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DIVAIRCITY

The power of Diversity & Inclusion for Climate Neutral Cities

DivAirCity pilot cities data sources and their acquisition framework

Deliverable 2.4 - Public

Lead beneficiary: -

Disclaimer:

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History of Changes

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List of Acronyms

Acronym	Meaning
AB	Advisory Board
CA	Consortium Agreement
DoA	Description of Actions
GA	Grant Agreement
GeA	General Assembly
ICT	Information and Communication Technologies
NBS	Nature-Based Solutions
PC	Protected Categories
PCU	Project Coordination Unit
WP	Work Package

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Executive summary

Deliverable 2.4 - DivAirCity pilot cities data sources and their acquisition framework - analyses and selects the possible sources for the acquisition of the required data to be used in assessing needs at project and city-level as well as measuring the impact of NBS (Nature-Based Solutions) interventions.

The deliverable therefore plays a role in mobilising data sources and data collection to be used by project partners across the five pilot cities and most work packages moving forward covering the co-creation process, the implementation of living labs, smart contracts and impact evaluations.

In producing the deliverable content Task 2.4 (Identification of the data sources and their acquisition framework for DivAirCity) carried out the steps 1 to 6 in compliance with the data technical framework in dialogue with cities (DivAirCity data management steps of Digital Innovation and D&I Data Management Framework presented in D2.2). The generic framework has been utilised to the extent possible and various local conditions and data availability issues have been taken into consideration.

The deliverable describes the 33 indicators selected and the associated data sources identified. It is divided up into descriptive data intended to identify needs of citizens and detail the challenges at city, and (where possible) district level and impact assessment data. These impact assessment data are intended to analyse and describe the impacts of NBS interventions in the cities as well as the co-creation process itself for the participants.

For each data source described the Quality Assurance Maturity is assessed to facilitate the future work on particular data sources.

The deliverable further describes the impact assessment scenarios with city representatives. During the impact scenarios development, it became clear that some of the city partners expressed a need to measure e.g., temperature changes caused by the reflections of buildings and how shading could affect this. Therefore, the discussion of possible NBS-interventions with city partners has highlighted deficiencies among the indicators, provided an opportunity to expand the number of variables and adjust them according to the needs of the cities.

The deliverable also presents specific data gathering tools for consistent processes across cities and to support the needs analysis at city level as well as for the impact assessment. In addition, it details specific protocols for data gathering activities to facilitate the learning process needed to conduct the activities in the best possible way.

In the future work of DivAirCity, WPs 2, 3, 4, 5 and 6 will need to integrate piloting of data collection activities to test data material and relevance to index development, living lab implementation, blockchain business model implementation and impact assessment.

Work therefore remains to collect, analyse and present data findings for comparison and feasibility of generating valuable insights and knowledge for adjustment of co-creation processes, recommendation of measurement methods and NBS implementations.

1 Introduction

1.1 The objectives

The objective of WP2 is to provide the data analytics framework for the entire DivAirCity project, which will enable decision making and management of social involvement, through a strong Diversity and Inclusion (D&I) Data Framework (D&IDF). In this context, deliverable 2.4 analyses and selects the possible sources for the acquisition of the required data to be used in assessing needs at city-level and measuring the impact of NBS (Nature-Based Solutions) interventions. It includes the technical specifications for gathering, processing, and using data. Building on five city use cases, this deliverable creates data source scenarios that reflect a specific location, with inherent challenges and possible NBS interventions.

The deliverable builds on the following subtasks:

- Subtask 2.4.1 Develop the technical framework for the acquisition and processing of static data (such as the data from periodic reports, city, stakeholder, and regional statistical sources) and dynamic data (such as IoT and sensor networks, live data sources on weather and observatories etc.).
- Subtask 2.4.2 Identify requirements for Quality Assurance (QA) and Social Inclusion (SI) and the required actions for potential correction and missing data simulations.

1.2 Relation to other tasks and WPs

This deliverable plays a role in mobilising data to be used by project partners and the cities. It further creates links to the following tasks and work packages:

- Starting from the long indicator list developed in Task 2.1 and prioritising based on dialogue with cities and scientific partners the list of indicators according to relevance, impact assessment of NBS interventions in cities, feasibility, and data availability.
- Building on the data structure and steps developed in Task 2.2 by operationalising this structure in relation to the co-creation process phases.
- Building on the ethical code of conduct developed in T2.3 for primary personal data collection, analysis, and presentation. All personal data collection and processing will be carried out within the framework identified in Task 2.3.
- Contributing to the establishment of the indexes that represent important milestones in the DivAirCity project and will allow DivAirCity pilot cities to measure and compare how well they deal with air pollution and carbon reduction from a diversity point of view (T2.5).
- Contributing to the establishment of smart contracts with citizens that will offer citizens incentives to contribute to the improvement of air quality for diverse

groups of citizens in the participating cities. Citizens will actively be engaged to contribute data while at the same time contributing to improved air quality, carbon reduction as well as diversity among benefitting citizens (WP5).

- Supporting the measurement of the impact of NBS interventions at city and project level in relation to social, environmental, and economic effects (WP6).

2 Methodology

The methodology used in Task 2.4 and for the production of D.2.4 is described in this section covering selection and prioritisation of actionable data indicators, description of the technical methodology utilised for data acquisition and description of data sources, data availability/gathering methods.

2.1 Selection and prioritisation

Indicators have been defined in previous WP2 work and are important parameters to guide the needs analysis and impact assessment to be undertaken in DivAirCity. More than 100 hundred indicators were defined in T2.1 and for operational reasons it was necessary to prioritise the indicators.

For selection and prioritisation of indicators and related data sources, each city partner has been given the opportunity to rank and prioritise relevant indicators and from that identify available data sources (primary and secondary) as well as types of data related to the indicators specified in DivAirCity deliverable D 2.1. Data availability (see Deliverable 2.1.). For each of the DivAirCity Indicators listed in D.2.1, the city partners were able to indicate in columns categories of data availability, priority shortlist and comments for each indicator. The city partners were asked to specify the data availability and rank each of the 67 listed indicators based on relevance, data availability and feasibility for impact assessments. The purpose of this exercise was to understand the level of detail (times, information richness), and cross-city-comparability of existing data and data sources from each city partner, but also to identify areas where data collection and available data sources might constitute a challenge for the cities.

The city partners were asked to assess the importance of each of the 67 shortlisted indicators by ranking them from one to five (1= least relevant for their project - 5 = most relevant for their project). By comparing the rankings of each of the indicators provided by each city partner we were able to single out 33 indicators that seemed to be of relevance for all city partner (see Annex 4).

Based on these rankings, meetings were held with representatives of each partner city to discuss their ranking, collection of data, the availability or lack of availability of data for the selected 33 indicators (see Annex 5).

Apart from giving an indication to data availability, these meetings also clarified needs for data gathering instructions and challenges faced by each city not covered by the selected indicator and data sources (e.g., exact definition of indicator; possible metrics and data gathering methods).

2.2 Technical methodology utilized for Data Acquisition

Digital Innovation and D&I Data Management Framework, provided the guideline for cities to conduct data processing. The proposed data management steps are shown in Figure 1.

Figure 1: DivAirCity data management steps (See Deliverable 2.2 Digital Innovation and D&I Data Management Framework)

Task 2.4 carried out the steps 1 to 6 in compliance with the data technical framework in dialogue with cities. The generic framework has been utilised to the extent possible and various local conditions and data availability issues have been taken into consideration.

The section below provides an overview of the steps completed and the steps still to be carried out based on the framework.

It compares the nine steps of the data management structure with the four co-creation phases introduced in Deliverable 3.1 on co-creation covering the double diamond and its four phases - Discover, Define, Develop and Deliver. From this, DivAirCity developed the Diversity and inclusion co-creation framework with the following phases - Co-creation, co-design, co-develop, co-monitoring plus a fifth phase covering "Deliver and make it sustainable phase".

Steps 7-9 are not covered at this stage as the project data framework management is not quite ready for these steps yet.

2.2.1 Step 1 - Target and Objective Definition

Step one covers Target and Objective definition including defining the challenges and impacts planned of interventions. It aims to define the overall objectives which cities have and find related indicators to monitor changes to these action areas.

Table 1: Status of Data Management Step 1

Step	1. Target and Objective Definition
Framework Proposition	• Identify the impact planned • Identify the categories and subcategories of the objectives, such as social, environmental, and economic categories
Actions carried out with Cities	• The core objectives identified by the cities during the project initiation and later during Task 2.1 actions have been taken as reference • Meetings held with city stakeholders on further identification of the high-level objective • These insights are used to further define and prioritise the key indicators
The co-creation phase	• This step is expected to be done during the "A) Understanding & establishing co-creation" phase and "B) Defining & co-designing discover and define" phases (See p. 9, Deliverable 3.1. A Diversity and Inclusion Co-creation Framework)
Completion Level	• The objective definition is still under development, but can be completed according to the co-creation process

2.2.2 Step 2 - Indicator Selection

Step two covers Indicator selection in terms of how the project will monitor progress, achievements, and impact. It aims to select relevant indicators which can monitor progress towards meeting these initial objectives.

Table 2: Status of Data Management Step 2

Step	2. Indicator Selection
Framework Proposition	• Analyse the long list of indicators related to the city objectives (available as an excel tool and Deliverable 2.1 in the DivAirWiki site) • Filter through the indicators to create a short list of target indicators for each city
Actions carried out with Cities	• Task 2.4 has initiated the data source work based on the objectives and indicator selection • A short list of 33 indicators have been created via workshops with cities • The indicators' technical requirements have been further analysed
The co-creation phase	• This step is expected to be done during the "A) Understanding & establishing co-creation" phase and "B) Defining & co-designing discover and define" phases
Completion Level	• Completed as a short list • Further prioritisation of "low hanging fruits" is possible for specific data analysis requirements

2.2.3 Step 3 - Data Requirement Analysis

This step covers Data requirement analysis examining the data requirement for each of the indicators selected. For each indicator selected by the city, its factsheet should then be consulted for more detail about what is required and specifically what data sources are needed to calculate the indicator.

Table 3: Status of Data Management Step 3

Step	3. Data Requirement Analysis
Framework Proposition	• For each indicator selected by the city, the factsheet shall be consulted for more detail about what is required in the data collection phase. • Analysing specifically what data sources are needed to calculate the indicator.
Actions carried out with Cities	• Analyses are made for each indicator on the data each city already possesses

	• The availability and acquisition needs of the data are defined • The missing data is identified • Data acquisition needs discussed, and source identification initiated • Various data compensation or alternative calculation models are analysed
The co-creation phase	• This step is expected to be done during the "A) Understanding & establishing co-creation" phase and "B) Defining & co-designing discover and define" phases
Completion Level	• The actions related to this phase is ongoing. • Findings are shared in this document as narrative and as look-up tables in the following sections • Further analysis during data (co)creation process will support this step

2.2.4 Step 4 - Data Planning

Step four covers the Data Planning incl. Data collection, storage and analysis. Prior to an organisation collecting any data, planning is the important first step in the process of the data lifecycle, beginning with determining what data needs to be collected and how it will be managed.

Table 4: Status of Data Management Step 4

Step	4. Data Planning
Framework Proposition	• For planning data collection and storage, the framework provides: o A Digitized asset catalogue/entity table – this provides data on entities and sources created (Excel sheet) o Indicator fact sheets including data samples o A template for data exchange agreement
Actions carried out with Cities	• The data sharing agreements and collection planning are analysed, but official data sharing agreements and finalised plans are not within the scope of the task
The co-creation phase	• This step is expected to be done during the "A) Understanding & establishing co-creation" phase and "B) Defining & co-designing discover and define" phases
Completion Level	• Not within Task 2.4 scope

2.2.5 Step 5 - Data Collection

Step 5 covers how Data Collection will take place. This includes the ingestion of pre-existing data from secondary sources as well as the collection of new data to improve the quality of that which already exists. In this stage, it is important to prepare data for storage in a uniform way to make it easier to maintain in the future. The tools devised in Deliverable 2.4 (see Appendices) will support this uniformed data collection.

Table 5: Status of Data Management Step 5

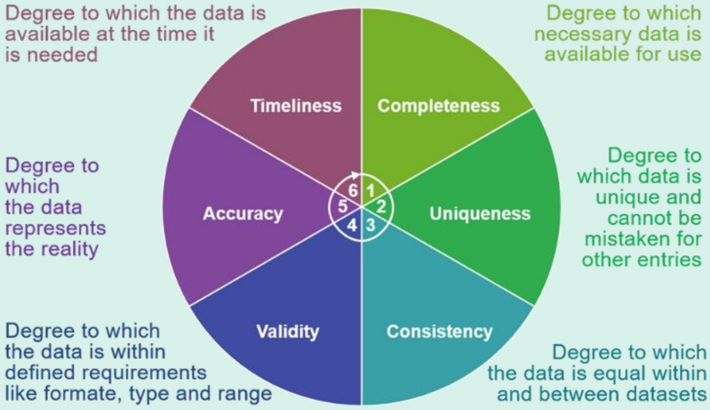
Step	5. Data Collection
Framework Proposition	• This step includes acquisition of pre-existing data from secondary sources as well as the collection of new data to analyse and enrich the data pool.
Actions carried out with Cities	• The data collection phase is not in the scope of T2.4 and has not been initiated • Sample data has been researched for quality and scope analyses purposes
The co-creation phase	• This step is expected to be carried out during co-creation phases. Some descriptive KPIs need to be collected during "A) Understanding & establishing co-creation" phase to understand the intervention area, some KPIs during "B) Defining & co-designing" and "C) Materialising & co-developing" phases to monitor engagement, and others need to be collected before and after the co-creation
Completion Level	• Not within Task 2.4 scope

2.2.6 Step 6 - Compliance to Quality Assurance requirements

Step 6 covers the process of ensuring Compliance to Quality Assurance requirements in the data collection and management procedure.

Table 6: Status of Data Management Step 6

Step	6. Compliance to Quality Assurance requirements
Framework Proposition	• The data quality requirements are defined in Deliverable 2.2, Chapter 4.6. The core 6 compliance requirements for data QA are: o Accuracy o Completeness o Timeliness o Uniqueness o Consistency o Validity

	
Actions carried out with Cities	• The data quality analyses have been initiated • Three data quality maturity levels have been identified to classify the actions needed for the data quality assurance needs: o QA Satisfactory – Compliant with the predefined requirements and common practice. In case of sensors, the accuracy is satisfactory based on the utilization of approved calibration processes. o QA Needs further Investigation – Not sufficient information is available now on the compliance of the QA requirements. The compliance will be further analysed and documented. o QA In Development – where the data needed is still to be compiled and the related procedures are being established
The co-creation phase	• This step is expected to be carried out during the "D) Co-monitoring" phase in co-creation framework (See p. 9 Deliverable 3.1. A Diversity and Inclusion Co-creation Framework) regarding impact assessment KPIs, but it is important to be checked during co-creation phases whenever the data is collected.
Completion Level	• Needs further analyses during data availability enhancement • The QA Maturity levels are used for definition of future actions needed

2.3 Data source identification/availability

2.3.1 Secondary Data

Each of the five pilot cities have contributed to identifying their city, regional and national secondary data sources of relevance to the DivAirCity project which will help the project understand the environmental, social, and economic needs at city level.

2.3.2 Model-based Data

Both at city level and at global level the project will make use of data that have been derived from calculated local estimates that builds on other data of less granularity. As an example, spatially distributed annual mean values for air pollution data in Aarhus is calculated at street level using a specific model that is validated against accurate measurements from two monitoring stations located in the city of Aarhus, but which has been validated against measurements from many other cities in Denmark and abroad. Similarly, other model-based data will be needed to describe the likely needs in specific intervention areas to be verified with primary data where possible during the project. Model based data therefore will allow DivAirCity to deal with limitations in both secondary data and primary data, incl. limitations of simply not being able to gather data.

2.3.3 Primary Data

It has become evident from the discussions with city representatives that the need for primary data gathering is substantial. It covers social, environmental, and economic data and to ensure comparability, consistency, completeness and timeliness in relation to ongoing co-creation activities, it was deemed necessary to undertake detailed exchanges on specific data gathering tools in particular for social and economic (before and after) impact assessment data.

The application of data source in relation to the overall stages of the DivAirCity project at city level as well as at city intervention level is illustrated in Figure 2 below:

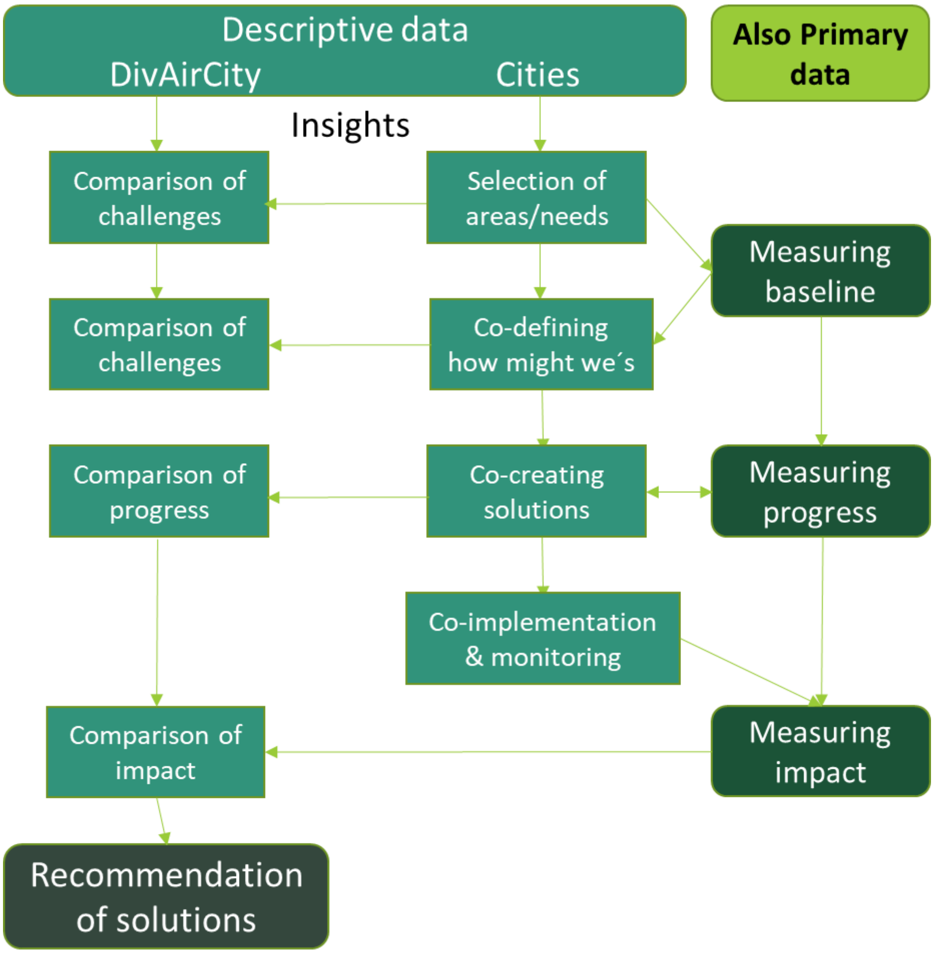


Figure 2: Use of data in relation to main DivAirCity stages

3 Data sources, collection & presentation requirements

This chapter will describe the 33 indicators selected and the associated data sources identified. It is divided up into descriptive data intended to identify needs of citizens and detail the challenges at city, and (where possible) district, level and impact assessment data intended to analyse and describe the impacts of NBS interventions in the cities as well as the co-creation process itself for the participants.

3.1 Data sources and collection for selected indicators

This section details the data sources identified or remaining to be identified to address and measure the indicators selected by the cities for citizen needs and challenge analysis as well as co-creation and NBS intervention impact assessments. It covers both secondary and primary data sources, the use of modelled data and covers the three focal areas social, environmental, and economic assessments.

Depending on the data availability, various information through different visualisation methods can be produced. In this chapter, the KPI visualisations are suggested for guidance purposes (e.g., cities can understand 'what can be done if we provide the data'). The following tables show the five cities' status of data availability according to the colour code in Table 9.

Table 7: Data status code

Data is available	Data is available, but need to be reshaped for use	Data need to be collected, and tools are available	Data is not identified

3.1.1 Secondary data

Secondary data represents data that has been gathered, produced, and made available by other data providers. DivAirCity will gather and analyse this data to understand needs and facilitate impact assessment of its living lab interventions.

3.1.1.1 Social

Indicator 1.1.1 Actors available

Cities will have registrations of voluntary organisations, associations, social and sports clubs with relevance to diversity, inclusion, air quality or climate action.

It is important to register NGOs, associations, social clubs, schools and children's institutions with relevance to the 6+1 target groups (See Annex 1).

Furthermore, the cities may need participation from associations, NGOs etc. relating to the environmental topics and progression of these for the benefit of citizens within DivAirCity activities (See Annex 2).

By providing data above, the cities can identify the key civil society organisations and types of their activities with the 6+1 groups. Through this, DivAirCity project manager can monitor the project, and city partners can understand their participatory culture and engage more stakeholders.

Total number of identified stakeholders by city: Total number of identified stakeholders by city can be mapped with the geolocation. With data before and after interventions, the DivAirCity project and stakeholder contributions to nurture participation in cities can be examined.

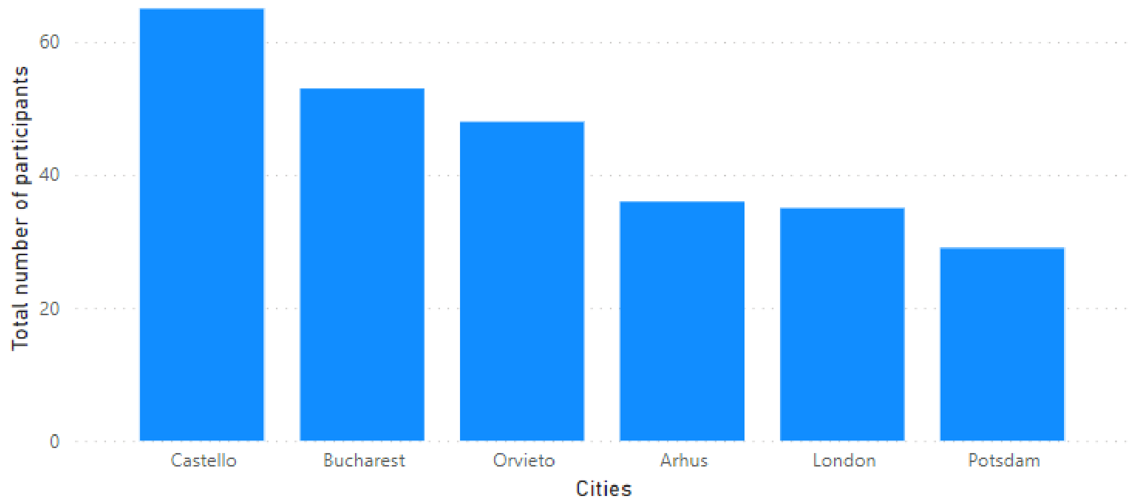


Figure 2: Total number of identified stakeholders by city (synthetic data)

Table 8: Data quality maturity level of total number of identified stakeholders by city

Input data	Data source	Status
Maps with district borders	Open maps	Maps exist
Total number of stakeholders	Manual input	Five cities' data is collected in the beginning of the project but need to be updated and reformulated in the template structure

Collection Date	Manual input	Five cities' data needs to be updated and reformulated in the template structure
Data quality maturity level: QA Satisfactory		

Count of stakeholders by 6+1 categories: The stakeholders can be categorised by 6+1 groups. It will show the cities' context, e.g., which communities are relatively more active. It can be filtered by city.

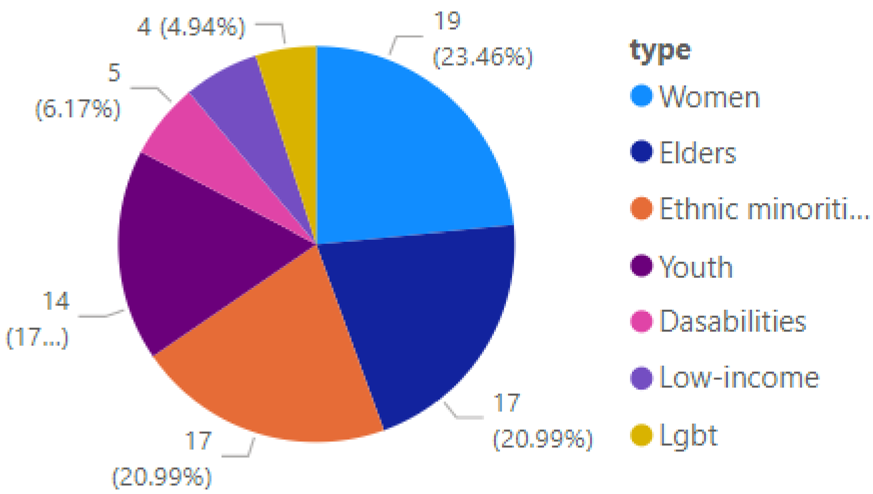


Figure 3: Count of stakeholders by type (synthetic data)

Similarly, other stakeholders will be categorised by type of environmental theme covered with relevance to DivAirCity challenges.

Table 9: Data quality maturity level of count of stakeholders by 6+1 categories

Input data	Data source	Status
Maps with district borders	Open maps	Maps exist
Total number of stakeholders	Manual input	Five cities' data is collected in the beginning of the project but need to be updated and reformulated in the template structure
Location of each organisation	Manual input	
Types of stakeholders	Manual input	

Data quality maturity level: QA Satisfactory

Ratio of committee participants: The data can show how many organizations participate in DivAirCity committee (see DivAirCity Deliverable 1.10) among the identified organizations. It will show the level of engagement in DivAirCity project. It can be filtered by city.

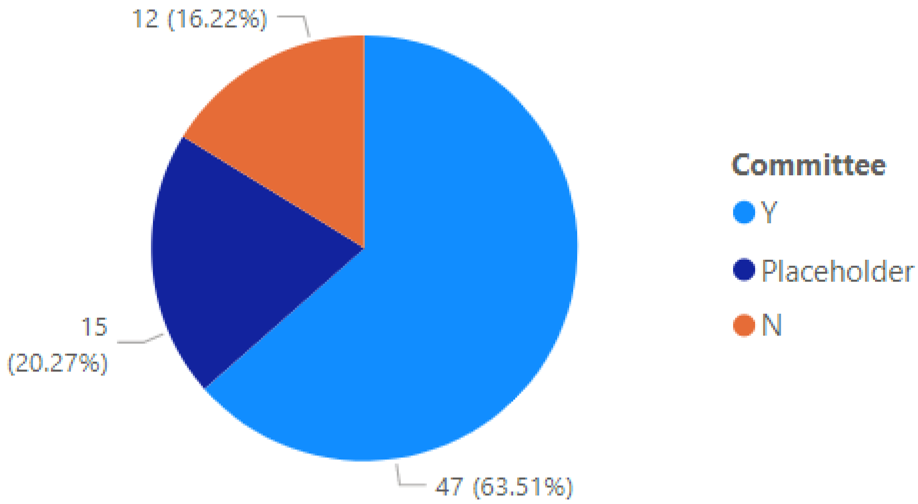


Figure 4: Ratio of committee participants (synthetic data)

Table 10: Data quality maturity level of Ratio of committee participants

Input data	Data source	Status
Total number of stakeholders	Manual input (tool XX)	Five cities' data is collected in city DNA but need to be updated and reformulated in the template structure
City where each organization located in	Manual input (tool XX)	
Location (address) of each organisation	Manual input (tool XX)	Orvieto data is available
		Other four cities' data need to be collected
Steering committee participation	Manual input (tool XX)	Orvieto data is available
		Other four cities' data need to be collected
Data quality maturity level: QA Needs further Investigation		

A dashboard of actors available, containing the information above, can be produced as below:

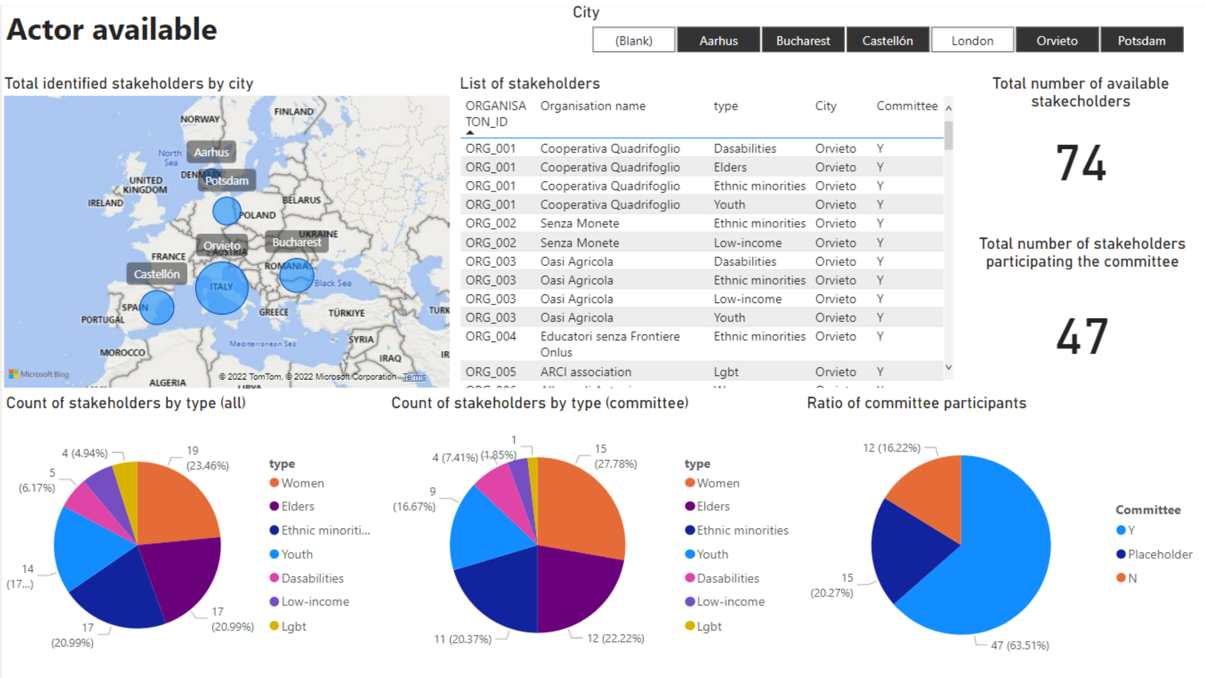


Figure 5: Actor Available dashboard (synthetic data)

<u>Indicator 1.1.2 Participatory culture in relation to air quality, carbon emissions and diversity/inclusion.</u>

With this indicator, DivAirCity wishes to measure the capacity of each city to conduct citizen participation. In other words, cities are asked to register the existing capacities and measures put in place to address the issues relating to DivAirCity's challenges.

For instance, cities may have a strategy and or a plan for climate actions. As an example, Aarhus has a climate action plan approved in 2020 by C40 Cities Climate Leadership Group and Denmark's leading climate think tank Concito.

The data will be analysed by cities and categories similarly to the Indicator 1.1.1.

Table 11: Data quality maturity level of Participatory culture

Input data	Data source	Status
Type of the policy and target year	Manual input	Data need to be collected, and the template is drafted (see Annex 2)
Data quality maturity level: QA Needs further Investigation		

Indicator 1.1.4 Population composition

In order to understand the representation of relevant citizens groups and coverage of 6+1 target groups in the city interventions, DivAirCity needs to understand how the population is composed in the city and its districts where the interventions are being implemented. Therefore, measuring this indicator requires two datasets, one for the city as a whole and one for the city district(s) covered by the interventions.

The two data sets will also help DivAirCity calculate the population density of the city and relevant districts based on the map coordinates provided for the districts, calculated as number of people per Sq. kilometre. This is relevant to examine, because research (Borck and Schrauth, 2021) shows that higher urban population density leads to higher levels of air pollution. Also, it will allow the project to calculate the existing amount of green space in Sq. meters per inhabitant. This is relevant to understand how difficult it may be for people to find green recreation areas near households in the district. There will be individual differences in terms of how difficult it is but if from the outset there are limited green spaces, then the individual difficulties are bound to be even more severe.

As far as possible district populations should be drawn from most recent census and broken down into:

1. Gender
2. Age (0-4; 5-9; 10-14; 15-64; 65-84; 85+)
3. Ethnicity
4. Citizenship
5. Household income (in percentage of the city average; in percentage of the EU average)
6. Occupation (employed, unemployed, self-employed, student, retired, other)
7. Educational Attainment levels (low –0-2; Medium 3-4; High 5-8)

This population breakdown is important to understand as far as it is possible the representation of different vulnerable groups in the city populations in the districts.

This measurement method will therefore also address the *indicator 1.3.10* on income and work to the extent it is possible in the designated districts. In other words, it will show the level of unemployment/employment as well as average household income compared to other city districts. The indicator 1.3.10 will also be addressed with primary data gathering from questionnaires (see section on 1.3.10)12

Total population of city: Total population of city is a basic information of cities. The DivAirCity project includes cities with various sizes, so having total population information can be useful to understand interventions and other KPIs.

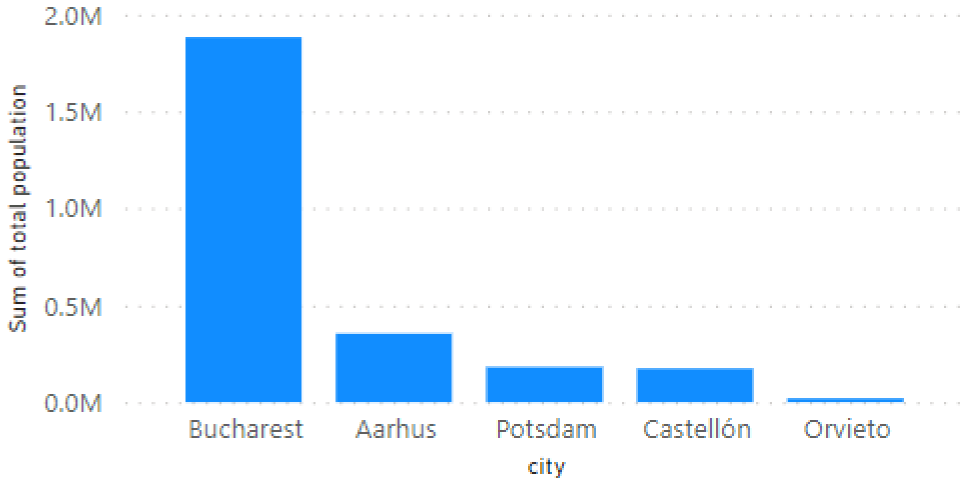


Figure 6: Total population of city (Five pilot cities' recent Census data)

Table 13: Data quality maturity level of total population of city

Input data	Data source	Status
Maps with district borders	Open maps	Maps exist
Total population	Census data of each city	Censuses exist but need to be reformulated in the template structure
Data quality maturity level: QA satisfactory		

Population aged under 17 and population aged over 65: Another basic demographic information of a city is the age groups of the population. Among 6+1 groups, the total population of elderly and children can be identified relatively easily compared to ethnic minorities or LGBTQI+ communities. Comparing the data among five cities can be beneficial to understand the city's context. For example, Orvieto shows a higher proportion of elderly communities compared to other cities as can be seen in the data, which means elderly groups might be the important target group, especially in Orvieto.

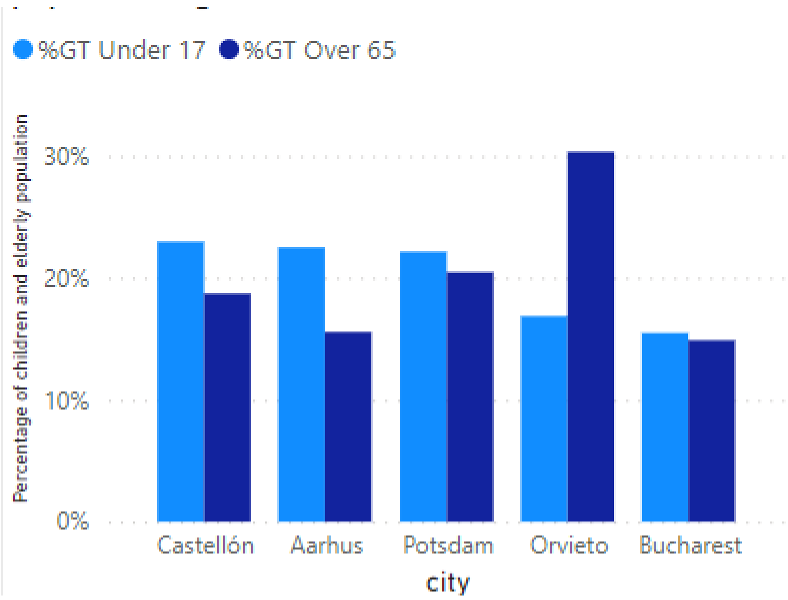


Figure 7: Population aged under 17 and population aged over 65 (Five cities' recent Census data)

Table 14: Data quality maturity level of population aged under 17 and population aged over 65

Input data	Data source	Status
Maps with district borders	Open maps	Maps exist
Population of children and elderly	Census data of each city	Censuses exist but need to be reformulated in the template structure. The existing data structure of Census of each city need to be checked (e.g., definition of age groups in each city's Census)
Data quality maturity level: QA satisfactory		

Population holding other citizenships: Census commonly have data about citizenships. Population holding other citizenships can be used as an indicator reflecting city's diversity although it is different from the ethnicity data.

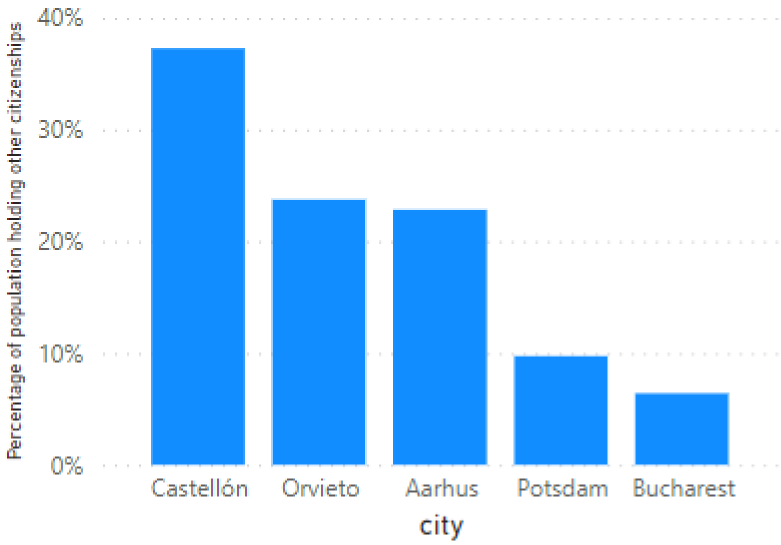


Figure 8: Population holding other citizenships (Five cities' latest Census data)

Table 15: Data quality maturity level of Population holding other citizenships

Input data	Data source	Status
Population holding other citizenships	Census data of each city	Censuses exist but need to be reformulated in the template structure.
Data quality maturity level: QA satisfactory		

The dashboard of population composition, containing information above, can be produced as below:

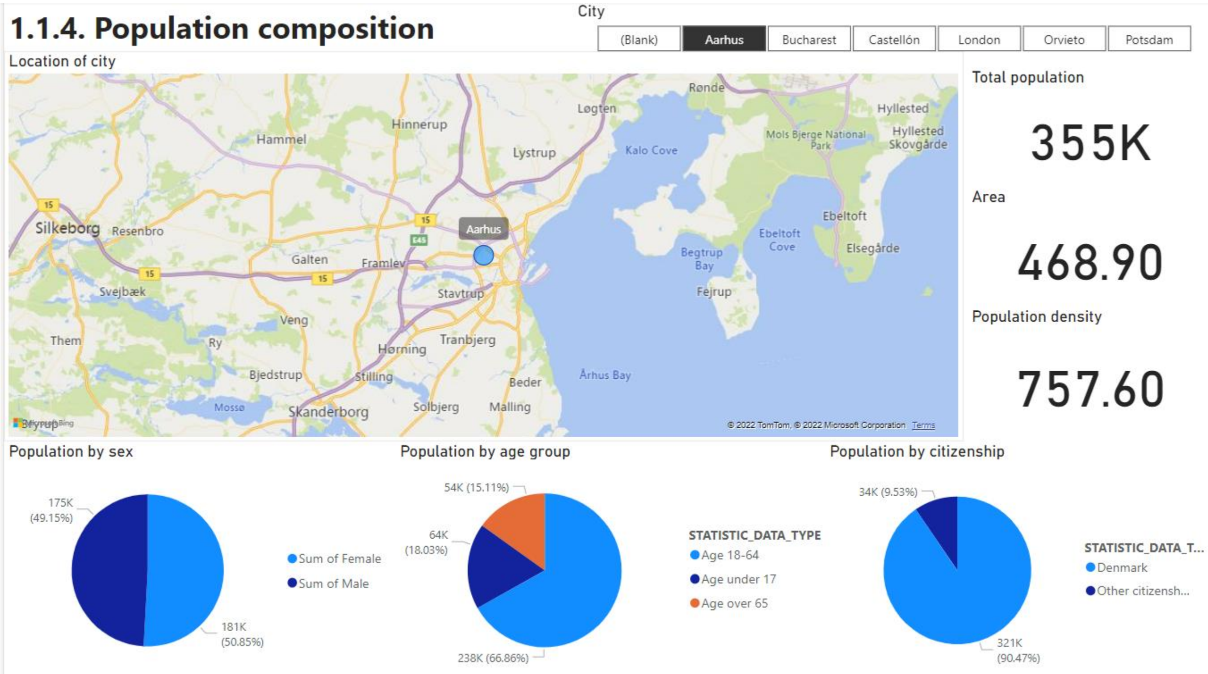


Figure 9: Population composition dashboard 1 (Five cities' latest Census data)

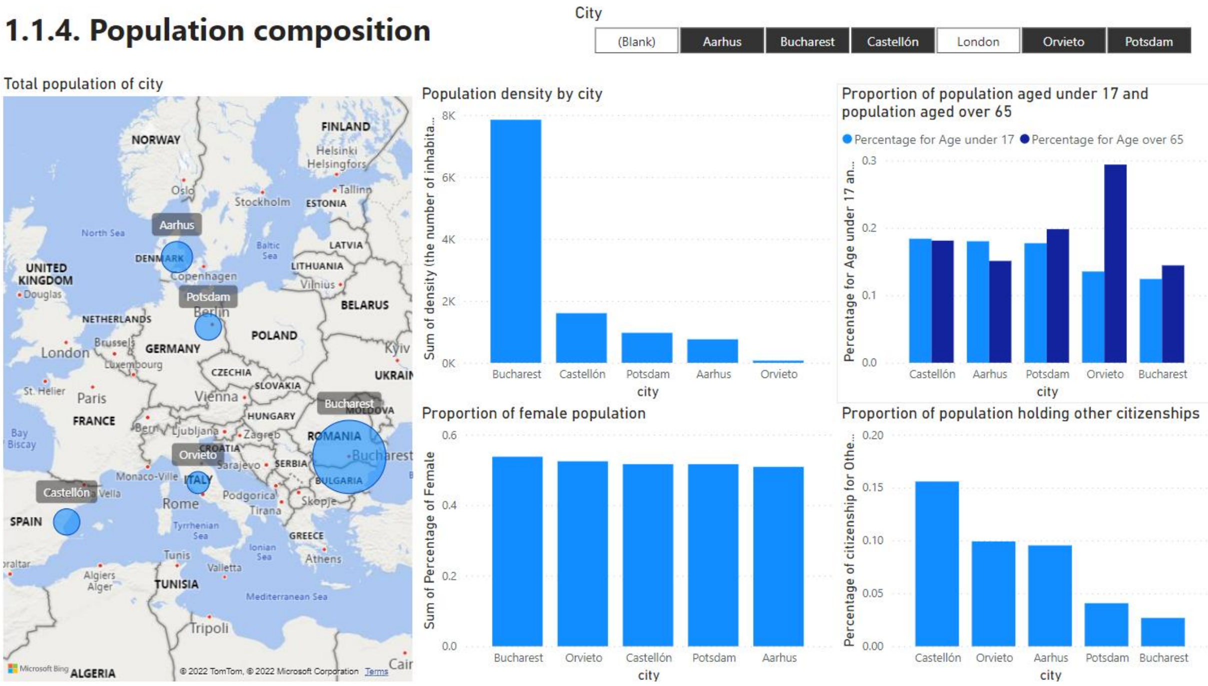


Figure 10: Population composition dashboard 2 (Five cities' latest Census data)

Indicator 1.3.14 Safety and security

This indicator should be addressed by accessing data statistics on crime incidences and accidents from the local police office or municipal data collections of registered incidences. The question is how densely the data can be collected and whether in fact it is registered per street. Also, there are in some of the five countries secondary data on people's sense of security and safety in public spaces, in streets and in traffic. This is however difficult to obtain broken down into districts. As an example, in Denmark it can be broken down into police districts and Aarhus is part of a police district with six other local authorities. The general sense of security is good for 88.6% of the population, but for Aarhus (the most urbanised of the 7) it is 86.0% and certain districts with large proportions of citizens with other ethnic backgrounds it is much lower than that (59-68% of the population feel safe in these areas). However, these areas in Aarhus do not have air quality issues and have not been chosen for interventions.

This data from 2021 in Aarhus also shows where most people feel insecure and that is on paths, at train stations or bus stops and in parks/playgrounds. The national data from the same 2021 report from Ministry of Justice (Justitsministeriet, 2021) shows that generally a larger proportion of women feel insecure than men and the young feel more insecure than the elderly.

There is an opportunity to measure this indicator for all five cities using the granularity of data provided (subject to availability) as an indicator of the extent to which security and safety are critical issues in each of the cities. Additional detail on security parameters can be found in Annex 3.

The method of data analysis needs to be developed depending on the data availability and structure.

Table 16: Data quality maturity level of Safety and security

Input data	Data source	Status
Survey result regarding sense of security and safety	Secondary data such as city level safety report	Not yet identified over all five cities. Metrics and data inventory need to be finalised with five cities.
Data quality maturity level: QA Needs further Investigation		

Indicator 1.3.18 Air quality and diversity

By combining modelled air quality data with citizens characteristics from several statistical databases (incl. age, history of residence, health journal, family situation, education, housing, income, tax, employment, and social services) it is possible to identify areas where larger proportions of vulnerable groups live and where they are exposed to episodic or permanent high air pollution concentrations. This was the approach to selecting the two city districts in Aarhus to be the basis for DivAirCity interventions in Aarhus.

Some cities are using similar methods to the selection of districts and areas of intervention whereas other cities have selected districts based on the existence of vulnerable groups in areas with lack of green environment.

Percentage of ethnic/income/age groups by neighbourhood: There is a benefit of the smaller scale demographic data rather than city level data. The city partners can identify which area has more concentrated 6+1 groups compared to other parts of city.

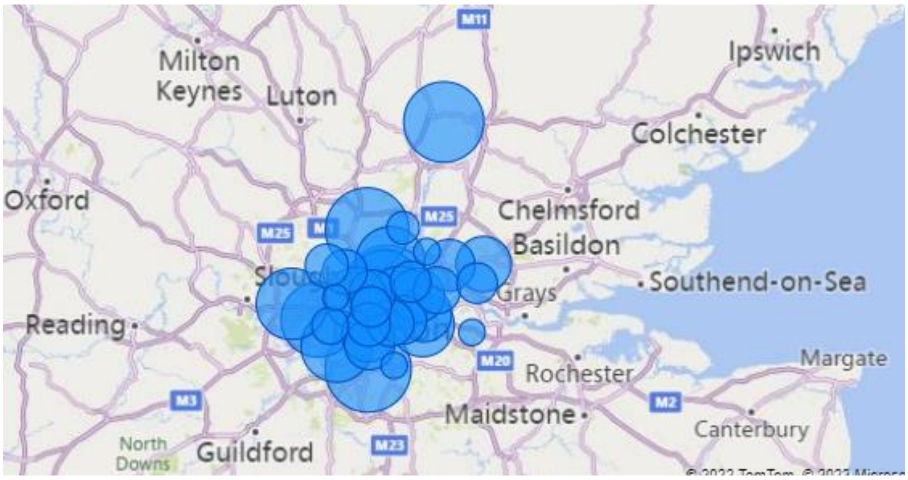


Figure 11: Percentage of Asian population by neighbourhood (Synthetic data on London map)

Table 17: Air quality and diversity

Input data	Data source	Status
Maps with district borders	Open maps	Maps exist
Neighbourhood level census data – ethnic groups	Census	Not yet identified
Data quality maturity level: QA In Development		

Average air pollution level and household income by neighbourhood: This smaller scale data is also beneficial to do cross-referenced analysis such as the correlation between air pollution and income level as seen in Figure 13. The specific parameter to use (e.g., PM2.5 annual mean) will be decided through the consultation with technical partners.

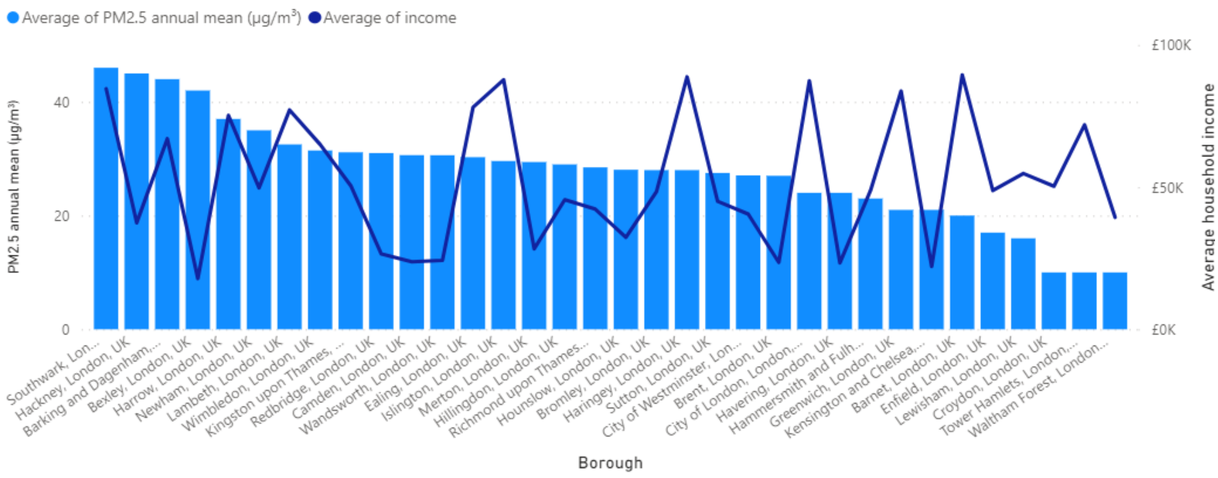


Figure 12: PM2.5 annual mean (μg/m³) and household income by neighbourhood in the year (Synthetic data on London map)

Table 18: Air quality and diversity

Input data	Data source	Status
Neighbourhood level census data - household income level with household's ethnicity	Census	Not yet identified
Neighbourhood level air quality data	Air quality data	Cities have a number of sensors, but the data availability need to be further discussed to provide uniformed and comparable data
Data quality maturity level: QA In Development		

The information such as ethnicity breakdown in neighbourhood and air quality can be produced as an interactive dashboard as below.

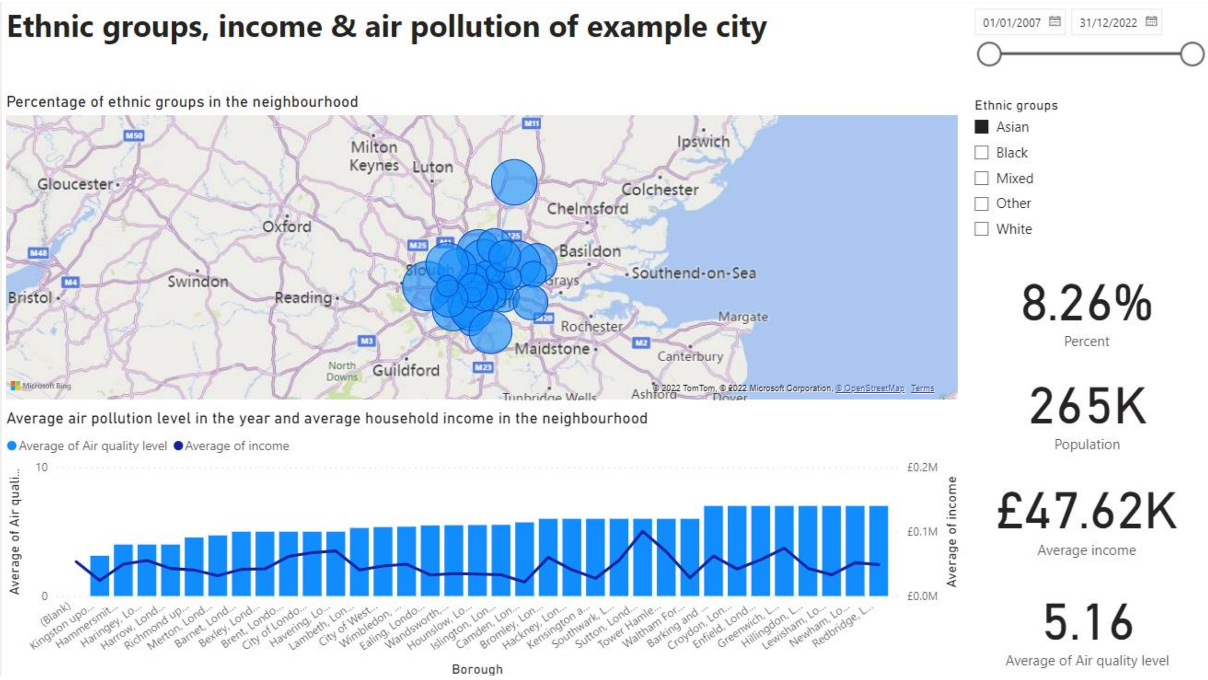


Figure 13: Air pollution and diversity dashboard (Synthetic data on London map)

3.1.1.2 Environmental

<u>Indicator 2.1.1 Residential building quality</u>

There are two factors relating to this indicator. The first is to what extent indoor climate of residential buildings in the city intervention areas are affected by outdoor pollutants. The outdoor pollutants enter the house through natural ventilation sources (open windows, doors); mechanical ventilation; and through filtration. The filtration is to do with the general quality of the building and the building materials used. The second factor is the energy rating of the buildings in terms of energy consumption for heating and electricity and the implication for CO_2 emissions as well as potential for reductions.

There are EU databases on building stocks where it is possible to look up building quality data at least for the participating countries and perhaps even for cities where interventions are planned. Some of the data can be estimated simply from the age of the buildings and local knowledge of the building materials (window quality i.e., amount of glass panes used in the construction, wall material and thickness; insulation material used and thickness), where it is possible to look up building quality data at least for the participating cities and perhaps even for city districts where interventions are planned. Some of the data can be estimated simply from the age of the buildings and local knowledge of the building materials (window quality i.e., amount of glass panes used in the construction, wall material and thickness; insulation material used and thickness).

The data available covers:

- U-value of building envelope, walls, floors, roofs, and windows measured as the rate of transfer of heat through a structure (W/m²K)
- Residential energy consumption at normal climate in Kwh/m2
- Residential buildings according to construction date
- Share of nearly zero-energy building in construction for residential (for some countries)

It is unclear what sources are available at national and city level to supplement these EU data resources.

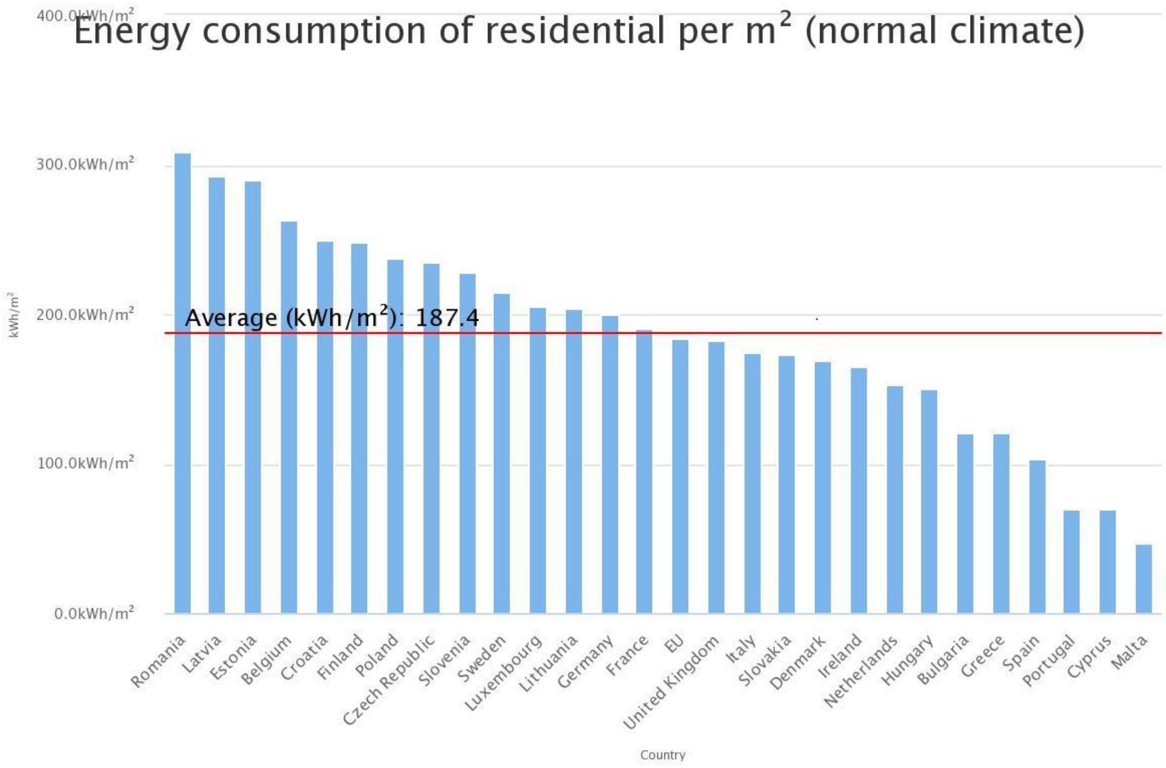


Figure 14: **Energy consumption of residential per m2 (normal climate 2016**

Table 19: Data quality maturity level of Residential building quality

Input data	Data source	Status
Building quality (age and material of buildings)	Building stock GIS data	The data availability needs further investigation.
Data quality maturity level: QA Needs further Investigation		

Indicator 2.1.2 Connectivity of green space

This indicator will be addressed using secondary GIS data to measure the structural connectivity providing grades of connectivity from 1 (very low) to 5 (very high). In fact, this has been conducted in Aarhus via a North Region project[1] reporting in 2021 examining green space connectivity in five northern cities. It found that the mean distance to parks in Aarhus was 2.4 km: 880 meters to cemeteries, 118 meters to forests and for green spaces in general 109 meters. Similarly, the other cities may be able to measure using GIS data the mean distance from dwellings to green spaces for citizens in their cities. Here, it needs to be considered that in the Nordic countries, cemeteries are very green parks and used for recreational purposes as well as spiritual connection to deceased loved ones. This is not necessarily the case in other countries.

- The restriction of green spaces in urban areas strongly accentuate a negative impact on the quality of life and health status of the population. As a comparison to Aarhus, Bucharest has a net loss of green space average surface, i.e., 9,67 m2/ inhabitant in 2008, compared with the standard of the European Union which is 26 m2/inhabitant. It is estimated that Bucharest has lost since 1990 and to date, over 1.5 million trees. The green areas extinction rate is estimated at 100 ha / year, which has led to a significant reduction of green spaces of the Bucharest capital's city area (National Journal no. 4658 / April 24, 2008, p. 5). Today, it is estimated to be 7m2 per capita in Bucharest2

The data can be calculated through open-source map or satellite image, but the contribution of technical partners is needed. Otherwise, other secondary data such as green space reports can be used if it is available. Through the information, city partners can identify their target area and monitor the green space connectivity.

Functional and structural connectivity of green spaces: It can be calculated through satellite images.

[1] Layout-WP-1.pdf (nordregioprojects.org)
[2] Romania: area of green spaces per inhabitant 2021 | Statista

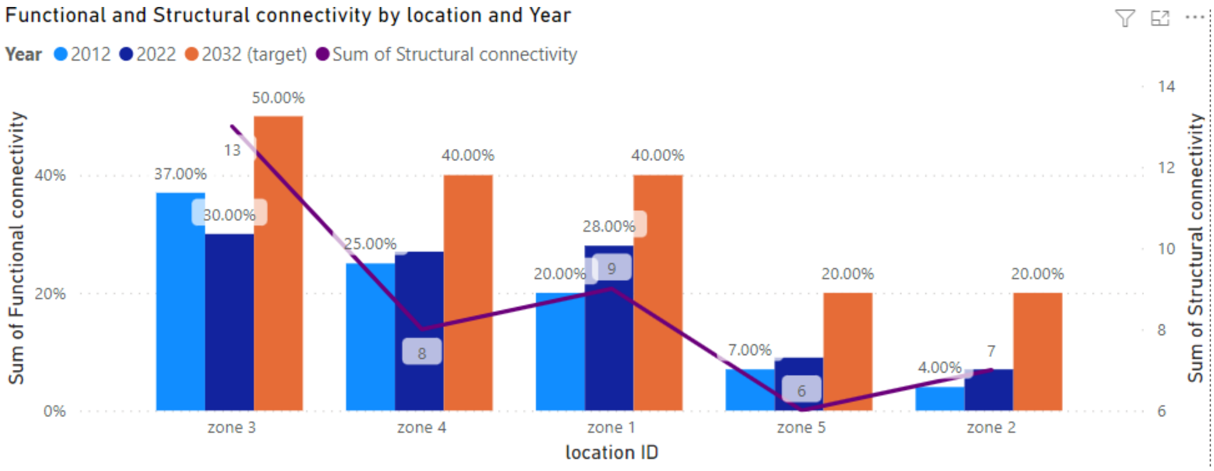


Figure 15: Functional and Structural connectivity of green spaces (Synthetic data)

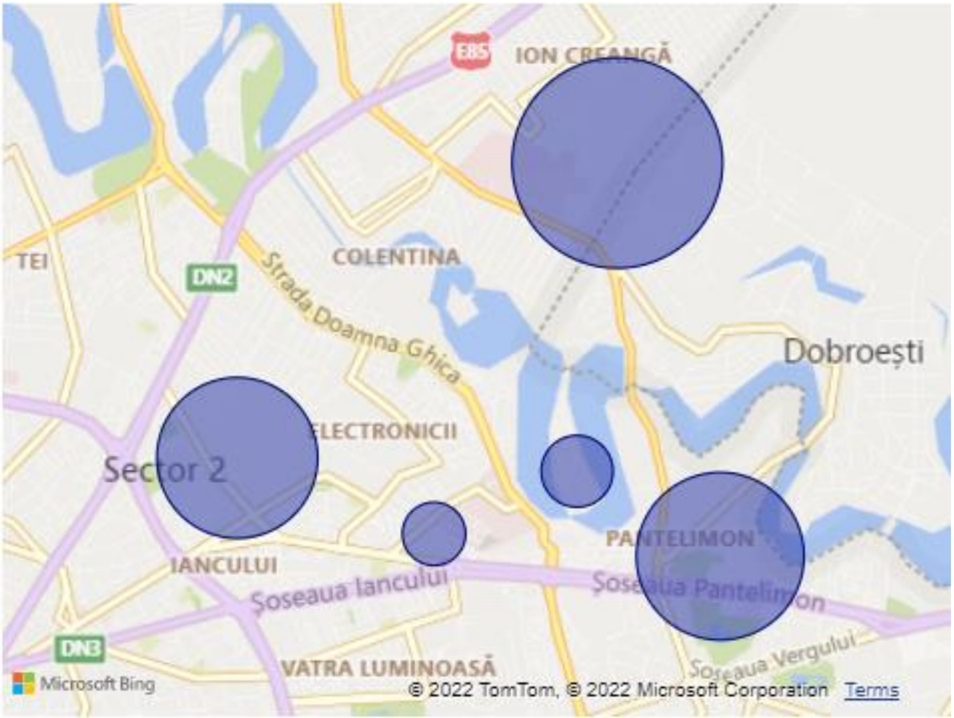


Figure 16: Functional connectivity by location (Synthetic data)

Table 20: Data quality maturity level of Functional and Structural connectivity of green spaces

Input data	Data source	Status
Satellite image	Open-source data	Data exists but need to be processed by a technical partner
Data quality maturity level: QA Satisfactory		

Indicator 2.1.3 Green space management

For this indicator the purpose is to measure the amount of green space within the city boundaries prior to the project interventions per capita. This is possible via national statistical sources of space breakdown into types. For instance, it can be found that for Aarhus the Sq. meters of parks, sports fields and other recreational spaces have diminished from 46.7 m2 per capita in 2011 to 43.9 m2 in 2018.

Equally, woods Sq. meter per capital has decreased from 143.1 in 2011 to 130.3 in 2018. These decreases are not due to areas diminishing but mainly due to the population of Aarhus increasing. Incidentally the statistical source can also provide data of Sq. meters of roads, buildings, agricultural land, meadows, lakes, and streams, etc.

- More detailed green space calculation for intervention areas will require accurate coordinates of the area and an examination of satellite data to quantify green spaces. Like the connectivity, the open-source map or satellite image can be used to calculate the data although the technical knowledge is required.

Green space per capita: It can be calculated by using satellite images, and total population of the area (1.1.4. Population composition)

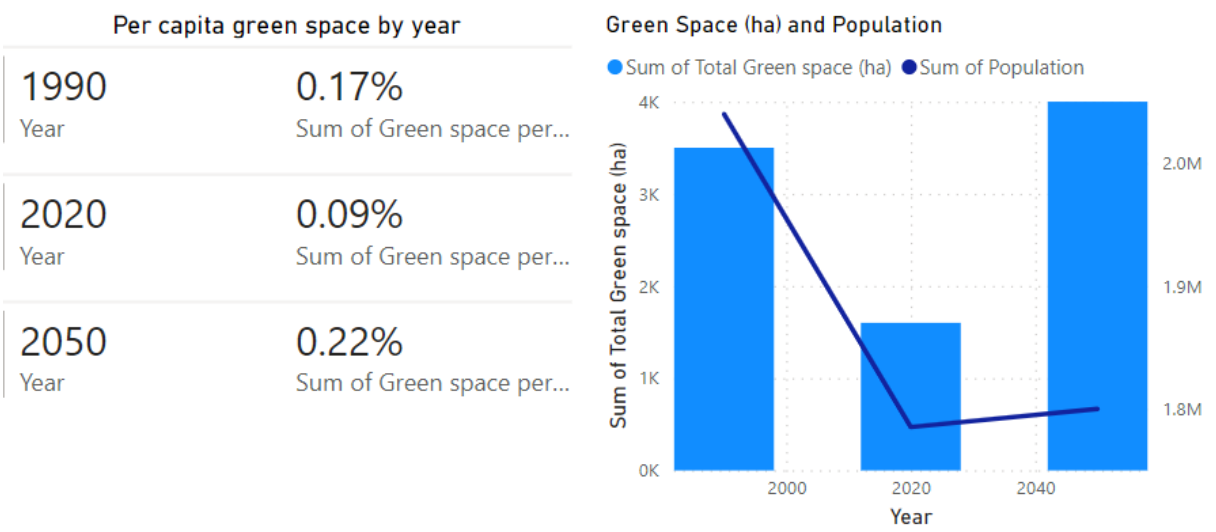


Figure 17. Green space per capita (Synthetic data)

Table 21: Data quality maturity level of green space per capita

Input data	Data source	Status
Satellite image	Open-source data	Data exists but needs to be processed by a technical partner

Total population of city	Census	Censuses exist but need to be reformulated in the template structure
Data quality maturity level: QA Satisfactory		

The dashboard of green spaces, containing information above, can be produced as below:

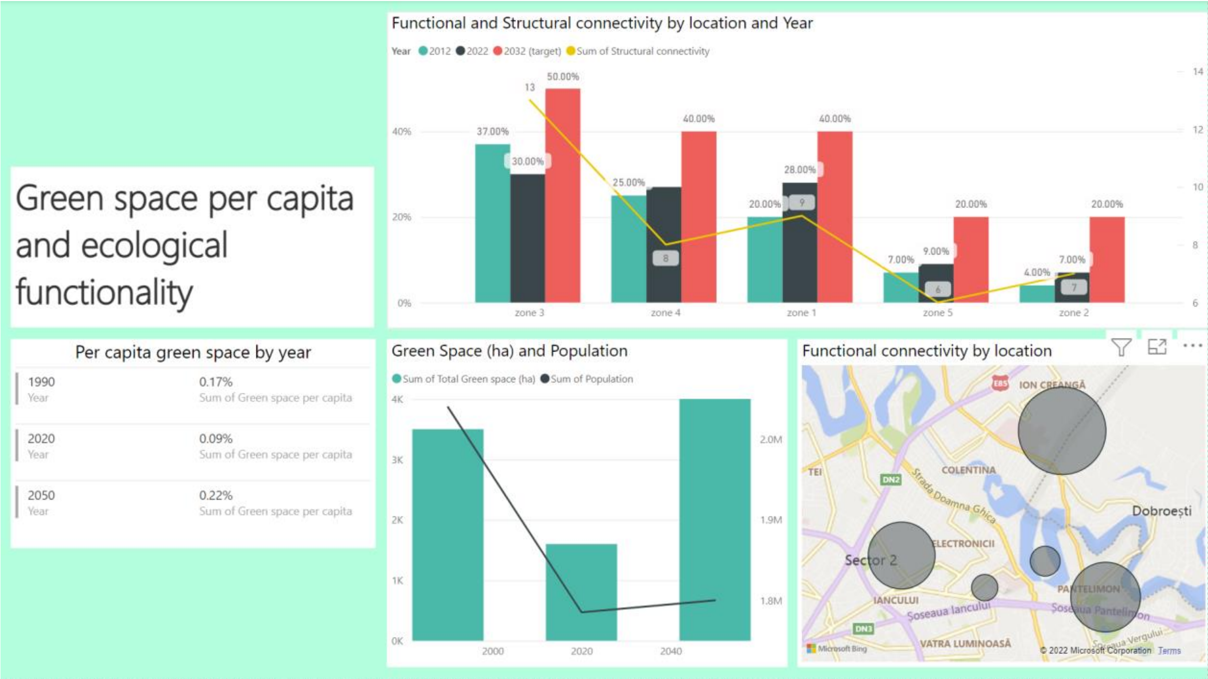


Figure 18: Green space per capita and ecological functionality (Synthetic data)

Indicator 2.2.1 Evaluation of existing NBS (plant CO2 absorption)

This indicator will primarily measure the CO2 absorption of plants in the designated intervention areas. It will be measured by combining the NDVI (see 2.3.8) with CO2 absorption according to the estimates. A tree absorbs around 5.5kg of carbon dioxide per year, however, it obviously varies depending on size and foliage type.

For green walls in the designated areas, this will have to be calculated separately based on measured sq. meters of green walls times average CO2 absorption capacity of the mix of plants on the wall. It is estimated[3] that 1 Sq. meter of living green wall can absorb up to 2 kg of CO2 per annum.

With this data it will be possible to measure a before and after CO2 absorption from plants and trees in the intervention areas, however it is not anticipated to be large impacts as no cities will be planting 100s of trees as part of the DivAirCity project and trees planted are likely to be small initially. Therefore, impacts are expected to be less than 1 ton of CO2 per annum per city.

Nevertheless, it can be used to measure the CO2 absorption of existing city green spaces to understand the starting point of the city (high level or lower level).

Some cities may be planning other mechanical or other installations that may have significantly higher CO2 absorption capacity than normal green plants and trees. For these it would be necessary to register the CO2 absorption capacity per annum for impact assessment.

Size and mature CO2 sequestration potential of NBS: The estimated CO2 sequestration can be calculated based on the size of green area.

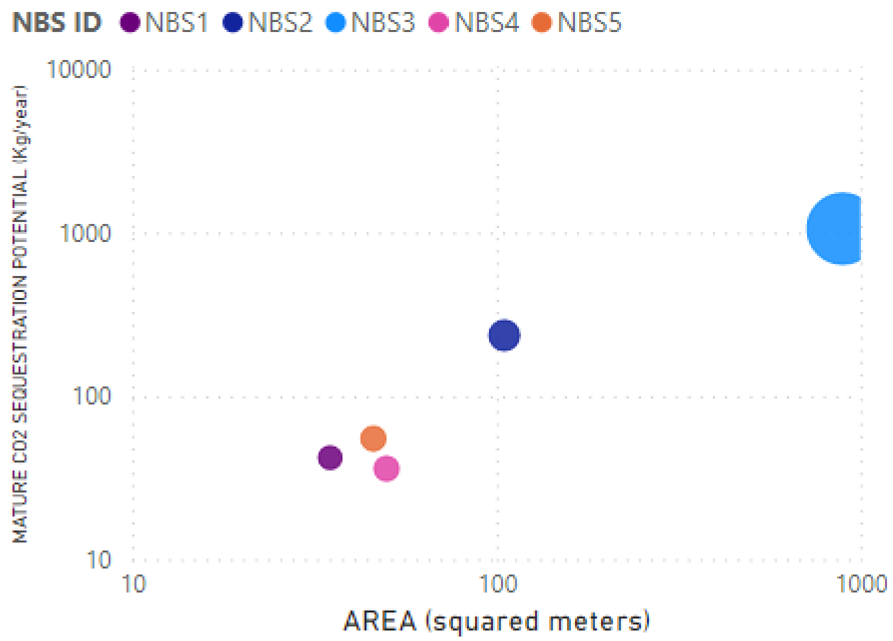


Figure 19: Size and mature CO2 sequestration potential of NBS

Table 22: Data quality maturity level of Size and mature CO2 sequestration potential of NBS

[3] Is the boom in green roofs and living walls good for sustainability? (architectsjournal.co.uk)

Input data	Data source	Status
Satellite image	Open-source data	Data exists but needs to be processed by a technical partner
Data quality maturity level: QA Satisfactory		

Indicator 2.3.7 Common Air Quality Index (CAQI)

This indicator will be measured using two mandatory measurements for the roadside CAQI NO_2 concentration and PM_{10} concentration (particulate matter less than or equal to 10 µm in diameter), with O_3 concentration also required for the 'background' index. There are five categories that go from very low to very high levels in the index.

This can be accessed via existing measurements conducted using static sensor or monitoring stations installations in the five participating cities. Some cities will have a sensor installation also in the district where the interventions are planned others will need to rely on modelled data. The modelled data can be accessed for specific streets in the city, but the accuracy for specific street analysis is insufficient. Therefore, data cannot be used to determine the nature of the problem in detail (time, weather, source of air pollution, etc.) neither the best possible solution to deal with the air pollution (redirect person away from polluted area, offering air pollution protection to person, or create barrier between person and air polluted area). The modelled data therefore should be supplemented by primary data collection at street level considering different times of the day, different weather, and traffic conditions.

In Potsdam there are 4 monitoring stations owned by the local government Land Brandenburg - Landesamt für Umwelt where two of them are located relatively close to the possible intervention areas: one station in Großbeerenstraße 4 kilometers away from Schlaatz and another on Bassinplatz 1,2 kilometers away from Rechenzentrum. The local environmental ministry (Ministerium für Landwirtschaft, Umwelt und Klimaschutz) publish reports about air quality every year as well as monthly. These reports are made available online.

In Aarhus, two monitoring stations are used of which none are in the districts where the DivAirCity project will do implementations. The two measurement stations are managed by Aarhus University (AU) who deliver the data online. However, AU has a confidentiality agreement with Danish Environmental Agency that prevents them to publicly disclose the data before a given amount of time, so the effective availability of these data in a useful timeframe must be assessed.

To examine the air quality problems more precisely and possible solutions in the intervention areas, cities will need to set up temporary and/or introduce mobile air quality sensors to produce primary air quality measurement data that can be acted upon (see primary environmental data below).

Table 23: Data quality maturity level of Common Air Quality Index

Input data	Data source	Status
Air quality data	Air quality data	Cities have a number of sensors, but the data processing methods need to be developed along with data from new sensors to provide uniformed and comparable data. Task 2.6 data processing service will support it.
Data quality maturity level: QA Needs further Investigation		

Indicator 2.3.8 Normalised Difference Vegetation Index (NDVI)

Using satellite data from Copernicus this can be accessed and calculated for areas as small as 10 Sq. meters and therefore can be accessed at street level and in the designated districts where interventions are planned. All that is required is the geographical coordinates for each city district. As shown above (2.2.1) this data may be used to also calculate CO2 Absorption capacity of the green areas of the selected districts.

It may also be used to calculate the Sq. meter green space per capita in the city district subject to census data for the city district. Subsequently, it may also be used to calculate the proportion of citizens living in the district with 15 minutes walking distance or less to a green space. As indicator 2.1.2 shows, these data are available for the cities, but for districts we rely on satellite data combined with population and household data.

Table 24: Data quality maturity level of NDVI

Input data	Data source	Status
Satellite image	Open-source data	Data exists but need to be processed by a technical partner
Data quality maturity level: QA Satisfactory		

Indicator 2.3.9 Number of days in which air quality parameters exceed threshold values

This can be calculated using measurements from the national monitoring sites in the respective cities and the national models for calculating number of days above threshold values. It does however require that hourly values are available from the monitoring sites in the cities, and this is important to get verified from the monitoring sites.

Subject to periods when air quality parameters exceed thresholds, these measurements can be used to consider interventions during specific periods per year when selected districts in the city are affected by particularly poor air quality. It may not necessarily be relevant for all five cities.

Table 25: Data quality maturity level of Number of days in which air quality parameters exceed threshold values

Input data	Data source	Status
Air quality data	Air quality data	Cities have a few sensors, but the data processing methods need to be developed along with data from new sensors to provide uniformed and comparable data. Task 2.6 data processing service will support it.
Data quality maturity level: QA Needs further Investigation		

Indicator 2.3.10 Proportion of population exposed to air pollution above thresholds

This indicator measures urban population exposed to air pollutant concentrations above EU standards and WHO air quality guidelines. The newest WHO guidelines have found a need to adjust the thresholds for $PM_{2.5}$ fine particulate matter and PM_{10} particulate matter as well as nitrogen dioxide as it has found the health risks of air pollution to be more severe than first anticipated when the previous guidelines were presented in 2005.

Figure 20: WHO air quality guidelines (Source: WHO Air quality guideline 2021)

This obviously has implications for all cities in the DivAirCity project including those that had annual air pollution concentration below the previous limit values.

This measurement is linked to other indicators such as 2.3.2 and 2.3.3 on the concentration of particulate matter and will be measured using Airly sensors and where relevant mobile sensors.

It will be used to identify areas (streets; public spaces) with periods of severe air pollution and therefore health risks in the districts, where DivAirCity will intervene.

Table 26: Data quality maturity level of Proportion of population exposed to air pollution above thresholds

Input data	Data source	Status
Air quality data	Air quality data	Cities have a number of sensors, but the data

		processing methods need to be developed along with data from new sensors to provide uniformed and comparable data. Task 2.6 data processing service will support it.
Data quality maturity level: QA Needs further Investigation		

Indicator 2.3.11 Sustainable transport

Each city will be able via the local public transport systems to access use of public transport by citizens in the form of journeys by busses, trains, metros and trams.

For some cities it will be possible to get detailed number of journey by types of public transport to/from the chosen district to/from other districts in the city.

Also, some cities have detailed journey accounts of cycling, car, e-scooters, etc. uses by citizens in and out of the city and pertaining to certain streets. It may be difficult to get this kind of data for specific streets and districts unless the sensors are set up to count passings of different modes of transport.

However, as an example Aarhus provides annual data on cycling journeys for 20-30 main streets in Aarhus that allows for trend analysis.

Similarly, cities may have analysis of mode of transport habits and how this may have changed over time.

These data can be used to examine the general level of sustainable transport modes in each of the cities studied in DivAirCity. It may also be used to examine potential for mobility and other interventions/actions that can be assessed in future measurements. This could for instance be about incentivising more people to cycle using blockchain based reward systems and then to measure at the end of the project whether this has led to increases in cycling journeys from the designated district to other districts.

Apart from public transport operators, operators of car-sharing, e-scooter and bicycle rental services will be able to offer detailed data. There may be costs involved in accessing data from these operators. The municipality departments conducting measurements of traffic will also be able to provide data.

For general comparison of the cities, it would make sense to compare the following metrics:

- Share of walking and cycling trips of all trips (non-motorised)
- Share of public transport modes of all trips

For Aarhus inner city[4] walking represents 33% of all trips; cycling 21%; car is 33%; train/tram is 3%; bus is 7% and other means of transport is 3% (e-scooters).

Table 27: Data quality maturity level of Sustainable transport

Input data	Data source	Status
Transportation modes and uses	Secondary data such as city level transportation report	Not yet identified over all five cities. Metrics and data inventory need to be finalised with five cities.
Data quality maturity level: QA Needs further Investigation		

3.1.1.3 Economic data sources

Indicator 3.3.2 Maintenance cost of existing NBS

The city park and road administration should be able to provide maintenance cost of different types of public spaces from its accounts. If not within the department the external suppliers used by the public and private owners of public spaces will have account and invoice information on current cost of NBS operation and maintenance.

This data is important because when cities in intervention areas begin to change the current NBS, the change because of temporary or permanent physical environment changes as well as behavioural changes (people practising new habits) in maintenance and operations cost needs to be measured. The costs should be itemised as follows:

- Policing
- Trash, debris removal
- Snow removal
- Mowing, edging, and trimming
- Tree, shrub, landscape, and brush maintenance
- Hard surface maintenance and site work (incl. Sweeping)
- Amenity* maintenance
- Work at park by other sections
- Electricity for lighting and other installations

[4] Valg af transportmiddel_2019-2021 (aarhus.dk) in Danish

- Other

*Amenities are man-made structure, monument, statue, vase, fountain, pole, wall, fence, railing, bench, picnic table, trash receptacle, arbor, shade structure, playground, building, landscaping, natural vegetation, lighting system, sprinkler system, barbecue, shelter, walking or biking trails, paths or walkways and waterways.

Annual maintenance cost of NBS: Annual maintenance cost of NBS can be compared over different green spaces, or timeseries analysis of maintenance cost of each NBS can be produced.

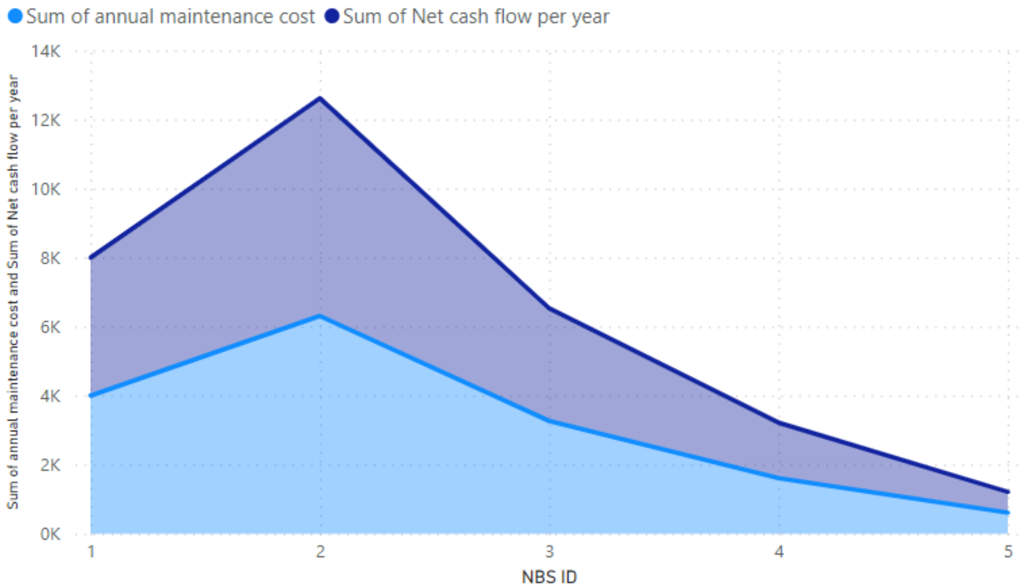


Figure 21: Annual maintenance cost of NBS

Table 28: Data quality maturity level of Annual maintenance cost of NBS

Input data	Data source	Status
Annual maintenance cost	Manual input	Data not yet available Template is drafted
The list of existing NBS and their locations	Manual input	Data not yet available Template is needed
Data quality maturity level: QA In Development		

3.1.2 Primary data

1.1.1.1. Social

Indicator 1.2.1 Engagement of target audiences for the NBS to be designed

This indicator is to understand what % of the target audiences in the intervention areas are represented in the co-creation phase 2 (co-design of solutions). There are two main metrics: a) Measurement of the identified stakeholders being represented by one or more persons in the co-creation process. A participating person will be registered as a representative of one of these stakeholders. Participation at co-creation events may be online or offline; and b) registration of how the participants break down in relation to the 6+1 target groups and how the participation compares with the population composition in the intervention area. This is taking the breakdown achieved for indicator 1.1.4 and comparing it with the breakdown of the participants at co-creation events.

This means asking participants to anonymously register data about themselves to the extent they are happy to provide this data. With this data, the city and DivAirCity will understand to what extent it has a reasonable representation of the target audiences in the district where interventions are designed. Cities may do separate events with different target groups to tailor the timing, placing and format of these events to the special needs of certain target groups. If this is the case the registrations of several co-creation events are accumulated into one registration overview for all phase 2 events.

Total participants by city: Total participants during co-creation processes can be compared between cities as below. The method to monitor the level of participation needs to be developed through consultation with cities. For example, comparing cities by total participants can be limited. The social context of 6+1 groups in each city is different, and there might be barriers for a certain city to draw many participants. Timeseries analysis, such as whether the number of participants in a city is increasing or decreasing, can be a suitable method depending on the purpose of the analysis. Nevertheless, the total number of participants needs to be collected as a baseline for other indicators, such as the percentage of 6+1 groups. The manual input of project partners, such as the attendance list of events, is needed as data input.

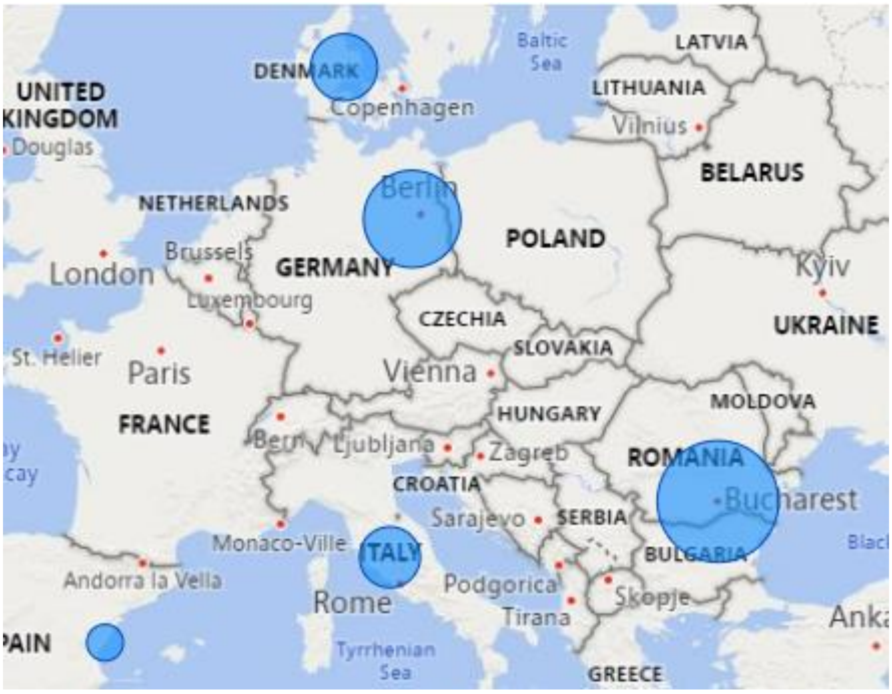


Figure 22: Total participants by city (Synthetic data based on the draft survey questionnaire)

Table 29: Data quality maturity level of Total participants by city

Input data	Data source	Status
Maps with district borders	Open maps	Maps exist
Participant registration	Manual input	Data not yet available Template is needed
Data quality maturity level: QA In Development		

Count of participants by 6+1 categories: By using the structure registration form or attendance list, the participants can be analysed by 6+1 groups. The project participants can monitor which group engaged more and include less engaged groups if it is necessary.

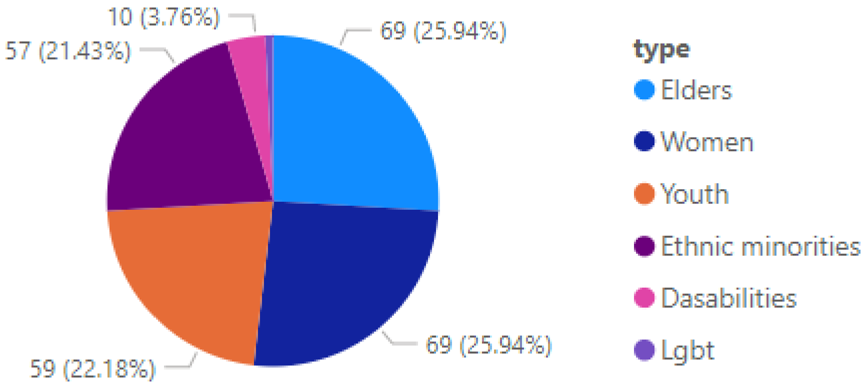


Figure 23: Count of participants by 6+1 categories (Synthetic data based on the draft survey questionnaire)

Table 30: Data quality maturity level of total participants by city

Input data	Data source	Status
Participant registration	Manual input	Data not yet available Template is needed
Co-creation survey data	Survey	Draft survey questionnaire needs to be confirmed through the consultation with cities
Data quality maturity level: QA In Development		

The participation in co-creation can be monitored through the interactive dashboard as below.

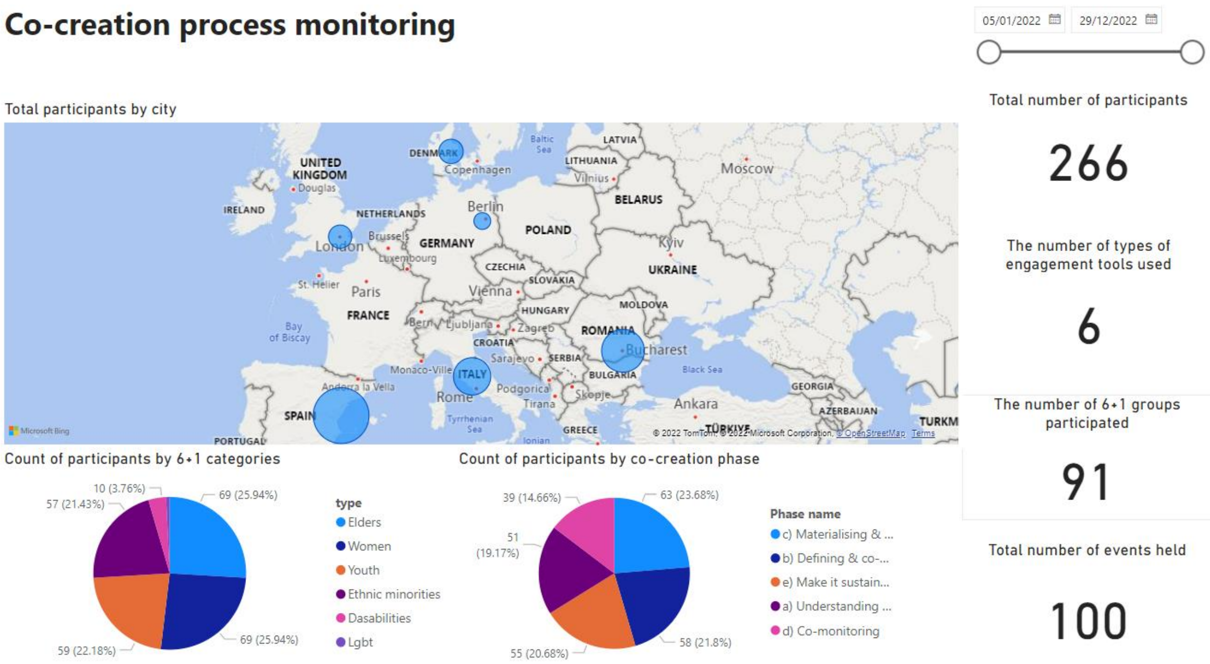


Figure 24: Engagement of target audiences for the NBS to be designed (Synthetic data based on the draft survey questionnaire)

Indicator 1.2.2 Users and use of green spaces

This indicator is measured through a behaviour observation method where persons (observers) are placed in a green space at a specific spot, specific days, and time with specific weather conditions to count behaviours of green space users. The template has icons for certain activity types and the observer will also register the observable details of each user. This is repeated typically for different weather conditions, different days and several observation spots can be used if the space is large. The initial template for behaviour observation can be found in Annex 14. It is important to note that days and times during the day to observe should be chosen when users are expected to be present in the area. The important thing is to apply consistency when conducting observations following interventions in the green space. The observation methodology must meet the ethical policy of the DivAirCity project.

These measurements will be used to measure a difference in behaviour between before interventions and after interventions to understand how the NBS intervention has impacted behaviour.

The data will be a registration of the position of the observer and the area covered in the form of map coordinates, the day and time of observation, the weather conditions during the observation (temperature, sun, cloudy, rain, snow), plus a breakdown of users observed by age, perceived gender, ethnicity of person and a breakdown of the types of activities observed.

It is important to note that this behaviour observation will only quantify users and activities, it will not measure perceptions or opinions of users. To measure this, interviews will need to be carried out (see Annex 9)

The use of green spaces: The survey on the use of NBS can be helpful to analyse the diversity of the uses of green spaces.

Figure 25. the use of green spaces (synthetic data based on the draft questionnaire)

The users of green spaces: Providing spaces for diverse users including 6+1 groups after the NBS implemented, not only involving them in co-creation processes is an important objective of the DivAirCity project. The survey on the users of NBS will provide the information on it.

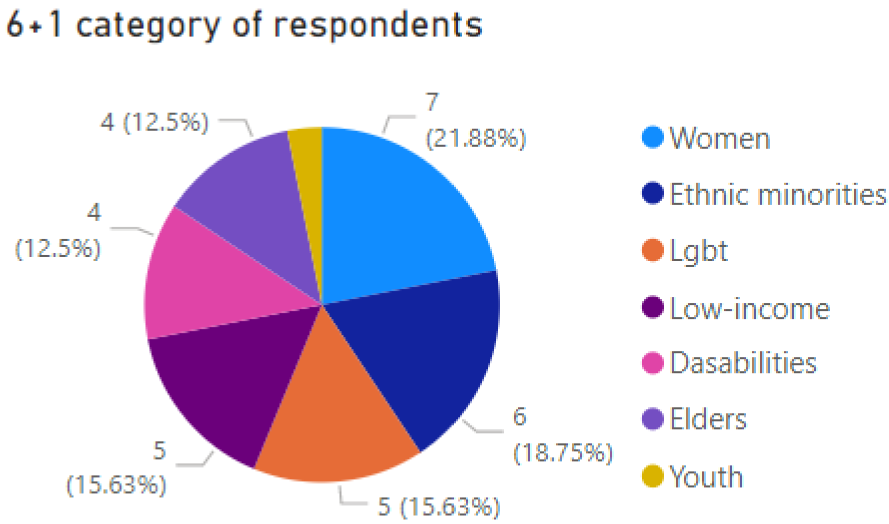


Figure 26: the users of green spaces (synthetic data based on the draft questionnaire)

Table 31: Data quality maturity level of users and use of green spaces

Input data	Data source	Status
NBS use survey or observation	Survey or observation template	Collection method and templates need to be confirmed through the consultation with cities
Data quality maturity level: QA In Development		

Indicator 1.2.3 Comfort and Safety of green spaces for diversity

This data is required to understand the perception of safety and security levels in the public spaces of the district. A sample of persons representing the target groups in the city district with priority to women, LGBT+, people with other ethnic background, children, and elderly (singled out in other studies as specifically vulnerable) should be interviewed or asked to complete a small Likert Scale survey. The questions should ask the respondents about their sense of comfort, safety, and security as well as opinions about the usefulness and attractiveness of the green spaces they visit.

This primary data gathering method may be combined with asking other questions about life in their neighbourhood (see indicators 1.3.12 place attachment; 1.3.14 safety and security in general, 1.3.18 on air quality and diversity).

See Annex 8 for the questionnaire to be used.

When asking these questions before and after specific interventions in green spaces it will be possible to measure whether these interventions have affected perceptions of users in relation to comfort and safety plus the other factors the NBS intervention seeks to influence.

By using the same questionnaire translated to local languages on comparable samples of users and tailoring questionnaire parts to certain cultures/age groups etc., it will be possible to measure and compare how different interventions in different green spaces effect on different requirements of target groups in the five cities.

Table 32: Data quality maturity level of comfort and safety of green spaces for diversity

Input data	Data source	Status
Maps with district borders	Open maps	Maps exist
Location of NBS	Manual input	Cities provided the location of the NBS, but it might be changed through co-creation process

6+1 breakdown of the respondents	Survey template	Survey questionnaires need to be confirmed through the consultation with cities
NBS use and user survey	Survey template	Survey questionnaires need to be confirmed through the consultation with cities
Data quality maturity level: QA In Development		

The survey result can be mapped with NBS location and city. The group specific result and comparison can be possible when sufficient samples are collected.

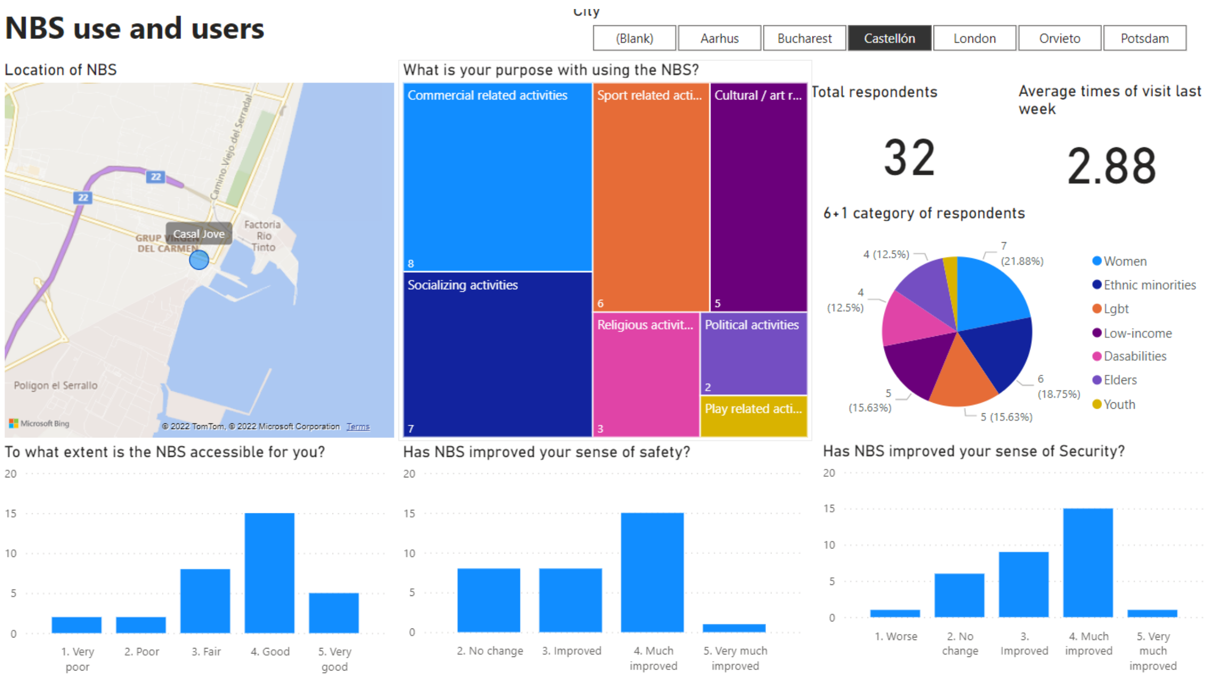


Figure 27: Comfort and Safety of green spaces for diversity dashboard (synthetic data based on the draft of survey questionnaires)

Indicator 1.2.4 Level of digital participation

Digital participation in co-creation activities as well as in organising and running events has great potential for inclusion and diversity in the participatory processes, but it also holds challenges and risks. The participants' perceptions of advantages, opportunities, risks and challenges from digital participation need to be measured to allow DivAirCity to adjust and improve co-creation processes and produce recommendations moving forward.

The actual participation needs to be measured through the registrations to mark which target groups participate online and which participate physically at the event. In some instances, the co-creation process may require both in which case participation should be registered as both digital and physical.

The questions on perceptions of digital and physical participation in co-creation process can be found in Annex 6.

The registration of digital participation should be done in a template for registration for co-creation process events (online, offline, hybrid).

Table 33: Data quality maturity level of Level of digital participation

Input data	Data source	Status
Type of the policy and target year	Manual input	Data need to be collected. The template is drafted
Data quality maturity level: QA In Development		

Indicator 1.2.5 Accessibility of green spaces

With measurements for indicator 2.3.8 we are also able to measure accessibility of green spaces in terms of walking or driving distances along public paths and streets from the different residential areas to green spaces in the districts where DivAirCity will be intervening. This, however, will only measure distances in time and kilometres. It will not measure people's perceptions of their access to green spaces.

For this indicator, the interview questionnaire to be used prior to interventions and post interventions should also ask questionnaire regarding people's perception of their route to and use of the green space, their opinions of the relevance and attractiveness of the green space.

This is measured to understand how the perceived accessibility of the green spaces may have changed due to the NBS interventions carried out.

These questions are included in the questionnaire provided in Annex 9.

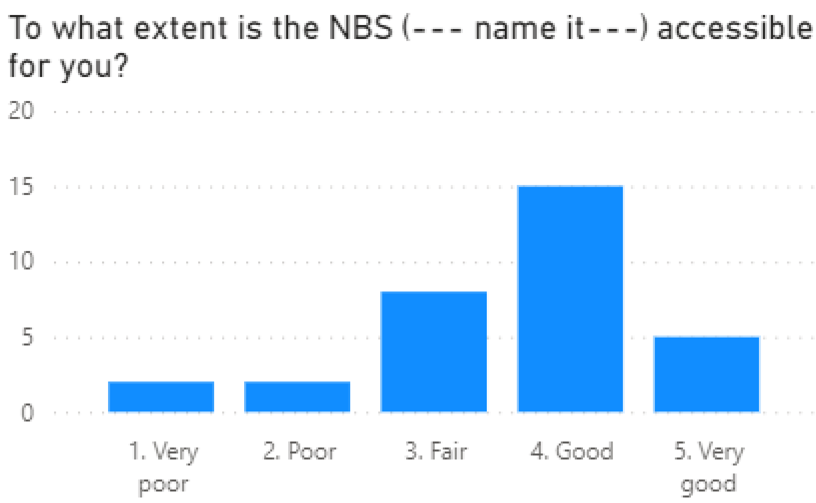


Figure 28: The accessibility of the NBS (synthetic data based on the draft of survey questionnaires)

Table 34: Data quality maturity level of the accessibility of green spaces

Input data	Data source	Status
Maps with district borders	Open maps	Maps exist
Location of NBS	Manual input	Cities provided the location of the NBS, but it might be changed through co-creation process
6+1 breakdown of the respondents	Survey template	Survey questionnaires need to be confirmed through the consultation with cities
NBS accessibility survey	Survey template	Survey questionnaires need to be confirmed through the consultation with cities
Data quality maturity level: QA In Development		

The survey result of safety, security (Indicator 1.2.3) and accessibility of the NBS (Indicator 1.2.5) can be mapped with NBS location and city. The group specific result and comparison can be possible when sufficient samples are collected.

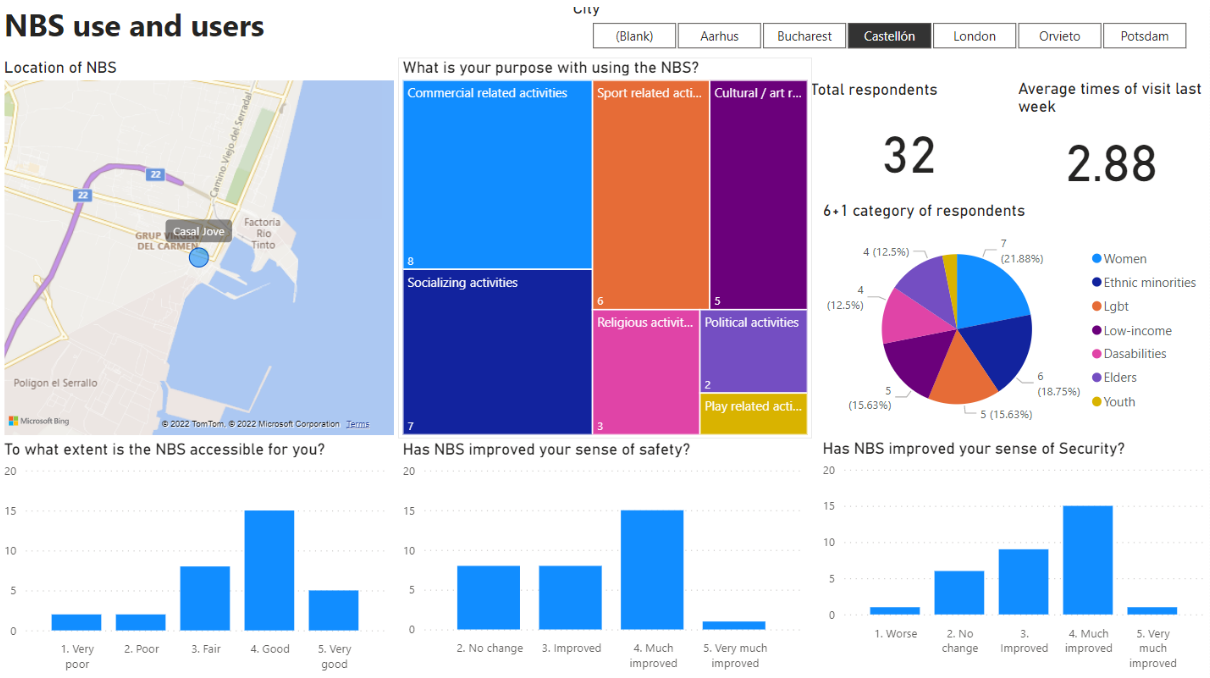


Figure 29: Comfort and Safety of green spaces for diversity dashboard (synthetic data based on the draft of survey questionnaires)

Indicator 1.2.6 Perceived control and trust over decision-making of NBS

This indicator is measured using a questionnaire to be completed by people attending the co-creation processes. It is to be completed at least twice to ascertain whether the co-creation process will have an impact on people's perceptions: First during the design and implementation process and again following the completion of the intervention.

It measures the perceived control and trust over decision making around the NBS interventions being co-produced. Trust and perceived control relate to the position and power of the citizen compared to other citizen groups, the municipality decisionmakers as well as other stakeholders influencing the process.

The point of the measurement is to understand whether the process can influence participants' perceptions of inclusion, power, trust, and control during the co-creation process and as the NBS intervention becomes a reality.

The questionnaire to be completed by participants at least twice during co-creation processes can be found in Annex 6.

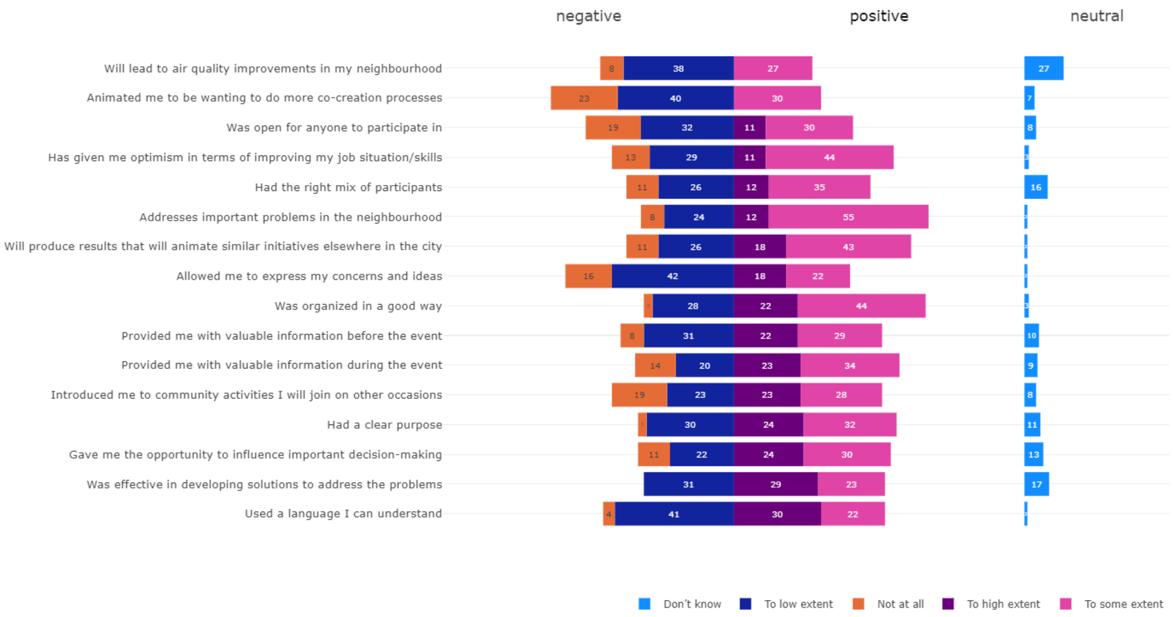


Figure 30: Perceived control and trust over decision-making of NBS (synthetic data based on the draft of survey questionnaires)

Table 35: Data quality maturity level of perceived control and trust over decision-making of NBS

Input data	Data source	Status
6+1 breakdown of the respondents	Survey template	Survey questionnaires need to be confirmed through the consultation with cities
Survey on perceived control and trust	Survey template	
Data quality maturity level: QA In Development		

<u>Indicator 1.2.7 Target audiences for the NBS to be validated</u>

This indicator is like indicator 1.2.1 and will at this point be measured by registering participants in the co-creation process phase 3. it will use the exact same two registration forms (again to be found in Annex 1 and 2).

The purpose is to measure whether the participation is changing during the co-creation process and how in numbers. Therefore, it will add one data registration from the previous form which is to register whether the person attended previous co-creation events during the DivAirCity project. It will allow the project to understand whether the recruitment and co-creation processes influenced the participation and how.

Reasons for changes in participation will need to be studied from interviews and focus group interviews and will be recorded in terms of inhibitors of participation and enablers of participation.

The same data analysis methods for Indicator 1.2.1 can be used. The analysis can be filtered according to the phases.

Table 36: Data quality maturity level of Target audiences for the NBS to be validated

Input data	Data source	Status
Participant registration	Manual input	Data not yet available Template is needed
Data quality maturity level: QA In Development		

Indicator 1.2.8 Target audiences for the NBS to be implemented

This indicator is similar to indicator 1.2.1 and 1.2.7 and will be measured by registration of participants in the implementation of the NBS (this could be number of persons per category using a newly promoted path, visiting a green space, changing habit from driving in car to cycling/walking/bus transport or attending an opening event at the NBS) As such the data collection may need to use observation forms and techniques in order to do the registration unless, there is a formal registration via use of online forms/block chain contracts with the participating citizens.

The purpose of this measurement is to understand whether with the NBS interventions it is possible to achieve significant behavioural change and how big a behavioural change is possible.

What works and how it worked in changing behaviour will need to be measured using a different data gathering mechanism focused more on interviews with participants and users of the NBS (see Annex 6 for questionnaire) to understand what persuaded them to change habits and what was attractive in the NBS.

Table 37: Data quality maturity level of Target audiences for the NBS to be implemented

Input data	Data source	Status
Participant registration	Manual input	Data not yet available Template is needed
Data quality maturity level: QA In Development		

Indicator 1.3.10 Income and work

When measuring for Indicator 1.1.4, the population is also broken down in relation to average household incomes and occupation. In indicator 1.3.10 it is also necessary to measure how participation in co-creation processes or indeed implementation of NBS is perceived by participants to affect their employment prospects and future income. DivAirCity is committed to measuring the impact of interventions for people with low incomes as well as measuring the impact of interventions on income and work situations of people taking part. It is not expected that the DivAirCity project activities will have a huge effect on participants prospects. Nevertheless, the questionnaire used for participant interviews will also pose questions in this regard.

See the questionnaires in Annex 8 and 9.

The data analysis method will be developed further according to the questionnaire.

Table 38: Data quality maturity level of Income and work

Input data	Data source	Status
Survey on perceived impact of NBS on their work and income	Survey template	Survey questionnaires need to be confirmed through the consultation with cities
Data quality maturity level: QA In Development		

Indicator 1.3.12 Place attachment

Like indicator 1.3.10, this indicator will be addressed through the questionnaire used for participant interviews to measure the extent to which the participation has improved or worsened their attachment to their neighbourhood.

See the questionnaire in Annex 8.

Table 39: Data quality maturity level of Place attachment

Input data	Data source	Status
Survey on perceived impact of DivAirCity project on place attachment to their neighbourhood	Survey template	Survey questionnaires need to be confirmed through the consultation with cities
Data quality maturity level: QA In Development		

Indicator 1.3.14 Safety and security

This indicator was also addressed above with secondary data tools to examine the general state of people's sense of security and safety in the five cities.

Here, the indicator will also be examined with primary data to examine whether people see safety and security issues locally in the districts where DivAirCity will intervene. Also, the primary data collection will address to which extent the NBS intervention has affected the sense of security and safety focusing very much on the places where the secondary data identified issues and the interviews raised local issues.

This data will be collected through interviews, either by hired interviewers or by eco-system members that have the interview-skills, both prior to intervention and post intervention. The questionnaires to be used are found in Annex 8 and Annex 9.

By using the questionnaires including the information of respondents (e.g., age groups, gender, and other 6+1 information), the responses of questionnaire can be analysed by 6+1 groups when there is a sufficient sample size.

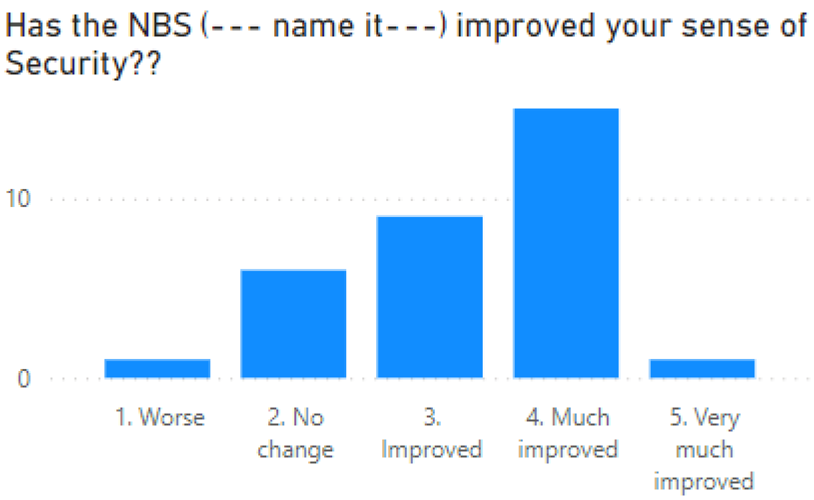


Figure 31: Perceived security (synthetic data based on draft questionnaire, Annex 8)

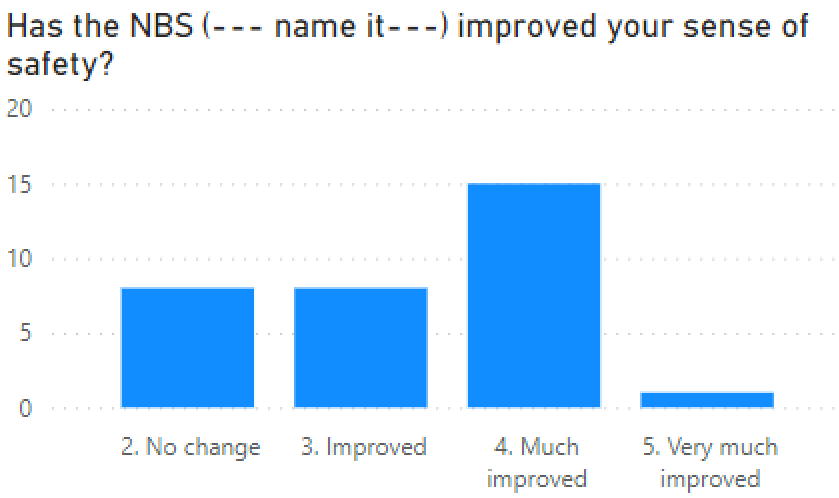


Figure 32: Perceived safety (synthetic data based on the draft questionnaire)

Table 40: Data quality maturity level of Safety and security

Input data	Data source	Status
Safety and security survey	Survey template	Survey questionnaires need to be confirmed through the consultation with cities
Data quality maturity level: QA In Development		

Indicator 1.3.18 Air quality and diversity

This indicator has been explored using secondary data (see above) and here it will also be addressed collecting primary data.

The purpose is to examine whether people with different characteristics see a connection between the living conditions in their neighbourhood and the air quality that they face in their local environments. Also, the primary data collection will address to which extent the NBS intervention has affected their opportunities to deal with air pollution in the neighbourhood focusing very much on reducing and/or avoiding air pollution places where primary and secondary Air Quality data identified issues and the interviews raised local issues.

This data will be collected through interviews both prior to intervention and post intervention. The questionnaires to be used are found in Annex 8 and Annex 9. This data can further be combined with Air Quality measurements carried out to verify whether in fact perceptions of air quality can be confirmed from actual measurements.

Table 41: Data quality maturity level of Air quality and diversity

Input data	Data source	Status
Survey on air quality and diversity	Survey template	Survey questionnaires need to be confirmed through the consultation with cities
Data quality maturity level: QA In Development		

1.1.1.2. Environmental

Indicator 2.2.2 Evaluation of NBS prototypes tested in city districts

This indicator only relates to NBS prototypes consisting of plants, trees and other installations that may absorb CO2 as also detailed in relation to indicator 2.2.1 above. This may be green walls, green barriers, green city woods, green plantations in new park areas (which before was paved or brown field) or CO2 absorbing machines.

The purpose is to measure the CO2 absorption capacity of the new prototypes or permanent NBS implementations as an additional capacity in the district over and above the existing CO2 absorption capacity.

As mentioned before, this is not expected to be substantial, but nevertheless worth measuring. The same methodology used for indicator 2.2.1 will be used in 2.2.2. The municipality department for parks and roads should have access to the necessary data or indeed the supplier delivering the plant solutions may be able to calculate the impact of the new NBS.

Indicator 2.2.1 was suggested to use satellite image since it focuses on overall green spaces in a city. However, in terms of individual prototypes and NBS evaluation, the manual input such as size of NBS and types of plants by a project personnel can be more suitable. The Green Infrastructure Valuation (GI-Val) by Mersey Forest provided calculation tool for this individual green implementation (https://www.merseyforest.org.uk/services/gi-val/).

Table 42: Data quality maturity level of Evaluation of NBS prototypes tested in city districts

Input data	Data source	Status
Size of NBS and type of plantation	Manual input	Data is not yet identified Data template needs to be developed
Data quality maturity level: QA In Development		

Indicator 2.2.3 Changes to the size and distribution of public green space due to the DivAirCity interventions

Again, for indicator 2.2.3, the expected impact of DivAirCity interventions for the cities is likely to be small, but for a specific district or street it may be significant. It will be necessary therefore to consider the framing of the locality when measuring impact of new green space in terms of Sq. meter size changes. This will require a before and after measurement of changes including if new green spaces will be wall-based.

GI-Val template can be used for the calculation of Indicator 2.2.3 like Indicator 2.2.2 (also see Annex)

Table 43: Data quality maturity level of green space per capita

Input data	Data source	Status
Boundary of impact area	Manual input	Data is not yet identified Data template needs to be developed
Size of green space implemented by DivAirCity project	Manual input	
Data quality maturity level: QA In Development		

Indicator 2.3.2 Concentration of particulate matter

This indicator is related to the next one. The Data required can be obtained during projects gathering primary data. The effect of NBS absorbing particulate matter will depend on the type of NBS implemented (size, selected vegetation positioning of the NBS, plant species, seasonality etc.), and both the positioning and the impact in terms of reducing concentrations of particulate matter will be measured with strategically placed sensors and eventually supplemented with reference measurements. Recommendations on NBS design with a specific focus on particulate was produced during the Thrive Zone Amager project (Gehl Copenhagen, 2022).

Indicator 2.3.3 Concentration of particulate matter at respiration height along roadways and streets

This indicator will be measured by using Airly low-cost sensors calibrated up against other local reference measurements. Sensors will be placed in locations where likely air pollution has been identified areas that may affect people using the space. The sensors can also be applied to learn where plants could absorb the air pollutants or pollutants stopped through barriers being implemented. Other wearable sensors with may also deal with the problem may involve creating a barrier between the air pollution and the persons affected; directing persons affected away from the polluted area; or providing persons affected from the air polluted area with protection from air pollution such as masks.

For certain groups like children and persons using wheelchairs it will be important to adjust the sensors to a height where it is possible to measure the impact on these groups of people. This will require measurements at a maximum height of 1.5 m above the ground surface, or height of wheelchair users and children, to represent the air quality experienced by citizens.

The data analysis will depend on Airly's capability of wearable devices and data structure. When the wearable devices are available, the data analysis such as route, total distance of physical activities, and air pollution can be possible. The types of particulate matter needs to be decided with the sensor availability.

Table 44: Data quality maturity level of Concentration of particulate matter at respiration height along roadways and streets

Input data	Data source	Status
Air quality data	Air quality data	The data processing methods depend on Airly's data structure and capability of wearable devices. Task 2.6 data processing service will support it.
Data quality maturity level: QA In Development		

The perceived health survey can be conducted along with the monitoring of walking activities and air pollution. The compiled monitoring dashboard can be produced as below.

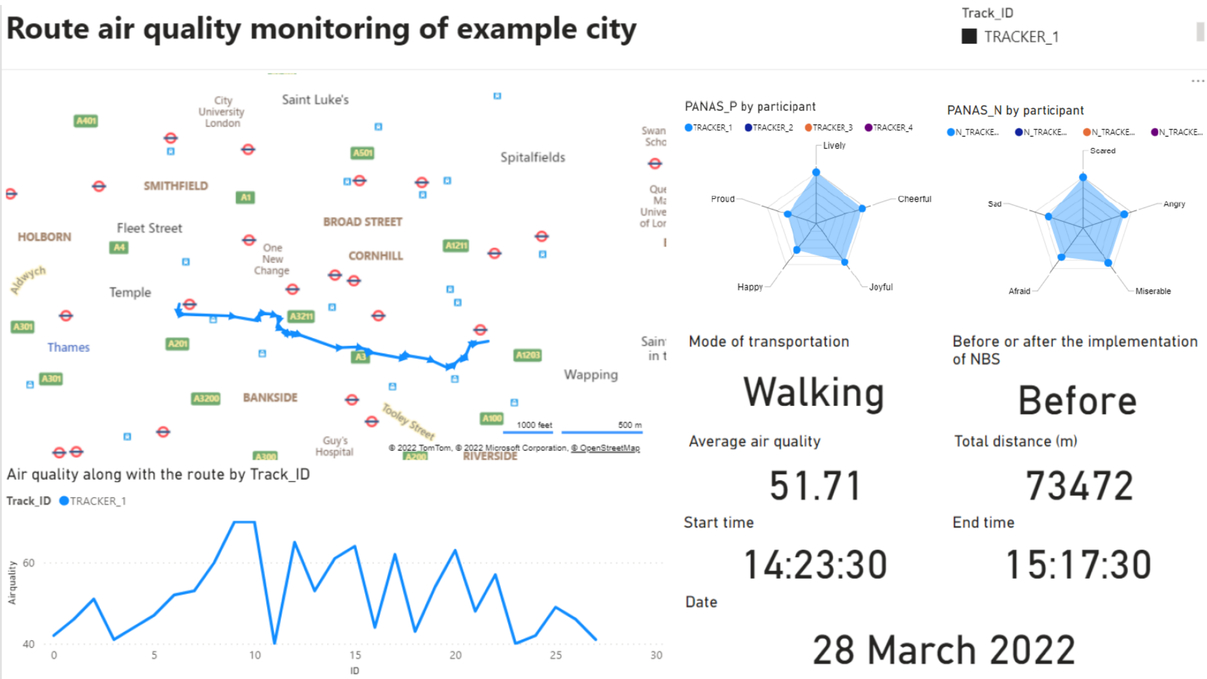


Figure 33: Air pollution along routes and perceived health

<u>Indicator 2.3.6 Carbon Sequestration in vegetation</u>

This indicator will be difficult to apply with only small impacts expected to be achieved during the DivAirCity project. Most cities will find it difficult to co-create vegetation of sufficient volume to reach large biomass Carbon Sequestrations during the DivAirCity activities.

Nevertheless, cities have indicated that it is relevant for measurement, Method and tools for measurement are still in need of adaptation for DivAirCity. In the Deliverable 2.2. Digital Innovation and D&I Data Management Framework, the traditional tools to calculate carbon sequestration was suggested.

The evaluation can be performed by using:

1. Traditional tools such as:
   - trunk diameter at breast height with a calliper or diameter tape
   - tree and crown height with ipsometer/clinometer
   - crown width with metric tape
2. Digital technologies such as "Field-map" (Antelope model - https://www.fieldmap.cz/), consisting of laser meter distance, an electronic compass, GPS, and tripod, providing a georeferenced 2D visualization of the single tree. This method includes the acquisition of the software/hardware and of the instruments need for the measurements.
3. More user friendly and less expensive methods, available to obtain biomass data as the ones using the Lidar scanner incorporated in some new generation smartphone together with application (https://www.arboreal.se/en/) allowing the measurements of tree height, crown height and width (Pace *et al.*, 2022)

The templates can be applicable for five cities such as excel sheets in five languages need to be developed.

Table 45: Data quality maturity level of Carbon Sequestration in vegetation

Input data	Data source	Status
Carbon Sequestration in vegetation	Manual input	Data is not yet identified Data template needs to be developed
Data quality maturity level: QA In Development		

1.1.1.3. Economic

Indicator 3.2.1 Initial cost of NBS implementation

For this indicator the NBS can be both a physical NBS, an immaterial NBS implementation or a combination of the two. For physical NBS (a hedge, a row of trees, a greenhouse, etc.) the cost will add up the cost of the materials used, the process of engineering and approval, the cost of installation, promotion, and commissioning.

For immaterial NBS, the cost may include the cost of online and media promotion, digital tool development, etc.

The form for cost calculation is still to be finalised.

Table 46: Data quality maturity level of Initial cost of NBS implementation

Input data	Data source	Status
Initial cost of NBS implementation	Survey template	Survey questionnaires need to be confirmed through the consultation with cities
Data quality maturity level: QA In Development		

Indicator 3.3.2 Maintenance cost of NBS

The measurement for this indicator is important to understand the maintenance cost of the NBS to be implemented. Maintenance cost may take many forms including watering, replacing plants, repair of installations, cleaning, collecting rubbish, updating signage, plus operation costs like for electricity and water, etc.

The form to be used to estimate and account for NBS maintenance costs is still to be developed.

Table 47: Data quality maturity level of Maintenance cost of NBS

Input data	Data source	Status
Maintenance cost of NBS	Survey template	Survey questionnaires need to be confirmed through the consultation with cities
Data quality maturity level: QA In Development		

Indicator 3.3.3 Valuation of NBS

The economic valuation of implemented NBS can be measured as one of many possible factors influencing increases in the valuation of real estate in the neighbourhood of the NBS. This will however require a high profile NBS implementation that would attract dwellers from a far and hence making properties more attractive in the neighbourhood. The effect, however, will take longer than the DivAirCity project period to show itself in increased property prices. It is possible though to ask property owners and dwellers in NBS intervention, whether the implemented NBS has made it more attractive to live in the area.

This indicator will primarily be measured through interviews with citizens in the area to understand their perception of how NBS implementations have changed their purchasing habits in the district, and what value they associate with the NBS.

See Annex 7 for the interview questionnaire to be used by users of the NBS.

Finally, this indicator will be measured through interviews with commercial shops, services, cafés, and markets in the intervention districts that may or may not be affected by the NBS implementations. The commercial operators may as evidence contribute account data before and after to document sales and/or cost changes. Additionally, pictures could be taken to document the level of traction achieved before and after NBS implementation, as well as examples of the promotional effort conducted by the commercial operators to market the combined attraction of their business and the NBS.

See Annex 7 for the questionnaire to be used for these measurements.

Initial investment of NBS and payback period: by combining the initial cost of NBS implementation (3.2.1) and valuation of NBS (3.3.3), the calculation of payback period can be calculated.

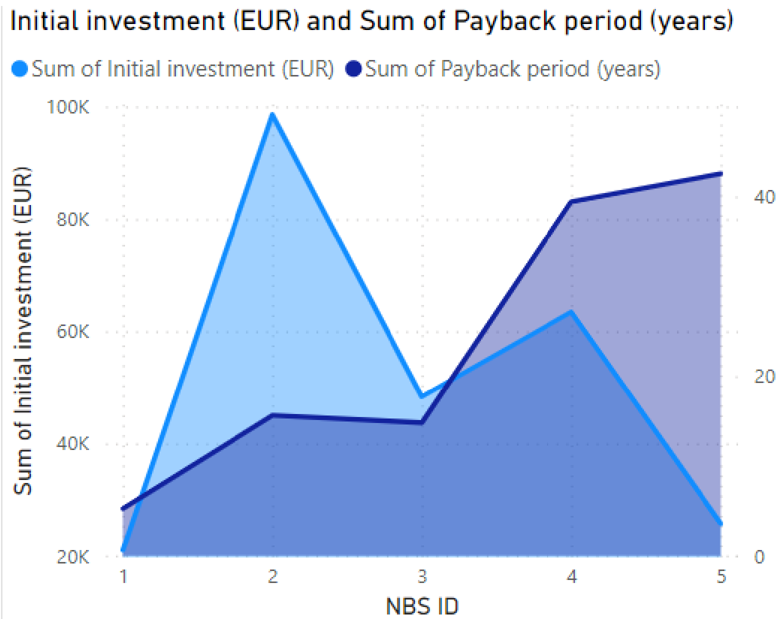


Figure 34: Initial investment of NBS and payback period

Table 48: Data quality maturity level of Initial investment of NBS and payback period

Input data	Data source	Status
Initial cost	Survey template	Survey questionnaires need to be confirmed

Estimated value of NBS	Survey template	through the consultation with cities
Data quality maturity level: QA In Development		

Indicator 3.3.10 Energy consumption and cost of operation of blockchain

This indicator relates to the measurement of the energy consumption and cost of operating the blockchain. The DivAirCity project is planning to introduce Blockchain based contracts with citizens that will allow the citizens to be rewarded for data contributions or actions that improves air quality. The energy consumption from using the blockchain technology will obviously depend on the number of contracts implemented and the likely number of transactions. The energy consumption can be estimated based on initial projections of number of contracts and transactions to be accounted for during the operation of the blockchain business.

The data can be possibly analysed through the real time use of transactions if the Smart City Contract Service application support the dynamic data.

Table 49: Data quality maturity level of Energy consumption and cost of operation of blockchain

Input data	Data source	Status
Energy consumption and cost of operation of blockchain	Need to be confirmed with blockchain partners	Need to be confirmed with blockchain partners
Data quality maturity level: QA In Development		

EVA - Economic Valuation of Air Pollution (focusing on health costs)

Description of the EVA system methodology

EVA is an integrated model system based on an approach developed within the ExternE project (Friedrich & Bickel, 2001). In this approach, emissions for a specific source or source sector are followed through atmospheric dispersion and transformation to the impacts in humans following from exposure to the pollution concentration resulting from the emissions.

Chemical components important for health impacts and included in the EVA system are: nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone (O_3) and particulate matter ($PM_{2.5}$), where the individual constituents of $PM_{2.5}$ are: mineral dust, black carbon (BC), organic matter (OM), secondary inorganic aerosols (SIA – i.e., nitrate, sulphate and ammonia), secondary organic aerosols (SOA) and sea salt.

Health impacts include both mortality (premature deaths) and morbidity (a number of health outcomes, e.g., hospital admissions, asthma attacks, lung cancer, restricted workdays etc.). The costs calculated from EVA are based on the costs for society of premature deaths and costs for the health care system from morbidity endpoints. Mortality is valued based on the value of a statistical life and the value of a life year lost. Morbidity costs are based on actual costs for hospital admissions and medication prescription as well as costs for society of e.g., work loss days.

Regional scale and local scale air pollution is calculated with the models DEHM (Danish Eulerian Hemispheric Model) and UBM (Urban Background Model) and combined with gridded population data, exposure-response functions for the various health impact end points and economic valuation.

In practice, when the impacts of the air pollution levels from emissions from a specific source or sector are calculated, concentrations and address-level population data are combined to estimate human exposure. Then the response is calculated using an exposure-response function of the following form:

$R = A \cdot C \cdot P$,

where R is the response (e.g., in cases, days, or episodes), C the concentration (i.e., the concentration resulting from emissions of a particular emission source or sector), P the affected share of the population, and A is an empirically determined constant for the health outcome, typically obtained from published cohort studies.

Indicators in the DivAirCity project, for which the EVA system can be applied

1.3.18: Air Quality and Diversity. With the EVA system it will be possible to derive the percentage of children experiencing air pollution levels above and below current air quality standards for Aarhus with a spatial resolution of 1km x 1km for different years, e.g., in the period from 1990 to 2021. It needs to be examined to what extent this could also be derived for the other cities in DivAirCity.

2.3.2: Change in air pollution – changes in concentration of PM2.5, NO2, O3 and SO2. With the UBM model (also part of the EVA system) it is possible to determine the concentration change between different emission scenarios and/or calendar years for Aarhus with **a spatial resolution of 1km x 1km.**

2.3.9: Number of days in which air quality parameters exceed threshold values: With the EVA system we can calculate the number of days within a given calendar year, for which specific areas have air quality parameters above thresholds. On high resolution for Aarhus, but on country/regional resolution for the rest of the cities/regions included in DivAirCity.

2.3.10: Proportion of population exposed to ambient air pollution: With the EVA system we can assess the proportion of citizens in Aarhus that at the residence have air pollution values above the current standards/guidelines.

With the EVA system it is possible to calculate the health impacts and costs from specific emission or concentration level changes. This means that in scenarios where air pollution levels go down, we can calculate the benefits for society. The indicator for this has not been selected initially but could benefit the project to assess also. On high resolution however this is only possible for Aarhus, but on country/regional scale, it is possible to do these calculations for all the European countries – provided that the reductions in emissions or concentrations are made available.

The system from AU operates on a 1 km^2 scale (as that is what the underlying health functions are valid for). The air pollution interventions planned for the project, will on the other hand only be important very locally (likely within meters from the interventions). **So, the effect of these cannot be directly evaluated with this tool. It might be possible to make some upscaling "scenarios", but the question is how realistic they will be? This will be further assessed.**

4 Exemplary Impact scenarios with five cities

(Data collection before, during and after a possible NBS-intervention)

To illustrate how the selected 33 indicators could be applied for collecting data in relation to possible NBS-interventions we have reached out to each city partner and asked them to participate in an exemplary impact assessment scenario workshop centred around how likely NBS-solutions would impact assessed in one of the possible intervention areas. During these sessions we have delved into one of the possible NBS-interventions to discuss which indicators could be applied as obvious means of collecting data before, during and after the intervention.

We have emphasised to each city partner that these impact scenarios were conceived as inspiration and not something that should influence the NBS-intervention(s) to be chosen by citizens (including the 6+1 groups) in the co-creation workshops. The idea behind the impact scenarios was to enable the city partners to facilitate the co-creation workshops and provide them with sufficient knowledge to discuss the possible NBS-interventions and their data implications in depth with the participating citizens.

Conducting the impact scenarios have contributed to the development of deliverable 2.4. During the impact scenarios it became clear that some of the city partners expressed a need to measure e.g., temperature changes caused by the reflections of buildings and how shading could affect this. Therefore, the discussion of possible NBS-interventions with city partners has highlighted deficiencies among the indicators, provided an opportunity to expand the number of variables and adjust them according to the needs of the cities.

4.1 Bucharest scenario

Development of an area in the city centre affected by heavy polluting traffic with the possibility of adding more plants and trees, improving the facilities in the paved and parking areas and providing better access to greener solutions for target groups living in the area. There is a very busy road right next to a residential area which houses large groups representing several of the 6+1 target audiences. The road is a likely source of high levels of air pollution at least during peak hours. The area has several smaller and larger shops on both sides of the busy road.

Figure 33: The intervention area at the corner of Bulevardul Carol I and Strada Paleologu (Courtesy: Google Street View)

Improvements to the area may offer opportunities for attractive and healthy leisure and commuting activities for 6+1 target audiences living in the area (limited traffic, safe crossings, good light, no dangerous surfaces), healthy (fitness, better air quality) with something attractive to experience (stimulating use of senses).

The co-creation intervention in Bucharest consists of: identifying problems, developing potential improvements, recording perceptions of the area and mobility issues and opportunities in the area, measuring key environmental dimensions in the area, incl. inner climate issues relating to pollution from the busy roads next to the intervention site, measuring use of the area and by whom, making the improved facilities known to people (promotion), measuring changes to the use (incl. which facilities are used and for what activities compared to before) and perceptions among users and shop owners on economic benefits from changes).

4.2 Castellón scenario

In Castellón one possible site for intervention is the street Carrer de la Marina Espanyola – a street that connects the Parc de la Panderola + bus stop (El Grau?) with the primary school C.E.I.P. La Marina and is used by many school children (pedestrians) commuting to and from school every day. There are only a few shops on to the street whereas it is mostly apartment buildings with residents parking their cars directly on the street. Casal Jove, a youth community center, houses different youth activities and has a vast 'empty' public space in front of the building that could make room for a temporary living lab. The Centre Polifunctional La Marina, a museum/

exhibition centre is also located on Carrer de la Marina Espanyola. A possible collaboration with the museum could be a part of the DivAirCity-project.

Figure 34: Carrer de la Marina Espanyola. Casal Jove is seen to the right. (Courtesy: Google Street View).

An intervention on Carrer de la Marina Espanyola would be to make it a pedestrian street, ensure better accessibility and make more space for the school children using the street every day. If the cars are removed from the street this would make room for more greenery, which today is scarce. Perhaps also provide the street with better shading/cooling provided trees or greenery as seen on other streets in the neighbourhood.

The co-creation intervention in Castellón consists of: identifying problems, potential improvements, recording perceptions of the street (and the space in front of Casal Jove) and accessibility of the street, measuring use and by whom, improving routes, making the improved street and area known to people (promotion), measuring changes to the use (incl. which facilities are used and for what activities compared to before) and perceptions among users and market participants on economic benefits to the local area).

4.3 Orvieto scenario

Development of the park at Tramercato by adding more plants and trees and improving the facilities in the park and providing better access to the park for target groups. There is a busy road right next to the park which is a likely source of air pollution. The park is placed close to a residential area with representation of 6+1 target groups. During the year a market is organized in the park. The improved park should allow citizens healthy and attractive stay and use of the park facilities (limited traffic, safe crossings, good light, no dangerous surfaces), healthy (fitness, air quality) with something attractive to experience (stimulating use of senses).

Figure 35: The Park at Tramarcato located at center of the photo. (Courtesy: Google).

4.4 Potsdam scenario

Development of a citizen centre Bürgerhaus am Schlaatz, a facility built in 1986 in the former German Democratic Republic, by adding more plants, green walls and possibly a rooftop garden improving the facilities for the target groups. The citizen centre is located close to a school and a residential area (housing association) consisting of several apartment blocks with representation of 6+1 target groups.

Figure 36: Bürgerhaus in Schlaatz. (Courtesy: Google)

Potsdam has increasingly periods of high temperatures and humidity and lacks spaces with sufficient shade and cooling effect for citizens to occupy as part of their relaxation or exercise.

The co-creation intervention in Potsdam consists of identifying problems, potential improvements, recording perceptions of the citizen centre and getting to the citizen centre, measuring use and by whom, making the improved citizen centre known to people (promotion), measuring changes to the use (incl. which facilities are used and for what activities compared to before) and perceptions among users of the citizen centre and the economic benefit to the local café.

4.5 Aarhus scenario

This NBS is tasked with improving the quality of life for target group 6+1 through an increased use of the most attractive and healthiest paths in and around one of the intervention areas. The paths should take citizens through areas that are safe (limited traffic, safe crossings, good light, no dangerous surfaces), healthy (fitness, air quality) with something attractive to experience (stimulating use of senses).

Figure 37: The intervention area in Aarhus where the citizens are exploring alternative routes for walking and biking to avoid the bigger roads and to get to the train station at the top right corner. (Courtesy: Google).

The co-creation interventions in Aarhus are identifying routes, recording perceptions of the routes, measuring key dimensions of the routes, measuring use and by whom, improving routes by modifying the route and conditions along the route, making the routes known to people (promotion), measuring changes to the use (incl. which paths were used before) and perceptions among users.

5 Data gathering tools

The project requires specific data gathering tools that are consistent across cities and will support the needs analysis at city level as well as the impact assessment. These tools will be used to gather primary data from participants in co-creation, users of NBS interventions, economic units who may or may not benefit financially from the interventions and observed behaviour that will document (no) impact.

5.1 Secondary data collection tools

Secondary social data which need to be collected in DivAirCity can include:

- Census and demographic data
- National and International statistics on economic, education, health, and similar metrics

In terms of environmental data, GIS metadata can be important to analyse the DivAirCity KPIs. Based on the preliminarily defined project indicators, there is likely to be a need for several GIS datasets across all the project's cities. Some of these will be open source, such as imagery from publicly available satellite missions, whereas some will need to be acquired from public and private sources and will be specific to each city. These data sets include, but are not limited to, the following:

- Building data
- Population information such as spatially aggregated census data
- Climatological data tied to weather stations
- Digital elevation models of cities (DEMs)
- Water Distribution Network Pipeline data with customer links
- Remote sensing data including satellite imagery
- City Assets Data
- City land use maps
- Water quality sample network
- Basin geomorphology parameters

The data are mainly static data, which means a fixed data set or data that remains the same after it's collected. It needs be compiled in a unified template, so-called metadata catalogue to analyse. The set of relational tables which constitute DivAirCity metadata catalogue is proposed in the Deliverable 2.1. Digital Innovation and D&I Data Management Framework.

These datasets are produced and collected by different agencies. Their availability may vary from city to city and whether they will all be required in every city is yet to be determined. Multiple datasets can be stored within one database and directly loaded into a mapping interface.

5.2 Needs and Interest in relation to inclusion and air quality

This will be analysed using a telephone questionnaire survey and will make use of tick off questions that will examine the state of perceptions, needs and interests within the 6+1 target audiences. It will also be analysed using the empathy map examining what people say, see, do, and what goals they have in relation to their air quality in their neighbourhood.

5.3 Citizen engagement evaluation

This is needed to understand the coverage of the 6+1 groups during the co-creation processes.

It will be analysed by comparing secondary data collected on population compositions from statistical sources with primary data collected on citizens engaged in the DivAirCity activities to understand the coverage also in relation to key 6+1 target groups. As such the tools are:

- Census data
- Anonymised participant registrations
- Anonymised Blockchain and other online activity registration tools
- Comparative analysis

5.4 Co-participatory process evaluation

This will be a short questionnaire provided to co-creation participants for them to assess the co-creation process. It will be used once following the process to co-define "How might we..." questions and once more following the NBS intervention co-designing process and/or the co-implementation of the NBS interventions.

The evaluation of the co-creation process is asking participants to give their perception of the relevance, influence, trust, value, and future perspective they felt during the co-creation process.

5.5 Evaluation of economic impacts of NBS interventions

This will be a short questionnaire used for interviewing economic actors like suppliers of NBS installations and maintenance services, public or private operators of NBS facilities, social economy and commercial entities influenced by the facilities and activities in the intervention areas.

This questionnaire will be used before the NBS is implemented to gage the economic costs and revenues prior to installation/activation and again after the NBS has been in place/active for a period long enough to gage an impact at which time the same questions are addressed in terms quantitative and qualitative economic impact experienced from different types of economic actors.

5.6 Evaluating the NBS and intervention following implementation and use

This will be assessed using the following tools:

- Questionnaire used for telephone or face-to-face interviews
- Observation form used to observe behaviour before and after
- Questionnaires as in 5.5
- Measurement of environmental impacts in relation to for example CO2 reduction, avoidance of air pollution, reduction of air polluting traffic, effectiveness of barrier between source of air pollution and persons occupying space near air pollution, increase in CO2 and particle absorption from newly introduced plants. This will require the use of:
  - Airly low-cost sensors
  - Other type sensors (to be specified by technical partners) to measure particles and gasses
  - Plant performance data (to be specified by technical partners)
  - Sensors counting traffic

5.7 Citizen science methods

The project will make use of data collection methods that build on citizen science and may be governed by block chain solutions where reward systems are combined with tasking citizens to conduct structured data collections.

These data collections may relate to collecting:

- Citizen Mobility data
- Biodiversity monitoring data
- Air quality data
- NBS maintenance data
- Energy efficiency data
- Citizen NBS participation and usage data
- Citizen NBS and co-creation evaluation data
- Etc.

Citizen science data collection methods require strong motivation factors, very detailed instruction for participating citizens and stringent use of well specified tools. On the other hand, citizen science may offer very effective and efficient data collection methods with a broad reach and a strong connection to desired behavioural change.

5.8 Protocols

To facilitate the easy implementation of data gathering and collection processes, this chapter describes protocols for these processes helping city representatives and ecosystems to conduct the especially the primary data gathering and collection in unified ways (where possible).

5.8.1 Empathy mapping

The city co-creation processes will use an empathy mapping tool to measure what people say, see and do and what their goals are. The empathy maps are used during workshops and/or discussions in the street to map actions from participants in the form of what they say, what they see and do and what they express as their goals. The empathy mapping tool can be found in Annex 10.

5.8.2 Walkthroughs

A good way for DivAirCity projects to understand needs, challenges and opportunities at street, pavement, park and alley level is to conduct walkthroughs. These also serve as an opportunity to collect data from what participants say, see and do and what their goals are. The protocol for walkthroughs can be found in Annex 11.

5.8.3 Face to face interviews

Face to face interviews allows the interviewer to understand the perspective of the interview person. If successfully conducted the interviewer gains access to the social world of the interview persons, their opinions and embodied experiences of the surroundings. According to pedagogical psychologist Steinar Kvale (2007: 55) the interview can be considered as an ”inter-change of views” between the interviewer and the interview person, however, the outcome of this inter-change is dependent on the interviewer's ability to show ”interest, understanding and respect” for what the interview person says.

Interviews can be conducted in both structured (i.e., planned following and interview guide covering specific topics) and unstructured ways (more spontaneous and perhaps spurred by experiences shared by the interviewer and interview person for example during a walkthrough). In the DivAirCity project we provide a protocol (see Annex 12) that can serve as inspiration for an interview guide to conduct interviews with relevant stakeholders.

Before conducting face to face interviews, the interviewer is obliged to secure that the interview persons consent to participating in the interview. The interviewer informs the interview persons about the expected outcome of the interview, the range of questions that the interview will cover, how data provided in the interview will be used in the DivAirCity project and to what extent the interview person can be anonymised. The interviewer will ask for permission to record the interviews.

During the interviews the interviewer will have listen carefully to what the interview persons tell and from time to time confer with the interview guide to make sure that all the predetermined topics are covered during the interviews. After covering the predetermined topics, the interviewer can ask the interview persons if they have any considerations not covered during the interview or something to add. After turning off the recording many interview persons feel at ease and start to talk less formally - if something important or valuable comes up during this conversation the interviewer can ask for permission to start the recording again and ask the interview person to elaborate a talking point.

The recorded interview contains important data that must be deducted from the overall interview. A way to deduce insights is to transcribe important sections of the interview or alternatively the interview in total. After the interview has been turned into to readable text the interviewer will have to analyse it by e.g., looking for central (and perhaps recurring) themes and to summarise the most important statements made by the interview person.

5.8.4 Telephone interviews

See description of Face-to-face interviews above. Telephone interviews follow the same protocol developed for face-to-face interviews (see Annex 12).

5.8.5 Focus Group Interviews

A focus group is a method for collecting qualitative data that combines interview and observation of a group of individuals that share a particular experience or knowledge about a specific topic. In a focus group, the moderator poses a series of predetermined questions to the group aiming to explore their perceptions, opinions, and experiences on these topics. The interactions established between participants during the session are also important sources of information that require the moderator's attention. The moderator functions as a facilitator of the conversation and it might prove beneficial to enlist an assistant moderator responsible for practicalities (e.g., arranging chairs, welcoming participants, operate recording equipment and taking notes etc.)

According to internationally recognized authority on the use of focus group interviewing Richard A. Krueger (2002) setting the right scene and creating an *open environment* for the focus group is crucial as "the moderator must create a thoughtful, permissive atmosphere, provide ground rules, and set the tone of the discussion." The moderator(s) must secure an environment where the participators feel comfortable about sharing their thought and viewpoints and make sure that everyone feels and is heard during the focus group session. The DivAirCity project has developed a protocol for conducting focus group interviews (see Annex 13). This protocol provides guidelines for managing focus groups and important things to consider before, during and after the focus groups.

5.8.6 Observations (Behavioural Mapping)

To measure behavioural activity at district and intervention level, DivAirCity will make use of behavioural mapping forms. Such behavioural mapping requires detailed definition of the geographical area covered and recording of position from where the observation is carried out. Also, the time of observation and the weather condition will be important to register. When repeating the observation of behaviours for impact assessment the exact same geographical location, time and weather conditions must be adhered to.

From the two observation procedures it will be possible to quantify a difference in the location from before the intervention and again after the intervention showing possible increases in activities and which types of activities have increased.

Combining observations with interviews or focus group interviews, it will be possible to gain a validation and reasoning behind the increases (or no increases) as well as perceptions concerning the positive and negative implications of the observed changes.

At present a DivAirCity protocol for behavioural mapping is to be agreed upon by management and city partners to secure its scope and applicability for the specific cities involved in DivAirCity. It will be inspired by a similar tool for behavioural mapping developed by another European HORIZON project URBiNAT: Urban Innovative & Inclusive Nature. We have included initial instructions in Annex 14.

5.8.7 Other relevant quantifications

It will be possible where relevant to set up other types of quantifications. This could be:

- modes of transportation in number of journeys (using secondary or primary data sensor data),
- quantification of café or shop users accessing shop or café door sensor data
- observations of biodiversity in terms of plants, insects or animals relying on communities of biodiversity spotters for instance using I-nature or similar apps.

6 Social inclusion and diversity in data

Social inclusion and diversity are vital topics for DivAirCity to monitor in relation to air quality and Carbon deduction opportunities. DivAirCity has central objectives to make the following actions:

- reduce air pollution,
- improve accessibility to clean air environments
- reduce CO2 emissions
- improve green spaces

in a just and inclusive manner, so that all citizens have a realistic chance to benefit from the improvements and their outcomes.

Whether this will be achieved will be measured through the following data gatherings:

- Observations of activities in the implemented NBS improvements to assess the actual participation of 6+1 target groups
- Interviews (focus group/face to face interviews) with stakeholders and individual citizens to assess their perception of the diversity of the process leading to the NBS and the inclusiveness of both the process as well as the NBS solution.

7 Perspectives for next steps in DivAirCity

The data sources and data collection methods are not described in final versions and still requires general acceptance and consensus across partners. Therefore, the future activities in WP3 (co-creation process) and WP4 living lab NBS implementations, WP5 Blockchain cases and WP6 Impact assessment should consult this document when creating the final data collections to be implemented across the cities.

Some data collections related to initial insights and baseline measurement are urgent to be conducted due to the fast-progressing co-creation activities at city level.

It may be necessary for some WPs to conduct pilot data collection activities to access and test data material in relation to indicators and metrics relevant for each of the WPs.

Work remains to collect, analyse and present data findings for comparison and feasibility of generating valuable insights and knowledge for adjustment of co-creation processes, recommendation of measurement methods and NBS implementations.

8 Conclusion

Deliverable 2.4 further develops the data source and collection requirements of DivAirCity. The work is based on the facilitation of exchanges across work packages and across the cities to prioritise and assess data availability and data gathering feasibility using different sources.

The deliverable is also the result of a detailed development and assessment of data collection tools to be used and how to use them for the common benefit of the project partners and in order to meet the measurement requirements promised in the Grant Agreement of DivAirCity Project.

As such the deliverable follows the first six steps of the data management framework and seeks to guide cities, other work packages and technical partners in the completion of the data management framework.

This development and assessment process has required a common search for consensus that considers the practical and financial resources available in the project as well as a realistic view on which impacts can be achieved and measured during the short period of the project and the expected scales of the interventions foreseen in the project.

To make these impacts concrete, the deliverable presents an impact measurement approach for a possible scenario for each of the participating cities. These are designed to help cities and technical partners plan the impact assessments of actual NBS with a focus on actual measurement of real impact of NBS.

The deliverable also provides a detailed analysis of the prioritised indicators with suggestions for data sources, collection methods and quality assurance procedure to facilitate the implementation.

The data sources and data collection methods are not described in full detail as this would require access to and test of data material in relation to each of the indicators and metrics and this has not been possible within the timeframe of working with the data sources.

Therefore, the work remains to pilot and test data gatherings, analyse data and present findings for comparison and feasibility of generating valuable insights and knowledge for adjustment of co-creation processes, recommendation of measurement methods and NBS implementations.

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10 Annexes

Annex 1: Stakeholder engagement template

City: (state the DivAirCity city)

First list the stakeholders and address to be engaged related to target audiences covered by the stakeholder:

City	Stake-holder name	6+1 Categories	Steering committee partici-pation	Address of the organi-sation	Collection date
Orvieto		Women			Date that the data collected
Aarhus		Children-Youth			
Castellon		LGBT+			
Bucharest		Senior citizen			
Potsdam		Ethnical minorities			
		Persons with disabilities			

Second list stakeholders and address to be engaged related to their key themes of interest:

Stakeholder registration	Themes of interest	Steering committee membership
	Nature protection	
	Urban Gardening	
	Energy efficiency	
	Biodiversity	
	Renewable energy	
	Public transport	
	Non-polluting mobility solutions	
	Nature ethics	
	Green Nudging	
	Citizen engagement	

	Urban sports/physical activities	

Stakeholders should only be registered in one of the tables. In other words, they are either primarily stakeholder for a target audience or for a key theme of interest.

Annex 2: Participatory culture in relation to air quality, carbon emissions and diversity/inclusion Template

Table 50

Capacity and measures for DivAirCity participatory culture	Yes/ No	Name of policy	Collection date	Policy target year
Climate strategy/action plan with citizen driven activities				
Citizen Climate panel giving advice to politicians				
Online Climate action consultation portal for citizens				
Climate advisory board of experts and stakeholders				
Formal City citizenship policy				
Formal City diversity/inclusion policy				
Climate advisory city centre serving citizens				
Open citizen meeting on climate, energy efficiency or air quality				
Participatory budgeting in relation climate actions /air quality improvements				
Public access to city-based air quality measurements				
Internal municipality facilitators of citizen engagement				
External facilitators of citizen engagement				
Others				

Annex 3: Parameters of safety and security

Question:

On a scale from 1-7 how secure do you feel in your neighbourhood, where 1 is 'I feel very unsecure in my neighbourhood" and 7 is "I feel very insecure in my neighbourhood" Neighbourhood means in the vicinity of my home.

Lists of behaviours that make persons feel insecure:

- Reckless driving
- Threatening behaviour
- Noisy behaviour with consideration for others
- Vandalism Loitering Criminal activity dangerous to people
- Other criminal activity
- Other

Places where people may feel insecure:

- In your home
- On the street
- On paths
- In square/courtyard
- In staircase/corridor
- In parks, playgrounds, and other green spaces
- At stations and bus stops
- Other places in your neighbourhood

Annex 4: Indicator ranking made by city partners

Selected indicators are highlighted with green.

Indicator ID	Orvieto	Aarhus	Bucharest	Castellón	Potsdam
1.1.1	4	3	3	3 or 4	4
1.1.2	5	4	3	None	4
1.1.3	5	1	2	None	4
1.1.4	5	5	5	4	None
1.1.5	2	2	2	0	2
1.1.6	2	1	1	0	2
1.1.7	2	3	3	0	2
1.2.1	5	5	5	3 or 4	4
1.2.2	5	5	5	3 or 4	4
1.2.3	5	5	5	2	2
1.2.4	5	4	4	3	4
1.2.5	5	5	5	3	4
1.2.6	4	5	4	2	2
1.2.7	5	1	3	4	4
1.2.8	5	2	3	4	4
1.3.1	5	1	3	4	2
1.3.2	3	1	1	4	None
1.3.3	3	1	3	4	None
1.3.4	3	1	2	4	None
1.3.5	3	1	2	4	None
1.3.6	3	1	1	4	None
1.3.7	4	1	1	1	None
1.3.8	3	1	1	1	None
1.3.9	3	1	2	1	None
1.3.10	3	1	2	3	3
1.3.11	4	1	2	3	None
1.3.12	4	4	4	3	3
1.3.13	4	1	3	2	None
1.3.14	4	4	4	3	None
1.3.15	3 or 4	1	2	2	3
1.3.16	2	1	3	3	3
1.3.17	4	1	3	3	2
1.3.18	5	4	4	2	5
1.3.19	5	1	3	4	None
1.3.20	4	1	3	4	None
2.1.1	3	1	4	4	None
2.1.2	5	3	5	5	1
2.1.3	5	1	4	4 or 5	3
2.2.1	5	1	4	3	3
2.2.2	5	3	4	3	3
2.2.3	5	1	4	4	2

2.2.4	5	1	4	2	None
2.3.2	5	1	4	5	5
2.3.3	5	5	5	5	5
2.3.4	1	1	2	2	2
2.3.5	3	1	3	3	1
2.3.6	5	4	5	4	3
2.3.7	5	4	5	4	5
2.3.8	5	1	4	4	2
2.3.9	5	5	5	4 or 5	4
2.3.10	3	4	5	4	4
2.3.11	3	4	4	4	3
2.3.12	1	3	3	3	None
2.3.13	3	1	3	3	None
2.3.14	1	1	2	2	None
3.2.1	5	5	5	4	2
3.2.2	3	None	3	4	?
3.3.1	3	1	1	None	4
3.3.2	4	5	5	4	4
3.3.3	5	1	1	5	?
3.3.4	4	1	3	None	None
3.3.5	1	3	2	None	None
3.3.6	3	1	2	None	1
3.3.7	3	1	2	None	2
3.3.8	4	3	4	None	2
3.3.9	3	1	1	None	2
3.3.10	4	5	5	2 or 3	None

Annex 5: Data availability in relation to the selected 33 indicators

Indicator ID	Indicator	Metric	Orvieto	Aarhus	Bucharest	Castellón	Potsdam
1.1.1.	Actors available	Total number and list of relevant NGOs in city/city district Number of schools and kindergardens in city district & just outside city district Number of children living in district and going to kinder garden or school inside/just outside city district and living outside district but going to school/kindergarden inside district Number of people using social facilities (e.g. elderly centres and refugee centres) Proportion of different stakeholders and population groups 6+1 participating in the discovery phase co-creation activities (measured in tick off participation – to the extent that it is impossible to identify individuals)	yes	yes	yes	yes	yes
1.1.2.	Participatory culture	Total number and list of existing relevant action plans in the cities (air quality action plan. Sustainable energy and climate action plan, Action plans in place Carbon emissions of the transport infrastructure and industry Citizen participation/volunteering in co-governance task force/board for city DivAirCity projects (composition according to 6+1 and consistency of members) Experience with citizens science activities at city/district level – citizens having participated in citizens science; stakeholder with co-governance of citizens science projects.	yes	yes	?	yes	yes
1.1.4.	Population composition	Total population in city/district Population density (population per square meter) Proportion of population by gender, age, ethnicity, income, occupation, and education level	yes	yes	yes	yes	yes

1.2.1	Target audiences for the NBS to be designed	% of target audiences engaged in the co-creation phase 2 Representation of the target audiences in the co-creation phase 2 (Proportion and types of participating civic society organisations and related social groups)	yes	yes	yes	yes	yes
1.2.2	Users and use of green spaces for diversity	Number and variety of users accessing the public space (5 Likert scale survey) Number and variety of activities observed in the public space among time and space (5 Likert scale survey)	yes	yes	yes	yes	yes
1.2.3	Comfort and safety of green spaces for diversity	Perception of safety & level of security of the public space (5 Likert scale survey) Overall comfort using the public space, through maintenance, design and ambiental conditions with respect to 6+1 groups (5 Likert scale survey) Presence of a public space identity, defined by cultural background and users' enjoyment with respect to 6+1 groups (5 Likert scale survey)	yes	yes	yes	no	yes
1.2.4	Level of digital participation	Stats on populations digital access allowing for online participation vs actual digital participation measured during processes. Number of green blockchain contracts downloaded following intervention.	yes	yes	yes	no	yes
1.2.5	Accessibility of green spaces	Accessibility of urban green space assessed by participants and the demographic categories of participants [1] (5 Likert scale survey) Population in designated area not living within ten minutes walking from public green space. The routes taken between residential areas and schools	yes	yes	yes	no	yes
1.2.6.	Perceived control and trust over decision-making of NBS	Perceived control and influence over decision-making in respect to the types of stakeholders (survey of participants)[1]	yes	yes	yes	no	yes
1.2.7	Target audiences for the NBS	% of target audiences engaged in the co-creation phase 3	yes	no	yes	no	yes

	to be validated						
1.2.8	Target audiences for the NBS to be implemented	Representation of the target audiences in the co-implementation phase 4	yes	no	yes	no	yes
1.3.10	Income and work	Income average and Income average of diverse groups % of unemployment and % of unemployment in respect to the 6+1 groups	no	yes	yes	no	yes
1.3.12	Place attachment	Survey on Place Identity Scale	yes	yes	yes	no	yes
1.3.14	Safety and security	Crime counts in the neighbourhood Perceived crime level percentage of citizens feeling safe	yes	yes	yes	no	yes
1.3.18	Air quality and diversity	Percentage of children ages 0 to 17 years living in neighbourhoods with pollutant concentrations above the levels of the current air quality standards (By race/ethnicity and by family income) Percentage of days with good, moderate, or unhealthy air quality for children ages 0 to 17 years (By race/ethnicity and by family income)	yes	yes	No	no	yes
2.1.1.	Residential building quality	Average age of buildings and composition of built environment age in the designated districts	?	?	yes	yes	?
2.1.2	Connectivity of green space	Structural connectivity: Calculation of connectivity of green space from GIS data from 1 (very low) to 5 (very high) Functional connectivity: ha of potential habitat	yes	yes	Yes	yes	yes
2.1.3	Green space managemen t	Distribution of public green space: Per capita public space in the neighbourhood (m2) total tree cover area before DivAirCity project Total green space	yes	yes	yes	yes	yes
2.2.1	Evaluation of existing NBS	CO2 absorption capacity of current NBS in city district	yes	?	yes	no	yes

2.2.2	Evaluation of prototypes tested in city districts	CO_2 absorption capacity of current NBS in city district Number of households/businesses/residents nearby the existing NBS	yes	no	Yes	no	yes
2.2.3	Changes to the size and distribution of public green space due to the DivAirCity interventions	Changes in terms of conversion of paved area to green areas due to the DivAirCity interventions Changes to proportion of population in designated area not living within ten minutes walking from NBS interventions	yes	no	Yes	no	yes
2.3.2	Concentration of particulate matter	Change in air pollution - changes in concentrations in PM, NO_2, O_3, SO_2	yes	no	Yes	no	yes
2.3.3	Concentration of particulate matter at respiration height along roadways and streets	The concentration of PM2.5 and PM10, respectively, per cubic metre of air (units µg m-3) at a measuring height of 1.5 m above the ground surface, or height of wheelchair users and children, to represent the air quality experienced by citizens	yes	yes	yes	no	yes
2.3.6	Carbon sequestration in vegetation	Increase of biomass in vegetation as tonnes of carbon stored.	yes	yes	Yes	no	yes
2.3.7	Common Air Quality Index	The two mandatory measurements for the 'roadside' CAQI are NO_2 and PM10 (particulate matter less than or equal to 10 µm in diameter), with O_3 also required for the 'background' index. The five categories that from very low to very high	yes	yes	yes	yes	yes

2.3.8	Normalised Difference Vegetation index	Normalised Difference Vegetation index (NDVI)	yes	?	yes	yes	yes
2.3.9	Number of days in which air quality parameters exceed threshold values	Number of days in which air quality parameters exceed threshold values	yes	yes	Yes	yes	yes
2.3.10	Proportion of population exposed to ambient air pollution	Urban population exposed to air pollutant concentrations above EU standards and WHO air quality guidelines	no	yes	Yes	no	yes
2.3.11	Sustainable transport	Percentage of each mode of transportation (i.e. private, public, bicycles, pedestrians, availability of car-sharing solutions, availability of bicycles and eScooter renting services)	no	yes	yes	no	yes
3.2.1	Initial costs of NBS implementation	estimated initial cost (€)	yes	yes	yes	no	yes
3.3.2	Maintenance costs of NBS	Cost estimates or actual cost reporting from entitles administering the NBS and sub-contractors.	yes	yes	yes	no	yes

3.3.3	Valuation of NBS	Value of NBS using GI-Val toolkit. The toolkit provides a set of calculator tools and standard valuation techniques to assess the potential benefits provided by green infrastructure within a defined project area 3.3.1 + Residential land and property values uplift Commercial land and property values uplift Private sector investment levered Employment creation	yes	no	yes	yes	no
3.3.10	Energy consumption and cost of operation of blockchain	Total cost of operation of DivAirCity Smart Cities Climate Contracts against the benefit Total energy consumption of DivAirCity Smart Cities Climate Contracts against the energy saving through the project Energy consumption of DivAirCity Smart Cities Climate Contracts against the average energy consumption of blockchain	yes	no	?	yes	no

Annex 6: Co-creation process evaluation

Draft participatory process evaluation questionnaire

To what extent do you agree with these statements concerning the co-creation process you just took part in:

Questions **The co-creation process…**	**Not at all**	**To low extent**	**To some extent**	**To high extent**	**Don't know**
Addresses important problems in the neighbourhood					
Had a clear purpose					
Was open for anyone to participate in					
Allowed me to express my concerns and ideas					
Was effective in developing solutions to address problems					
Was organized in a good way					
Used a language I could understand					
Had the right mix of participants					
Provided me with valuable information before the event					
Provided me with valuable information during the event					
Gave me the opportunity to influence important decision-making					
Animated me to be wanting to do more co-creation processes					
Introduced me to community activities I will join on other occasions					
Has given me optimism in terms of improving my job situation/skills					
Will produce results that will animate similar initiatives elsewhere in the city					
Will lead to air quality improvements in my neighbourhood					

Annex 7: Evaluation of economic impacts of NBS interventions

Draft evaluation of economic impacts of NBS interventions (in ´000 EURO)

Commerce

Number of commercial entities entered: _____ (shop, market booth owner, café, etc.)

Questions per entity (before and after):

Quantitative

Cost of maintaining the immediate outside environment (if relevant) per annum?

Average revenue per month ______ plus highest _____ and lowest ______ monthly revenue

Cost of operations per month ______ plus highest _____ and lowest ______ monthly total costs

Qualitative

How would you expect the improvements from the ---- name NBS---- impact the business (increase revenue/decrease or unchanged)?

How have the improvements from the ---- name NBS---- impacted the business (increase revenue/decrease or unchanged)?

How much of the change is impacted from the ---- name NBS---- and how much from other factors (and which other factors?)

What will you do to promote the ---- name NBS---- and why (not)?

What did you do to promote the ---- name NBS---- and why (not)?

What would you improve in ---- name NBS---- to achieve a more positive impact for your business?

NBS Suppliers

Number of suppliers entered: _______ (NBS suppliers, green wall suppliers, traffic nudging consultancies, etc.)

Quantitative

Average revenue per month ______ plus highest _____ and lowest ______ monthly revenue

Cost of operations per month ______ plus highest _____ and lowest ______ monthly total costs

Qualitative

How would you expect the ---- name NBS---- implementation/reference to impact your business (increase revenue/decrease or unchanged)?

How has the ---- name NBS---- reference/implementation impacted your business (increase revenue/decrease or unchanged – increased/unchanged interest from other clients)?

How much of the change is impacted from the ---- name NBS---- and how much from other factors (and which other factors?)

What will you do to promote the ---- name NBS---- implementation and why (not)?

What did you do to promote the ---- name NBS---- implementation and why (not)?

What would you improve in ---- name NBS---- to achieve a more positive impact for your business?

Annex 8: Citizen evaluation of NBS and intervention

Draft questionnaire for e**valuating the NBS and intervention following implementation and use**

Registration of users by target group (names not included in the evaluation data).

Target of 20 full responses with representation of at least x out of 6 target audiences per intervention area.

Could be done by interviewer or given to users to complete and submit before they leave the area

The data will be gathered in terms of:

- Numbers of “yes” and “no” answers or “don’t know” answers
- Number of times certain themes are mentioned

Questions	Answers (leave empty if you do not know)
How did you hear about this place (---- name it-----)?	
Do you believe the (---- name it-----) was promoted well?	
Did you read the information provided about the NBS (---- name it-----)?	
Have you used this space before it became like it is today?	
What was it like then?	
If you did not use it before, what did you use instead?	
What is your purpose with using the NBS (---- name it-----)?	
How many times have you visited the space in the past week?	
To what extent is the (---- name it-----) accessible for you?	
What is you impression of the NBS (---- name it-----)?	
Will it improve living conditions for people in the local community?	
Are there certain groups of citizens that you think will benefit especially?	
Will you use (---- name it-----) with colleagues/friends and/or family?	
Will the (---- name it-----) improve your health?	
Which groups will benefit most from the health benefits of (---- name it-----)?	
Does (---- name it-----) animate to healthy activities, if yes which activities?	
Does (---- name it-----) animate to more environmentally sustainable activities, if yes which sustainable activities?	
Has (---- name it-----) improved your sense of security (avoiding criminal threats)?	
Has (---- name it-----) improved your sense of safety (avoiding accidents)?	
What would animate you to use the (---- name it-----) more often?	
Have you purchased anything on the way to the area or while in the area? If yes what?	
Has the (---- name it-----) improved the area?	
How would you improve (---- name it-----) and why?	

Annex 9: Insight survey questionnaire.

This insight survey questionnaire has undergone a process of city evaluation, selecting those questions that cities felt added insights that would be helpful to the design of relevant NBS interventions. Questions written in red was declined by a majority of cities. Questions marked in blue are optional questions

Question	Answer options
Geography location/country of residence	List
City centre, suburban, country side, seaside, mountain, Other (please define)	List
Age group (<20, 21-30, 31-40, 41-50, 51-65, over 65) - don't wish to answer	List
Nationality (options - prefer not to say)	List
Gender (Male/Female/Other) - don't wish to answer	List
Ethnical background (Options - prefer not to say)	
Work status - (employed, self-employed, student, unemployed, full time career)	List
Area of occupation or industry sector	List
Family composition If >= 1, Are they family members or others If Kids, can you tell us their age (<3, 4-8, 9-11, 12-17, >18)	List
Can you please describe your job and how, the logistic of the city impacts it?	Text
Did you ever work from home, and on what frequency?	
Do you feel you have to cross very polluted areas to go to your work place?	
Are you feeling safe in going to work?	
Are you happy with your journey to work?	
Is the place you work or study doing anything to reduce air pollution indoor or outdoor? If yes what?	
Can you describe the areas that you visit the most?	text
Do you spend time often in green areas of the city?	yes/No
If No, Why not? If Yes, to do what?	Text
Which is the area of your city where you feel safest?	text
Which is the part of your city where you feel happiest?	text
How would you characterize your daily routine around the city?	text
Which city in the world - other than yours - would like to live in?Why?	
What two things would you want to change about your city?	text

What two things you would never change about your city?	
Two negatives and two positives about your city?	
Do you worry about air pollution?	Yes/No
If You are worried more for you or for your family/friends/loved ones?	Text
Have you ever changed a route to avoid air pollution?	Yes/No
Have you ever chosen a specific transport solution to avoid generating air pollution?	Yes/No
What else are you doing or have you done to reduce air pollution or address climate change?	
For you is air pollution more important than personal comfort?	Yes/No
For you is air pollution more important than personal safety?	
Which are the reasons you chose your mode of transport?	Text
How has your routine changed since the pandemic?	
Did you or people in your home work from home or do homeschooling during the pandemic?	
Has your dayly routines changed since the pandemic?	
Compared to same time last year do you spend more time or less time outdoor?	The same, more or less
Compared to same time last year Do you spend more or less time in green areas?	The same, more or less
Do you have more or less time for yourself?	
What is your favourite time of the day and why?	
Specifically for children	
Could you describe a typical day when you go to school from home?	Text
Could you describe your school?	Text
Where do you usually meet your friends most often before or after school?	Text
Do your parents/carers work far from the school? Are you an independent traveller? Do you find your own way to school and back to your home)	Text
Additional questions for children	
Can you describe the place where mom and dad work?	
What is your favourite place of the city?	
Where do you go to play most often?	
Which one is your favourite outdoor game?	
Additional questions	
In general, how inclusive do you perceive your city to be?	
In general, how diverse do you perceive your city to be?	
Which area of your city would you say is more diverse?	

Which area of your city would you say is more inclusive?	
How, in your opinion, could your city improve diversity and inclusion practices?	
Could you please describe the relationship between diversity and built environment in your city?	
As citizen, what did you consider to be the most important decision to take to improve diversity and inclusion in your city?	
As a citizen, what city expectations do you have regarding diversity and inclusion?	
From your experience, how has the diversity in your city change in the last 15 years?	

Annex 10: Empathy Mapping

The empathy map developed by DivAirCity can be accessed via this link:

https://upvedues.sharepoint.com/sites/2020DivAirCity/_layouts/15/download.aspx?SourceUrl=%2Fsites%2F2020DivAirCity%2FDocumentos%20compartidos%2FGeneral%2F4%2E%20Events%20%26%20Meetings%2F03%20Consortium%20Meetings%2F3rd%20Consortium%20Meeting%202022%5F10%5F5%2D6%2F06%20Contents%2F18%2EWrap%2DUp%20and%20Next%20Steps%2F01%5FExercise%5FPack%2FEmpathy%5FMap%2Fempathy%20map%20%2D%20all%20cities%2Epdf

Annex 11: Walkthrough protocol

Document type: Internal document – Walkthrough protocol

Created by: Knud Erik Hilding-Hamann & Lasse Blond, DTI

Date: 27 October 2022

WALKTHROUGH

Introduction

A walkthrough allows participants to share their views, discuss improvements and point out areas of interests to researchers based on their experience of living in the area. It can help with identifying areas where interventions should be done or where NBS-solutions could improve livelihood in a specific area.

Step 1 - Before the walkthrough

1. Define the roles (who is going to ask questions during the walkthrough, who is responsible for taking notes + photographs. Prepare a work plan that specifies the walking routes to be visited and the questions that needs to be
2. Compare with existing data about the area, which topics might be covered during the walkthrough.

Define the time the visit may take; Define the number of participants (max. 10 citizens).

Check to visit limitations and impediments (dates, time, attends, weather, accessibility)

3. Send out invitations, set up posters in the area and/or use other means for recruiting relevant participants to participate in the walkthrough.

Material:

4. Maps in scale 1/50 in A4 or A3 format. Since the area is very large, it should be fractionated;
5. Prepare an interview guide with structured questions to note the answers;
6. Maps for participants to make their own notes + comments during the walkthrough.

Step 2 - During the activity

7. If the route is planned by the researcher, ask the participants to add their parallel paths (when compatible with the objective);
8. If the route is not planned by the researcher, ask the participants what places they would like to visit and plan the best route before starting. Route deviations are acceptable;
9. Before starting the walkthrough, make sure to inform the participants about i) objectives; ii) benefits for residents; iii) how their comments are used in the project and the purpose of taking photos and making other observations;
10. Suggested questions to motivate the discussion:
    a. What do you like in this place?
    b. What could work better or different? (e.g., lighting, green spaces, connections between neighbourhoods, pedestrian paths, etc.) Why?
    c. How do people use the square/garden/street/outer space of the neighbourhood? | Which activities happen in the square / in the garden / in the street / outer space of the neighbourhood?
    d. Where do you live? (If applicable)
    e. Observations (about the place, about the participants' comments, etc.)
11. Make sure to take photographs to illustrate questions and answers or areas of particular interest;

Step 3 - Analysing results

12. Record the words, avoid making interpretations;
13. Check the frequency of topics covered and connection to spaces;
14. The result can be checked in graphic form for better visualization of recurring themes;

15. Organize the answers in categories according to the goal already defined (nature, mobility, wellbeing, safety, cleanness, etc.)

Phase 4 - Reporting results

16. write a report following DivAirCity template (including purpose, process, outcomes and findings).
17. schedule a meeting to discuss results (highlighting main themes, issues, problems, etc., that arose in the session).
18. discuss how to proceed.

Annex 12: Face to Face Interviews

Protocol - Semi-structured face to face interviews

Semi-structured interviews may be conducted for the DivAirCity study areas:

- Retired persons
- Child/Young persons (subject to parent acceptance)
- Unemployed person
- LGTB person
- Person with disability
- Person with ethnic background
- Etc.

The interviews may be conducted at the district location, at a workplace of the respondent (in the residential area) or in city location (non-project territory), convenient for a meeting for the respondent.

The main themes explored through the interviews should focus on:

a) level of attachment of the respondent to his/her neighbourhood – identity with places, atmosphere.

b) things in the territory the respondents like/dislike,

c) identified potential for change. The things in the territory the respondents like/dislike were categorized as follows:

- Aspects of the environment (sources of emissions, air quality issues, physical and natural, mobility patterns, infrastructure, and social/community) in the target area, which they like and dislike.
- Communal environment and communication patterns – information, invitations, events, initiative.
- Safety and security – where the person feel safe and secure and where not – streets, parks, stations, bus stops, in dwellings, cellar facilities, etc.
- Citizens' participation – inclusive, diverse, interest, motivations, and degree of participation of the residents in the area.
- Attitudes towards district government and management of the district (respondent's residential area) - degree of satisfaction with mode of management of the district, communication, and interaction with citizens; The identified potential for change focuses on the areas of desired change; change agents (participants in the process); modes of informing, motivating, and sustaining interest and reactiveness to sustain the process.

The interview is written up with positive and negative comments in relation to the five themes.

Themes	Positives	Negatives
Environment		

Communal environment and communication		
Safety and security		
Citizen participation		
District government and management		

Annex 13: Focus Group Interviews

Document type: Internal document – Focus group protocol

Created by: Knud Erik Hilding-Hamann

Date: 29 September 2022

FOCUS GROUP PROTOCOL

Introduction

A focus group is a method for collecting qualitative data that combines interview and observation of a group of individuals that share a particular experience or knowledge about a specific topic. In a focus group, the researcher poses a series of predetermined questions to the group aiming to explore their perceptions, opinions and experiences on these topics. The interactions established between participants during the session are also important sources of information that require the researcher's attention.

Phase 1 - Before the focus group

1. identify the purpose and expected outcomes of the focus group;

2. determine how many focus groups will be conducted (multiple focus groups allow comparison and complementarity of gathered information);

3. identify the participants (how many? Ideally between 6 and 10);

4. identify a list of key attributes of participants (relevance for 6+1 target groups);

5. identify participants, their name and contact details and send invitations;

6. identify a set of questions (maximum 5-6 questions relevant for the purpose);

7. develop a script (plan the phases of the session: from welcome to closure);

8. select a facilitator (someone able to keep the discussion going, making sure all participants are heard; someone who does not actively participate in the dialogue);

9. choose a location (easy access, comfortable);

10. create local conditions (i.e., create conditions that every participant sees all others);

11. set a time (depending on the time consider food and/or drinks);

12. provide materials (notebook, computer, audio or video recorder, flip chart, list of participants, script, name tags, clock for time control, etc.).

Phase 2 - During the focus group

13. arrive before participants to set up the interview room;

14. welcome and introduction of facilitator (and note-taker, if exists);

15. ask participants to introduce themselves;

16. obtain informed consent;

17. conduct the session according to the script;

18. audio or video record the session;

19. monitor the time closely;

20. to finish, thank participants and tell them the next steps, including devolution of results.

Phase 3 - Analyzing results

21. after the session, the facilitator should write up a summary of impressions;

22. transcribe the audio recording of the session, as soon as possible;

23. read the impressions, the transcriptions and write down themes and trends, relevant comments and emotional responses;

24. interpret the results: what are the major findings?

Phase 4 - Reporting results

24. write a report following DivAirCity template (including purpose, process, outcomes and findings);

25. schedule a meeting to discuss results (highlighting main themes, issues, problems, etc, that arose in the session);

26. discuss how to proceed.

Annex 14: Observations (Behavioural Mapping)

Behavioural mapping is structured observation that applies various techniques for documentation, including mapping and counting of activities performed by people passing and occupying a defined space in chosen moments of time. Mapping and counting explore the quantity and the quality of various activities performed at places of interest (public, semi-public or semi-private spaces) related to non-motorised moving, staying, recreating or playing. The process of gathering data through observations and its analysis and visualization through tables and graphs, photos and collages, maps and other infographics can reveal the ways of presence of targeted groups in the study area and their behaviour. This information can be related to overall pictures of health, wellbeing, socialization, time budget and physical activity. The analysis can be made wider by comparing the data in time and space as well as correlating the data with other described characteristics and stated conditions of the residents, visitors, services and environment in and around the places of interest.

This procedure should be applied to parts of the intervention area that have been outlined as important places and focal points as well as prioritized by the DivAirCity city team as areas for intervention.

The method is adapted and modified for the purposes of DivAirCity from a combination of tools developed by Gehl and Gehl institute as well as RAND Health Care as follows:

- From Gehl's tools: Place inventory (PI); People moving count + Age&gender tally tool (PMC&AGT); Stationary activity mapping (SAM)
- From RAND's surveys: System for Observing Play and Recreation in Communities (SOPARC).

Methods for database management, analysis and visualization needs to be developed on the basis of previous experience and the general technological and visual framework of the DivAirCity project initial developed in D2.2.

There are several interlinked steps which should be followed in order to collect valuable data:

- Definition of scope
- Preparation of materials
- Recruitment or procurement
- Elaboration of the field work
- Data gathering and processing
- Analysis and visualization of data

Tools used in behavioural mapping to describe activities undertaken in spaces observed:

Posture		Activities	
Standing		**Passive**	
●	Standing	◦	Drinking (alcohol or else)
⊗	Waiting on public transport stop	ʃ	Smoking (tobacco cigars or else)
⊘	Leaning against a tree or other object	✕	Eating (e.g. hatching sunflower seeds)
Sitting in public spaces		⊏⊃	Listening to music
▲	Sitting at formal fixed places (benches and other)	⬡	Playing cards or board games
▶	Sitting at informal fixed places (do it yourself)	◯	Talking
▷	Sitting at places moveable or not fixed for the purpose (over the grass, stones, stairs, edges, etc.)	TV	Looking at TV
Sitting in semi-public / semi-private spaces		▯	Using telephone
□	Sitting at cafes and pubs	**Dynamic**	
◇	Sitting in front of or inside of shops and services	♡	Playing children
■	Sitting at the edge of private property (e.g. terrace on the 1st floor)	♥	Playing adults
Lying		☆	Dancing
▬	Lying in visually good condition	D	Walking pets (dogs)
▭	Lying in visually bad condition	**Others**	
Gender			
M	Male		
F	Female		

Figure: Basic legend for stationary activity mapping (source: UACEG adapted and modified from Gehl institute and Gehl's Public Life Data Protocol)

Method: Rand Health Care System for Observing Play and Recreation in Communities (SOPARC)		Place №		Date		Period		Names of observer:					Weather		
						Hour	Minutes						Temp.	Wind	
Gender	Age 0-14	Age 15-24	Age 25-64	Age 65+	Sum	Bulgarians	Chinese	Roma	Arabic	African	Sum	Sedentary	Walking	Vigorous	Sum
Primary (from the list of categories)															
Female															
Male															
Secondary (from the list of categories)															
Female															
Male															
Third (from the list of categories)															
Female															
Male															
Observation (spectators)															
Female															
Male															
Other roles (trainers, inspectors, security)															
Female															
Male															

Figure: Basic form for counting of recreation and play (Source: UACEG adapted from SOPARC protocol)

Activities	Icon	Activities	Icon	Activities	Icon	Activities	Icon
Fitness exercises		Tennis on court		Cycling		Playing cards	
Strengthening exercises (pull ups outside of fitness area)		Table tennis		Skateboarding		Lying on blanket	
Jogging		Featherball		Inline /roller blading		Lying in hammock	
Aerobics		Dancing		Slackline		Picnic	
Walking (sport)		Climbing		Hide-and-seek		Reading book / magazine	
Football Basketball Volleyball		Jumping (rope / ribbing)		Playing chest		Other	

Figure: Basic legend for mapping of recreation and play (Source: UACEG and free images)

Annex XX Template for green space valuation and change of the size

This part is drawn from the GI-Val toolkit (https://www.merseyforest.org.uk/services/gi-val/)

Table 51: Project data

		Before	After	unit	Note
Project area		n.a.	0	*ha*	Project area: Wider project area affected by investment.
Total area of greenspace		0	0	*ha*	Total area of greenspace
New green space created by the project		n.a.	0	*ha*	New green space created by the project
Pre-existing area of greenspace enhanced by the project		n.a.	0	*ha*	Pre-existing area of greenspace enhanced by the project

Table 52: Carbon sequestered by trees

New trees planted	No thinning	Thinned		
Broadleaf	0	0	*ha*	*Default is tree cover 'after' minus tree cover 'before' from Project Data sheet, all counted as broadleaf with no thinning*
Conifer	0	0	*ha*	