality levels.

NBS TYPES

1. Urban Garden BioFilter	This NBS uses a special substrate (mixture of urban by – products) as filter media to capture pollutants (mainly NOx and PM) form the air of underground car parks without waste generation.
2. Urban Trees including Planting and renewal of urban trees; Shade Trees; Cooling trees; Trees re-naturing parking and Arboreal areas around urban areas	This NBS includes individual large street trees, as well as the larger areas of woodland in the urban fringes. Trees perform multiple functions in urban areas. Urban trees are a vital element of our green infrastructure. Strategic positioning of large shade and cooling trees within urban areas can provide shade to buildings, reducing heat loading on building, provide islands of respite from high temperatures and capture some air pollutants (mainly PM) by dry deposition in our urban areas.
3. Green Façade	A green façade is a wall completely or partially covered with greenery. A green façade with climbing plants uses a trellis system to hold the vines of plants that are rooted in the ground or containers. Green façades offer economic, environmental, aesthetic and physiological benefits to the urban environment. Green façades are natural air-filters, creating a cleaner environment and provide high leaf surfaces.

4. Green shady structures	Pieces of stretched textile structure on which an inert substrate is installed. This inert substrate is covered with seeds, which germinate and grow on the textile structure. This NBS can be fixed to the facades of the buildings on the street or by posts fixed to the sidewalk. This green surface creates high leaf surfaces in pedestrian areas.
5. Green fences	This NBS is designed to reduce the traffic noise that arrives the pedestrian area and the homes on the street. On the one hand, the green noise barriers have a specific geometry that favours sound reflection and on the other hand, they have a vertical garden module with a specific substrate that favours sound absorption.

Table 2.14: NBS Types that can be measurable with this KPI.

METHOD

This KPIs is calculated from ground measurements by the official Air Quality monitoring networks in cities applying a methodology defined by URBAN GreenUP Project adapted from different sources. Additionally, information on the type of the zone (road traffic, city background, industrial, etc.) has been assigned to the different areas/streets of the city to weight population.

SENSOR / SOFTWARE

Air Quality monitoring stations network in major urban agglomerations as Valladolid (Atmospheric Pollution Control Network of the City of Valladolid (RCCAVA)), Liverpool or Izmir.

MEASUREMENTS

Concentrations of NO_2, O_3 and airborne particulate matter are measured by recording PM mass per cubic metre of air (PM2.5 and PM10).

UNIT OF MEASUREMENT

- PM - Micrograms (mcg) per cubic metre, $\mu g/m^3$. (Microgram (µg) One-millionth of a gram; a milligram (mg) = 1000 micrograms).
- NO_2 – Micrograms (mcg) per cubic metre, $\mu g/m^3$. (Microgram (µg) One-millionth of a gram; a milligram (mg) = 1000 micrograms).
- O_3 - Micrograms (mcg) per cubic metre, $\mu g/m^3$. (Microgram (µg) One-millionth of a gram; a milligram (mg) = 1000 micrograms).

CALIBRATION / VERIFICATION

Municipal Air Quality networks have very reliable verification and calibration protocols.

STUDY SITES

Data collection points are the locations of the stations of the Municipal Air Quality network and GIS model will extend the study sites to the whole city.

DATA SAMPLING

Continuous monitoring in the selected points hourly. Data example:

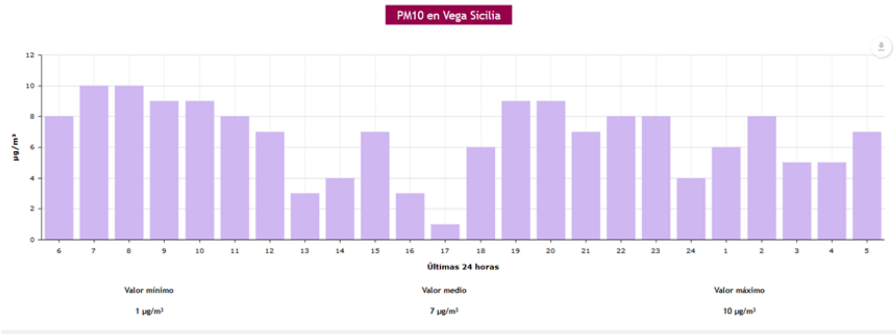


Figure 2.11. PM10 measurements in Vega Sicilia.

DATA PROCESSING

Calculation of annual and monthly mean levels of NO_2, O_3, PM10 and PM2.5 at each station location.

There are three main types of stations for city domains (excepting industrial sites that are no considered for this KPI).

- Road traffic
- Urban background
- Peri-urban background

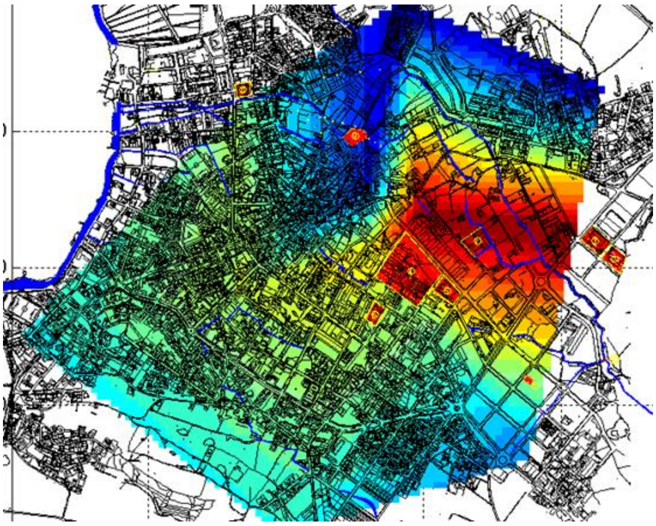
According to this classification, it can be obtained average values for road traffic areas, urban areas, and peri-urban areas. Then, using a GIS software, a model of the city can be built that classifies all locations/streets/areas of the city in those categories.

SPATIAL ANALYSIS SOFTWARE

QGIS is the GIS software proposed to be used, due to it is an open source and multiplatform software and it is distributed under Creative Commons Attribution-Share Alike 3.0 licence (CC BY-SA). We recommend using the last long-term release repository, most stable (QGIS 2.18 is currently the last one). Data processing involved in this KPI can be done with the standard version and the standard toolbox.

RESULTS

The main result of this KPI is a city map where can be shown air quality average levels for the city. This outcome can be used to define population exposition levels and to highlight buildings used by vulnerable groups such as schools or residences for the elderly.



REFERENCES

- AQEG (2005) Particulate Matter in the UK: Summary. Defra, London.
- Dover JW. 2015. Green Infrastructure: incorporating plants and enhancing biodiversity in buildings and urban environments. Routledge
- Hitchens et al. 2000 Concentration of submicrometre particles from vehicle emissions near a major road. Atmospheric Environment 34
- Air Pollution in the UK 2015. https://uk-air.defra.gov.uk/library/annualreport/index
- Baró, F., Haase, D., Gómez-Baggethun, E., Frantzeskaki, N., 2015. Mismatches between ecosystem services supply and demand in urban areas: A quantitative assessment in five European cities. Ecol. Indic. 55, 146–158. doi:10.1016/j.ecolind.2015.03.013.
- Bealey, W.J., McDonald, a G., Nemitz, E., Donovan, R., Dragosits, U., Duffy, T.R., Fowler, D., 2007. Estimating the reduction of urban PM10 concentrations by trees within an environmental information system for planners. J. Environ. Manage. 85, 44–58. doi:10.1016/j.jenvman.2006.07.007
- Grote et al., 2016. Functional traits of urban trees: air pollution mitigation potential. Front Ecol Environ 2016; doi:10.1002/fee.1426.
- Mullaney, J., Lucke, T., Trueman, S.J., 2015. A review of benefits and challenges in growing street trees in paved urban environments. Landscape Urban Plan. 134, 157–166. doi:10.1016/j.landurbplan.2014.10.013.
- Bottalico, F., Chirici, G., Giannetti, F., De Marco, A., Nocentini, S., Paoletti, E., Salbitano, F., Sanesi, G., Serenelli, C., Travaglini, D., 2016. Air pollution removal by green infrastructures and urban forests in the city of Florence. Agric. Agric. Sci. Procedia 8, 243–251. doi:10.1016/j.aaspro.2016.02.099.
- SDG indicator 3.9.1 https://unstats.un.org/sdgs/metadata/files/Metadata-03-09-01.pdf
- SDG indicator 11.6.2. https://unstats.un.org/sdgs/metadata/files/Metadata-11-06-02.pdf
- https://www.valladolid.es/es/rccava/rccava

- https://qgis.org/en/site/

2.4.7 MITIGATION THROUGH COOLING AND SEQUESTRATION/RUN-OFF MITIGATION

GI-Val is The Mersey Forest's green infrastructure valuation toolkit. The current prototype is free and open source and can be downloaded from http://www.merseyforest.org.uk/services/gi-val/. It takes the form of a spreadsheet calculator and a user manual. One of the tools, Tool 4.6, can estimate the impact of nature-based solutions on various air pollutants, in tonnes per year, and from those quantities it can estimate the avoided costs of other air pollution control measures. It uses a benefit transfer method, based upon the Chicago Urban Forest Climate Study by the USDA Forest Service (Nowak et al, 1994).

It is possible that monitoring in some cities will provide more accurate figures for the removal of air pollutants – if so, the tool can simply be used to put a monetary value on these.

4.6 Avoided cost of air pollution control measures

This tool uses currency exchange rates. To update these, right-click the table at the bottom of this sheet and click refresh.

What type of location is the project in?	Sub-urban	Select			
What is the existing land use type?	Vacant	Select			
Input existing area of tree cover (ha)	0	Ha OR	~~Number of trees~~	~~0~~	Tool uses Ha as default, using values entered in the Project Data sheet.
Proposed increased tree cover (ha)	36.00391967	Ha OR	~~Number of trees~~	~~0~~	If using Number of Trees, reduce C22 and C23 to Zero.

CURRENT LAND COVER - POLLUTANT REMOVAL	Tonnes/ha/yr	Tonnes/tree/yr	Gross removal (tonnes/yr)	Cost savings	
Carbon Monoxide removed (tonnes / year)	0.0008	3.6E-05	0.00	£0.00	Auto calculation cells
Sulphur Dioxideremoved (tonnes / year)	0.0028	1.3E-04	0.00	£0.00	Auto calculation cells
Nitrogen Dioxide removed (tonnes / year)	0.0025	1.1E-04	0.00	£0.00	Auto calculation cells
PM10 particulates removed (tonnes / year)	0.0063	2.9E-04	0.00	£0.00	Auto calculation cells
Ozone removed (tonnes / year)	0.0071	3.2E-04	0.00	£0.00	Auto calculation cells

PROPOSED NEW ADDITIONAL LAND COVER - POLLUTANT REMOVAL				Cost savings	Net impact of scheme on pollutants removal (tonnes/yr)		
Carbon Monoxide removed (tonnes / year)	0.0008	3.6E-05	0.03	£36.49	CO t/yr	0.03	Auto calculation cells
Sulphur Dioxide removed (tonnes / year)	0.0028	1.3E-04	0.10	£226.84	SO2 t/yr	0.10	Auto calculation cells
Nitrogen Dioxide removed (tonnes / year)	0.0025	1.1E-04	0.09	£546.89	NO2 t/yr	0.09	Auto calculation cells
PM10 particulates removed (tonnes / year)	0.0063	2.9E-04	0.23	£408.37	PM10 t/yr	0.23	Auto calculation cells
Ozone removed (tonnes / year)	0.0071	3.2E-04	0.26	£172.47	O3 t/yr	0.26	Auto calculation cells

Tool 4.6 output	33,770	£ NPV Discounting over 50 yrs already built in the worksheet below

Figure 2.12: Example of GI-Val toolkit

Improvements to or replacement of this tool is planned, as more robust methods are likely available.

RELATED NBS

Primarily trees, but also, to a lesser extent, other vegetation.

METHOD

The location type (urban) and the pre- and post-intervention tree canopy cover will be entered into GI-Val. In the case of Liverpool demo the tree canopy cover will be measured using the colour infrared imagery and height data available under the Aerial Photography for Great Britain agreement[34] and the landscape architects' drawings.

If the GI-Val tool is substantially changed, as planned, the method will also change somewhat.

2.4.8 Value of air quality improvements

GI-Val is The Mersey Forest's green infrastructure valuation toolkit (Appendix 1). The current prototype is free and open source, and can be downloaded from http://www.merseyforest.org.uk/services/gi-val/. It takes the form of a spreadsheet calculator and a user manual. One of the tools, Tool 4.6, can estimate the impact of nature-based solutions on various air pollutants, in tonnes per year, and from those quantities it can estimate the avoided costs of other air pollution control measures. It uses a benefit transfer method, based upon the Chicago Urban Forest Climate Study by the USDA Forest Service (Nowak et al, 1994).

'Annual mean levels of fine particulate matter' (above) will result in some measured air pollutant concentrations. Ideally, these would be used as a starting point to calculate the monetary value of any improvement. However, seeing as there is no obvious way to convert concentrations (in µg/m^3) into masses absorbed over time (in tonnes per year), it will not be possible to simply plug the measured concentrations into tool 4.6 in its current form. The ability to use the measured concentrations depends, therefore, on the exact form of the tool resulting from the planned improvements/replacement. If it is not possible to create a tool that can accept them, the tool will have to be used to model the impact of the interventions on air pollution for the purposes of this KPI.

4.6 Avoided cost of air pollution control measures

This tool uses currency exchange rates. To update these, right-click the table at the bottom of this sheet and click refresh.

What type of location is the project in?	*Sub-urban*	*Select*			
What is the existing land use type?	*Vacant*	*Select*			
Input existing area of tree cover (ha)	0	*Ha OR*	~~Number of trees~~	~~0~~	*Tool uses Ha as default, using values entered in the Project Data sheet.*
Proposed increased tree cover (ha)	36.00391967	*Ha OR*	~~Number of trees~~	~~0~~	*If using Number of Trees, reduce C22 and C23 to Zero.*

CURRENT LAND COVER - POLLUTANT REMOVAL	Tonnes/ha/yr	Tonnes/tree/yr	Gross removal (tonnes/yr)	Cost savings			
Carbon Monoxide removed (tonnes / year)	0.0008	3.6E-05	0.00	£0.00			*Auto calculation cells*
Sulphur Dioxideremoved (tonnes / year)	0.0028	1.3E-04	0.00	£0.00			*Auto calculation cells*
Nitrogen Dioxide removed (tonnes / year)	0.0025	1.1E-04	0.00	£0.00			*Auto calculation cells*
PM10 particulates removed (tonnes / year)	0.0063	2.9E-04	0.00	£0.00			*Auto calculation cells*
Ozone removed (tonnes / year)	0.0071	3.2E-04	0.00	£0.00			*Auto calculation cells*
PROPOSED NEW ADDITIONAL LAND COVER - POLLUTANT REMOVAL				**Cost savings**	**Net impact of scheme on pollutants removal (tonnes/yr)**		
Carbon Monoxide removed (tonnes / year)	0.0008	3.6E-05	0.03	£36.49	*CO t/yr*	0.03	*Auto calculation cells*
Sulphur Dioxide removed (tonnes / year)	0.0028	1.3E-04	0.10	£226.84	*SO2 t/yr*	0.10	*Auto calculation cells*
Nitrogen Dioxide removed (tonnes / year)	0.0025	1.1E-04	0.09	£546.89	*NO2 t/yr*	0.09	*Auto calculation cells*
PM10 particulates removed (tonnes / year)	0.0063	2.9E-04	0.23	£408.37	*PM10 t/yr*	0.23	*Auto calculation cells*
Ozone removed (tonnes / year)	0.0071	3.2E-04	0.26	£172.47	*O3 t/yr*	0.26	*Auto calculation cells*
Tool 4.6 output	**33,770**	*£ NPV Discounting over 50 yrs already built in the worksheet below*					

Figure 2.13. Example of GI-Val toolkit

[34] https://www.apgb.co.uk/

METHOD

The location type (urban) and the pre- and post-intervention tree canopy cover will be entered into GI-Val. In the case of Liverpool demo the tree canopy cover will be measured using the colour infrared imagery and height data available under the Aerial Photography for Great Britain agreement[35] and the landscape architects' drawings.

If the GI-Val tool is substantially changed, as planned, the method will also change to accommodate these revisions, which will be documented.

2.4.9 Value of air pollution reduction

Described in section above.

2.4.10 Total monetary value of urban forests including air quality

Described in section above.

2.5 URBAN REGENERATION

2.5.1 GREEN SPACE QUANTITY

INTRODUCTION

There is already a physical connection between Sasali region and Karşıyaka that is defined by a roadway and bike lane. The bike lane that extends all way from Karşıyaka to Sasalı Natural Life Park has intensively been used especially on weekends. The proposed green corridor, which starts from wild life park in Sasali region and merges into Peynircioğlu Stream and coastal promenade in Karşıyaka, offers a more comfortable, greener and sustainable cycle lane and connection. The coastal promenades and linear parks that encompass the Izmir bay all the all way from north to south would be linked to Sasalı Natural Life Park and South Gediz Delta through proposed cycling friendly greener corridor.

In the case of Izmir demo, this KPI is separated into 3 parts and assessed accordingly; connectivity, distribution-configuration and diversity of existing urban green spaces in two districts, Karşıyaka-Mavişehir and Sasali. This KPI is considered as a mean to assess existing picture of urban green spaces in some aspects in Izmir for two reasons: a) disconnectivity among urban green spaces and b) lack of sufficient green spaces are identified as major challenges based on previous studies and literature (please see Hepcan, 2013; Hepcan et al., 2013).

NBS TYPES

This KPI is related to NBS involving new green cycle lane and re-naturing existing bike lane.

[35] https://www.apgb.co.uk/

METHOD

In the case of Izmir, the distribution, configuration and 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, GYRATE_AM-area weighted mean radius of gyration, AREA_MN-patch area distribution), Aggregation metrics (NP-number of patches, CONNECT-Connectance index). The land use/cover map was derived from WorldView2 satellite images dated 2014. Landscape metrics are calculated at the class level by using FRAGSTATS 3.4 with a cell size of 1 m (McGarigal and Marks 2003).

In the monitoring period, a GIS based analysis will be made again at the city level using recent data and information to identify recent land use-land cover, and above-mentioned landscape metrics will be computed. Although URBAN GreenUP requires a two-year monitoring period after the implementations of the NBS to collect a complete data set and achieve a maximum accuracy in the evaluation process, the measurement for this KPI is going to be executed only once because this is not an analysis or assessment that needs to be repeated.

MEASUREMENTS

It is measured at the city level.

UNIT OF MEASUREMENT

% and numbers

CALIBRATION / VERIFICATION

For monitoring purposes, same assessments as in baseline calculations will be carried out only once using the above-mentioned metrics to evaluate the before and after performances of the NBSs.

STUDY SITES

In İzmir, study sites are Çiğli-Karşıyaka urban development zones.

DATA PROCESSING

The land use-land cover map will be derived from WorldView2 updated satellite images using screen digitalizing in ArcGIS 10. Based on land use-land cover map, urban green spaces will be defined and classified in ArcGIS 10 as well. Izmir Metropolitan Municipality (IMM) currently uses ARCGIS. On the other hand, the maps and models can easily be converted to an open platform such as QGIS.

RESULTS, REPORT FORMAT

Results can be displayed throughout maps and/or tables.

2.5.2 BENEFITS FROM INTERVENTIONS

INTRODUCTION

This is a global indicator which aims to analyze the urban regeneration (metropolitan or urban scale) considering the typology, functionality and benefits. The results will show the potential of a Nature Based solution to protect, improve, and regenerate the urban spaces.

This KPI called "Assessment of typology, functionality and benefits provided" is a complex indicator, which is compound by individual performance indicator (parameters). This KPI has multiple natures, composed, grouped and integrative. There have been defined a composed and weighted methodology to calculate this global KPI, through the addition of single KPI.

NBS TYPES

This KPI is a global indicator that can be applied to all technical interventions.

- Arboreal interventions: Urban carbon sink, planting trees, green areas, shady areas, green filter.
- Green corridor: green cycle lane, green resting areas, cycle-pedestrian green paths.
- Vertical and horizontal green infrastructures: green façade, shady areas, green roof, etc.
- Water interventions: floodable park, natural wastewater treatment plant, SUDs, rain garden.
- Singular interventions: electro-wetland, bio-filter.

METHODOLOGY

There have been defined a group of parameters that are the criteria to calculate the global indicator. These criteria are defined as single parameters, which are calculated departing from technical and statistical data collected or provided from other KPIs.

The parameters definition answers the following questions:

P1) Parameter: Typology. Question: What?

This parameter indicates the NBS improvement through the natural resources increase calculation. The definition of this parameter depends on the NBS type, so there are different ways to calculate this parameter, considering surface (m2), lineal (m) or single individuals (unit). In every case, the result is expressed in %.

- Green/Blue area increase (%): This method applies to all NBS that increase the green area, associated to a vegetation surface (trees, bushes, grass). This also applies to all NBS about water interventions that increase the water surface, associated to a blue area. This parameter can be calculated with mapping tools such as GIS (geographic information systems), My Maps, Google Earth and other.

$$\text{Green or Blue area increase } (\%) = \frac{\text{Increase green/blue area (m2)}}{\text{Green/blue area (m2)}} * 100$$

NBS - Green surface: Green resting areas, arboreal interventions, vertical green infrastructure, horizontal green infrastructure, urban orchard

NBS - Blue surface: Natural wastewater treatment plant will create a water ecosystem through a superficial lagoon; floodable park, although this NBS will not have a permanent water source; electro-wetland; SUDs, rain garden.

· Lineal NBS increase (%): This method applies to the NBS with lineal dimension, such as the green corridor with the cycle lane.

$$\text{Cycle lane increase }(\%) = \frac{\text{Increase cycle lane (km)}}{\text{Cycle lane (km)}} * 100$$

NBS: New green cycle lane and Renaturing existing cycle lane.

· Unit increase (%): This method applies to the NBS with unitary dimension, such as the green corridor with the cycle lane.

$$\text{Unit increase }(\%) = \frac{\text{New units (tree, recipient)}}{\text{Current units ex} - \text{ante (tree, recipient)}} * 100$$

NBS: Non-technical interventions (number of recipients); arboreal interventions (number of trees).

P2) Parameter: Functionality. Question: Where?

The functionality can be measured as the accessibility degree of the Nature-Based solution. It is related with the KPI 53 “Accessibility (measured as distance or time) of urban green spaces for population”. As it is defined, this social indicator evaluates the accessibility of urban green spaces for population in terms of total distance or time.

It is calculated as the shortest distance (linear) between the population in the NBS (line type), and the NBS location centroid (mean center). The result of KPI 53 is expressed in distance (m) or time (min), from an average velocity. This parameter can be measured throughout specific software, such as GIS software and spreadsheet software.

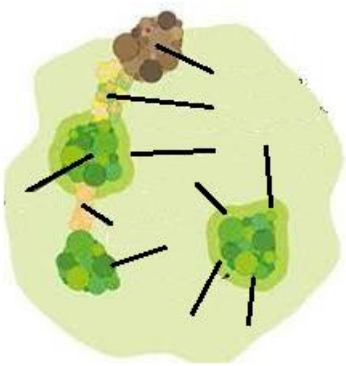


Figure 2.14: Accesibility of urban green spaces for population (Source: landscapeinstitute.org)

P3) Parameter: Sustainable benefits. Question: How?

This parameter shows the impact of the NBS taking into account economic, social and environmental aspects. It is related with the KPI 74 “Sustainability of green areas”. Sustainability has been also defined as a complex indicator, which is calculated through a check list with 30 items (requisites) that are classified into: Ecosystem items, Construction and operation items, and Social items.

The indicator will result in a Sustainability degree expression in 4 ranges, according to the score (rating): High (65-100 points), Medium high (40-65 points), Medium low (20-40 points) and Low level of sustainability (0-20 points).

RESULTS

The KPI "Assessment of typology, functionality and benefits provided" is a global indicator compound by three parameters. The result is calculated as the average of each parameter. It is expressed in %.

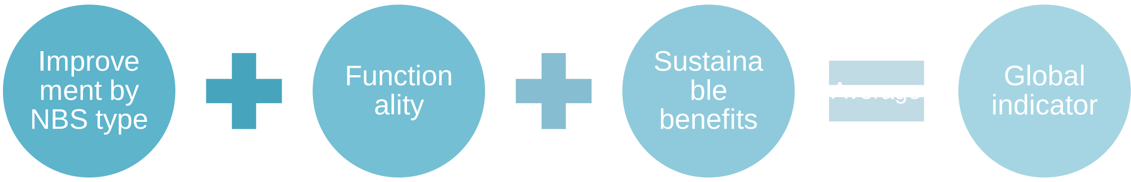


Figure 2.15: Results scheme.

DATA SAMPLING

This is an example of this KPI calculated to the NBS Arboreal interventions (*VAc5- Re-naturing parking trees (250)* in C1- Football Stadium Area (Parking).

$$\text{P1)}\ \text{Trees increase}_{\text{Footbal Std parking area}}\ (\%) = \frac{250\ (\text{tree})}{80\ \ (\text{tree})} * 100\ = 313\%$$

REFERENCES

- "References for Urban Green Space Characteristics: A Comparative Study in Three Portuguese Cities", Helena Madureira, Fernando Nunes, José Vidal Oliveira, and Teresa Madureira, 2018.
- "Urban Green Spaces and an Integrative Approach to Sustainable Environment" Shah Md. Atiqul Haq, 2011

2.6 PARTICIPATORY PLANNING AND GOVERNANCE

2.6.1 OPENNESS

INTRODUCTION

Nature-Based Solutions require planning approaches and governance architectures that support accessibility to green spaces, while maintaining their quality for the provision of ecosystem services. Urban environmental problems are often difficult to handle and successful solutions require combined efforts of different scientific disciplines but also an active dialogue between stakeholders from policy and society (Lemos and Morehouse, 2005).

In this context, transdisciplinary approaches for knowledge co-production provide insights about the ways and the rationale for engaging with multiple knowledge holders: experts and scientists as well as citizens and practitioners (Bergmann et al., 2012, Jahn et al., 2012). The scientific frameworks of urban ecosystem services were brought into the interface between policy and science to inform urban planning and governance (Frantzeskaki and Tilie, 2014).

The quality of the URBAN GreenUP project implementation depends on social learning and adequate technical solutions. This is possible through the support and cooperation between the involved parties and the resulting input of knowledge (Luyet, 2012).

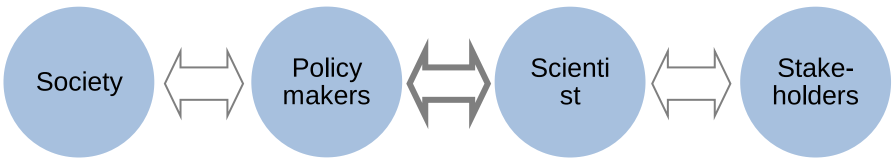


Figure 2.16: participatorie scheme

For this KPI definition "participation" is defined as "a process through which stakeholders influence and share control over development initiatives and the decision and resources which affect them" (World Bank definition, 1996). The stakeholder participation includes other stakeholders not mentioned in the other categories, such as civil society (individuals or organized society) and scientific community (the academia).

NBS TYPES

This KPI apply to all technical interventions of Valladolid Demo, in their designing, construction and monitoring processes, also knowledge co-production space.

METHODOLOGY

Participation is often reduced to the dissemination of information and the holding of workshops. These approaches generally do not take into account either the heterogeneity of stakeholders, or the complexity of the decision making process (Luyet, 2012).

The KPI "Openness of participatory processes" is based on the participation actions delivered in the city of Valladolid. There are defined two steps, data collection and data evaluation.

Step 1. Data collection and characterization.

The data collection about the participatory processes would have the following items:

Participation techniques: Newsletter, Reports, Presentations, public hearings, Internet webpage, Interviews, questionnaires and surveys, Field visit and interactions, Workshop, Participatory mapping, Focus group, Citizen jury, Geospatial/ decision support system, Cognitive map, Role playing, Multicriteria analysis, Scenario analysis, Consensus conference.

Degrees of participation: The participation action is classified into the following types.

- Information: explanation of the project to the stakeholders.
- Consultation: presentation of the project to stakeholders, collection of their suggestions, and then decision making with or without taking into account stakeholders input.
- Collaboration: presentation of the project to stakeholders, collection of their suggestions, and then decision making, taking into account stakeholders input.
- Co-decision: cooperation with stakeholders towards an agreement for solution and implementation.
- Empowerment: delegation of decision-making over project development and implementation to the stakeholders.

Co-creation & Co-production agent: There are identified the following stakeholders groups:

- Policy makers: The Valladolid City Council Departments.
- Experts: Scientific community and consultants.
- Community representatives: Economic agents. Civil society such as civil associations and local communities.

		Openness to participatory processes			
Date	Communication model	Participation technique	Degree of participation	Co-creation & Co-production agent	Participation action
dd/mm/yyyy	Classify: In-person meeting. Video conference / Online meeting. Audio conference / Call.	Classify: Newsletter, Reports, Interviews, questionnaires, Workshop, others.	Classify: Information, Consultation, Collaboration, Co-decission, Empowerment	Policy maker, Scientific community, Civil society, Economic sector, Other stakeholder	Name of the participation action and short description

Table 2.15: Data collection record table for KPI 111 "Openness to participatory processes".

The following activities might be included to calculate this KPI: Single Desk actions, open days such as Mobility week or the Day of the Earth, conferences about Smart city, environmental awareness, etc.

Step 2. Evaluation of participatory processes.

How do we evaluate the stakeholder participation? There are defined two techniques, quantitative and qualitative.

Quantitative evaluation: The "Openness of participatory processes" indicator is expressed through quantitative techniques such as (nº processes/year/participation technique/stakeholder) and population reached (number of attendees/agent type).

Qualitative evaluation: There is also calculated by qualitative technique. There will be assigned a final score from 1 to 5, depending on the following criteria:

- The quality of the process (conflict resolution, early involvement, transparency, equity, influence, stakeholder representativeness, integration of all interests and definition of rules).
- The outcomes (capacity building, emergent knowledge, impacts and social learning)
- The political, social, cultural, historical and environmental context.

The qualitative score evaluates from 1-5 points, where 1-Low quality and 5-High quality.

		Evaluation of participatory processes	
Date	Participation action	Number of attendees	Qualitative score
dd/mm/yyyy	Name of the participation action and short description	Number of people that attend to the activity, for every stakeholder type (political, academia, citizens, etc.)	From 1-5 where 1-Low quality and 5-high quality.

Table 2.16: Evaluation record table for KPI 111 "Openness to participatory processes".

Note. Valladolid Participatory Budgeting Process.

It is worth mentioning the Valladolid Participatory Budgeting Process[36]. Since 2016 Valladolid City Council yearly opens to the citizens the investment decisions for the city. Participatory Budgeting is a mechanism by which citizens decide the assignment of a portion of municipal resources by establishing priorities in terms of municipal expenditures. Citizens over 16 years can choose how and where the City Council is spending municipal budget. Some examples of the investment actions: Fix sidewalks, sewerage, pedestrian paths, cycle paths, public lighting, sports areas, parks and green areas, road signage, street furniture, improvement in urbanizations, small-scale equipment, improvement or conditioning of existing equipment (a public square, a school, a civic center, a library, etc.).

- For the KPI “Openness of participatory processes” there will be identified if the citizens choose Nature-Based solutions actions as part of the participatory budgeting process. Some examples of these NBS are: Planting new trees, green areas, biodiversity actions, green infrastructure.

SENSOR/SOFTWARE

No sensor or software is used for calculating this KPI. There is used an Excel sheet and statistics software (such as SPSS).

DATA SAMPLING

Data is being collected from Valladolid City Council participatory actions yearly.

DATA PROCESSING

Data is collected monthly. A global indicator is being calculated yearly. There will be included a statistic analysis of the participatory processes delivered.

- Internal meetings between Valladolid City Council Departments per year. Departments involved (#/month, #/year, n º attendees).
- Participatory actions with the scientific community per year (#/month, #/year, n º attendees).
- Participatory actions with civil society (individuals and organized citizenship such as civic center’s board and neighborhoods’ associations) per year (#/month, #/year, n º attendees).
- Participatory actions with economic agents per year. Economic agents involved (#/month, #/year, n º attendees).
- Participatory Budgets: Number of NBS projects requested by the citizens per year. There will be identifies the NBS type.

[36] Presupuestos participativos: https://www10.ava.es/presupuestosparticipativos

RESULTS

(#Participatory actions/month) (#/year) (# attendees) (nº NBS requests in Participatory Budgeting) (qualitative evaluation score).

REFERENCES

- Luyet V1, Schlaepfer R, Parlange MB, Buttler A. (2012). A framework to implement Stakeholder participation in environmental projects. International Journal of Environmental Research and Public Health.
- Frantzeskaki, Niki & Kabisch, Nadja & McPhearson, Timon. (2016). Advancing urban environmental governance: Understanding theories, practices and processes shaping urban sustainability and resilience. Environmental Science & Policy. 62. 10.1016/ j.envsci.2016.05.008.

2.6.2 CITIZEN PERCEPTION

RATIONALE

Citizens' perceptions, both individuals and communities, are essential when evaluating the well-being benefits from urban green spaces (Kothencz et al, 2017). Public and stakeholder perceptions of urban nature, and specifically the quality or functionality of nature, are critical to our understanding of the "value" people place on local environments (Priego et al., 2008).

Exploring visitors' perceptions of green spaces is challenging as it depends on cognitive, affective, and behavioural components and, therefore, sensory perceptions are individually different (Kothencz et al, 2017).

This KPI measures identified green space characteristics by the two following well-being variables and one geolocation variable:

- Green space visitors' level of satisfaction. Directly related with the urban green space (UGS) quality.
- Self-reported quality of life (QoL).
- Frequency of green space visitors' crowd-sourced geo-tagged data in NBS sites.

Visitors' level of satisfaction and perceived QoL contributions of UGS are key individual-level measures that are subjectively affected by area-based green space characteristics.

This KPI will reflect on how people assess change in their local environments in terms of satisfaction, quality of life and citizens' presence of urban green space (UGS) at a site (NBS), neighbourhood and city scale.

NBS TYPES

Green corridor (green cycle lane, resting areas, cycle-pedestrian green paths); Vertical and horizontal green infrastructure; Tree related actions; Natural Wastewater Treatment Plant, Rain gardens; Green Parking Pavements; Electro wetland. Non-technical interventions: Promotion of ecological reasoning and intelligence.

METHODOLOGY

The indicator is calculated from data captured by surveys and by the URBAN GreenUP mobile application (location data). The following diagram shows the calculation procedure.

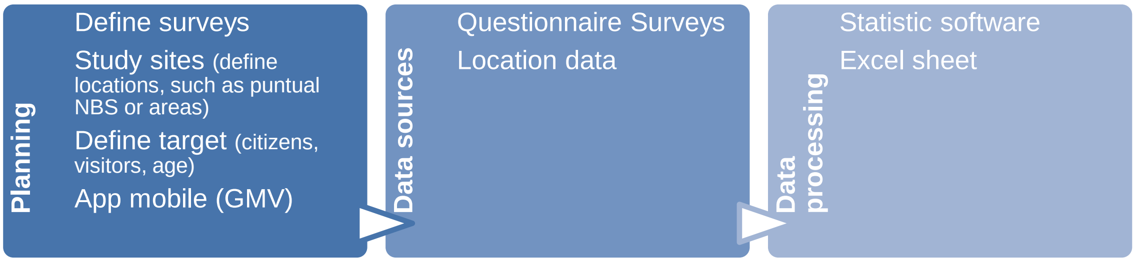


Figure 2.17: Workflow graphic example.

Surveys: On the one hand, Perceptions of citizens on urban nature applies questionnaire based-analytical methods. A social survey will ask individuals, communities and key stakeholders to rate the landscapes around the NBS in terms of their use/function, accessibility, and aesthetic quality.

Currently, social surveys are conducted periodically by the Local Agenda 21 of Valladolid[37]. The questionnaire includes Sustainability Items such as the following. This LA21 Survey is the starting point for this URBAN GreenUP KPI: "Percentage of population satisfied or very satisfied with the quantity and quality of green spaces in the city". Results in 2014 were 68% and 65% respectively.

The perceived quality of green spaces will be assessed via a combination of qualitative questions reflecting on the composition, function and utility of green space and quantitative questions using a scaled responses and pre-determined asset/value lists to assess the perceived greenness and quality.

Design of the survey: The survey will contain a maximum of 30 questions that evaluate the perceived quality of life (QoL) contributions, and the answers are measured on a Likert scale (1-5; 1-very dissatisfied; 5-very satisfied). The items categories are perception of nature, noise abatement, capacity for recreation, microclimate regulation, habitat, air purification and visual appearance, among others.

The survey will be launched *in situ*, person to person, close to the NBS locations (punctually and defining NBS areas). Surveys will be also send using randomly distributed mail questionnaires to capture green space users and non-users' attitudes towards NBS and UGS in Valladolid.

Location data: On the other hand, crowd-sourcing data is being obtained from geospatial location of citizens in the NBS areas, as second data capture methodology. UGS visitors of recent years can use location-aware technologies to spatially log their activities; for example, UGS visitors can geo-tag their photographs that they take during theirs UGS visits, or log trajectories of their physical activities (Kothencz et al, 2017). This spatial data might be captured by position

[37] Local Agenda 21 of Valladolid - Sustainability indicators http://www.valladolidagendalocal21.es/

interaction between the Mobile App, QR codes and a beacons network strategically located in the NBS area.

There might be designed systems to capture data from geo-tagged photos downloaded from the sharing website, input to a GIS as point features. The photography taken in the Study sites can be classified into categories: green space-with/without surroundings, vegetation-plant in detail, vegetation –larger habitat, water surface).

There are other systems to capture data from GPS track-logs downloaded from a social network sharing source (such as Nike+ run club and App).

Figure 2.18: Running trajectories touching or crossing the grounds of the study areas (Source: MDPI, Gyula Kothencz et al, 2017)

It is intending that surveys will be developed in the URBAN GreenUP Android mobile application (App) to identify social perception, wellbeing, and GPS location (beacons).

DATA SAMPLING

Measurements for social survey will be done in person (in situ surveys), via online platforms (on line surveys) and via the smartphone applications provided by the URBAN GreenUP Consortium members, such as GMV. There are identified the following two data sources:

- By surveys: The mobile application can show surveys, which ask simple questions to the population about issues of the social use of the NBS to evaluate aesthetic enjoyment and recreation: How many people are there in your environment? Do you feel better seeing this vertical façade?
- By mobile location: The volume of visits to NBS and the spatial patterns can indicate recreational capacity and aesthetic appreciation. In the URBAN GreenUP project the KPI could be calculated for these NBS:
    - Public transport use: GPS location + QR codes installed in the NBS location/areas.
    - Green corridor use: There is an Android API called *Activity*.
    - On foot movements: GPS location.

The KPI “Perceptions of citizens on urban nature” will be calculated with standard spreadsheet software (Excel or SPSS). The unit of measurement are: (% of satisfaction), (nº users).

DATA PROCESSING

Survey data can be processed by using spreadsheet software by Excel or SPSS and spatial analysis software like ARCGIS or QGIS.

RESULTS

Results can be displayed throughout maps and/or data tables.

REFERENCES

- Priego, C., Breuste, J.H., Rojas, J., 2008. Perception and value of nature in urban landscapes: a comparative analysis of cities in Germany, Chile and Spain, Landscape Online 7, pp.1-22.
- Gyula Kothencz, Ronald Kolcsár, Pablo Cabrera-Barona, Péter Szilassi. 2017. Urban Green Space Perception and Its Contributionto Well-Being. International Journal of Environmental Research and Public Health.

2.6.3 SOCIAL LEARNING

Social learning has long been established as essential to policy change, and thus is essential to mainstreaming NBS. To monitor social learning, it is essential to examine how policies and processes have changed. Such changes can encompass adoption of new interventions, techniques, policy, and processes in response to experience and new information (Hall, 1993). Semi-structured interviews, participant observation, and content analysis will all be used as part of baseline monitoring and throughout the project to understand how decision makers, policy makers and practitioners are incorporating new knowledge about NBS into their processes, discussions, and documents. This KPI will focus on a particular form of social learning known as policy learning. In both baseline and post-intervention monitoring, monitoring for this KPI will include structured content analysis on key policy documents relevant to the study area will be undertaken, using a range of techniques including word-frequency counting, key-word-in-context listings, concordances, classification of words into content categories, content category counts, and retrievals based on content categories and co-occurrences (Druckman 2005; Weber 1990).

In addition, using purposive, non-probability sampling, baseline and post-intervention monitoring will include interviews key individuals involved in making relevant policies and making decisions with respect to green infrastructure and NBS in the City of Liverpool, with data being collected until saturation (Minichiello et al. 2008). Sometimes these adjustments will require small, incremental changes, and sometimes they will require radical shifts in approach, and it may also require time for changes to be made on paper, so interviews will allow access to the most up-to-date thinking and information. To ensure consistency in data collection, an interview guide based on the key theoretical elements of policy learning (Suškevičs et al. 2017; Dovers and Hussey 2013) will be used to analyse baseline knowledge of NBS, examine current processes and implementation of policy, and identify adjustments to processes and policies. At the same time, participant observation will be used to analyse decision-making in real-time and evaluate how it evolves over the course of four years. Two levels of policy learning will be assessed: 1) how policy problems are constructed and how solving the problem should be approached (i.e., scope of policy and its goals), and 2) instrumental learning, where lessons about policy design and knowledge about when a particular policy instrument is appropriate or viable (May 1992).

Data from all methods will be analysed using standard qualitative data analysis software (e.g., Nvivo), using a combination of deduction and induction, using a priori codes from theory (Creswell 2013), followed by a second level of analysis where emergent themes were identified from coding patterns in the data (Miles and Huberman 1994). A selection of interviews will also be blindly coded by another researcher to check intercoder reliability is at least 85%.

2.6.4 URBAN FARMING EDUCATIVE/ participate activities, Learning for producers

Especially farmers living in the urban and peri-urban will be informed about climate change and its increasing affects, periodically. First of all, leading farmers living in the urban periphery (Çiğli and Menemen districts), agricultural cooperatives and students will be determined, and training seminars will be organized. Secondly, the visitors of the Sasalı Natural Life Park where the Demo Site area is also located will also benefit from these seminars. Visitors to the natural life park (around 1.500.000) area will be able to visit climate sensitive greenhouse and its garden. All visitors will be counted for measuring.

After each training seminar, the participants will complete detailed questionnaires and the success of the training will be measured.

The results of the specially prepared questionnaires will be analysed using statistical methods. Likewise, after analysing the questionnaires, the results will be shared by using ICT platforms.

2.6.5 ENGAGEMENT WITH NBS

The importance and significance of public access to environmental information and participation in environmental decision-making are enshrined in the Aarhus Convention, adopted in 1998 in the Danish City of Århus (United Nations Economic Commission for Europe, 1998). In England the National Planning Policy Framework also emphasises the importance of community engagement to achieving well-design places and public involvement in planning and decision-making (Ministry of Housing, Communities and Local Government, 2018). Moreover, academic sources highlight the benefits for environmental management of understanding the relationships between the views of different stakeholders, including the public (Baur et al. 2016). The monitoring of engagement with NBS in Liverpool is therefore of vital importance.

Fundamental to the monitoring of this KPI is the ability to monitor engagement at multiple stages of development and delivery of NBS. This KPI will therefore be monitored across the various public engagement activities and periods of the project using multiple data collection methods.

Participant observation and record keeping of engagement events and consultation activities will be conducted; this will include the collection of demographic information on the individuals and organisations involved for use as descriptive statistics during analysis. Participant observation allows for the collection of data in a naturalistic setting whereby the researcher observes and participates in the common and uncommon activities of the subject group (Musante and DeWalt, 2010) – in this case by attending, observing and participating in the public engagement activities.

Content analysis of engagement materials will also be conducted. As with other KPIs where content analysis will be used, a range of techniques will be used including word-frequency counting, key-word-in-context listings, concordances, classification of words into content categories, content category counts, and retrievals based on content categories and co-occurrences (Druckman 2005; Weber 1990).

To complement the above data collection methods and provide a richer source of data on how citizens and community groups engaged with NBS, qualitative semi-structured interviews will be conducted with targeted participants. Interviews can be used to attempt to understand the world from the subject's perspective, to understand their experiences and their interpretations of them (Kvale, 1996; Mann, 2016) and so can aid in the monitoring of this KPI to further our understanding of how citizens engaged, their motivations and their experiences of engagement in NBS. Purposive and non-probability sampling will be used to select interview participants. Interview participants will be selected based on organisation or participant 'type' to ensure a range of interviewees – for example, community organisation representatives, individual citizens, and interest groups.

As with other qualitative data collected, data for this KPI will be analysed using the qualitative data analysis tool, Nvivo. A combination of deductive and inductive coding will be employed, using a priori codes from theory (Creswell 2013), followed by a second level of analysis where emergent themes are identified from coding patterns in the data (Miles and Huberman 1994). As elsewhere, a second researcher will blindly code a selection of interviews to check intercoder reliability is at least 85%.

2.6.6 URBAN FARMING ACTIVITIES- Energy saving kWh

RATIONALE/INTRODUCTION

Izmir currently consists of 30 districts under the authority of Izmir Metropolitan Municipality. In this KPI, Izmir team will be focused on Balçova, Bayraklı, Ciğli, Karşıyaka, Konak and Narlıdere districts of city of İzmir. One of the reasons for the selection of these districts is located in the center of the city of Izmir and the other reason is that all Demo Sites are located in the districts of Çiğli and Karşıyaka (Figure 4-1). In these districts, where urban agriculture is intensively implemented, the production of food will be measured by tones/ha per year.

Figure 2.19 Urban farming in Balçova district of the city of Izmir (http://www.yurtsuz.net/ReadImage.ashx?id=7508)

NBS TYPES

Urban farming promotion: Urban orchard; Community composting; Small-scale urban livestock

METHOD

In these districts, the production of food resulting from urban farming activities will be measured by tones/ha per year based on fieldworks and data from the Ministry of Agriculture.

SENSOR/SOFTWARE

İzmır Directorate of Provincial Food Agriculture and Livestock database and field surveys.

MEASUREMENTS

The production of food resulting from urban farming activities will be measured by tones/ha per year based on fieldworks and data from the Ministry of Agriculture in Balçova, Bayraklı, Ciğli, Karşıyaka, Konak and Narlıdere districts of city of Izmir. If it is not able to be measured, an estimate of the amount generated will be made.

2.6.7 URBAN FARMING ACTIVITIES- Water savings

RATIONALE/INTRODUCTION

Demo Site for climate smart greenhouses is located on Northern periphery of the city of İzmir. Soils and water quality of Demo Site and surrounded agricultural lands has deteriorated for last ten years. The climate smart greenhouse will include vertical and hydroponic plantation system (Figure 2-14, 2-15).

To save water to be used in the greenhouse, roofing will be made from material that can condense the water vapor. After water vapor is condensed on the greenhouse roof, water will be stored by collection channels and reused in agricultural production. Some part of water demand for plantation will be obtained from a portable desalination unit (Fig. 2-16).

To save energy, parabolic type solar energy collector will be used for heating the greenhouse. Additionally, the photovoltaic solar energy system will be used for lighting (Fig 2-17 a,b).

Additionally, agricultural production methods will be demonstrated in the soil which becomes saline and alkaline soils in Demo Site B. To avoid product yield loss, a spatial seeding type on saline soil will be applied (Fig 2-18).

One part of the green house will be used for demonstrating future stress conditions due to climate changes and soil degradation including dried plants, dried soil with cracks and salt crust on the surface etc. Aims of this part of the greenhouse will be used for educative purposes through students and citizens. A seminar room will be establishing beside this part.

Figure 2.20 Climate smart greenhouse[38]

Figure 2.21 Vertical planting system in greenhouse[39]

38 http://urbanfarmingco.com

39 www.techbriefs.com

Figure 2.22 Portable desalination unit[40]

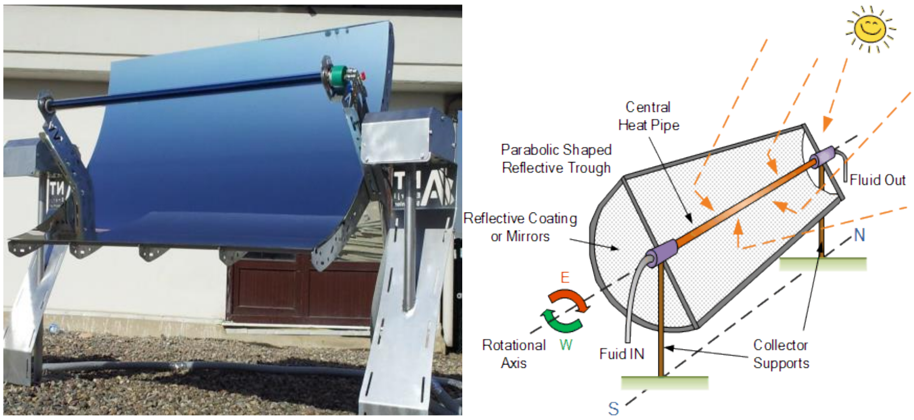


Figure 2.23 a,b. Parabolic type solar energy collector to storage of heat in subsoil tanks[41]

[40] http://www.globalsources.com/si/AS/Shenzhen-Heping

[41] http://www.alternative-energy-tutorials.com/solar-hot-water/parabolic-trough-reflector.html

Figure 2.24 Dibbling process will be done on high ridge (around 70 cm high from soil surface level)

NBS TYPES

Urban farming promotion: Singular GI, Urban Farming, Climate-smart urban farming precinct, educational activity

METHOD

Among of the saving water will be measured by collector in the greenhouse. Saving energy using solar energy will be measured for 200 m^2 greenhouse with comparing energy usage for heating and lighting process.

Desalinated water will be measured by given parameter from producer Company, such as how amount saline water purified in a hour (lt/h).

The agricultural production obtained from the unit area by conventional methods will be compared with the amount obtained from vertical agriculture (kg/m^2).

Visitors or number of the people for training in part of the greenhouse for demonstrating future stress conditions will be counted monthly by officials.

SENSOR/SOFTWARE

All data will be obtained and monitored using the specific equipment (data logger, etc.) to be placed in the greenhouse. Saving water and energy, producing desalinated water will be calculated for agricultural production per ton or kg.

Obtaining agricultural products kg/m^2 from vertical agriculture will be compared with conventional production from both in greenhouse and field (open agriculture). The amount of agricultural product obtained from vertical agriculture will be compared with the number of agricultural products produced from greenhouse and field by conventional agricultural methods.

MEASUREMENTS

Rainwater harvest measurement: Rainwater will be collected in gutters from roof of the greenhouses into barrels to store it for later use as irrigation water or for mixing with salty water to reduce salt concentration. A water level measurement system will be installed on barrels. The amount of collected rainwater after each rainfall will be recorded. The amount of collected rainwater annually will be calculated at the end of the rainy season.

Measurement of heat energy from solar energy; To save energy, parabolic type solar energy collector will be used for heating the greenhouse. The heating process consists of storing the heat in an isolated water tank to be supplied to the greenhouse with a radiator and fan at night. The water temperature inside the isolated tank will be measured daily with a digital thermometer fixed to the tank.

Measurement of agricultural product from vertical agriculture; the agricultural product gained from vertical agriculture will be measured in weight (kg/m) and quantity (piece). Finally, it will be compared with conventional production from both in greenhouse and field (open agriculture).

Desalinated water will be measured (lt/h) by a flowmeter that fixed on desalination unit.

Measurement of agricultural production from high ridge soil preparing system; Agricultural production methods will be demonstrated in the soil which becomes saline and alkaline soils in Demo Site B. To avoid product yield loss, a high ridge soil preparing system for seeding on saline soil will be applied. The measurement of product gain will be compared to the control parcel production quantity. For this purpose, a traditional soil tillage system will be applied in a control parcel on saline. The agricultural product gained from high ridge soil preparing system will be measured in weight (kg/m).

2.7 SOCIAL JUSTICE AND SOCIAL

2.7.1 CRIME REDUCTION

INTRODUCTION

This indicator is included in the list of indicators *Challenge 8. Social Justice and Social Cohesion*.

According to Oxford dictionary, crime is an action or omission which constitutes an offence and is punishable by law.

The installation of urban furniture as a measure of protection against crime, vandalism and terrorist acts has been developing successfully since the 70s and it is called "Crime Prevention Through Environmental Design (CPTE)". The main technique is to reduce crime opportunities through modification and manipulation of the built environment that make it more difficult (Massoomeh et al, 2016).

Green Infrastructures can help to reduce the causes and opportunities crime and vandalism because the structures that look well cared for discourage crime and increase social justice and cohesion. It is a measure that through well planning, designing and managing of the built environment (Massoomeh et al, 2016).

NBS TYPES

This indicator affects all NBS which may suffer and/or prevent vandalism and /or crimes.

For example, a well design of a cycle lane can prevent collisions between cars and bikers and/or between bikers and pedestrian; and a well care green façade is more respected.

METHOD

This KPI can be assessed throughout specific software, such as GIS software and spreadsheet software. Results can be displayed throughout maps and/or tables.

This KPI can be considered for the entire municipality of Valladolid, giving a single resulting value for each study campaign. However, a street or neighbourhood level study is recommended since it can be useful for detecting the difference between areas and the influence of different NBS.

There is the possibility of combining the data of this KPI with those of the KPI 52 (Distribution of public green space - total surface or per capita), to determine if there is a correlation between crimes and green areas.

SENSOR/SOFTWARE

Data are acquired by statistic and external sources like fire department, law enforcement information or City Council. So, no sensor is required. The criminality data will be compared before and after the installation of the NBS to know if this has influenced the study area.

Spreadsheet software can be required.

On the other hand, crime map for the area of the intervention produced by modelling software can be helpful but not necessary. For example, data can process by GIS with QGIS (is the GIS software)

Spatial Analysis software is required. QGIS is the GIS software proposed to be used, due to it is an open source and multiplatform software and it is distributed under Creative Commons Attribution-Share Alike 3.0 licence (CC BY-SA). We recommend using the last long-term release repository, most stable (QGIS 2.18 is currently the last one). Data processing involved in this KPI can be done with the standard version and the standard toolbox.

DATA SAMPLING

It is necessary to define the crimes that this KPI will be processed according to the definition of crime and the kind of data that it is possible to obtain.

Datasets are provided by Valladolid City Council. All Datasets need to follow INSPIRE principles. An appropriated Coordinate Reference Systems must be defined for each location (city). The image below shows the recommended CRS for Valladolid location.

Figure 2.25: coordinate system to use for Valladolid.

This is considered as a very stable KPI, so frequency could be the same as city council's demographic statistics, therefore, annual. To set the starting situation a preliminary study is also needed.

The data demanded to 010, Valladolid City council, police, and fire department.

The required and recommended inputs for the calculation of this KPI are:

- Number of crimes (acts of vandalism or unintentional actions) around the location of the NBS
- Number of urban furniture damages around the location of the NBS
- Number of attestations around the location of the NBS
- Number of Written, complaints, suggestions related to actions.

Ideally, the data should be provided each year with geographic coordinates or with the street where it is produced, or at least by postal code or district.

DATA PROCESSING

Data processing depends on the data provided.

If the data provided included the coordinates or the street and number street, it is possible to show the proportion of crimes near the NBS and its increase or decrease if the NBS has a direct influence in the crime level.

Thus, a simple geoprocessing analysis is proposed. Firstly, a buffer is established at a certain distance from green areas to obtain a relevant area of influence around them. Then, this dataset is evaluated with the dataset containing coordinates of the crimes throughout the tool Count points in polygon. Finally, using the Fields calculator and Basic Statistics tools, this KPI is shown as a percentage.

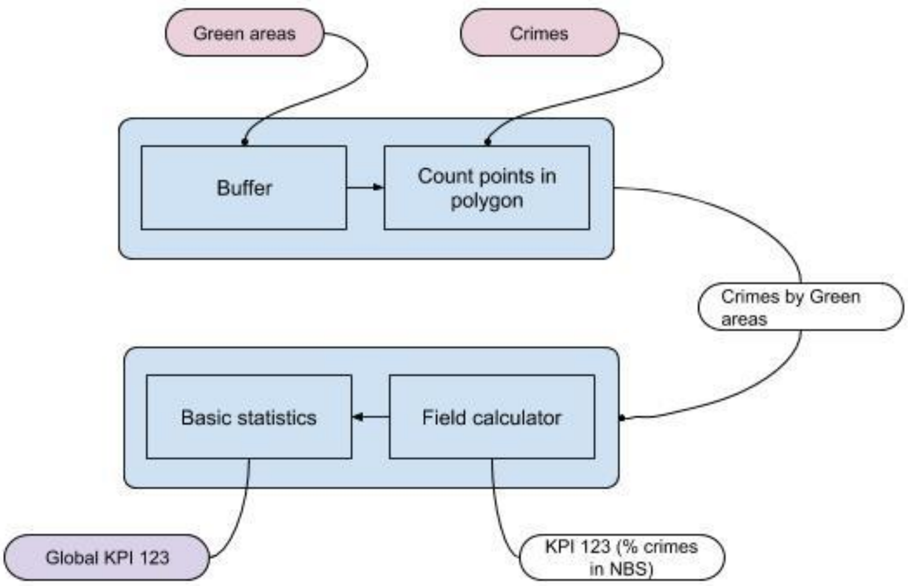


Figure 2.26: KPI algorithim dataflow scheme

RESULTS

Results depends on the data provided. Ideally, the data should be provided by streets and by date, to show the results in more detail. Like that, several figures are obtained for this KPI. For example, a figure will show the distribution of the crimes by zones or areas close to the actions before and after their installation (%).

Two final figures are obtained at the end of the process for this KPI. One of them shows the distribution of green areas surface in terms of total surface (%), and the other shows the distribution of green areas surface in terms of inhabitants (m2/inhabitants).

REFERENCES

- Raymond, C.M., Berry , P., Breil, M., Nita, M.R., Kabisch, N., de Bel, M., Enzi, V., Frantzeskaki, N., Geneletti, D., Car dinaletti, M., Lovinger, L., Basnou, C., M onteiro, A., Robrecht, H., Sgrigna, G., Munari, L. and Calfapietra, C. (2017) An Impact Evaluation Framework to Support Planning and Evaluation of Nature-based Solutions Projects. Report prepared by the EKLIPSE Expert Working Group on Nature-based Solutions to Promote Climate Resilience in Urban Areas. Centre for Ecology & Hydrology, Wallingford, United Kingdom
- Massoomeh Hedayati Marzbali, Aldrin Abdullah, Joshua Ignatius, Mohammad Javad Maghsoodi Tilaki, Examining the effects of crime prevention through environmental design (CPTED) on Residential Burglary, International Journal of Law, Crime and Justice, Volume 46, 2016, Pages 86-102, ISSN 1756-0616, https://doi.org/10.1016/j.ijlcj.2016.04.001. (http://www.sciencedirect.com/science/article/pii/S1756061616300490) Keywords: CPTED; Victimization; Higher-order construct; Measurement; Validation
- Taehoon Ha, Gyeong-Seok Oh, Hyeon-Ho Park, Comparative analysis of Defensible Space in CPTED housing and non-CPTED housing, International Journal of Law, Crime and Justice, Volume 43, Issue 4, 2015, Pages 496-511, ISSN 1756-0616, https://doi.org/10.1016/j.ijlcj.2014.11.005. (http://www.sciencedirect.com/science/article/pii/S1756061614000834)
- 2017 Valladolid city police annual report https://www.valladolid.es/es/ciudad/seguridad-prevencion/servicios/policia-municipal/memoria-policia-municipal-2017
- QGIS 2.18 – Userguide. https://www.qgis.org/en/site/

2.7.2 GREEN INTELLIGENCE AWARENESS (EDUCATIONAL ACTIONS)

INTRODUCTION

Changes in behavior and human attitudes are fundamental to achieve a more sustainable world, so that, it is very interesting to analyze the potential of an activity or intervention to increase the green intelligence awareness of a population.

There is enormous opportunity for nature-based solutions to promote understanding of sustainability in ways that positively influence citizen behavior. There are numerous available resources to learn and understand the fragility of our environmental and the responsibility of humans to protect, preserve and respect the world. Therefore, this KPI aims to reflect how the intervention is used for educational purposes and enhancement of public awareness.

NBS TYPES

Non-technical interventions: educational activities: Educational paths (A, C); Urban farming educational activities.

METHODOLOGY

Quantify the number of activities, publications or campaigns focused on the enhancement of green intelligence awareness per year, related to a NBS:

1) **Activities**:
   - Number of guided tours.
   - Number of educational meetings: courses, conferences, lectures, workshops, seminars, and symposia.
   - Civil participation through competition activities raising public awareness about environmental protection.

2) **Publications**
   - Articles, texts, photographs or videos published in magazines, newspapers, books with technical and educational content.
   - Online social networks campaigns (YouTube, Twitter, Facebook…) with technical and educational content.
   - Distribution of brochures.

SENSOR/SOFTWARE

No sensor is needed.

DATA PROCESSING

Sum of the educational activities per year and sum of the publications with educational content per year, separately, because the concept and magnitude of each result are different.

RESULTS

2 numbers: Number of activities per year and number of publications per year.

The result can be expressed as: nº a/nºp. Per example, 12a/6p means 12 activities and 6 publications per year related to a NBS.

REFERENCES

- "Educating for a Sustainable Future: a Transdisciplinary Vision for Concerted Action". UNESCO, November 1997.

2.7.3 GREEN INTELLIGENCE AWARENESS (INHAB. ATTENDED)

Explained in section above.

2.8 PUBLIC HEALTH AND WELL-BEING

2.8.1 NOISE REDUCTION

Noise pollution by traffic, construction works, etc. is a common city problem. Nuisance from noise is detrimental to neighbourhood liveability, living comfort and work environments, and can increase risk of serious health problems such as hearing loss and cardiovascular disease.

Urban ecosystems provide noise reduction services by serving as a natural sound buffer. Vegetation provides both a direct and an indirect barrier to environmental noise. Starting with its direct functions, green belts attenuate noise by absorption, dispersal, and destructive interference of sound waves, though sound levels can intensify locally if measured right below tree crowns. Indirect noise reduction effects are generated by lessened wind speeds and the absorptive capacity of pervious soils. UGS also proved to offer noise reducing services via psychological effects: just observing the presence of a green wall can lead people to perceive less noise nuisance or alter the perception of noise as sounds such as flowing water, bird singing, and leaves rustling in the wind mask disturbing background noise.

On the other hand, the methodology proposed for this KPI is based and uses the methodology and tools proposed by the European Commission Working Group Assessment of Exposure to Noise (WG-AEN).

The Environmental Noise Directive (END) requires two main indicators to be applied in the assessment and management of environmental noise. The first indicator (Lden) is the noise level for the day, evening and night periods and is designed to measure ‘annoyance’. The END defines an Lden threshold of 55 dB. The second indicator (Lnight) is the noise level for night-time periods and is designed to assess sleep disturbance. The END defines an Lnight threshold of 50 dB. Member States must report the numbers of people who are exposed to noise levels above both thresholds for each noise source (e.g. roads, railways, airports, industry).

NBS TYPES

This KPI is related to NBS involving vertical green infrastructures, such as green noise barriers, green façade, or green fences.

Green Noise Barriers, Green Façade, Green shady structures, Green fences, Urban Trees including: Planting and renewal of urban trees; Shade Trees; Cooling trees; Trees re-naturing parking and Arboreal areas around urban areas, Green roof, Green covering shelters.

METHOD

This KPI is calculated from measured data using a methodology defined by URBAN GreenUP Project.

It is accounted for two factors that influence noise reduction services: vegetation (NBS) characteristics and distance to the noise source. The analysis is focused on road traffic noise as this is a constant source and most disturbing to people.

BACI (BEFORE, AFTER, CONTROL, IMPACT)

Measure noise levels at sampling points at a range of radii from NBS street tree/green wall locations both pre- and post-intervention (with or without) to serve as input to model simulations and to create a noise map. The measurements before and after the intervention must be made on similar dates, same day of the week and hour. Simulations with and without NBS will be assessed to define the impact of the NBS.

A strategic noise map[42] is the presentation of data on one of the following aspects:

- A noise situation in terms of the noise indicators L_{den} and L_{night};

- The exceeding of a limit value.

- The estimated number of dwellings that are exposed to specific values of a noise indicator;

- The estimated number of people exposed to noise.

Values of L_{den} and L_{night} can be determined either by computation or by measurement (at the assessment positions) and that for prediction, only computation is applicable.

2.8.2 WALKING AREA INCREASE

INTRODUCTION

This is a social indicator, which links to human health and well-being, as walking and cycling in nature has been shown to improve both physical health and psychological well-being. This KPI measures how NBS interventions can increase engagement of citizens specifically related to walking and cycling inside the interventions and in proximity. NBS, and specifically green infrastructure, interventions, is thought to increase street attractiveness, which leads to increased engagement with active transport (Adkins, 2012; Tzoulas et al. 2007).

NBS TYPES

This KPI is related to NBS involving green infrastructures, such as green corridor, new green cycle lane, horizontal green interventions, floodable park, etc.

[42] 'Strategic Noise Map' shall mean a map designed for the global assessment of noise exposure in a given area due to different noise sources or for overall predictions for such an area.

METHOD

This KPI can be measured throughout specific software, such as GIS software and spreadsheet software. Surveys may be done as well, to know the walking use of the walking zones. These surveys can involve residents, users and businesses of their perceived and actual use of NBS for walking, cycling and other activities pre-and-post-investment.

In Liverpool, this KPI will be measured qualitatively through direct observation and as an item in the questionnaire, as above. If budget allows, this qualitative data will be complemented by quantitative data from walking and cycling counters.

MEASUREMENTS

L_{den} and L_{night}. (In situ measurements and modelled values by software assistance)

Frequency counts from both qualitative data and sensors

UNIT OF MEASUREMENT

L_{den} and L_{night} in decibel (dB).

Number of users and trips (estimated)

CALIBRATION / VERIFICATION

Where noise-related interventions are proposed, calibration of the sound level meter will be used for in situ measurements following standard procedures (EN 61672-2:2013/A1:2017, EN 61672-2:2013, EN 61672-1:2013, EN 61672-3:2013).

STUDY SITES

In Valladolid, study sites will be:

a) Stretches of road where noise barriers or other interventions are proposed (intervention study sites) selected at random from qualifying intervention locations (random stratified sampling); and

b) A matching number of locations along equivalent stretches of road (road of similar width and with comparable building heights to intervention site) where NBS interventions are not proposed (control study sites). Control sites should be a sufficient distance away from street tree/green wall intervention sites for the observations made to be considered independent from the effects of street trees/green walls.

In Liverpool, study sites will be focused around in and around the areas of the NBS interventions designed to enhance walking and cycling.

DATA PROCESSING

QGIS is the GIS software proposed to be used in Valladolid, as it is an open source and multiplatform software distributed under Creative Commons Attribution-Share Alike 3.0 licence (CC BY-SA). We recommend using the last long-term release repository, most stable (QGIS 2.18

is currently the last one). Data processing involved in this KPI can be done with the standard version and the standard toolbox.

Data are acquired by statistic and GIS processing, so no sensor is required. This data can involve new subscriptions to the bicycle loan system. 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).

Survey data will be analysed in standard software (Excel and SPSS), to determine if there is a statistical difference between walking and cycling pre- and post-intervention for residents and users in the sub-demo areas.

RESULTS

Results can be displayed throughout maps and/or tables.

Figure 2.27: Example of results displayed in maps

REFERENCES

- Adkins, A., Dill, J., Luhr, G. and Neal, M., 2012. Unpacking walkability: Testing the influence of urban design features on perceptions of walking environment attractiveness. *Journal of Urban Design*, *17*(4), pp.499-510.
- Good Practice Guide (GPG). European Commission's Working Group "Assessment on Exposure to Noise" (WG-AEN). 2006. http://sicaweb.cedex.es/docs/documentacion/Good-Practice-Guide-for-Strategic-Noise-Mapping.pdf
- Derkzen, M.L., van Teeffelen, A.J.A., Verburg, P.H., 2015. Quantifying urban ecosystem services based on high-resolution data of urban green space: An assessment for Rotterdam, the Netherlands. J. Appl. Ecol. 52, 1020–1032. doi:10.1111/1365-2664.12469
- Sustrans. 2014. Monitoring and evaluation of walking and cycling. *In:* Sustrans Design Manual Chapter 16. Sustrans: Bristol, UK

- Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kaźmierczak, A., Niemela, J. and James, P., 2007. Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. *Landscape and urban planning*, *81*(3), pp.167-178.
- WHO (2014) WHO | 7 million premature deaths annually linked to air pollution, http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/
- WHO (2011) Burden of Disease from Environmental Noise. Quantification of Healthy Life Years Lost in Europe. WHO Regional Office for Europe, Copenhagen.
- Conference of European Directors of Roads. 2013. Best practice in strategic noise mapping. https://www.fomento.gob.es/NR/rdonlyres/CB0F3D92-E801-47AD-9028-FC7E306D3E97/120805/1CEDRJRNoiseMapping_August_2013.pdf

2.8.3 CYCLING AREA INCREASE

This is a social indicator, which links to human health and well-being, as walking and cycling in nature has been shown to improve both physical health and psychological well-being. NBS, and specifically green infrastructure, interventions, is thought to increase street attractiveness, which leads to increased engagement with active transport (Adkins, 2012; Tzoulas et al. 2007). In addition, walking and cycling have been shown to improve the level of social interactions and community cohesion. This is especially relevant to young families and older people who may be less mobile or lack private transport options. Increased opportunities to engage in walking or cycling have also been seen to be indictors of a liveable city, as they citizens with various options to engage with the landscape.

The KPI measures how NBS interventions can increase the opportunities for engagement of citizens specifically related to walking and cycling inside the interventions and near NBS.

In Liverpool, this KPI will be measured qualitatively through direct observation and as an item in social survey questionnaire. This will focus on the perceptions of provision of cycling and walking infrastructure locally (and specifically in/around the NBS), how people access these opportunities and how investment in NBS can promote engagement with walking and cycling.

Participants will be selected using a convenience sampling technique on-site in each of the demo areas. Additional online surveys may also be conducted with participants drawn from Liverpool City Council and Mersey Forest contacts of individuals and communities who have engaged with cycling, walking or community activities and will include people have signed up to hear about the URBAN GreenUP project.

2.8.4 HEALTH QUALITY PERCEPTION

A social survey of residents will be conducted to understand perceptions of general, physical, and mental health, as well as general, individual, and communal well-being. This will be measured primarily via questionnaires administered in person and online. Residents will be asked a series of questions, which will be the same during the baseline monitoring period and after the interventions to measure initial perceptions and changes post-intervention. Perceptions of general, physical, and mental health and well-being will be measured on 5-point Likert scales and analysed statistically in standard software (Excel and SPSS). The survey will also examine perceptions of urban nature and its impacts on the health and well-being of respondents more generally and specifically in their neighbourhoods linked to the NBS interventions. If appropriate, perceptions of quality and social values will also be analysed alongside other survey data using cluster analysis to identify variation within the population. Using a stratified probability sampling technique, the researchers will aim for a minimum of a 95% confidence interval and a sample that is representative of the broader target populations that live near the interventions and those who use the sites.

2.9 ECONOMIC OPPORTUNITIES

2.9.1 Energy savings

RATIONALE

Improved green infrastructure results in energy savings through a variety of mechanisms. These include:

- Reducing the need to heat buildings by insulating them against the cold
- Reducing the need to cool buildings by insulating them against the heat
- Reducing the volume of stormwater entering the sewer system, thus reducing energy consumption in sewage processing

The energy savings resulting from these three mechanisms are estimated by GI-Val[43] tools 1.1, 1.5 and 2.1 respectively.

METHOD

The following input values will be entered into GI-Val:

- Tool 1.1: number of additional residential buildings with large trees within 10m, based upon landscape architects' drawings and Ordnance Survey's AddressBase[44], which can be used to determine whether a building is residential.
- Tool 1.5: net additional area of green roof (m^2), based upon landscape architects' drawings.
- Tool 2.1: pre- and post-intervention land cover percentages for areas where groups of interventions have been made, based upon Ordnance Survey's MasterMap[45] and the landscape architects' drawings.

2.9.2 JOB CREATION

INTRODUCTION

This KPI, related to economic aspects measurements, evaluates how NBS interventions can increase the attraction of businesses, or how to increase the value of the existing ones. This value, evaluated through the measurements of number of jobs created and the percentage of the gross value added, will reflect the economic opportunities and potential of NBS solutions.

Green jobs should contribute to environmental benefits. They should strive for minimisation of resources, create decent employment opportunities, and build low-carbon sustainable societies.

43 https://www.merseyforest.org.uk/gi-val/

44 https://www.ordnancesurvey.co.uk/business-and-government/products/addressbase.html

45 https://www.ordnancesurvey.co.uk/business-and-government/products/mastermap-products.html

International Labour Organization (ILO) has methodology to estimate green jobs. According to ILO's various country-wide studies, primary green activities (i.e., Organic agriculture, sustainable forestry), secondary activities (i.e., Renewable energy, clean industry, sustainable construction) and tertiary activities (i.e. recycling, sustainable tourism, sustainable transport) are defined.

RELATED NBS

This KPI is related to NBS involving: 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 wastewater treatment.

METHOD

The KPI-141 value comes from the measured data using a methodology defined by URBAN GreenUP Project.

BACI (BEFORE, AFTER, CONTROL, IMPACT)

Essentially a 'before-after' indicator which captures the part of the employment increase that is (a) direct consequence of NBS implementation (workers employed to implement the NBS project should not be directly counted). The positions need to be filled (vacant posts are not counted) and increase the total number of jobs in the enterprise. If total employment in the enterprise does not increase, the value is zero – it is regarded as realignment, not increase. Safeguarded etc. jobs are not included.

Gross: Not counting the origin of the jobholder if it directly contributes to the increase of total jobs in the organisation. The indicator should be used if the employment increase can plausibly be attributed to the support.

Full-time equivalent: Jobs can be full time, part time or seasonal. Seasonal and part time jobs are to be converted to FTE using ILO/statistical/other standards.

Durability: Jobs are expected to be permanent, i.e., last for a reasonably long period depending on industrial-technological characteristics; seasonal jobs should be recurring. Figures of enterprises that went bankrupt are registered as a zero-employment increase.

Timing: Data is collected before the project starts and after it finishes; the NBS holders are free to specify the exact timing (depending on the NBS time needed to get the profit). Using average employment, based on 6 months or a year, is preferred to employment figures on certain dates.

MEASUREMENT INSTRUMENTS

City official data, city platforms, questionnaires, small-medium enterprise accounts… (Related to de NBS investment zone)

UNIT OF MEASUREMENT

(nº jobs) (€/m^2)

(nº jobs or nº users) (kg/year) (€/year)

CALIBRATION / VERIFICATION (STANDARDS)

The following factors should be considered in correct calibration:

- Each climate resilience challenge area can be addressed by multiple individual actions, and indicators can be used to assess the effectiveness of individual actions in addressing each climate resilience challenge
- Indicators for assessing specific types of NBS impacts of NBS across aspects of multiple systems, including socio-economic, socio-cultural and ecosystems, although geographic and temporal scale may be relevant to the interactions
- The applicability of indicators can vary across geographic scales, highlighting of considering regional, metropolitan, urban, street/neighborhood and building impacts separately
- There is a need for assessing the impacts of NBS over the short, medium and long-term, and thus mechanisms are needed for monitoring NBS effectiveness beyond the end of the project
- Synergies and trade-offs can be associated with NBS impacts, including across elements of the ecosystem and socio-cultural system. NBS impacts are, therefore, likely to be multi-directional and complex
- Investment in NBS can maximize the benefits for provision of environmental, socio-cultural and economic services if multiple challenge areas are considered concurrently and the different stakeholder are involved in the planning and implementation process.

DATA PROCESSING

Monitoring systems need to be improved with systematic quality checks in order to ensure that data collected are reliable and there needs to be effective coordination between regional/ area authorities, and MAs generally, to ensure that the data reported are consistent and comparable. The guidelines, spelling out the frequency of checks, the concept used, the methods for carrying them out and so on should be provided for each NBS by specific region.

RESULTS

Number of jobs created (Direct employment)

Direct value on employment by zone, before and after implementation, during the established period.

Number of jobs created= n * Z [(nº jobs) (€/m2)]

Where n is referring to the direct full time employment in during the time defined (directly related to the each particular NBS); Z- affected zone/area in reference to the NBS (should depend on NBS the definition of the area)

Gross value added (GVA)

Defined as the difference between the value of goods and services produced and the cost of raw materials and other non-labour inputs, which are used up in production. The research should conclude what is the total contribution of NBS in % of the total GVA to the region/area economy in Euro/ by year.

REFERENCES

- An impact evaluation framework to support planning and evaluation of nature-based solutions rojects; An EKLIPSE Expert Working Group report, 2017
- "The Model of the Environmental Sustainability Matrix" ("El Modelo de la matriz de Sostenibilidad Ambiental"); La ordenación Urbana y el Desarrollo Sostenible, Angel Ibañez Ceba, Fermín Cerezo Rubio, August 2009
- The five principles of the urbanization theory of Cerdá, Engineering and Territory Magazine, Spanish edition, 2009
- Expert evaluation network delivering policy analysis on the performance of Cohesion policy 2007-2013, 2013, "Job creation as an indicator of outcomes in ERDF programmes", Synthesis report, August 2013, A report to the European Commission Directorate-General for Regional and Urban Policy
- Forestry Commission, Scotland, The economic and social contribution of forestry for people in Scotland, David Edwards, Jake Morris, Liz O´Brien, Vadims Sarajevs and Gregory Valatin, September 2008

- Guidance Document on Monitoring and Evaluation – ERDF and Cohesion Fund, Concepts and Recommendations, Programming Period 2014-2020, European Commission, April 2013. Annex1
- Draft to the deliverable D1.2 "Challenge catalogue" URBAN GreenUP, June 2018

2.9.3 LAND AND PROPERTY PRICE CHANGE

Rental and market prices for homes and retail/commercial spaces can be seen as a good barometer of economic prosperity. A wealth of data exists illustrating the association between high quality green space and NBS and increased real estate values. Research suggests that prices can increase by up to 20% of home or retail spaces overlook or are located near to high quality green and open spaces. It has also been reported that an improved physical environment in terms of aesthetic quality is used by businesses when deciding to locate to an area. Thus, with interventions in NBS there is a potential for improved economic development activities to be situated in each of the demo sites. Such data would also allow Liverpool City Council to think more strategically about how they align their economic development targets with their understanding of how, where and NBS could be implemented in the future.

The change in house/rental prices in NBS intervention areas will be measured primarily using secondary analysis of property market data (assessments n Zoopla or similar). A full database of property market value will be collected prior to the interventions, and then monitored for a period of 2 years afterward, then analysed to determine if significant change in property values near the interventions has occurred. This will focus on changes in average rental or sale prices for apartments and houses within a 100-metre radius of the NBS interventions, a standard measure of used in such studies. This data will also be complemented by GI-Val calculations.

An important consideration in monitoring this KPI over the life of this project will be wider economic changes in the City of Liverpool, the UK (e.g., Brexit), the EU and beyond. For this reason, it will be important to analyse housing prices against relevant benchmarks, to see how values have changed in relative – and not just absolute – terms.

2.9.4 NEW BUSINESSES

Change in revenue from businesses in the NBS intervention areas, as self-reported via questionnaires administered in business owners and representatives in person and online. Businesses in the local catchment areas of the interventions will be asked a series of questions, which will be the same during the baseline monitoring period and after the interventions to measure initial perceptions and changes post-intervention. Data will be collected on both their perceptions of the influence on NBS and other environmental interventions using 5-point Likert scales and economic data from businesses on increases in business rates collected by the council (related to the quality of the environment and its desirability as a location for retail/business). This data will be analysed in standard software (Excel and SPSS), to determine if there is a statistical difference between dwell time and sales pre- and post-intervention for businesses in the immediate vicinity. Given the relatively small number of businesses, the researchers will aim for a census or at least of minimum of a 95% confidence interval and a sample that is representative of the business communities that operate near the interventions. Where appropriate, survey data will be complemented with targeted in-depth interviews to help understand the other factors influencing business rate returns.

3 Data Management

ASSESSMENT OF EXISTING DATA

This research will make use of several existing datasets (e.g., spatial data, crime statistics, property price data, economic data, census data). Open data published by government departments will be used.

Spatial data will be obtained from open repositories. None of this data will contain identifiable information about individuals, but secondary data analysis will nonetheless be included in the ethics application.

INFORMATION ON NEW DATA

With respect to the socio-economic monitoring, there will be several new data sets created for use in the project, including:

1) qualitative data from multiple sources,
2) geospatial data and scenario mapping process, and
3) social survey data.

Ultimately, the project will produce a transferable process for developing, implementing, and monitoring NBS. Not only will all the data be published publicly, but also access to this data will be organised and presented.

QUALITATIVE DATA

Qualitative methods generate a large volume of text-based data. To reduce the risk of re-identification, the interview transcripts will not be provided in their entirety, and instead the data will be organised by themes prior to archiving. Participatory planning and engagement exercises (e.g., public events, community consultation, workshops) occurred over the course of the project.

To encourage deliberation and dialogue, activities are not recorded verbatim, but rather the key points and themes from the activities will be summarised in Microsoft Word and sent to all participants, where feasible, as a record of the workshop. This information will not include personal identifiers and archived in RTF format. Background documents and workbooks provided to participants will also be archived in RTF format.

GEOSPATIAL DATA

Geospatial data will be converted to one of the ESRI Shapefile formats, while the images will be in the form of standard or geo-referenced TIFF.

SOCIAL SURVEY DATA

Survey data will be analysed in Microsoft Excel and SPSS, and the raw data will be exported CSV format for archiving.

QUALITY ASSURANCE OF DATA

Quality assurance of data is integral to ensure the overall quality and reliability of the monitoring of KPIs in Urban GreenUP. The UK Data Service advice and guidance on quality assurance of data will be followed to maintain high quality data, this includes measures taken during data collection, data entry, and data checking (UK Data Service, 2018). Fundamental to quality assurance of data is the need to develop, ahead of data collection, a protocol for data collection, entry, handling and checking procedures (UK Data Service, 2018).

Systematic data collection: The data will be collected using the KPIs as an overarching framework, with subcategories from the literature providing a consistent structure for data collection throughout the project. This ensures that the same categories of data are collected at each point in time to enable consistent data collection and comparison across them. Qualitative data will be transcribed semi-verbatim and then analysed using NVivo. Eklipse outlines the literature underpinning the KPI framework, helping to guide a deductive approach to data analysis and being clear about the conceptual framework improves reliability of data (Miles et al. 2013; Neuman 2013). The interviews will use purposive sampling to select interview participants based on the conceptual underpinnings of the KPIs and to reach the spectrum of individuals engaged in NBS design and delivery in the city, with data being collected until saturation (Minichiello et al. 2008). A selection of interviews will also be blindly coded by another researcher to check intercoder reliability is at least 85%.

Triangulation: The research also uses a mixed methods approach to provide a means of triangulation, along with several different means of accessing data (Neuman 2013; Yin 2009). It is possible that some interviews, workshops, survey responses, and other activities will contain inaccurate or misleading information provided by participants, as well as subjective opinions that cannot be verified, but quality control will be undertaken to ensure the transcripts themselves are an accurate record of the data collected.

To clean the data from the questionnaires administered throughout the project, the entered data will be spot-checked against the raw data, along with logic checks based on the findings during the research.

Quality assurance for geospatial data will refer to the ISO/TC 211 standards and use both automatic rules for checking the data and spot checking, using a data reviewer extension to facilitate the process.

BACKUP AND SECURITY OF DATA

Data and metadata will be stored securely in each city local data storages and global repository platform, which is a centralised, secure, and supported data storage facility set up to store digital research data throughout the lifespan of a project. Although not sensitive data, personal data will need to be processed as a part of this research, especially before the transcripts are edited to remove identifiers. Access to transcripts and audio files will be password protected and limited to the four researchers directly employed on the project. Clear version numbers and dates will be recorded as part of the file name while the project is active, and the final versions will be archived. When working in the field, the PI will ensure any laptop conforms to the University of Liverpool Code of Practice for use of Data on Laptops and Mobile Devices, and data will still be able to be stored on the secure Active DataStore server.

MANAGEMENT AND CURATION OF DATA

Data will be recorded using consistent, agreed upon formats for each category of data to minimise any further preparation prior to archiving. To ensure the description, annotation, formatting, and contextual information are accessible and practically useful, we will have discussions with end users as part of the project.

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions:

Successful Development and Implementation: The UrbanGreenUP H2020 project has demonstrated its effectiveness in promoting sustainable urban development and improving the quality of life in the participating cities. Through the careful selection and monitoring of key performance indicators (KPIs), the project has successfully tracked progress, identified challenges, and facilitated evidence-based decision-making.

Holistic Approach: The use of a multidimensional set of KPIs has allowed for a comprehensive assessment of the project's outcomes. By considering environmental, social, and economic dimensions, the project has addressed the complex nature of urban sustainability, fostering a balanced and inclusive approach.

Tailored Framework: The adaptation of the Eklipse mechanism framework to the specific requirements of the participating cities has ensured that the KPIs and monitoring program are relevant, context-specific, and aligned with the goals and targets of the project. This tailored approach has enhanced the accuracy and applicability of the monitoring process.

Data-Driven Decision Making: The monitoring program has provided valuable data and insights that have informed decision-making processes throughout the project's lifecycle. By relying on objective measurements and analysis, stakeholders have been empowered to make informed choices, optimize interventions, and maximize the impact of the project.

Collaborative Effort: The successful development and implementation of the KPIs and monitoring program would not have been possible without the collaborative efforts of all project partners and stakeholders. The collective expertise and contributions have enriched the monitoring process and fostered a sense of ownership and commitment to the project's goals.

4.2 Recommendations

Knowledge Transfer: To ensure the longevity and applicability of the KPIs and monitoring program, it is recommended to disseminate the knowledge and experience gained from the UrbanGreenUP project. This can be achieved through workshops, training sessions, and the publication of guidelines, allowing other urban sustainability initiatives to benefit from the lessons learned.

Long-Term Monitoring: Although the UrbanGreenUP project has reached its conclusion, it is recommended to establish a framework for long-term monitoring of the implemented interventions. Continued monitoring will enable the assessment of the project's long-term impact, the identification of emerging challenges, and the refinement of strategies for sustained urban sustainability.

Scaling and Replication: The successful implementation of the project's interventions and the robust monitoring framework provide a solid foundation for scaling up and replicating similar initiatives in other urban contexts. It is recommended to explore opportunities for sharing best practices, collaborating with other cities, and leveraging the knowledge gained to drive broader sustainable urban development.

Policy Influence: The findings and outcomes of the UrbanGreenUP project, as evidenced through the KPIs and monitoring program, should be shared with policymakers at local, regional, and national levels. By highlighting the positive impact of the project, policymakers can be encouraged to adopt supportive policies, allocate resources, and integrate sustainable practices into urban development strategies.

Continuous Improvement: As the field of urban sustainability evolves, it is crucial to continuously review and refine the KPIs and monitoring program to stay aligned with emerging trends, technologies, and methodologies. Regular updates and revisions will ensure that the monitoring process remains relevant and effective in capturing the multifaceted aspects of urban sustainability.

The conclusions drawn from the UrbanGreenUP project, and the recommendations outlined above will guide future endeavours in urban sustainability, fostering a culture of data-driven decision-making, collaboration, and continuous improvement. The project's legacy will extend beyond its completion, serving as a catalyst for positive change and inspiring transformative urban development practices worldwide.