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Integrated NBS-based Urban Planning Methodology
for Enhancing the Health and Well-being of Citizens

D4.2

Report on cultural, social, economic and environmental impacts of NBS

WP4 - Public Health and Well-being with related Social and Behavioral aspects

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Lead Contributors	Anna Domaradzka, Magdalena Kołodziejczyk, Mikołaj Biesaga (ISS), Ranko Bozovic (EnPlus), Kinga Krauze, Renata Włodarczyk (ERCE)
Other Contributors	Anja Randjelovic, Filip Stanic (FCEBG), Alix Aliaga, Alfred Figueras (Amphi), Sandra Baki (NTUA), Athanasia-Nancy Kazantzi (RG), Ksenja Pantelic (MIKSER), Konstantinos-Kostas Fokeas (GSH), Stanislava Boskovic, Cedo Maksimovic (ICL), Juliana Uribe Aguando (CEE)
Reviewers	Emmanuel Sardis (NTUA) and Eftychios Protopapadakis (NTUA)

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Executive summary

This document presents Deliverable D4.2 'Report on cultural, social, economic and environmental impacts of NBS' corresponding to Task 4.2 (Methods and tools for the assessment of the social aspect of PH and WB impacts of NBS), Task 4.3 (Methods and toll for the assessment of the spill-over effects of NBS on the local economy, and Task 4.4 (Methods and tools for the assessment of the environmental aspect of PH and WB impacts of NBS) of the euPOLIS project.

In chapter 2, we explain our approach to the data collection and measurement of socio-cultural, economic, and environmental indicators. In principle, we will use a longitudinal design that allows for comparing the results before and after planned interventions. Moreover, in chapter 2, we describe specific tools and methods for the measurement of NBSs impact indicators.

Following chapters 3 to 5 discuss indicators for the assessment of the Nature-Based Solutions impact in all three fields. Under each category, we introduce an integrated strategy for the assessment of the interventions' impact.

First, in chapter 3, we propose a three-layer theoretical approach to socio-cultural impact assessment. At its fundaments lays a set of evaluation indicators that were carefully selected to cover the whole spectrum of the socio-cultural processes on the community and city level. Many of them are directly and indirectly related to the health and well-being of citizens. At the second layer, we introduce an euPOLIS livability model that integrates indicators into seven factors that match New European Bauhaus priorities. Finally, as the third layer, we propose the social sustainability approach to our NBS interventions, to ensure its long-lasting positive impact.

In the following chapter 4, we describe economic indicators for the assessment of the NBS intervention spill-over effects. Moreover, we introduce an innovative approach for the identification of potential business opportunities that planned intervention creates in the demo locations – the Business Activation Matrix. This unique tool allows for creating synergy between resources already existing in the demo site (before euPOLIS intervention) with potential benefits stemming from different forms of NBS. Therefore, we propose it as a tool for urban planners and city authorities.

Finally, in chapter 5, we focus on environmental indicators for the assessment of the NBS interventions' impact. We also introduce the circularity model that allows for tracing inputs and outputs of materials, organic matter, and water for the site before and after the intervention. This approach highlights euPOLIS focus on recovering and maintaining the water cycle and reduction of waste.

To summarize, in this deliverable we present a holistic approach for the assessment of the Nature-Based Solutions socio-cultural, economic, and environmental impacts. It will allow for tracking the effects of NBS implementation on both the environment and local community. By linking the indicators with specific places and their social and economic resources we are also looking to better understand the citizens' WB and PH in the context of specific use of NBSs.

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List of Acronyms

Abbreviation	Explanations
BAM	Business Activation Matrix
BGS	Blue Green Solutions
BVOC	Biogenic Volatile Organic Compounds
CD	Communicable disease
CLPP	Community level physiological profiling
CSUP	Sole carbon source utilization patterns
DS	Demo site
ESS	Ecosystem services
FL	Follower cities
FR	Front Runner cities
GA	Grant Agreement of the euPOLIS project
GHG	Greenhouse Gases
GIS	Geographic Information Systems
GDPM	Goal Driven Planning Matrix
HRQoL	Health-Related Quality of Life
KPI	Key Performance Indicator
LDEN	Population exposed to noise levels
LT	Long Term
LTS	Leisure Time Satisfaction Measure
MF	Multi-functional
NBS	Nature-based solutions
NCD	Non-communicable disease

NDVI	Normalized Difference Vegetation Index
OEQ	Outdoor Environment Quality
PH	Public Heath
R1	NBS-related Resources 1
R2	NBS-related Resources 2
SOM	Soil organic matter
ST	Short Term
SWL	Satisfaction with Life
SUDS	Sustainable Urban Drainage Systems
QoL	Quality of Life
UGS	Urban Green Space
UHI	Urban Heat Island
UTCI	Universal Thermal Climate Index
UWOT	Urban Water Optioneering Tool
WB	Well-being
WHO	World Health Organisation
WTC	Wastewater Treatment Coverage

1 Introduction

In principle, euPOLIS aims to bring nature back to the city. The project targets this objective primarily via implementing Nature-Based Solutions (NBSs) in the carefully selected areas in four European cities: Belgrade (Serbia), Gladsaxe (Denmark), Łódź (Poland), and Piraeus (Greece). By definition, the NBSs are inspired and supported by nature to help build resilience and alleviate incrementally visible effects of climate emergency. Moreover, they are designed to have positive effects not only on the environment, but also on the local community and economy (European Environment Agency et al., 2021). In this deliverable, we will focus on tools and methods for measuring the impacts of the planned interventions in the context of specific assessment indicators described in detail in Deliverable 4.1.

Our general approach is similar for all three areas of impact measurement. In most cases, we will use a longitudinal framework that involves at least two measurements of each variable (indicator) – before and after the NBSs implementation. Such an approach will allow for tracking the wide variety of potential changes both in the site itself as well as in the local community. As a result, we will test the euPOLIS framework in detail, and link specific aspects of health and well-being with a wider spectrum of social, economic, and environmental processes. Consequently, such data collection and analysis will help us draw wider conclusions regarding the impacts stemming from the implementation of NBSs

In following chapter 2, we first present the general description of all main methods and tools that can be used for impact assessment. In chapter 3, we focus on linking social impact indicators with specific methods as well as outlining the livability model that will be an analytical tool supporting the impact assessment. We also describe euPOLIS social sustainability factors, which relate to important characteristics of local communities that should be addressed during the participatory planning process. In chapter 4 we link economic indicators with specific methods and tools for data collection. We also present the Business Activation Matrix, which allows us to systematically assess the site's concerns, also addressed by specific indicators of economic spill over effects. Chapter 5 focuses on environmental indicators and lists potential methods of data collection, to assess the impact in terms of physical habitat qualities. It also describes the circularity model that is relevant in the euPOLIS context.

1.1 Relationships with the other euPOLIS work packages

This deliverable summarizes the outcomes of Tasks 4.1, 4.2, 4.3, 4.4. All actions associated with these Tasks were developed closely together to create deliverables D4.1 and D4.2. D4.1 describes in detail the relationship between WP4 and other work packages.

The outcomes of Tasks 4.2-4.4 will be used in Task 4.5 for the development of participatory processes tailored to local needs and context.

The main part of this document was formulated based on WP2 and WP3 results. While Tasks 2.1 and 2.2 were crucial for the planning process of stakeholders engagement, WP3 set the project requirements and potential solutions according to the needs, concerns, and available resources.

Activities planned in WP4 will be implemented through WP5, WP6, WP7, and WP8.

WP4 provides inputs for WP5 that aims at developing technologies to support the deployment of NBSs in the euPOLIS Front Runners cities (WP6) and their deployment together with monitoring solutions (WP7).

The Livability model, the Business Activation Matrix, and the environmental methods and tools will be used for the assessment of the NBS impacts. WP8 will use the aforementioned methods and tools for the evaluation of Nature-Based.

Additionally, Tasks 4.2-4.4 will help with the identification of potentially influential stakeholders that might bridge and distribute the results of the euPOLIS project throughout their professional networks in the fields of health, urban planning, ICT, etc. This strategy aims to stir unconventional and innovative proposals to global adoption of the project’s innovations. WP4 activities will be useful for the preparation for the creation of a long-term euPOLIS Roadmap in Task 10.5.

Summing up WP4 aims to conduct a mixed-method participatory innovation that will enable the implementation process of the euPOLIS’ tailor-made interventions as well as measuring the NBS’ health, WB, social, environmental, economic, and behavioural direct and indirect impacts of NBS.

1.2 Partners’ contribution in D4.2

ISS – Leader of D4.2. leads Task 4.2. Responsibility: social and cultural methods and tools for measuring the impact of NBS; Livability Model; social-cultural impact indicators; preparation of the final document.

FCEBG - as WP4 Leader supported the whole process and work.

ENPL – leads Task 4.3. Responsibility: economic methods and tools for measuring the impact of NBS, economic impact indicators; spill-over effects on the local economy.

RG - supported ENPL in economy part.

ERCE - leads Task 4.4. Responsibility: Environmental methods and tools for measuring the impact of NBS, environmental impact indicators, circularity models.

AMPHI – supported ERCE in the environmental part.

GSH – supported ERCE in the environmental part.

ICL – supported ERCE in the environmental part.

CEE – supported ERCE in the environmental part.

MIKSER – supported ISS and author graphics.

2 Tools and methods for measuring the impact of NBSs

Below, we present a detailed description of the tools and methods that in our opinion best fit the purpose of euPOLIS impact assessment. They are organized in three categories that match social, economic, and environmental aspects of NBSs impacts.

2.1 Methods and tools for measuring socio-cultural impacts of NBSs

The growing body of literature shows the social benefits of green spaces. In general, well-maintained blue-green areas create more opportunities for social interactions and consequently help to build social capital and strengthen local culture. This effect has been especially visible under the ongoing COVID-19 pandemic, during which local green areas became for many people the only escape and space for interactions under mandatory social distancing rules introduced in many countries (Luo, Xie, and Furuya, 2021). Moreover, while the well-maintained green spaces play a vital role in spatial interactions for residents with different socio-economic backgrounds (Krellenberg, Welz, and Reyes-Päcke, 2014), closeness to parks also inhibits perceived loneliness (Astell-Burt et al., 2021), reduces visitors' level of stress (Roe et al., 2013), and increases the sense of community (Francis et al., 2012).

However, much of the aforementioned evidence on the social benefits of blue-green spaces has been gathered throughout correlational design studies (Bowen and Parry, 2015; WHO, 2016; Jennings and Bamkole, 2019). In euPOLIS, we aim to support these results with the evidence from a longitudinal-designed study. Under the project, we will have a unique opportunity to assess the socio-cultural impacts of the planned interventions by comparing the results before and after the implementation of NBSs.

Moreover, the euPOLIS methodology involves designing specific interventions in a participatory manner, focusing on engaging citizens in decision making and allowing for the expression of their different preferences. Therefore, the needs of local communities, including often marginalized voices of such groups as women, elders, minorities, and migrants, will be addressed by the possible NBSs implemented in the selected areas.

Therefore, in euPOLIS, the measurement of the socio-cultural impacts of the NBSs will have to account for two aspects: (1) the effects of the intervention itself and (2) the effects of the participatory processes that will lead to designing and implementing of the NBSs. To track both pathways, we will use a variety of methods and tools to collect needed data. Below we present a 'toolbox' approach that allows for selecting the most appropriate method and tool for the given location and its specific context.

Traditionally, in social sciences, research methodology is divided into two main categories: qualitative and quantitative. However, nowadays, a mixed-method approach is preferred in evaluation studies as it allows for triangulation of data sources and methods to ensure higher validity and reduces bias. In general, the quantitative approach assumes that the observed phenomena can be measured and subjected to statistical computations, while qualitative research assumes a certain subjectivity of the world and allows us to reach deep into the studied phenomenon, expanding our understanding.

In quantitative research, we collect data from a large number of people to get a picture of generalized tendencies, opinions, or preferences. The quantitative approach is often used in macro-social research to better understand the scale of the phenomenon and its relation to socio-demographical factors. On the other hand, qualitative research requires a smaller number of respondents and is often applied to investigate smaller groups and to identify the roots of certain phenomena or intrinsic motivation of behaviour.

2.1.1 Quantitative Data

Methods and tools for obtaining quantitative data include:

Survey – method for gathering information through special or standardized questionnaires, usually filled by the respondent. The survey questions are usually specific and single problem. Survey questionnaires mostly consist of closed questions, listing all potential answers. Sometimes a limited number of open-ended questions are also used. The survey allows to describe the characteristics of the community, as well as collect facts and opinions about events. Surveys can be conducted face-to-face, based on paper or digital questionnaires (computer-assisted, tablet- or smartphone-assisted), but also through online questionnaires (web-assisted), or telephone (computer-assisted telephone interviews). A traditional method involving the filling of paper questionnaires is still used to ensure that anyone can participate in the survey. However, its use increases the risk in the context of the pandemic and may have to be replaced by web-assisted methods. Despite their shortcomings, in recent years online surveys have gained great popularity and will be used as our main source of data, supplemented with other methods.

Poll – the method used to learn about the preferences of the society (selected group/groups) concerning one or two simple issues. Polls are a simple form of a survey, often used for a quick collection of opinions during events, in the public space, etc. In euPOLIS, polls will be employed during participatory processes to ensure a quick response from the engaged group of stakeholders.

Although due to the COVID-19 restrictions the face-to-face contact is under scrutiny we will try not to limit our impact assessment only to internet-based methods. One of the main objectives of the euPOLIS project is to include often marginalized voices of people, including those without access to the Internet or digital competencies. Therefore, we will try to use both street polls and Internet polls. In the case of the former, we will carefully review the protocol to meet adequate safety measures.

Document analysis – the method used to collect preliminary, descriptive, and quantitative information about the studied community, institution, etc., based on the existing documents and databases e.g., statistical yearbooks, commune documents, yearly reports.

Under WP2 and WP3, we already collected data through desk research. Together with city representatives, we analysed data from statistical yearbooks, maps, and the city's yearly reports. Acquired information helped us in the identification of the project's external stakeholders. Moreover, we were able to better understand the specificity of the local community and the demo sites themselves. However, the gathered data was not sufficient. In many cases, we encountered the issue of data availability, i.e., available data was 10 or even 15 years outdated or the level of aggregation was too sparse. Therefore, we had to use other methods (i.e., internet polls) to gather basic information about the demo sites and the local community.

Modern technologies tools – in the context of social research, the new technologies shed new light on already existing theories and enable us to ask new questions, or test new hypotheses. The relatively easy access to ICT tools enriches the traditional ways how social scientists conduct research, but also brings new challenges concerning data validity and representativeness.

The COVID-19 pandemic forced many euPOLIS activities to move online due to the imposed safety protocols. Therefore, with the use of ICT tools, we organized events, that were initially planned to take place in the demo locations, virtually. On one hand, it allowed us to gather more project partners who do not live in the vicinity (or even the country) of the demo locations. On the other hand, the usage of the ICT tools always poses a danger of excluding residents who do not use them for various reasons. Therefore, it is crucial to try to reach people whose voices are at risk of being excluded using more traditional methods, i.e., telephone interviews, etc.

Wearables and smartphone data collection – is based on high volume and a high variety of data continuously generated by users of such devices. These data sources can be used for advanced statistical analysis, predictive analytics, data visualization, AI, and machine learning. Data can be collected using dedicated smartphone applications (prepared for the use of the euPOLIS project), sensors such as wristbands, as well as social media data, etc.

We will equip a certain number of participants in each demo location with wearables that will gather physiological data from their wrists. Bracelets will be provided by leading companies in the field – SENTIO Lab and BIOASSIST. The devices will measure the heart rate of the participants and with the usage of advanced machine learning algorithms will return the measure of well-being. Apart from the hardware, the companies will also provide multifunctional web applications and customer service including online doctor appointments during which the data concerning the participant will be analysed.

Wearables themselves are an attractive incentive for citizens, which hopefully will lead to their wider engagement in participatory processes and social research. Users will be asked to wear wristbands until the end of the project as well as to participate in social surveys. The data gathered from the bands will be processed and managed in line with local data protection laws as well as the General Data Protection Regulation (GDPR). With the use of dedicated software, citizens will be able to assess their physical condition based on data from the wristbands. The wider description of euPOLIS protocols concerning wearables will be described in Deliverable 5.1.

2.1.2 Qualitative Data

Methods and tools for obtaining qualitative data include:

Observations – a method that allows for gathering data through systematic observation of a certain space and its users, to learn first-hand about ways how things happen. The researcher observes and collects observations for a specified period to detect, or explore the existing patterns of behaviour and relationships between physical and social phenomena. Observation can be overt, hidden, or participatory. Conducting observations sometimes involve behaving as a member of the studied community, or regular user of the space. It is common to keep an observation diary, or to fill an observation sheet, which is then analysed both qualitatively (what and when happened and who participated) and quantitatively (number of users or participants, number of activities or functions observed, etc.).

Spatial audit – is a specific type of observation method that allows evaluating spatial organization, available functions, and infrastructure, as well as its quality. It is one of the suitable methods for focusing on specific characteristics of NBS upgraded sites to diagnose its different features. This procedure allows for the collection and processing of information to show social, economic, and environmental public space qualities and diversity. The basic condition for the spatial audit is the selection of a relatively small and functionally and morphologically homogeneous area, in our case the euPOLIS pilot sites.

In euPOLIS, observations will be very important to diagnose the activities present in the pilot locations, deduce the needs of space users, and note existing problems and barriers. Although this is usually one of the most efficient methods used by social scientists, due to the COVID-19 pandemic safety measures and restrictions its usage might be limited. Having this in mind, we will try to use the whole variety of observation types because they often deliver insight about the location on different levels in terms of details but also objectivity. For example, participatory observation usually allows discovering relationships and specific patterns of behaviour that are hidden from plain sight but lack the bigger picture perspective and might ascribe too much importance to insignificant behaviours. On the other hand, a hidden observation takes a more objective approach but at the same time might miss the importance of locally specific motivation or customs. The spatial audit often only captures the static description of the space. Therefore, our approach will combine a wide range of observation types.

Document analysis – to complement quantitative document analysis, an in-depth study of existing materials, information exchanges, reports, opinions, assessments, or instructions can be analysed. For a more structured analysis, we will create special categories or codes which will allow the researcher to organise and analyse the collected material.

Social media analysis – a type of e-document analysis, based on the process of gathering and studying data from social networks such as Facebook, Instagram, or Twitter. It allows to track online conversations about places and community issues, as well as gather reactions concerning planned or carried out activities.

In euPOLIS, we will review the existing documents concerning local activities, existing regulations, ongoing conflicts, etc. It will help us to better plan the participatory processes and understand the local context. Moreover, the collected data will complement the knowledge and interpretation of data gathered during social research before the NBS intervention and will help to observe the change during the second study – after the intervention. We count on the Cities and local Supporting partners to be of much help in accessing this type of data and also assisting the translation from and to the local languages. All the information about ongoing events, activities, regulations or conflicts will be crucial for understanding the local community and tailoring the stakeholders' engagement plan locally.

Interviews – one of the basic methods of qualitative research, involves the interviewer talking face-to-face with the respondent using the previously developed list of questions or instructions. In this technique, what matters is not only what the respondent says, but also how he/she replies to specific questions. Types of interviews include:

- **individual in-depth interview (IDI)** – involves conducting individual interviews with one respondent at a time to explore her/his perspective on the particular idea, program, or situation.
- **questionnaire interview** – based on a prepared questionnaire, involves asking pre-established questions in the right order.
- **free interview** – when the interview has a form of natural conversation on the topic of interest, an issue, an event, or a specific problem. The researcher creates interview dispositions, which include issues to be discussed.
- **narrative interview** – based on asking the respondent to recall a fragment of her/his biography, for example, to relate an event, a stage in his/her life. It is the interviewee who structures the statement, makes assessments, and draws conclusions.
- **focus group interview (FGI)** – researcher moderates the discussion between a group of 4 to 12 people, who are asked a specific set of open questions. The goal of the moderator is to stimulate the discussion between the participants to allow for a more dynamic exchange of opinions and ideas.

We will conduct IDIs to gather detailed feedback concerning individual needs, preferences, and experiences. This will be a crucial technique to reach out to people whose voices are often marginalized, or who might not have access to ICT tools. However, with the COVID-19 pandemic restrictions, we will have to be very careful with the usage of this technique, especially in the case of people from high-risk groups. IDIs will be also used to gather data from important stakeholders, like local leaders or business owners, representatives of civil society organizations, or institutions.

FGIs will be used whenever there will be a need to explore the relationship between stakeholders as well as better understand their needs and interests on a group level. FGI allows to observe interactions among stakeholders and support the common process of setting goals, designing solutions, and mitigating conflicts. Similarly, to IDIs, we will make sure that adequate safety measures are met, to avoid the spread of COVID-19.

2.2 Methods and tools for assessing the economic impacts of NBSs

The regeneration of urban ecosystems by means of NBSs could be an important driver towards economic growth. There is currently an emerging need to reveal and consequently maximize the economic potential of NBSs by means of (a) developing appropriate methods and tools for their economic impact evaluation, and (b) unlocking their full business potential. The approach that was adopted for quantifying the economic impacts of the NBS interventions is founded on a set of evaluation indicators related to the site's economy. For assessing the defined economic performance metrics, data needs to be collected from the site condition before and after the implementation of the NBSs, to allow tracking of NBS-driven changes that concern the periods of pre and post the site upscaling.

Data will be collected based on the document analysis (e.g., annual reports on the local economy) as well as through surveys and interviews. Specifically, a questionnaire that city representatives, NGOs, and other local community organizations will complete before and after (between 6 and 12 months) NBS implementation will be one of the main data sources. Additional sources of data include the survey with real estate agents, observation of economic activity at the site and in its surroundings, as well the estimations of the number of visitors before and after (between 6 and 12 months) NBS implementation. Moreover, methods like an assessment of food production can be used to establish the income/benefits produced at the site. Monitoring the number of socializing events before and after NBS implementation can also help assess the nature of potential clients or income generated for to local businesses.

To bring economic impact assessment to a new level, euPOLIS also introduces a whole new concept, namely the **Business Activation Matrix (BAM),** that aims to become part of the mainstreamed urban planning process in the near future.

> **BAM** – is in principle an interdisciplinary systematic innovative planning concept, that is proposed for supporting the identification process of the short and long-term, direct and indirect, economic potential of the NBS interventions that are considered to be implemented in a particular location. The proposed BAM strategy essentially blends the business potential associated with each NBS intervention with the available resources at the site of interest, to fully activate the former.

The implementation of euPOLIS NBS interventions at the demo site creates opportunities for a spectrum of potential business activities. As a part of the BAM system, we call these NBS interventions Resources 1 (R1). On the other hand, there is a list of locally available resources we call Resources 2 (R2). The cross-relation between R1 and R2 defines potential business activities at a demo location of interest. Therefore, the BAM system uses analysis of potential interactions between the newly introduced NBS interventions and the existing in demo site resources to identify potential business activities deriving from these interactions.

2.3 Methods and tools for assessing the environmental impacts of NBSs

The assessment of the environmental impact of NBSs will require a broad range of indicators. For their measurement we will employ a variety of methods and tools that will allow for relevant data collection:

Continuous measurement with in-site loggers – in collaboration with the groups involved in WP5 and WP8, the WP4 team will determine the range of parameters that should be monitored on-site in order to create the picture of biochemical background and its changes as implementations' follow up, and with considering the options to apply modelling of NBS impact on human health and well–being. For factors such as air quality, soil moisture and temperature, air temperature, rainfall or water quality, the in-situ instruments that will enable continuous measurements at given intervals and easy transfer of information and its processing, are proposed. Such data can also be easily illustrated and shared with citizens with e.g. information panels.

Repeated measurement with mobile equipment – data on water and soil physical characteristics, biodiversity of fauna can also be measured with mobile equipment whenever it is not possible to install data loggers in demo-site due to technical problems, vandalism, or for logistic reasons. Additionally, repeated measurement can be carried to define surface temperature of particular elements of demo sites.

Laboratory analyses – laboratory analyses, and in fact also desk studies, refer to complex parameters that cannot be derived from direct measurements. Such parameters comprise soil vitality: biodiversity, metabolism, heavy metal content in soils and sediments, but also analyses of orthophotomaps for connectivity and NDVI, habitat distribution or impermeability of surfaces. Simple desk studies refer also to site statistics regarding water use and reuse, biomass reuse, and energy savings.

Modelling – complex indicators, that involve more parameters and relationships between them must be modelled. This refers to all parameters related to flood control, thermal comfort, space connectivity assessment, or forecasting the cooling effect of NBS.

Observations – are a non-invasive way to collect information about society and environment. In the case of euPOLIS demo sites, the potential use of observations is restricted mostly to biodiversity monitoring (birds, insects, mammals) supported by dedicated taxonomic applications (citizen science) and to the observation of local communities' members – their use of the space, routines, distribution of people of different genders, ages, handicapped people, etc.

Interviews – will complement or substitute other forms of measurements. They may contribute to behavioural mapping, but also provide information about different aspects of comfort, biodiversity, quality of environment, or performance of NBS.

Behavioural mapping – an observational technique that allows studying the interrelationship of people's behaviour and the environment (Golicnik and Ward Thompson, 2010; Ng, 2016). Its purpose is to record behaviours in a given space with minimal observer intervention. To conduct an observation, a map of the area, the types of activities to be observed, an observation schedule, a coding and counting system are needed (Ittelson et al., 1970; Marušić and Marušić, 2012, Ng, 2016).

Learning about users' preferences and usage patterns can contribute to creating spaces that are aesthetically pleasing, useful and well-functioning, consistent with people's expectations of spaces. From this point of view, behavioural mapping allows to avoid conflicts, protect routines of place users and thus attachment with the place. Conducting observations before and after design intervention allows determining its impact on users’ behaviour patterns (Unt and Bell, 2014). From the euPOLIS project perspective, it can be considered as a method to determine the impact of the NBS intervention on the frequency and use of the space. This will also allow determining whether the new solutions have made the space attractive to different people in accordance with the design intentions.

Data on the use of space are collected primarily during the outdoor season, during the week and on weekends, periodically at intervals throughout the day (in three-four time periods: morning, early afternoon, afternoon, and late afternoon for 10-30 min.). The recording of behavioural and physical location information can be done in tables (behavioural mapping matrix) or/and directly on maps. They include date and time of observation, weather conditions (approximate temperature, rainfall, cloud cover, wind) additional impressions of the observer, behaviour types (varieties of walking and sitting, sports activity, vandalism, etc.), gender and age group of users, duration of activity (Marušić and Marušić, 2012, Ng, 2016). In the case of large spaces, they can be divided into more sub-areas.

At the analysis stage, digital maps are created to summarize the data from field surveys (for example by using GIS). The results can be also presented by descriptive statistics (number and percentage of combinations of behaviour pattern attributes e.g., the type of activity, gender, age).

In the euPOLIS project, we propose the choice of three approaches to conducting behavioural mapping. The selection of the final approach should be based on given site’s characteristics and the equipment capabilities of those involved in the study. Based on our knowledge with regards to the demo sites, we suggest frame registration as the most appropriate approach that matches the needs of the project.

Direct on-site observation. Mapping the type of behaviour of each land user at the specific location by systematically writing notes and filling in formatted tables and maps, according to the schedule of observation (Fig. 1).

Frame registration. This is an observation technique that uses photo-video tools. The behaviour of users in the observed area is recorded using time-lapse photography in a specific time frame in transects on the demo site. Maps are then created based on registered behaviours of the users of the place: meeting points, areas of particular uses, user groups, space division, etc. (Fig. 2).

Individual stories registration based on focus groups or interviews. Identification of places, where different activities are undertaken by different stakeholder groups indicated by users themselves. Similarly, the information extracted from the interviews is plotted on a map to indicate the functionality of the area. This self-reporting can be associated with disadvantages such as users’ reluctance to give honest answers (illegal activities or social norms) or lack of memory of activities undertaken (Fig. 3).

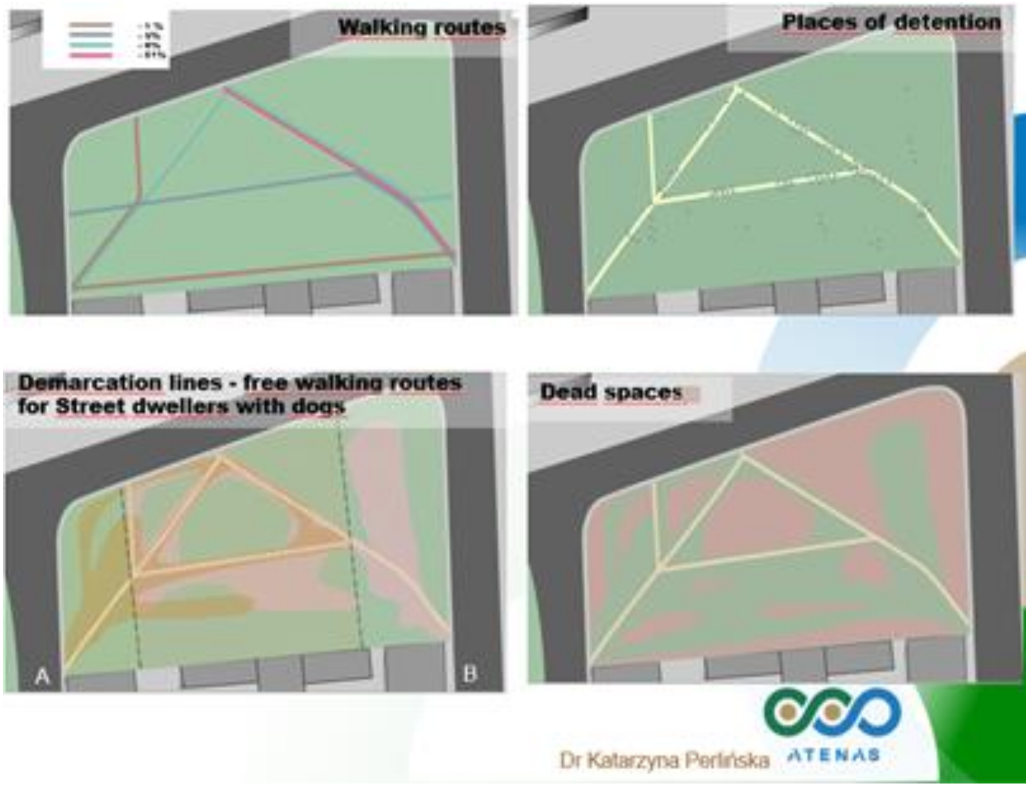

Figure 1. Behavioural mapping technique based on drawing and noting the behaviour of individuals in the demo site, the approach used in ATENAS Project (ERA-NET WaterWorks 2017).

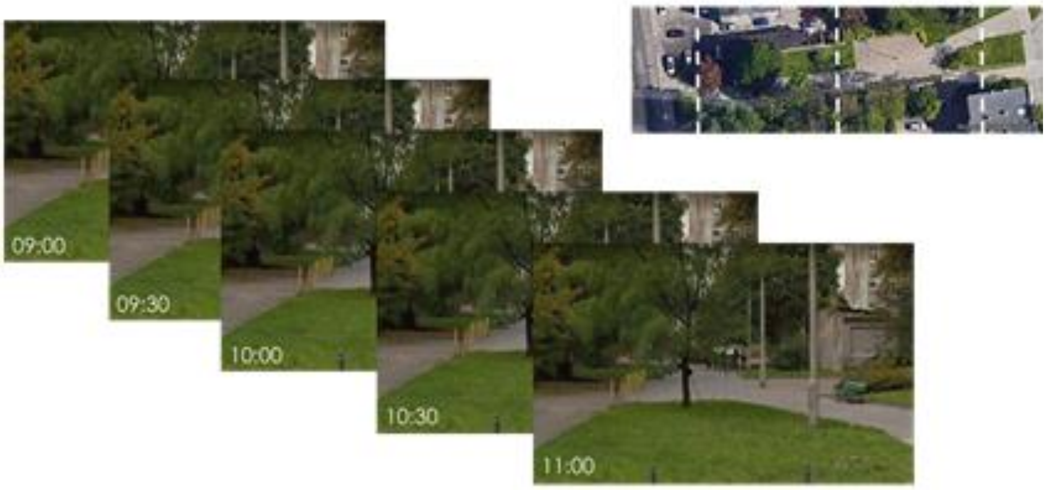

Figure 2. Registration of time frames

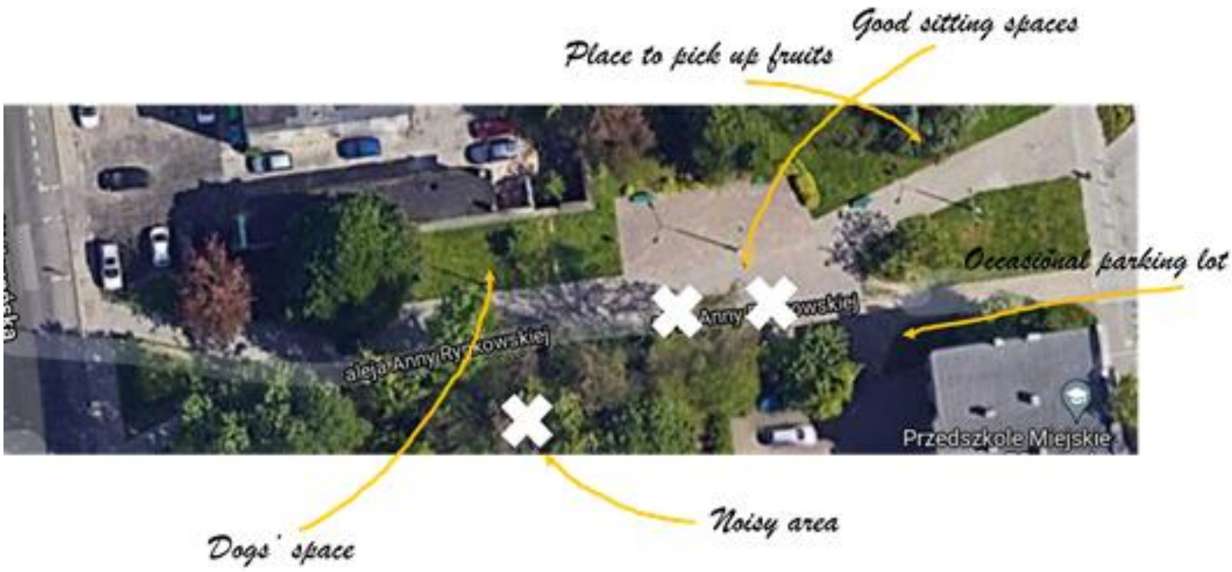

Figure 3. Mapping based on stories and interviews.

There are numerous advantages and disadvantages of behavioural mapping. Regardless of the specific technique among pros, one should mention:

- Detailed information about the area and its elements important to citizens;
- Detailed information about the users: gender, age, activities performed, a timeline of activities;
- Registration of a number of users to understand impact intensity;
- Registration of problems: crimes, unsafe spaces, gentrification;
- Getting familiar with the place and the users by the observer.

Among cons one should mention:

- Time and work intensity – to obtain coherent information observations should be carried out in different seasons, at different times of the day, for at least 2-3 weeks, each season.
- The necessity to apply and keep certain standards by all the involved observers to minimize subjectivity of observations, especially in direct on-site observation and individual stories registration, where the way of making notes or observation may induce outcomes.
- Problems of observer’s safety in particular areas or times of the day.

3 Socio-cultural impact indicators

3.1 Introduction

The euPOLIS project proposes a **three-layered approach to social impact assessment**. The first layer focuses on collecting data for a set of **socio-cultural indicators**, for each site, before and after the implementation of NBS interventions. The numbers of covered indicators depend on the data availability. For each of the main indicators, alternative measures were defined, to ensure that regardless of the circumstances some type of assessment will be possible. This will allow for a simple comparison of two points in time and to identify areas, where the social impact of NBS could be observed. Those indicators were selected based on the extensive literature review and include different social and cultural aspects, as well as place and community characteristics (relevant to the introduction of NBS) that according to the existing studies directly, or indirectly relate to health and well-being.

The second layer is based on **livability modelling**, for each euPOLIS intervention site. The livability model covers a set of multidimensional aspects related to the qualities of the site and its neighbourhood, which are recognized as important prerequisites to well-being (WB) and public health (PH). Considering the multiple impacts of NBS on the public space, it is necessary to identify a set of multidimensional indicators for the assessment of change in terms of livability.

Vast literature conceptualizing livability includes numerous subjective and objective indicators applied at various levels of local management. Giap et al. (2014) postulated that livability is a place-based concept that contributes to the quality of life and well-being of residents, while Pacione (1990) argues that livability is also a function of personal characteristics and should include people's perception of the place and its suitability to their needs. Indicators covering a range of different place-based issues such as accessibility, safety, comfort, available services, walkability, transit, and participation are often used together to build livability indexes.

In the case of the euPOLIS project, the livability model will be one of the important tools of impact measurement in our demo sites. Based mainly on social factors, it will also include urban development and environmental aspects, to touch upon the social dimension of urban form and natural resources. Seven factors of livability were selected, based on the extensive literature review, and tailored to grasp the specificity of NBS impacts. As a result, the euPOLIS model will provide a comprehensive assessment of how the NBS influenced the livability of the neighbouring community. For each of the sites, the model will be reviewed, to make sure that the most relevant indicators are used for assessment.

The third layer concerns the **social sustainability** of implemented changes and relates to the future and long-term effects of NBSs on the local community and its culture. While livability relates to the physical context necessary for a 'good life', social sustainability focuses on the socio-cultural context of community well-being, as well as the longevity of introduced implementations and innovations. In the case of euPOLIS demo sites, social sustainability will relate to the potential level of acceptance of planned changes as well as readiness to embrace NBS as an important part of the community's better future.

In euPOLIS, we will focus on the social sustainability framework proposed by Missimer, Robèrt, and Broman (2017). They distinguished the unique characteristics of a sustainable social system, which can prosper even in the context of uncertainty and change. Five community characteristics essential for achieving sustainability include: (1) diversity, (2) common meaning, (3) trust, (4) capacity for learning, and (5) capacity for self-organization.

3.2 Socio-cultural indicators with methods and tools

Table 1 presents the selection of social indicators (includes indicators from both Public Health and Well-being and social categories presented in Deliverable 4.1) best suited for the euPOLIS goals. Each indicator is described in relation to existing studies, which link them with health and well-being results. The collection of data will require the triangulation of methods, to ensure each of the indicators is measured in the best possible way considering the local circumstances. Most data for the social indicators should be collected through a quantitative survey, with community members and volunteers engaged in the longitudinal study (see Section 7 of Deliverable 4.1). We will employ the specific scales for several of the indicators, based on the tested sets of questions. However, each scale will be reviewed and may be modified or shortened, to ensure the feasible length of the questionnaire.

Table 1. Socio-cultural impact indicators

Indicator	Description	Methods	KPI
Quality of Life (QoL)	The main indicator of WB QoL refers to a person's cognitive assessment of their overall standard of living, or their 'personal assessment of life satisfaction' (Price and Harding, 2004). WHO underlines the importance of culture and value systems for the individual's perception of QoL, in relation to their needs, goals, expectations, standards and concerns. QoL is affected by the person's physical health, psychological state, personal beliefs, social relationships and relationship to the environment (WHO, 1995).	**Survey**: - Environmental QoL scale[1] - QoL scale	KPI_5
Health-Related Quality of Life (HRQoL)	Supporting indicator of PH HRQoL refers to the cognitive appraisal that a respondent makes about the impact their health has on their daily life (Yin et al., 2016).	**Survey:** - HRQoL scale	KPI_3
Healthy lifestyle	Supporting indicator of PH	**Survey**:	KPI_4

[1] All scales will be reviewed and adjusted to euPOLIS needs. While we will try to use well-tested and generally recognized scales, in some cases they will have to be shortened to ensure the feasibility of measurement. In some cases, two or more scales are mentioned out of which the most fitting will be chosen.

Indicator	Description	Methods	KPI
	Frequency of reported activities defining a healthy lifestyle, including a non-smoking, balanced diet, regular exercise (Reeves and Rafferty, 2005). The extent to which healthy lifestyle is considered during NBS planning and implementation	- self-reported frequency of healthy behaviour in-door and out-door **On-site observations:** - number of people cycling, running, exercising - the assessment of planning process in terms of the level of encouragement of healthy lifestyles (from 1-none, to 5-extensive online and offline encouragement)	
Satisfaction with Life (SWL)	Supporting indicator of WB Life satisfaction (Diener, Emmons, Larsen, & Griffin, 1985) is a cognitive, judgmental process based on a comparison of one's current state of affair with a standard that each individual set for him or herself (i.e., not externally imposed). Diener et al. (1985) developed the Satisfaction with Life Scale (SWLS) which asks subjects for an overall judgment of their life.	**Survey**: - SWL scale - satisfaction with the neighbourhood and the site as a place of living	KPI_5
Perceived loneliness	Supporting indicator of PH and WB Loneliness, or social isolation, can be defined as disengagement from social ties, institutional connections, or community participation (Hawkley and Cacioppo, 2010).	**Survey**: - self-reported loneliness - social isolation scale - convoys of social relations questionnaire - site as a space to meet and connect to other people - relation with neighbours	KPI_4
Leisure Time Satisfaction Measure (LTS)	Supporting indicator of PH and WB Leisure Time Satisfaction (LTS) can be defined as a subjective assessment of the quality of leisure time (Francken and Van Raaij, 1981).	**Survey:** - LTS scale - site as the place for leisure time activities and self-expression	KPI_4
The perceived safety of the site and neighbourhood (feeling)	The main indicator of Livability Self-reported perception of neighbourhood/community crime and safety (Baum et al., 2009). Fear of crime, accidents, and harassment in public green spaces.	**Survey**: - the self-reported feeling of safety in the neighbourhood and on-site - fear of crime, accidents, or harassment in the neighbourhood and on-site - trust towards other space users **On-site observations**:	KPI_4

Indicator	Description	Methods	KPI
		- members of vulnerable groups present at the site after dark	
The perceived safety of the site and neighbourhood (experience)	Supporting indicator of Livability Self-reported experience of being a victim of a crime, traffic accident, or violence in the neighbourhood.	**Survey**: - self-reported (including observed) experience of crime/violence in the neighbourhood / on-site	KPI_4
Friendliness	The main indicator of Livability Presence of different age, gender and minority groups, presence of people with disabilities, low-income and high-income users.	**On-site observations**: - the presence of different age, gender and minority groups, people with disabilities **Survey:** - perception of the friendliness of the site to youth, seniors, women, newcomers, families, etc. - opportunities for families to spend time locally - opportunities to socialize - opportunities for sports/recreation **Interviews with local leaders**	KPI_4
Walkability	The main indicator of Livability Easiness of reaching the NBS place on foot, by bike or public transport (Lo, 2009).	**On-site observations**: - the presence of walkers and bikers, styles of commuting **Spatial audit:** - evaluation of accessible entry points, public transport stops, functions encouraging walking and cycling - access for trolleys and wheelchair - the quality of walking paths and biking routes	KPI_4
Perceived quality of space and its maintenance	Supporting indicator of Livability Self-reported perception of the quality and aesthetics resulting from the space maintenance (Beck, 2009). The comfort of use is an important aspect of livability as it measures if the space is easy to use and offers a high quality of experience	**Survey**: - satisfaction with public space cleanness, lightning, urban furniture - satisfaction with aesthetics - the quality of experience - the comfort of use **Spatial audit:**	KPI_4

Indicator	Description	Methods	KPI
		- evaluation of cleanness, lightning, urban furniture, aesthetics	
Place attachment	The main indicator of Livability The emotional, cognitive, and behavioural bond that people develop with the place (Lewicka, 2011). Intangible qualities of the place measured by intrinsic value, perceived essentialism and anti-essentialism are important predictors shaping the response to change (Roszczyńska-Kurasińska et al., 2021). They capture the site's perceived historic value, inherent value (uniqueness and importance of the place) and (anti-)essentialist character of a place.	**Survey**: - place attachment scale - the sense of place Scale - the intrinsic value of the place and perceived essentialism of the place - openness to change of the site and neighbourhood - fear of gentrification/ openness to gentrification **Interviews with local leaders**	KPI_5
Perceived ownership and sense of belonging	The main indicator of Livability The consciousness of responsibility and ownership for the neighbourhood, and a sense of belonging to the community (Pierce, Van Dyne and Cummings, 1992). Civic consciousness can be described as an individual's awareness of their community, civic rights and responsibilities and their relationship with the community (Ng, 2015).	**Survey**: - place ownership scale - local civic consciousness scale - recognizing NBS as part of the common good **On-site observations:** - behaviours and signs signalling the sense of ownership **Documents analysis**: - events contributing to the sense of ownership and civic consciousness **Social media monitoring:** - events and # connected with the neighbourhood and site **Interviews with local leaders**	KPI_5
Collective efficacy	Supporting indicator of Social Sustainability Grounded in mutual trust, describes a community's ability to create change and exercise informal social control (Cohen, Inagami and Finch, 2008). Collective efficacy is associated with better self-rated health, lower rates of neighbourhood violence, and better access to health-enhancing resources.	**Survey**: - collective efficacy scale - trust within a community - informal social control scale - opportunities to have a say on important issues **Documents analysis**: - events and activities showcasing collective efficacy **Social media monitoring:**	KPI_6

Indicator	Description	Methods	KPI
		- events and activities showcasing collective efficacy	
Community social cohesion	Supporting indicator of Social Sustainability Refers to the strength of relationships and the sense of solidarity among members of a community – the sense of collective commitment to carry 'costs' (financial, social, emotional, or otherwise) to assist others (Prainsack and Buyx, 2012). Includes tolerance and respect - attitudes paramount to overcoming conflict.	**Survey**: - community perception scale - a sense of solidarity, tolerance and respect - community acceptance of diverse cultures - a sense of pride in being part of the local community - involvement in community activities and local volunteering **Observations**: - community events - interactions within the space - reactions to conflict **Interviews with local leaders**	KPI_6
Involvement of citizens in a participatory process	Supporting indicator of Social Sustainability The proportion of residents involved in the public participation processes in a given municipality per 100 000 residents per year.	**Documents analysis:** - reports from consultations and participatory events - the proportion of residents interested in the project - the proportion of residents involved in longitudinal studies/drop-out rate **Interviews with local leaders**	KPI_6
Diversity of stakeholders involved	Supporting indicator of Social Sustainability The indicator is defined in terms of the mix of stakeholders involved in a co-production process, based on the backgrounds and sectoral logic.	**Observations:** - observation of stakeholders involved in the participatory process **Documents analysis:** - reports from consultations and participatory events **Interviews with local leaders**	KPI_4
Involvement of citizens from traditionally excluded groups	Supporting indicator of Social Sustainability The extent to which the NBS project has led to increased participation by groups of people who are typically not well represented in society.	**Observations**: - the presence of traditionally excluded groups members at different participatory events **Interviews with local leaders**	KPI_4
Trust in the decision-making procedures and decision-makers	Supporting indicator of Social Sustainability The evaluation of the perceived trustworthiness of decision-making and	**Survey**:	KPI_6

Indicator	Description	Methods	KPI
	decision-makers, based on three dimensions: 1) perceived competence: perception of government organization as capable, effective, skilful, and professional; 2) perceived benevolence: perception of government organization as caring about the welfare of the public and motivated to act in the public interest; 3) perceived integrity: perception of government organization as sincere, truthful, and fulfilling its promises.	- perceived competence, benevolence, and integrity of local decision-makers **Observations**: - the atmosphere at local meetings, and participatory events **Interviews with local leaders**	
Sustainability consciousness	Supporting indicator of Social Sustainability. It is commonly described as a measure of awareness of environmental issues. It is described on three dimensions: Sustainability knowingness, Sustainability attitudes, and Sustainability behaviour (Gericke et al., 2019).	**Survey**: - environmental consciousness - pro-environmental and circular behaviours and expectations **On-site observations:** **-** behaviours and signs signalling the environmental consciousness	KPI_5

3.3 Livability model

The concept of livability emerged within the framework of Environment-Behaviour Studies, combining architecture, urban design, and urban planning with social and behavioural sciences. Since the 1950s and 1960s, researchers tried to describe design strategies and guidelines by analysing how people use the urban environment and by assessing their needs and expectations (Mirzahossein and Mohghaddam, 2021). In the 1980s and early 1990s, those studies resulted in the growing popularity of livability as a concept for planning in future cities (Ahmed et al., 2019; Moore, 2004).

As Okulicz-Kozaryn and Valente (2019) point out, livability usually refers to the standard of living, or general well-being of a population in a specific region, area, or city. It is often presented as a sum of factors that add up to a community's quality of life (like economic prosperity, social equity and stability, educational opportunities, recreation, cultural possibilities, etc.). As a result of this approach, main livability indexes rate European cities highest on livability (see Mercer Quality of Living Survey, 2011; Okulicz-Kozaryn, 2013).

In euPOLIS we need a more site-specific approach, directly related to the potential impacts that the NBS can have on the well-being and health of local population. Therefore, we start from the discussion of the diverse approaches to livability to arrive with the euPOLIS Livability model, tailored for the impact assessment of NBS implementation.

Livability is defined as 'suitability for human living' (Webster Dictionary), as (objective) quality of life, welfare, 'level of living,' or habitability (Veenhoven, 2000). Another definition of livability relates to the quality of place, environmental quality, or urban quality, defined as "the physical characteristics of community, the way it is planned, designed, developed, and maintained" (Burton, 2014: 5312). The already mentioned Mercer Index focuses on measuring the material standards, or objective levels of living. However, as Okulicz-Kozaryn and Valente (2019) rightly noted, the shortcoming of such livability measurement is that it fails to include the intangible qualities of place such as its historical, or cultural value, vibrancy, authenticity, or distinctiveness. Still, it is a much more comprehensive approach to place evaluation than the traditional socio-economic approaches that tend to equate development with income and consumption (Okulicz-Kozaryn and Valente, 2019). Instead, it focuses on the relation between space quality and accessibility of services on the well-being of the local population. Veenhoven (2008: 2) defines subjective well-being as "overall judgment of life that draws on two sources of information: cognitive comparison with standards of the good life (contentment) and affective information from how one feels most of the time (hedonic level of affect)." Therefore, the expected relationship between livability and well-being is positive: if livability is high, human needs are satisfied and happiness follows (Diener et al., 1993; Veenhoven, 1991; Veenhoven and Ehrhardt, 1995).

In euPOLIS, we strive to ensure better WB and PH by means of place-changing, the introduction of NBSs and higher involvement of communities in their planning. We expect that the implementation of NBSs will result in higher livability for the surrounding community. Therefore, we propose to monitor livability through a multidimensional set of social and urban development indicators to assess the euPOLIS intervention impact. Developing a livability model allows us to be more space-specific and consider different local needs, expectations, and general challenges today's cities face.

Well-being is a function of basic needs (as defined by Maslow, 1954), but in a more affluent context, it depends on the higher dimensions as well (Inglehart, 1997). The 'affluence paradox' (Pacione, 2003) illustrates that the higher the income, economic development, or affluence, the less these basic needs fulfilment matter for subjective well-being. This means that in efforts to increase well-being we must strive to also address the higher needs in measuring the livability of a certain place. The Mercer livability Index captures most of the characteristics at the bottom of the pyramid (basic economic and survival needs) and some of the aspects of the higher dimensions. In the case of euPOLIS, we want to include the dimensions of safety and aesthetics, along with values, belonging, and available functions.

It is important to draw the line between livability and the quality of life (QoL), which despite their similarity, have different designates. Livability is considered a programmable and targeted concept (Mirzahossein and Mohghaddam, 2021), while the quality of life relates to the individual experience (VanZerr and Seskin, 2011). For example, livability can include planning to increase citizens' choice of transportation, while QoL relates to the fact that the right to choose transportation can increase citizens' health and reduce pollution, resulting in improved quality of life. Livability has a complex nature and is often measured using a multi-method approach, for example, multi-criteria decision-making models (Ye et al., 2020) or in connection with GIS studies (Antognelli and Vizzari, 2016).

Moreover, people with different cultural, social, and economic backgrounds will have different perspectives about a place's livability and quality of life. Therefore, various aspects of livability can be affected by the users' relationship with the environment (Knox and Mayer, 2013). Depending on the individual or cultural preferences, some aspects of place livability may be more important than in other places or for other groups. Also, as Mirzahossein and Mohghaddam (2021) point out the criteria for livability and quality of life change over time and are influenced by technological development. Smart city technologies create new challenges and opportunities for the livability of a place as well as introduce new methods and criteria for measuring it.

According to Kovacs-Gyori et al. (2019), livability reflects the quality of the person-environment relationship, and how well the built environment and the available services fulfil the needs and expectations of residents. As such the livability assessment is important for the implementation of Green Deal and New Urban Agenda goals (European Commission, 2019) by providing a feasible framework to assess the quality of the urban environment. However, the key elements of livability have to be defined to represent the person-environment relationship. This way livability becomes more than a statistical index and can serve to improve the quality of urban life. The euPOLIS Livability Model is therefore guided by three New European Bauhaus (European Commission, 2021a) values:

(1) sustainability – to ensure biodiversity, circularity, and addressing the climate goals,

2) aesthetics – going beyond functionality, relating to the quality of experience in places and

(3) inclusion – to secure accessibility and affordability for all, through valorising diversity.

The euPOLIS's approach of planning for people recognizes that increasing livability contributes to such important aspects of development as sustainability as well as individual and collective health and well-being. By linking the health- and well-being-related indicators and activities with specific NBS implementation in our pilot sites we aim at showing the link between reshaping public spaces in line with euPOLIS methodology and their increased livability as a direct condition for increased PH and WB.

Improved livability should result in both healthier lifestyles (enabled by NBS), as well as positive emotional attachment to the site and an increased sense of responsibility or being part of the local community. EuPOLIS sites are expected to contribute to local livability in terms of increasing the amount and quality of green and blue areas, ensuring safety and accessibility to diverse groups of users, introducing new attractive functions, and encouraging more intensive use of the space resulting in a higher number of interactions. This requires a place-based urban planning and design approach, with innovative livability-related planning criteria, that build upon local characteristics. In particular, it should acknowledge the preferences and needs of the local community in terms of contact with nature (close to local centres and housing estates), recognizing its primary role in supporting a community's access to healthy living, socializing opportunities, and a better living environment.

To enhance the impact measurement of the euPOLIS implementation as well as the process of participation in planning, we propose the theory-driven, yet practice-oriented livability model, developed in line with the New European Bauhaus (European Commission, 2021a) philosophy. Importantly, our approach to assessing livability is rooted in universal values but then tailored to the local conditions and data availability. We want to consider how people actually use and perceive urban space to be able to ingrain this knowledge into design guidelines and the stakeholders' engagement plan.

To summarize, we treat livability as a place-related and anthropocentric concept, concerning the 'here and now' of a specific place and the community of its users. Based on the common set of livability principles available in the literature, we decided to focus on those aspects that directly relate to PH and WB through green space design, accessibility, available infrastructure, and services or functions. Those aspects are grouped into seven categories that directly relate to the New European Bauhaus priorities (see Fig. 4): (1) sense of safety, (2) multifunctionality, (3) contact with nature, (4) comfort of use, (5) walkability, (6) friendliness, and (7) sense of place.

Our euPOLIS Livability Model, built on those seven major categories, is related to the direct and indirect impacts of the Blue-Green spaces designed within the framework of the project. While we perceive PH and WB as central areas of impact, we also point out to the desired socio-economic impacts including local civic engagement (stimulated through the use and possibilities offered by NBS as well as indirectly resulting from better health), positive place attachment (which relates to mental well-being as well as willingness to engage on the local level) and local economic growth (resulting from higher attractiveness of the area to people and businesses).

Figure 4. EuPOLIS Livability model.

Sense of safety	Multi-functionality	Contact with nature	Comfort of use	Walkability	Friendliness	Sense of place
						
Self-reported perception of neighbourhood crime and safety	Variety of public space: formal, informal, structured, unstructured	The proportion of greenery to concrete Density of greenery	Quality of experience Perceived quality of green and blue infrastructure	Length and quality of walking paths	Perception of the friendliness of the site to women, children and youth, families	Place attachment
Fear of crime, accidents, and harassment in public spaces	Infrastructure enabling different functions	Presence of flora and fauna Biodiversity	Satisfaction with aesthetics Harmony of design	Length and quality of biking paths	Perception of the friendliness of the site seniors and people with disabilities	The intrinsic value of the place Pride of this place
Self-reported experience of being a victim of crime, accident or violence in the neighbourhood	The place brings people together	Water quantity and quality	Perceived quality of small infrastructure Satisfaction with cleanness	Access for trolleys and wheelchairs	Perception of the friendliness for minorities, newcomers, low-income users	Perceived essentialism of the place
Space maintenance signalling that the place is taken care of	Perception of equipment as adequate to needs	Amount of sun vs. shade	Level of sensory comfort: noises, smells, colours, lightness, heat and wind	Pedestrian accessibility to public transport	Opportunities for families to play locally Opportunities to socialize Opportunities for recreation	Openness to change of the site and neighbourhood Fear of gentrification

Is this place safe for everyone to enjoy?	*What kind of opportunities and activities this place offers?*	*Is this place green and alive?*	*Does this place offer comfort and positive stimuli to all users?*	*Is this place easily reachable on foot, by bike or public transport?*	*Is this place open for all people?*	*Does this place enable positive attachment?*

Figure 5. Seven aspects in euPOLIS Livability Model.

3.4 Social sustainability

Sustainability is commonly defined as meeting the needs of present generations without compromising the ability of future generations to meet their own needs. It is about ensuring that humans have what they need, now and in the future. Part of that means ensuring that their physical environment is taken care of and remains livable. However, the emphasis on social sustainability is on ensuring humans have what they need.

As Ricee (2021) explains, social sustainability cannot be created simply through the physical design of the community, however, neither can environmental sustainability be created by physical design alone. It is important to realize that while physical design cannot ensure that individuals, families, and communities will lead environmentally sustainable lifestyles, it can help to make such environmentally sustainable everyday choices easier. Equally, the physical design of the neighbourhood can make it either easier, or more difficult for communities to be socially sustainable.

As one of the active social enterprises defines it: “social sustainability is a process for creating sustainable successful places that promote well-being, by understanding what people need from the places they live and work. Social sustainability combines the design of the physical realm with the design of the social world – infrastructure to support social and cultural life, social amenities, systems for citizen engagement, and space for people and places to evolve.” (Social Life, 2012). Moreover, some scholars suggest that all the domains of sustainability are social: including environmental, economic, political, and cultural sustainability. Indeed, all these domains of sustainability are dependent upon the relationship between the social and the natural, defined as human embeddedness in the environment.

In our approach, we follow the findings of Vallance, Perkins and Dixon (2011), who identified the ‘maintenance sustainability’ – concerning ways of life, that people would see maintained or improved that builds on the re-humanised, context-aware concept of sustainability by highlighting why people ignore or resist change and ecological messages. The authors acknowledge the conflicts that often arise between doing what is environmentally friendly (in our case introducing Blue-Green Solutions) and doing what has been always done, what is easy, or simply doing what one likes.

As advocates of sustainability, we cannot assume the facts about environmental issues will ‘speak for themselves’ and we must consider why people resist change, even when there are very good arguments for introducing certain solutions. The adverse impacts some eco-implementations may have on already disadvantaged groups have to be recognized and combined with a deeper understanding of the ways in which technical aspects of Blue-Green Solutions influence everyday life. These are central to ensure a smoother and equitable transition to a more sustainable future, in which the importance of social development is recognized as a central goal.

To implement the various innovations that will transform societies in the direction of environmental sustainability, it is necessary to have well-functioning societies — from a social, political, and economic standpoint — that can meet the new challenges successfully (Rogers et al., 2012). Healthy and happy individuals with a strong sense of place, identity, and relations based on trust are more likely to prioritize the protection of their environment (Geller, 1995). Therefore, the empowerment of local communities and increased social sustainability is an essential condition for long-term grassroots, legal and political protection of the natural environment (Heiman, 1997).

While environmental sustainability examines living within the limits of the natural world, likewise, social sustainability emphasizes living in ways that can be sustained because they are healthy and satisfying for people and communities. This requires providing for material, social, cultural and emotional needs, avoiding behaviours that result in poor health, emotional distress and conflict, and ensuring that we do not destroy the social structures (such as families and communities), cultural values, knowledge systems and human diversity that contribute to a vibrant and thriving human community. In other words, social sustainability means meeting the needs for human well-being.

Our starting point is the universal framework for studying social sustainability proposed by Missimer, Robèrt, and Broman (2017). Building on the complex adaptive systems analysis, they distinguished five characteristics of a sustainable social system, that allows it to prosper in the situation of uncertainty and change: 1) diversity, 2) common meaning, 3) trust, 4) capacity for learning, and 5) capacity for self-organization.

However, in the case of euPOLIS interventions, we can propose a more complex approach to assessing social sustainability and focus on characteristics of the site and local community that are relevant to NBSs. We suggest following the social sustainability model developed and tested within the framework of the CLIC project (Roszczyńska-Kurasińska et al., 2019). The proposed dimensions of social sustainability are presented on the graph and include a more detailed approach to the original 5 categories described by Missimer et al. (2017). Those ten characteristics of the studied communities that are decisive for the social sustainability of planned interventions include: (1) diversity, (2) connectivity, (3) openness, (4) trust in neighbours, (5) trust in authorities, (6) trust in local business owners, (7) shared values, (8) compatibility with NBS, (9) capacity for learning and (10) capacity for self-organization. For each of, the aspects of social sustainability a specific set of survey questions can be asked. However, in the case of euPOLIS, we will employ already collected social and cultural indicators to build a site specific model describing the strengths and weaknesses of a given social context in terms of ensuring the social sustainability of NBS

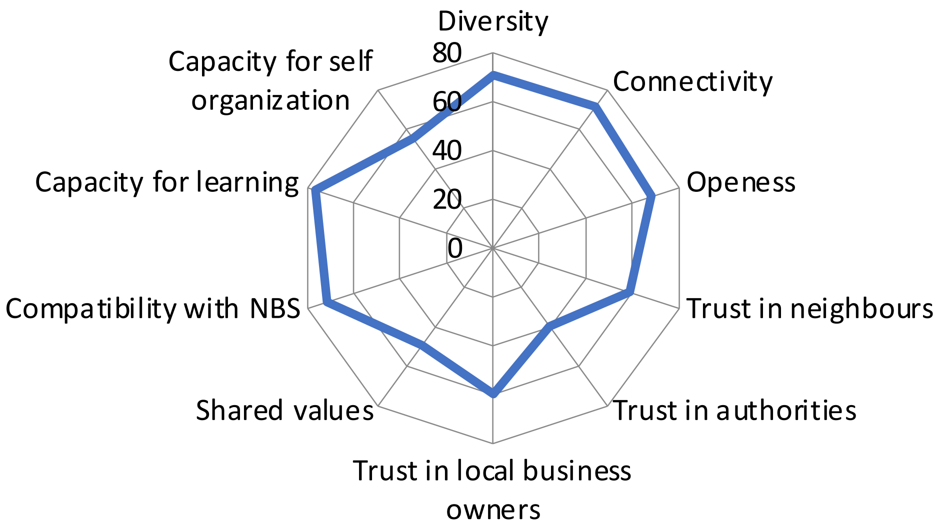

Figure 6. Example of social sustainability graph for a local community.

4 Economic impact indicators

4.1 Introduction

The evaluation of the direct and indirect economic impacts of NBSs on regenerated urban sites and their surroundings is facilitated in the euPOLIS project by utilizing a cluster of performance metrics that aim, among others, to assess the economic consequences and the business opportunities from the implementation of such infrastructure. Demonstration of NBSs introduction's short- and long-term effects on the local economy (e.g., new on-site businesses and jobs, reduced maintenance costs) is crucial for demonstrating their sustainability, offering greater insight, and consequently enabling, with the aid of a holistic framework of indicators, the needed transition from traditional models to innovative NBS urban planning and design.

Up until now, the research on NBSs has focused on providing evidence mostly with regards to their environmental benefits, whereas the documentation for other impact dimensions, including the economic one, remained sparse and mostly vague (Frantzeskaki et al, 2019), as well as poorly acknowledged by the European citizens in pertinent surveys (Faivre et al, 2017). Hence, there is currently an emerging need to develop multi-criteria evidence-based identification and evaluation methods that explicitly address the economic impact of the NBSs in either existing or new re-naturing urban projects.

For defining an appropriate set of economic evaluation indicators, we considered four potential challenges related to (a) their definition being overly site-specific, (b) the timescale considered for their assessment not being suitable for measuring any impacts (e.g., within the duration of the euPOLIS project), (c) the spatial scale over which their impacts should be monitored not being appropriately identified and (d) the assessed quantity being affected by additional, and often unspecified, factors.

To properly tackle the aforementioned challenges, the data collection/monitoring needed for estimating the proposed economic indicators is mostly restricted to the realm of the demonstration site and accounts for changes that could be observed shortly after the implementation of the NBSs at the site of interest, yet still not necessarily fully appreciable within the project timeframe (i.e., number of new jobs, number of new on-site businesses, increase in the number of visitors, the value of food/plants produced at the demonstration site, annual maintenance savings).

On the other hand, a few other indicators were mostly defined to assess the long-term economic impacts of the NBSs (i.e., changes in the property sale prices and new businesses in the surrounding neighbourhood, attracted private financing) and their data collection will be expanded in some cases beyond the demonstration site boundaries. Therefore, they will not allow for the assessment of the NBSs pertinent impact within the project timeframe, but they should provide valuable information for the city representatives and other local stakeholders in the long-term perspective.

4.2 Economic indicators with methods and tools

Table 2 outlines indicators addressing typical economy-related issues at the demonstration sites of the Front Runner (FR) cities demo sites and will be used to assess achieved economic benefits deriving from the NBS related business activation.

Table 2. Economic evaluation indicators.

Indicator	Description	Methods	KPI
Number of new jobs	The number of new jobs created at the demonstration site (e.g., in site maintenance, security, businesses operating at the demonstration site) after the NBS implementation	• A questionnaire that city representatives, NGOs, and other local community organizations will complete before and after (between 6 and 12 months) NBS implementation.	KPI_9
Percentage of new jobs addressing unprivileged social groups	Percentage of new jobs created at the demonstration site after the NBS implementation that address unprivileged social groups	• A questionnaire that city representatives, NGOs, and other local community organizations will complete before and after (between 6 and 12 months) NBS implementation.	KPI_9
Change in the residential / business property sale prices in the proximity of the demonstration site	The percentage change in the residential and business property sale prices in the proximity of the demonstration site.	• A survey that local real estate agents or other experts will complete before NBS implementation. Data providers will be asked to estimate the sale price change within 2 to 5 years after the euPOLIS project completion	KPI_9
Number of new businesses established in proximity to the demonstration site	The number of new businesses created around the demonstration site	• Documents analysis (i.e., annual reports on the local economy)	KPI_9
Change in the number of visitors at the demonstration site	The percentage change in the number of visitors at the demonstration site	• Observation and documents analysis: In coordination with city representatives, NGOs, and other local community organizations, we will estimate the number of visitors before and after (between 6 and 12 months) NBS implementation.	KPI_9
Value of food/plants produced at the demonstration site	Tangible and non-tangible added values from the foods/plants produced at the demonstration site	• Assessment of food production to establish the amount of income/benefits produced at the site. • Monitoring the number of socializing events before and after NBS implementation	KPI_9
Private financing attracted to the demonstration site	Number of companies and private investments financing additional NBSs at the demonstration site	• Collecting city data on the number of companies and the amount of private money financing additional NBSs at the demonstration site.	KPI_9

Annual maintenance savings from biomass reusage	Any biomass collected at the demo site and used as a resource	• Documents analysis: With help of relevant organizations, we will monitor the biomass usage in the demo location and consequently its tangible benefits.	KPI_9
Annual maintenance savings from rainwater harvesting and/or grey water treatment and re-usage	Any site recycling water usage tangible benefits	• Documents analysis: With help of relevant organizations, we will monitor the recycled water usage in the demo location and consequently its tangible benefits.	KPI_9

4.3 Business Activation Matrix

The business potential of the NBSs will be identified and enabled in the euPOLIS project by the utilization of the innovative **Business Activation Matrix** (BAM). It is important to acknowledge herein that the evaluation of the indicators (Table 2) and BAM are interconnected. The selected indicators would be used to measure the economic spill over effects mainly derived from measures defined through the BAM system.

The BAM concept is an interdisciplinary approach that is based on the "Develop business around NBSs" strategy. This is materialized through interactive synergies between Resources R1 (i.e., Opportunities opened by Potential NBSs or NBS related interventions) on the one side, and Resources R2 (i.e., Existing site resources) on the other. The goal is to identify which combinations between these two groups of resources produce a business opportunity or a positive economic impact. The outcome of this process is the identification of a spectrum of theoretically possible positive solutions.

The BAM system is essentially a tool for the identification of potentially profitable activities deriving from the demo site existing resources, on one side, and NBS induced resources on the other. Once potentially applicable economy-related euPOLIS demo site interventions are selected within the BAM system, they will be evaluated by the economic evaluation indicators (Table 2).

The Business Activation Methodology (BAM) concept is in line with an important project objective that is stated in the project Grant Agreement (GA): "To ensure the sustainability of project outcomes by creating the feeling of ownership among residents/users and enhancing motivation for BGS-based business activation in support to PH and WB issues".

4.3.1 BAM construction process

The BAM construction process constitutes of four main steps:

- **Step 1:** Define NBS-related Resources 1 (R1) and identify the list of opportunities for potential business activities (Table 3)
- **Step 2:** Identify locally existing resources (R2)
- **Step 3:** Combine R1 and R2 to identify the potential business activation
- **Step 4:** Develop the Business Plan

The BAM methodology is presented in Figure 7.

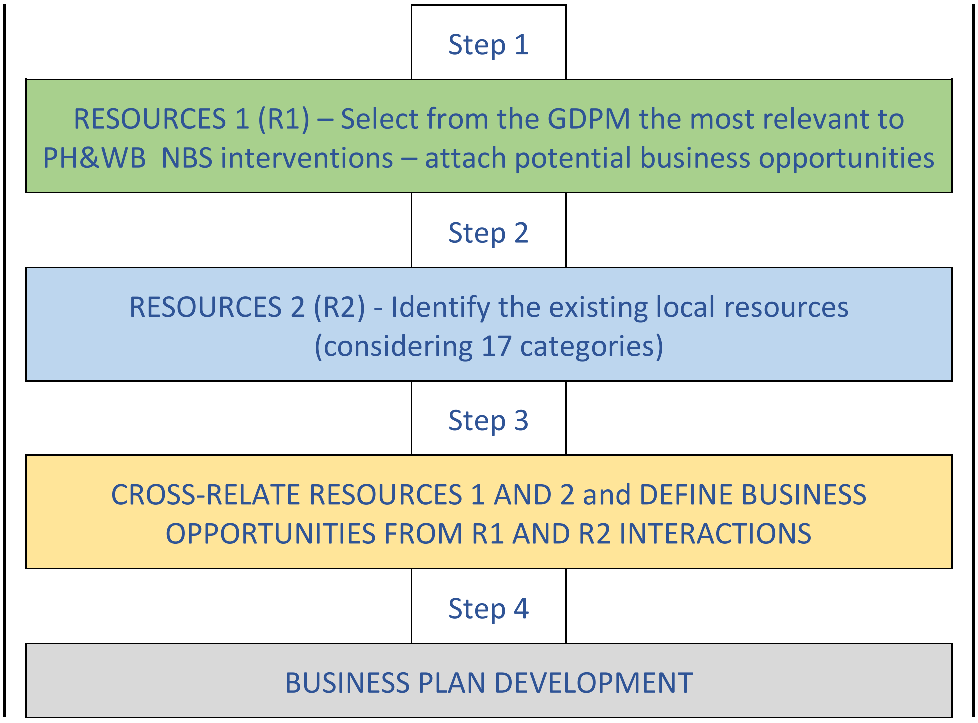

Figure 7. Business Activation Matrix construction methodology.

Table 3 specifies selected NBSs, that within the BAM framework are called Resources 1 (R1), (Column 1). Colum 2 contains the list of opportunities for business activities that theoretically can be activated by each of the selected resources R1. Column 2 analysis is designed to help identify R1 (Table 3, column 1) and R2 (Table 4) productive combinations.

Table 3. Selected Resources 1 (R1) and potential business activity which theoretically can be activated against each selected R1.

No	Column 1, RESOURCES 1 (R1) - potential BGS interventions	Column 2, Opportunities for potential business activities created by NBS interventions (LT - Long Term, ST - Short Term)
1	Evaluate existing greenery and introduce measures for their protection and maintenance	1. (LT) Maintenance, introducing durable change of attitude towards green spaces and their 2. (LT) Biomass utilization
2	Multi-Functional pocket parks with MF green spaces designed to affect Outdoor Environment Quality (OEQ) and site's summer and winter microclimate. They are designed to not only enrich location's beauty but also to mitigate the heat island effect and provide shading for people. They might include surface waterway with fresh water aquatic biotope. In general, MF pocket parks should also serve as convenient socialization areas and family outing areas. Therefore, they should attract visitors and subsequently new business and enhance the existing business environment quality (production, marketing). This place will develop human / Eco System Services regular interaction points	1. (ST) Business for expert consultants engaged to design BGS improvements 2. (ST) Business for the construction industry (landscape, earth moving and water contractors) engaged in improvement works 3. (LT) Business for local citizens to be engaged in the maintenance 4. (LT) Walking convalescents through NBS rich environment with improved microclimate (potential for people from medical industry) 5. (LT) Regular testing/monitoring of the parameters critical for the euPOLIS NBS's functions 6. (LT) Organization of social events 7. (LT) Tourist attraction - small business 8. (LT) Researchers from universities, institutes and alike utilizing facility for their research (institutional or private as contract) – payments to community 9. (ST) Surface water management system upgrade (contractor paid for upgrade and also for regular maintenance and servicing) (LT) Regular maintenance of evaporation system 10. (ST) Business for educated seniors - systemic, regular city heat island spots mapping 11. (LT) Business for kids' entertainment and sports 12. (LT) Enhancement of existing business with an attractive environment 13. (LT) Any small services or trading business (painting, advising, education, selling) 14. (LT) Business for educated seniors - systemic, regular city air polluted spots mapping 15. (ST) Business for educated seniors - systemic, regular city heat consumption savings monitoring 16. (LT) Business for the city - income increase from new businesses
3	Vertical farms and pocket farms irrigated with rainwater harvested from surrounding buildings. With proper education campaign on vertical farms, the concept might be adapted or expanded to other neighbourhoods.	1. (LT) Business production of food, flowers, aromatic herbs, 2. (LT) Business to producers of vertical and horizontal small farm devices – to sell and educate buyers

No	Column 1, RESOURCES 1 (R1) - potential BGS interventions	Column 2, Opportunities for potential business activities created by NBS interventions (LT - Long Term, ST - Short Term)
4	Energy-related conditions - Summer Shading of buildings, Introduction of a system for the utilization of biomass for energy	1. (LT) Extracting benefits from developers as a trade-off for increased comfort and reduced energy consumption 2. (ST) Biomass regular collection
5	Select, implement and monitor vegetation reduced emission of negative compounds such as BVOC	1. (LT) Analysis of this site and immediate extrapolation to neighbouring locations and other, frequently visited public areas of the city
6	Planning with NBS tool “gender planning criteria”	1. (ST) Consultant’s business in designing new public facilities as well as enhancing existing ones 2. (LT) Business for young citizens to perform regular testing of visitors (questionaries) on the subject of gender / different groups equality regarding introduced public space functions (cities need this information regularly)
7	Counter neurological decline (typically seen among the elderly) - create a stimulus for senior people for a daily exercise walk - (These methods to be developed by our social and health experts and other partners if they have proposals)	1. (LT) Business as small regular assistance to seniors (for nurses to accompany seniors on regular basis)
8	New gardens with Nature Based water evaporation systems as a potential resource for research and tourism	1. (LT) Seniors and/or youngsters educated for educators and tourist guides, and research activities
9	Social–Urban Hub created as BGS demo/Edu-centre and community activator in the domain of culture and environmental regeneration with MF roof garden, VF, experimental area, alternative space for public art installations and seasonal eco café (demonstrating sustainable, nature-friendly mode of operation, cooling and resource recycling). Including citizens education on how to create a natural environment in their immediate surroundings	1. (LT) Business for citizens to operate, educate and maintain
10	Enhance interaction BGS's / People - Introduce measures to increase the use of green areas, systematically increase awareness of city greenery, recreation areas promotion on all media and stimulate the number of pedestrian day trips to green areas, green areas sustainable usage education	1. (ST) Mapping of suitable new NBS locations 2. (LT) Marketing for city, dissemination business 3. (LT) Marketing for city, dissemination business 4. (LT) business for the recreation industry 5. (LT) business for educators

We already prepared a detailed description of existing resources R2, in 22 different categories. Here we present only the general areas in which the local resources can be categorised (Table 4). Detailed specifications of the resources for each FR city demo site, signifying site characteristics, will be presented to the local stakeholders.

Table 4. Areas of locally existing resources (Resources 2 - R2).

No	CITY OF XXX, demo site RESOURCES 2 (R2) – AREAS of LOCALLY EXISTING RESOURCES
1	Human resources (knowledge, training level/area)
2	Material resources
3	Cultural resources
4	Social resources
5	Geographical resources (location advantages)
6	New local knowledge resources
7	Outside - locally applicable resources
8	Market receipt potential for new business (market non saturated segments)
9	Local problems as resources (solving problem creates business - problem is costing someone and they pay for remedial action)
10	Unemployed become employers
11	Renewable energy resources
12	Energy sources available
13	Waste management and recycling (links that create circular economy)
14	Food & agriculture
15	Water & wastewater
16	Healthcare
17	Housing & construction
18	Information & communication technology
19	Integral solutions
20	Retail
21	Financing
22	Government

4.3.2 BAM Table

The BAM table represents a combination of R1 and R2 resulting in potential business activation at each euPOLIS project demo site.

The purpose of BAM is to identify a productive combination between Table 3, Column 1 (R1), and existing demo site resources (R2) specified in Annex Table (see Annex 1). Each item marked as R1 is checked against each item marked as R2, to test their economic / business potential. Once a productive combination between any two R1 and R2 resources is identified it is marked as a potential for business activation.

This process enables us to identify the interactive effect of business/economy from each potential NBS intervention (or group of NBS interventions) most relevant to PH&WB, when checked against each locally available resource. If any of these combinations is found to signify a business opportunity and/or have a positive economic effect, it is recorded as an adequate potential.

The enclosed Table 4 demonstrates R1 and R2 combining methodology, and its subsequent results. However, what is presented here is only a generic example. The detailed BAM Annex table (Annex 1), developed for FR cities demo sites, are presented in the Annex chapter.

In Table 4, resources R1 (from Table 3) are presented in Column 1. Column 2 contains the list of resulting, NBS induced business-related potential activities which theoretically can be activated against each selected R1 as presented in Table 3.

Resources marked as R2 are specified in table in Annex 1. Column 3, which is the resulting Potential Business column, contains R1 and R2 descriptions and describes business potential as a result of a combination between R1 and R2.

Table 5. BAM table example - method of combination between R1 and R2 with business potential as a result

	1	2	3
	SELECTED NBS INTERVENTIONS (Common for FR cities)	Resulting, NBS induced business-related potential activities (LT - Long Term, ST - Short Term)	Combination: Each item from Column (R1) checked against each item from Tables 6,7,8,9 (R2) – Resulting Column: POTENTIAL BUSINESS
1	Introduce measures to evaluate and protect-properly maintain existing and new vegetation	1. (LT) Maintenance of euPOLIS standards by local people 2. (LT) Biomass utilization	1(R1) + 1/4/6(R2) - Introduce measures to evaluate, protect and properly maintain existing and new vegetation - involve senior citizens and their knowledge in preparing traditional food (weekend business) - involve senior citizens and their knowledge in gardening - involve young unemployed people willing to work >> Negotiate with the city's implementation of public green space maintenance on private land and soil and nutrient improvements
			1(R1) + 1/6(R2) - Introduce measures to evaluate, protect and properly maintain existing and new vegetation - involve senior citizens and their knowledge gardening - involve young unemployed people willing to work >> Negotiate with an apartment building developer to fund a small private business for immaculate grounds maintenance (good marketing for him)

4.4 Spill-over effects

4.4.1 Direct spill-over from BAM

The first results of the BAM system, which defines the spill over effects from the implementation of NBSs, are several potential business opportunities and their positive impact on the economy as presented in Table 3, and in particular the column named “POTENTIAL BUSINESS”.

The column “POTENTIAL BUSINESS” essentially lists several proposals that can easily fit into the standard state of practice and be activated at any time. Some proposed items, on the other hand, require a mental shift towards an innovative strategy that promotes business and positive economic effects with the introduction of more functional NBS urban components into a city network.

There will be additional spill over effects in the form of economic effects (revenues and cost savings) within the city categories positively affected by NBS interventions, such as environmental quality, reduced pollutions, different city functional savings etc.

Further spill over effects will include direct benefits to the wider community resulting from this first layer of effects. They will mainly be noticeable in the category of public well-being improvements, which increases its economic viability.

4.4.2 Indirect economy effects - Natural Ecosystem Related Business Drivers

As euPOLIS legacy, we plan to produce a system which will assist cities to successfully develop concepts for NBS financing at a large scale – radically increase the number of NBSs in their living environment and create a methodology that will be adapted not only in the demo locations but also by cities worldwide.

In recent years, there is a tendency, initiated primarily by the private sector, to participate and gain from the active involvement in supporting the development of NBS-enhanced urban green areas in many cities across Europe and around the world.

There are various methods and instruments for these financing operations, commonly called “NATURAL ECOSYSTEM RELATED BUSINESS DRIVERS” (detailed descriptions of specified drivers and references are given in Table 5). The supplementary financing of NBSs by these drivers will result in the quality improvement of the NBS-enhanced environments which, in turn, will have a positive impact on the local businesses and the economy in general.

Therefore, the set of NBS Business Drivers could be exploited as a vehicle for enhancing NBSs, and NBS related financing, which could create spill over effects of considerable quantity and quality.

The activation of Business Drivers should be evidence-based. Hence, the euPOLIS should first produce positive PH&WB related project results from the pilot demo sites. Second, the results will be disseminated to the wider community.

Therefore, we would like to introduce a comprehensive systemic action designed to activate Business Drivers. First, similar European projects need to create more demonstration sites around Europe with more positive measurable results, to create a credible base for the action. It would allow for the comprehensive systemic research to identify locally available potential resources capable of activating Business Drivers. Once this is achieved, the Drivers should be activated through argument persuasion of the key players involved. For example, some existing local businesses would be interested in considering the category: STRAIGHTFORWARD BUSINESS: *Nature-based tourism (“Guidelines on Biodiversity and Tourism Development.”)* which is perhaps the best-known example of how private enterprise depends directly on the health of the surrounding ecosystems. In such cases, business owners and managers need little persuasion to invest in the conservation and sustainable management of natural resources.

The above short action plan results from our conviction that this conceptual proposal by the euPOLIS project opens the door for massive and extremely useful action.

To assess, activate and exploit potential NBS Business Drivers, several conditions must be met. The crucial conditions are deemed to be the proof that the implementation of NBSs in the cities have a significant positive effect on PH&WB. These proofs could then be used to simulate a whole set of activities based on the below described "Business Drivers Activation" strategy. For this purpose, at least as a beginning of the process, the final results from the euPOLIS project, related to PH and WB, will be needed.

Table 6 provides a provisional list of potential NBS Financing Drivers which could be analysed and exploited through the proposed long-term plan (Table 6).

Table 6. The list of potential NBS Financing Drivers to be analysed and exploited

No	Business Driver Title
1	**Straightforward business**: Nature-based tourism ("Guidelines on Biodiversity and Tourism Development.") is perhaps the best-known example of how private enterprise depends directly on the health of the surrounding ecosystems. In such cases, business owners and managers need little persuasion to invest in the conservation and sustainable management of natural resources.
2	**Increased demand for ecosystem services in urban areas**: urban residents need water, energy, food and fibre, recreation, and other goods and services. Increasingly, urban consumers demand environmentally friendly products. Meanwhile, the supply of ecosystem goods and services comes mainly from rural areas
3	**A growing environmental concern of more affluent consumers** (eco branded businesses), who increasingly insist on products and services that are demonstrably sustainable: 1. Demand for organic food, 2. sustainably harvested timber, 3. ecotourism See http://www.ecotourism.org; http://www.ifoam.org; http://www.unece.org
4	**Competitive advantage** to be gained: more and more businesses are realizing that there is a competitive advantage to be gained and, in some cases, profits to be earned, from the conservation of ecosystem services: companies first seek to distinguish themselves from competitors and win favour with consumers by supporting environmental causes: 1. the association of business product and services with "natural" environments in advertising campaigns, 2. reporting of business impacts on ecosystems or contributions to conservation activities, 3. subscribing to voluntary schemes that certify business compliance with certain environmental performance standards
5	**New business models developed**: new business models are being developed to deliver environmental benefits, including many intangible but valuable ecosystem services that can no longer be taken for granted due to increasing pressure on natural resources.
6	**Changing regulatory requirements**: other drivers of business investment in ecosystems include changing regulatory requirements and tax incentives, as well as growing demands from investors, shareholders, local communities and/or NGOs
7	**Nonregulatory, informal drivers**: nonregulatory, informal drivers should not be under-estimated. In many situations, a strong case for investing in ecosystems can be identified, based not only on business cost reductions or increased sales but more generally on the need to protect firms': • "License to operate"—companies that can demonstrate high environmental standards throughout their operations may be granted preferential access to resources and may also be favoured by prospective investors, insurers and business partners.

	• Relations with stakeholders—environmental investments can improve staff morale and help to recruit and retain employees, while also improving relations with surrounding communities and government regulators. • Sensitivity to emerging environmental regulations—companies that invest in ecosystems learn quickly how to integrate conservation in their operations and are well-placed to meet new regulatory requirements or to advise governments on cost-effective, business-friendly options for environmental protection.
8	**Identifying the main threats to ecosystems**: mapping of potential risks for ecosystems and devising mitigation measures
9	**The private sector should do is to reduce or refrain from environmentally harmful activities**: this may be achieved through mechanisms such as 1. environmental assessments and reporting, 2. mitigation requirements for large investments, 3. land-use planning and zoning, 4. restrictions on technology, 5. mandatory emissions standards, or 6. voluntary commitments to reduce waste and avoid damage to habitat. In this view, business is creating the problem and the solution is to force businesses to stop harming.
10	**Mitigate environmentally harmful activities**: So long as environmentally harmful activities are less costly or more profitable than eco-friendly practices, people will be tempted to cheat or make only token contributions to environmental protection, while continuing to devote most of their effort to "business-as-usual." This requires considerable effort in monitoring the environmental impacts of business, exposing poor performance and/or enforcing regulations.
11	**Environmental improvement enhancement measures**: • providing information to help producers, consumers, and investors make their choices based on social and environmental performance. • creating or strengthening property rights and liability regimes to reflect the values of ecosystem services; and • making direct payments to producers of ecosystem services (both public and private).
12	**Eco-labelling and certification schemes**: One of the best-established market-based mechanisms for ecosystem management is the use of eco-labelling and certification schemes to distinguish products and services by their social and environmental performance. The premise of such schemes is that consumers will prefer to buy or even pay more for certified goods and services.
13	**Organic agriculture**: Organic agriculture is by far the leading form of certified agriculture. IFOAM notes that the typical buyer of organic products is: • an urban resident, usually living in a big city. • a discerning consumer generally. • relatively well-educated. • relatively better-off.
14	**International policies to reduce environmental risks**: Several international banks have developed policies to reduce environmental risks, while some leading financial firms have identified biodiversity and ecosystem services as emerging issues that could significantly affect the value of their (and their customers') investments. For example, Insight Investment—a major UK fund manager—worked together with UK conservation NGO Fauna & Flora International to develop a tool to benchmark companies in the extractive and utility sectors with respect to biodiversity impacts, risk assessment procedures, and company efforts to manage such risks.
15	**Government subsidies and tax incentives** to encourage resource conservation: Governments in several countries have developed subsidies and tax incentives to encourage resource conservation. This direct approach that has been successfully implemented in several countries is payment for watershed protection. This is based on the growing awareness of water users that conserving natural forests in

	watersheds and reducing pollutant loads in runoff from upland areas can be a cost-effective means of providing reliable supplies of clean water for hydroelectric power generation, irrigation and industrial, domestic and recreational uses.
16	**Management of environmental liabilities**: Examples include 1. the emergence of wetland banking in the United States (Wilkinson et al., 2002), 2. trade in forest conservation obligations in Brazil (Chomitz, Thomas, & Brandão, 2005), 3. and markets for groundwater salinity credits in Australia (van Bueren, 2001). What all of these initiatives have in common is the possibility of a trade, namely buying and selling environmental obligations to meet government mandates or voluntary targets. Example 4 - for every hectare of wetland that is damaged or destroyed, developers may purchase credits from approved "mitigation" banks to support conservation efforts in the surrounding area, for habitat that is similar to that which they intend to convert. This has stimulated the rapid growth of a new business sector providing mitigation services.
17	**Reduction of companies' risks**: reduction of companies risks in areas: operational, Regulatory, Reputational, Access to capital; if they support ESS regeneration (https://www.iucn.org/content/business-and-ecosystems). Because of these inter-relationships, the trends and six challenges identified by the MA pose significant risks to companies (as well as to their suppliers, customers and investors) including: Operational – increased scarcity and cost of raw materials such as freshwater, disruptions to business operations caused by natural hazards, and higher insurance costs for disasters such as flooding. Regulatory – the emergence of new government policies such as taxes and moratoria on extractive activities. Reputational – damage to corporate reputation from media and nongovernmental organization (NGO) campaigns, shareholder resolutions and changing customer preferences. Access to capital – restrictions as the financial community adopts more rigorous investment and lending policies.
18	**Potential creation of new markets**: - New technologies and products – that will serve as substitutes, reduce degradation, restore ecosystems or increase the efficiency of ecosystem service use; - New markets – such as water quality trading, certified sustainable products, wetland banking and threatened species banking. - New businesses – such as ecosystem restoration and environmental asset finance or brokerage. - New revenue streams – for assets currently unrealized, such as wetlands and forests, but for which new markets or payments for ecosystem services could emerge.
19	**Maximize material and energy efficiency**: using recycled material and renewable energy resources with buildings optimal insulation will result in a minimal negative effect on ESS as well as higher operational profits.
20	**Create value from waste**: different waste utilization methodologies have already proved to be significant revenue earners.

5 Environmental impact indicators

5.1 Introduction

Since 2015 when the Rockefeller Foundation-Lancet Commission introduced the concept of planetary health (Whitmee et al., 2015), the evidence of the interconnection between the environment and human health has been frequently raised. Planetary health is grounded in the realisation that human health is dependent on thriving, well-balanced ecosystems (Halonen et al., 2021). However, the integrity of ecosystems tends to decline, followed by their performance, due to an increasing demand for goods and services, disregarding nature as a stakeholder.

This discrepancy between limited ability to serve services, due to degradation and societal expectation, is to be mitigated by nature-based solutions (European Commission, 2015). euPOLIS' NBS interventions aim to support nature in re-building its integrity and reverse degradation at least to the standards for well-being distribution and to set new management imperatives (Fig. 8).

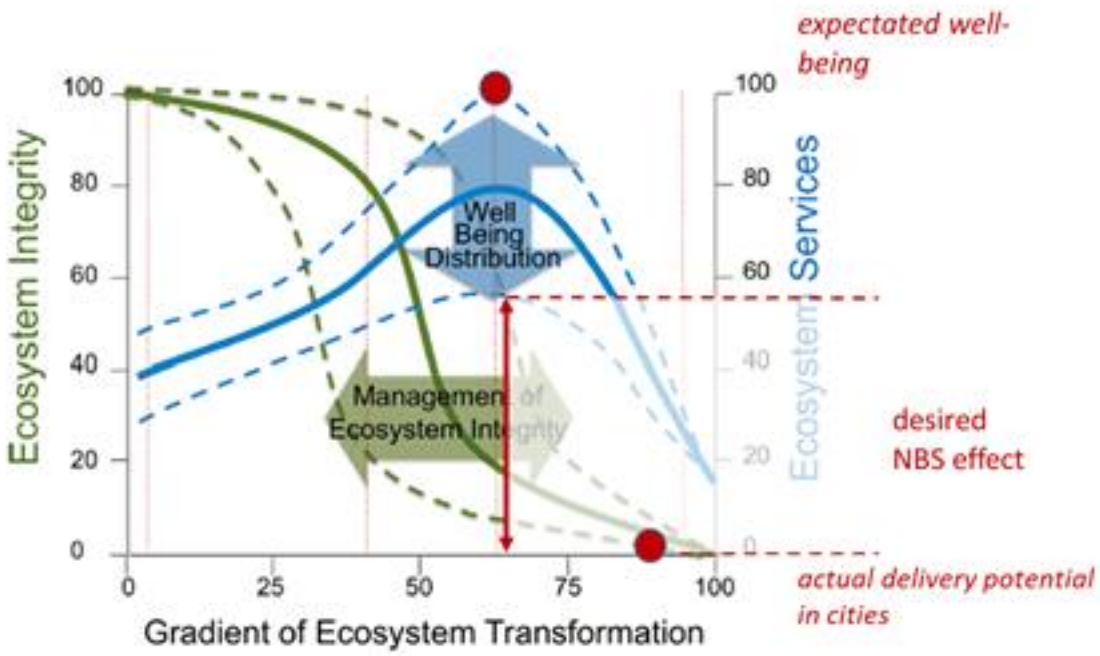

Figure 8. Interconnection between health / integrity of ecosystems and human well-being vs the role of NBS (modified Maass et al., 2016).

Environmental context influences human health and well-being twofold: directly through air quality, water quality, microclimate, soil pollution, or cultural values that affect mental health and feeling of comfort, and indirectly when environmental conditions promote biota that influences regulatory services supporting healthy lifestyles.

Following Artiga and Hinton (2018), genetics and healthcare constitute together ca 40% of the factors influencing a risk of premature death. The broadly understood environment is responsible for the rest of the impact, either through its quality or by enabling or triggering healthy lifestyle and beneficial societal interactions (Fig. 9).

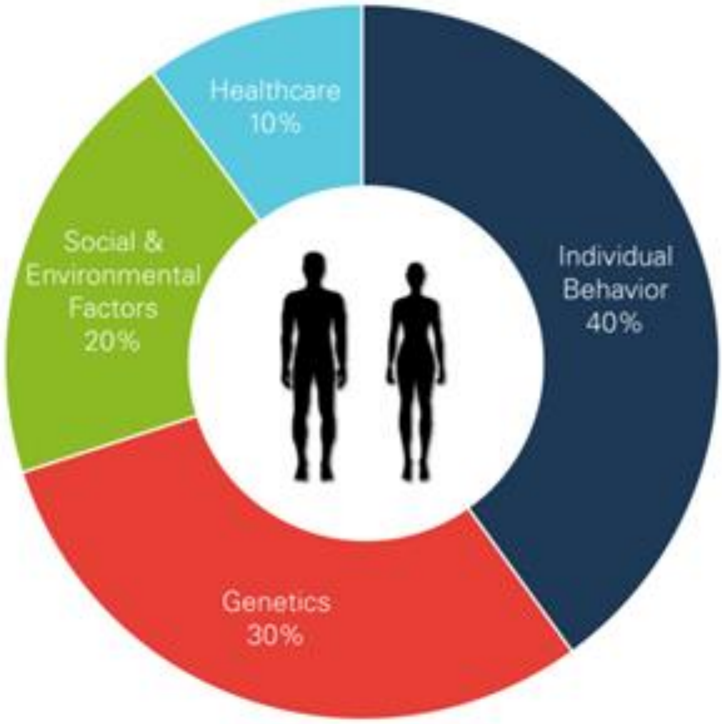

Figure 9. Impact of different factors on a risk of premature death (Artiga and Hinton, 2018).

5.2 Environmental indicators with methods and tools

Table 7. Environmental impact indicators

Indicator	Description	Methods	KPI
Air Temperature Reduction / Air Cooling	This indicator measures the difference in air temperature caused by the implementation of NBS through evapotranspiration and/or shading. It addresses the mitigation of the UHI effect, as well as climate change impacts and weather extremes.	The indicator can be measured in different ways, through on-site monitoring, remote sensing, or modelling. However, the most appropriate method depends on characteristics of the applications (e.g., scale), as well as the objectives of the analysis.	KPI_ 3, 7, 8
Universal Thermal Climate Index (UTCI)	It is based on the UTCI-Fiala model (Fiala et al., 2012), which combines a dynamic thermoregulation model of the human body together with a temperature-varying clothing insulation model, both describing distinct states depending on different ambient factors	UTCI is determined based on the meteorological data that are measured in the near vicinity of the NBS or the demo site.	KPI_ 3, 7, 8

	(https://utci.lobelia.earth/what-is-utci).		
Avoided or additional net energy consumption (or GHG emissions)	The difference in energy consumption before and after implementation. The NBS themselves can provide climate regulation leading to energy savings (e.g., heating and cooling, energy for the Urban Water Cycle – upstream or downstream, etc.). However, some implementations may increase energy consumption (e.g., on-site water purification, water supply, illumination, etc.).	Observation (and calculation) of different types of energy consumed on the site (before and after the implementation of NBS). Modelling of the water-related energy in the UWC (optional).	KPI_7, 8
Site Water Autonomy for NBS	A measure of the amount of locally sourced water to cover NBS water irrigation needs.	Observation (and calculation) of difference between requested water supply before and after NBS implementation (with focus on potable water use). Modelling of the UWC and decentralised technologies (optional).	KPI_7, 8
Potable water savings / Water reuse	A measure of the potable water savings of the site's water needs resulting from the implementation of NBS and supportive water technologies.	Difference between requested water supply before and after the implementation with focus on potable water use. Modelling of the UWC and decentralised technologies (optional).	KPI_7, 8
Wastewater Treatment Coverage	This indicator measures the wastewater treatment service provided by the implemented NBS.	Direct measurement (e.g., flowmeter) or modelling of the UWC (e.g., UWOT).	KPI_7, 8
Wastewater (and stormwater) managed on site	This indicator measures the amount of wastewater and stormwater managed on site (e.g., for irrigation) instead of entering the central wastewater and stormwater system.	Direct measurement or integrated UWC modelling. The percentage of stormwater and/or wastewater managed locally.	KPI _7, 8
Flood (risk) factor	Flood (Risk) Factor is the likelihood of flooding and the potential depth of that flood, in a particular location.	Flood factor tool (https://floodfactor.com/methodology) Flood frequency analysis (fluvial flooding) Rainfall return period vs rainfall response (pluvial flooding) IDF curves	KPI _ 3, 7, 8
Runoff coefficient	Surface runoff at the site in relation to the precipitation quantity.	Direct measurement USDA Curve Number Hydraulic modelling	KPI _ 3, 7, 8

Mitigation of the urban runoff peak	Relative difference between the inflow peak (rainfall intensity peak multiplied by the NBS area) and drained discharge peak.	In-situ gauges EO/RS methods for bigger sites Modelling	KPI_ 3, 7, 8
Delay of the urban runoff peak	Relative difference between the time when the inflow peak occurs and the time when discharge peak occurs.	In-situ gauges EO/RS methods Modelling	KPI_ 3, 7, 8
Water quality – general	Water quality depends on its chemical status, biochemical parameters, and pathogen content. NBS are proved to contribute to removal up to 90% of P and N compounds, reduce heavy metal content through processes generally called phytoremediation, and reduce pathogen content, e.g. E. coli up to 70%.	In-situ loggers Measurement with mobile devices Laboratory analyses	KPI _ 3, 7, 8
Exposure to Noise Pollution	Exposure to noise pollution is the proportion (%) of population exposed to noise levels (LDEN) above 55 dB, before and after NBS implementation. LDEN is a combination of equivalent sound pressure levels A – pondered on 3 periods of the 24h day (day, evening, night).	In-situ loggers Measurement with mobile devices Modelling	KPI_ 3, 7, 8
European Air Quality Index	The Index is based on concentration values for up to five key pollutants, including: • Particulate matter (PM10); • Fine particulate matter (PM2.5); • Ozone (O3); • Nitrogen dioxide (NO2); • Sulphur dioxide (SO2). It reflects the potential impact of air quality on health, driven by the pollutant for which concentrations are poorest due to associated health impacts.	Measurement with loggers	KPI_3, 8
Average NDVI values	Normalized Difference Vegetation Index (NDVI) quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs).	Remote sensed data analysis. Calculated: with the formula (NIR – RED)/(NIR + RED), based on processing of the freely available satellite images from Landsat and Sentinel	KPI_3, 8

Biologically active space (de-sealed area)	Share of de-sealed / not sealed area within demonstration site.	Data processing (orthophoto maps or GIS data) Difference between share of area not covered with impermeable surfaces before and after implementation calculated based on the maps and orthophotomaps. Data processing by using GIS software: manually drawing of areas in DS which are covered with impermeable/permeable surfaces and calculation of this surfaces by field calculator in GIS	KPI_ 3, 7, 8
Community level physiological profiling	A rapid screening method used to characterize microbial communities of different habitats, ranging between sediments to seawater and between oligotrophic groundwater to soil and fertilizers.	Soil sampling and laboratory measurements	KPI_3, 8
% of biomass reuse on site	Biomass produced on site and obtained from greenery maintenance which is not removed from the site and contributes to its regeneration.	Observation or survey on biomass reuse.	KPI_7, 8
Plant & animal richness of selected native indicator species	The total number of native species within a defined area before and after implementation. This can compromise one or more of the following taxonomic groups : a. Plants, b. Birds, c. Butterflies, d. Invertebrates, e. Mammals.	Surveys of specific fauna groups / vegetation by experts; Citizen science referring to i-Naturalist, Flora Incognita, Bird Net, etc.	KPI_3, 8
Changes in habitat quality	Habitat diversity being the effect of habitat de-homogenization.	Field surveys, observations, and habitat mapping.	KPI _ 3, 7, 8
Blue space availability	The % of blue space available within 1km of the participant's home.	Satellite images, fieldwork observations can be used to delineate all the blue elements in the vicinity of the demo site. GIS-based mapping, and calculations.	KPI_3, 8
Connectivity of urban green spaces	Degree to which urban green spaces allow humans and other species to move freely and ecological processes to function unimpeded	Modelling based on maps of blue-green spaces Tools: https://conservationcorridor.org/corridor-toolbox/programs-and-tools/ Interviews and opinions	KPI _8
Green space accessibility	The ability to reach and access green spaces.	Measuring of walking distance GIS buffer analysis	KPI_3, 8
Changes in Habitat Diversity	The change of habitat unit diversity, before and after NBS	Field surveys, Observations,	KPI_8

(Habitat Unit diversity)		Habitat mapping.	

5.3 Indicator-related tools and methods

5.3.1 Air Temperature Reduction / Air Cooling

The factor can be described in numerous ways. The simplest one is just to register the site temperature with the in-situ meteo-station and compare the time series for pre- and post-intervention phases. It may not, however, reflect the differences in NBS cooling impact across the demo site. Point measurement or fixed area measurements can be carried out with mobile pyrometer and thermal camera/thermal sensors respectively. They allow tracing temperature deviation per surface type, and in case of fixed cameras or sensors even registration of temperature distribution.

NBS cooling effect can be illustrated with mean or peak daytime temperature (Cheng et al., 2010), or daily temperature range (Demuzere et al., 2014) and is described as temperature reduction in % or 0C.

5.3.2 Thermal Comfort Indicator

Effects of the thermal conditions on humans are described by thermal indices based on the energy balance of the human body: Predicted Mean Vote (Dyvia and Arif, 2020), PET (Physiologically Equivalent Temperature) (Verein Deutscher Ingenieure,1998; Höppe, 1999; Matzarakis et al., 1999), Standard Effective Temperature (Gagge et al., 1986), or Outdoor Standard Effective Temperature (Spagnolo and de Dear, 2003) and Perceived Temperature (Tinz and Jendritzky, 2003).

Out of the range of methods, euPOLIS proposes a few like: Universal Thermal Climate Index (UTCI), which represents air temperature of the reference condition with the same physiological response as the actual condition, thus providing a one-dimensional value that reflects the human physiological reaction to the multi-dimensional outdoor thermal environment. The UTCI dynamic model response can be calculated with an online tool available from http://utci.org, while the interpretation of the relationship between UTCI temperature and physiological stress has been provided in the NBS indicator handbook (European Commission, 2021b, p. 64).

The most straightforward method of evaluating thermal comfort is the measurement with a wet-bulb thermometer. The wet-bulb temperature is the lowest temperature that can be reached under given ambient conditions (dry thermometer) by the evaporation of water only. The outdoor activities threshold has been set for a wet-bulb temperature of 32 °C (heat index 55°C) while the theoretical limit to human survival for more than a few hours in the shade is a wet-bulb temperature of 35 °C (Raymond et al. 2020).

The least precise but fast and informative method is also interviewing the space users with the Thermal Sensation Scale. If the score is zero, the occupant satisfaction regarding the environment is at the maximum level – the temperature is assessed as neutral therefore feeling as comfortable (Ekici, 2016; European Commission, 2021b, p.365).

5.3.3 Avoided or additional net energy consumption (or GHG emissions)

Following the simplest approach, the indicator can be estimated as the difference in energy consumption before any interventions (conventional arrangement) and following the implementation of NBS interventions and any new technologies substituting conventional solutions (e.g. solar energy, vs grid energy). For the indicator estimation, various factors resulting in direct or indirect energy savings could be relevant and should be taken into account.

One of these aspects to directly avoid building energy consumption is for example residential combustion and indirectly by electric heating and cooling with and without NBS implementation (kWh/y and t CO2/y saved). The data that would be required, if available, include: electrical energy use, as well as supplemental energy sources such as district heating and local combustion, with numerical values for the community as a whole (MWh), as well as population equivalent (MWh/person), to allow compensation for population change. All forms of energy need to be considered, including electricity consumption, natural gas or thermal energy for heating and cooling, and other fuels.

Besides the building sector, the UWC is another aspect that needs to be taken into account in terms of energy savings or additional energy consumption due to the implementation of NBS. On one hand, the implementation of NBS especially combined with alternative sources of water (rainwater, greywater, etc.) can result in a reduction in the volumes of potable water supplied and volumes of stormwater and wastewater conveyed and treated, by the central water and wastewater system/utility. The reduction in the conveyance, distribution, and treatment of these water and wastewater volumes can be translated into a reduction in energy consumption related to these processes (Baki and Makropoulos, 2014). This conversion requires the energy intensity values of the different phases of the UWC of a particular urban water system. If these are not available or known, more generic values from literature can be used (Plapally and Lienhard V, 2013). The on-site or neighbourhood water flows, as well as the water-related energy can be estimated through simulations of the Urban Water Optioneering Tool (UWOT) (Rozos and Makropoulos, 2013; Baki and Makropoulos, 2014). This is especially useful in the case of the use of decentralised water technologies. The resulting overall net energy savings is calculated as:

$$NES = \sum ES_i - \sum EC_i$$

where:

ESi: Energy Saving due to NBS

ECi: Additional energy consumption due to NBS

i: energy component (e.g., buildings' cooling & heating, water supply, water treatment, etc.)

Evidently, the particular indicator can be estimated through a mixture of different methods (calculations, monitoring, modelling) depending on the energy aspect being examined, the availability of data and the use of specific simulation tools. The avoided or additional energy consumption and hence the net energy savings, are calculated in kWh/y and from this estimate the associated Greenhouse Gases (GHG) emissions can also be estimated in kg CO2/y by using the appropriate emission factors.

5.3.4 Site Water Autonomy for NBS

Sustaining city greenery usually involves substantial costs. In addition to daily and seasonal maintenance, pest protection, counteracting effects of pollution and vandalism, meeting greenery water needs is also quite costly, if possible, at all, especially in water-short seasons and water-scarce regions. Water requirements vary between plant species. However, it needs to be considered that the average 10m tall tree needs at least 133l of water per day (Kramer, 1987). In Poland, the water standard for watering gardens and recreational plots accounts for 2.5 dm^3/m^2 per day for 15 days per month, usually for the entire period from mid-April to mid-September. This results to ca. 1875m^3 of water per ha (Wagner et al., 2014).

Therefore, when introducing NBS at a site, it is very important to design for environmentally sustainable solutions that do not cause further environmental pressure on water resources, especially in water-scarce areas. To achieve this target besides striving to minimize water needs through appropriate design by adapting the site and selected vegetation structure to local conditions (e.g. removal of impermeable surfaces, change of species from water demanding to native or water stress tolerant, aggregating trees and shrubs to lower their physiological water demand, etc.), it is also crucial to investigate the use of alternative water sources. Indeed, the use of local water through rainwater harvesting and greywater recycling can significantly reduce the use of potable water.

The specific indicator is a measure of how autonomous/self-sustained an NBS is in terms of adequately covering its water needs. It should be noted that it is of great importance that the greenery is properly maintained and irrigated. In fact, in many cities' greenery is not properly maintained, therefore not supplied with adequate water. Changes in site management caused by euPOLIS interventions shift attention from the simple existence of green sites of unknown condition towards high-quality greenery, not struggling with stress, that is able to provide regulatory services. Especially climate regulation by vegetation strongly depends on water availability. This indicator is estimated as the percentage of locally sourced water to the total water required for sustaining the NBS and can be estimated through estimations considering hydrologic factors, as well as plant irrigation needs; estimations should be carried out for at least one year. Additionally, the urban water cycle within the site or neighbourhood and the use of alternative water sources can be simulated through the Urban Water Optioneering Tool (UWOT) (Rozos and Makropoulos, 2013; Bouziotas et al., 2019).

5.3.5 Potable water savings / Water reuse

This indicator is closely related to the indicators Site Water Autonomy for NBS, and Wastewater (and stormwater) managed on-site and can be used in conjunction with these indicators or individually, depending on the pilot application characteristics and associated impacts.

Decentralised water reclamation and water recycling technologies besides contributing towards the water autonomy of the NBS, they could also provide additional benefits, covering part of the existing water demand through recycled water, therefore, reducing the site's pre-existing potable water demand for various uses. For example, in the case that greywater recycling is employed to cover NBS irrigation needs, it could also potentially cover other site water needs, such as toilet flushing or irrigation of existing green areas. Such a function leads closer towards a circular economy paradigm in terms of water reuse and needs to be accounted for in terms of the associated benefits.

The indicator assesses the potential potable water savings due to the implementation of NBS and supportive interventions on site. It is calculated as the difference between the requested (potable) water supply for covering the water needs of the site/neighbourhood before and after implementation. It needs to be assessed for at least an entire year and can also be estimated as a percentage of potable water supply decrease. As in the case of the Site Water Autonomy for NBS indicator, these estimations can be facilitated through simulations of the site's, or neighbourhood's urban water cycle and employment of decentralised water technologies via the Urban Water Optioneering Tool (UWOT) (Rozos and Makropoulos, 2013; Bouziotas et al., 2019).

The indicator can be easily translated into an economic benefit when the required/avoided potable water supply is expressed in monetary values.

5.3.6 Wastewater Treatment Coverage

The WTC indicator refers to the water purification function of the implemented NBS. Appropriate systems can facilitate the on-site wastewater treatment which can be measured with the volume of wastewater treated per total volume of wastewater at the site or modelled as a volume of wastewater treated on-site to the total inflow.

The input data comprise wastewater statistics including inflow volume, pollution load, and outflow parameters. The water purification function is an important service of blue-green infrastructure; however, it is rarely applicable in the urban context, where the wastewater discharge is high compared to space availability for purification functions. Usually, NBS can perform a supportive role in dealing with less polluted effluent, but usually, they cannot maintain the constant and required efficiency in pollution removal throughout the year to allow water discharge into water bodies or open spaces (Pawęska and Kuczewski, 2013; Ozimek et al., 2015).

In the case that the site is to be designed with a clear focus on water purification, to meet specific outflow standards, the recommended approach is to apply relevant models. In such a case the range of input data is much broader including the substrate characteristics, pollutant concentration, reactions coefficients, wastewater discharge, hydraulic residence time, depth, and area of NBS, etc. (Maina et al., 2012).

5.3.7 Wastewater (and stormwater) managed on site

Green infrastructure and associated supporting decentralised water technologies, such as rainwater harvesting and greywater recycling, intercept part of the stormwater and wastewater generated on-site from entering the main stormwater and wastewater systems, respectively. Stormwater is intercepted either directly from the vegetation through infiltration, or indirectly through storage systems for later use. These flows are hence treated locally and are re-used to cover part of the irrigation and even other water needs in general, instead of burdening the central system in terms of transportation and treatment, reducing thus the associated costs.

The indicator is complementary to two others, Site Water Autonomy for NBS and Potable water savings/Water reuse, as well as to the included flood-related indicators, flood risk factor, runoff coefficient, mitigation of urban runoff and delay of urban runoff. It is also related to the Avoided or additional net energy consumption indicator since it estimates the flows that will be diverted from the central system, which are used for estimating the associated energy savings of the UWC.

The indicator is estimated as the percentage of stormwater and/or wastewater managed locally instead of centrally and needs to be estimated for at least an entire year. These estimates can be facilitated through the Urban Water Optioneering Tool (UWOT) as all different water flows (potable water, greywater, stormwater, wastewater) of the site's urban water cycle can be simulated (Rozos and Makropoulos, 2013; Bouziotas et al., 2019).

5.3.8 Flood (risk) factor

Flood factor is a complex indicator combining information about the location of the site, digital elevation model, soil properties, and rainfall intensities. The only approach to consider all the variables is to apply modelling. Such option is offered by many modelling tools or GIS devices, e.g. flood factor tool (https://floodfactor.com/methodology), STORM (https://www.sieker.de/en/software/software-gis/product/storm-software-for-modelling-of-water-management-systems-44.html), Analytic Hierarchy Process (Fernández and Lutz, 2010), Hydrologic Engineering Center-River Analysis System (HEC-RAS) (Wiles and Levine, 2002), Hydrological Simulation Program-FORTRAN (HSPF) (Becknell et al., 1993), Storm Water Management Model (SWMM) (Cole and Shutt, 1976), Urban Flood Cell Model

(MODCEL) (Gomes Miguez et al., 2017), Genetic Algorithm Rule-Set Production (GARP) or Quick Unbiased Efficient Statistical Tree (QUEST).

All those tools and models allow the quantification and mapping of urban flood risk, but in fact, can also serve the following indicators, like runoff coefficient or peak runoff delay.

An alternative way of providing the indicator value is to construct Intensity-Duration-Frequency curves (IDF) reflecting runoff in relation to precipitation quantity. The method is data-intensive. It requires annual maximum series of precipitation depth for a number of durations (15min, 30min, 45min, 1h, 2h, 3h, 6h, 12h, 24h, and 48h), defining a suitable probability distribution to illustrate different return periods (2, 5, 10, 25, 50, and 100y), plotting rainfall intensity versus duration for different frequencies with regard to all locations in focus (European Commission, 2021, p. 141).

The analysis of return periods lies also at the basis of flood frequency analysis (fluvial flooding) for a given location and rainfall return period vs rainfall response (pluvial flooding) analysis (Bach et al., 2014; Salvadore et al., 2015), which enable the delineation of flood vulnerable areas before and after NBS interventions to indicate a decrease in the area, probability, or severity of flooding. Pluvial flooding in this case is understood as rain-driven ponding or overland flow that results from the exceedance of natural or engineered drainage capacity (Rosenzweig et al., 2018).

Flood factors are important to translate environmental factors into economic ones through costs of substitution or avoidance.

5.3.9 Runoff coefficient

Defining runoff can be accomplished by the range of methods starting from direct measurement with gauging stations through USDA Curve Number ending with hydraulic modelling.

The direct measurement includes weirs, pressure transducers/loggers, tipping-bucket gauges, flumes, and orifices.

USDA Curve Number takes into account losses (interception, infiltration and storage) as well as antecedent moisture conditions. Curve Numbers (CN) are published and can be applied to particular sites. CN values are the function of soil type, hydrological conditions, and land cover (Gill et al, 2007). The basis for the methodology is the USDA National Engineering Handbook (USDA, 2004).

Modelling uses one-dimensional or two-dimensional drainage system models like the Stormwater Management Model (SWMM) (Macro et al., 2019), CityCat (Newcastle)[2] , MIKE (DHI)[3] and InfoWorks for SUDS[4].

Usually, the impact of NBS on runoff is evaluated using the design storms. They require rainfall measurements, and the characteristics of the drainage area (area, slope, land use / cover).

5.3.10 Mitigation of the urban runoff peak / Delay of the urban runoff peak

The peak flow defines the maximum value of the flow for a rainfall event. In the context of NBS implementation, it indicates how much of the river, or a stormwater discharge can be diverted or stored with NBS.

This impact can be therefore measured directly with in-situ gauges monitoring the amount of runoff entering NBS per the rainfall volume. Alternatively, it can be calculated via simulation models. The European Commission (2021) recommends three models: the PFVar expressing the peak flow variation

[2] http://www.urbanfloodresilience.ac.uk/documents/factsheet-citycat.pdf
[3] https://www.mikepoweredbydhi.com
[4] https://www.innovyze.com/en-us/products/infoworks-icm

as percentage change before and after NBS application (gardens, parks, street trees and green roofs), URBS (Rodriguez et al, 2008) useful for the catchment scale and TEBHydro for city-scale (Stavropulos-Laffaille et al., 2018).

The indicator can be also derived from EO/RS methods although Earth observatories usually deal with larger sites. Those involve mapping of inundation areas with and without NBS, supplemented with water surface elevations obtained with radar altimetry. They may also engage citizens and their observations and mapping of flooding events.

5.3.11 Water quality – general

Implementing an NBS can result in a positive or negative impact on water quality. This depends on various factors, including the quality of water entering the system, the type of NBS, the age of NBS, and the water quality parameters of interest. Water quality refers to a broad variety of substances and characteristics therefore improvement in one parameter may not necessarily indicate improvement of the others. Both positive and negative impacts of NBS on water quality are of relevance for this indicator.

Many quality parameters can be monitored automatically in-situ, e.g., temperature, pH, conductivity, turbidity / suspended solids, O2 concentration, nutrient concentration.

The indicator is meaningful only when it can be compared against long-term data series, reflecting at least seasonal changes and extreme events, and in case of post-implementation monitoring also a time for system stabilising down and maturing.

In principle water quality parameters can also be monitored with mobile devices, which results in smaller time-series less populated but allow for sampling across the site without investing in monitoring stations and loggers.

There are also parameters that require laboratory analyses: heavy metals content in water and sediments, PCBs concentrations, BOD, COD, organic matter content in suspended / sedimentary solids, pathogens, hydrocarbons, etc. In this case, recommended methods should allow the long-term comparison within the site (maintaining the same analytical methods over time) and eventually elaboration of calibration methods for cross-site comparisons.

Since the evaluation of water quality is a resource-intensive endeavour, it can be optimized by using a combination of field/laboratory measurements and models. Such techniques are usually used for NBS when estimating their performance in terms of emerging contaminants (Birch et al., 2013, Randelovic et al., 2016) or pathogens (Chandrasena et al., 2012).

5.3.12 Exposure to Noise Pollution

Exposure to noise pollution corresponds to the proportion (%) of the population exposed to noise levels (L_{DEN}) above 55dB, before and after NBS implementation. L_{DEN} is a combination of equivalent sound pressure levels A - pondered on 3 periods of the 24h day (day, evening, night). Alternatively, exposure to noise pollution can be evaluated as the change in noise levels before and after NBS implementation (without estimating the proportion of the population exposed to elevated noise levels).

Noise levels can be measured or modelled, in both cases they are A-weighted long-term averages: day – 6-18h, evening (penalty 5dB) 18-22h, night (penalty 10dB) 22-6h. Devices used for measurement of the environmental noise levels are usually Sound Level Meters that have an A-weighting filter to simulate the subjective response of the human ear. Smartphones may be an alternative tool for screening of environmental noise levels (Ibekwe et al., 2016). Environmental noise levels simulation tools include both commercial and open-source options, with the European Commission Handbook (European Commission, 2021b) suggests the open-source tool "NoiseModelling"[5].

5.3.13 Air Quality

The air quality assessment refers in the first round to variables considered in the European Air Quality Index, thus being reported in the European air monitoring system of air monitoring (https://airindex.eea.europa.eu/Map/AQI/Viewer/). Choosing this set of parameters allows cross-site and cross-country comparisons.

The Index is based on concentration values for five key pollutants: Particulate matter (PM10), Fine particulate matter (PM2.5), Ozone (O_3), Nitrogen dioxide (NO_2), and Sulphur dioxide (SO_2).

All the variables are detectable with fixed monitoring devices, whose characteristics are to be decided jointly with WPs 5, 7 ,and 8 that are responsible for the harmonization of devices, data collection, data processing and use for modelling of NBS impact on human health and well-being.

5.3.14 Average NDVI values

The source of data for the Normalized Difference Vegetation Index NDVI are multispectral orthophotomaps. Two ranges of electromagnetic radiation recorded in the red range of visible light (RED) and near-infrared (NIR) are used to calculate the average NDVI. Its values correlate with the amount of biomass and chlorophyll content of plants. The NDVI index takes values from -1 to 1, with values below 0.2 indicating areas without vegetation - built-up areas, exposed soil, dead organic matter, water, snow, etc. Values between 0.2 and 0.4 indicate the presence of residual vegetation. Above a value of 0.4, green vegetation is considered to be significantly present, and the higher the value of the index, the greater the amount of biomass and the better the condition of the vegetation which also indicates also a higher supply of eco-system services, especially regarding to microclimate, water, nutrient and air quality regulation.

5.3.15 Biologically active space (de-sealed area)

The indicator defines the water storage capacity of the site resulting from the infiltration process and soil retention capacity. In this sense, it complements indicators describing flood risk mitigation or stormwater re-use options. It is calculated as a difference between the share of an area not covered with impermeable surfaces before and after implementation, which can be done based on maps and orthophotomaps, and applying cartographic or GIS tools.

Additionally, also de-sealed areas can be characterized according to their value for water and climate management. There are different methods, however, they all are based on scoring of the area according to substrate type, the structure of the site and type of vegetation.

The examples are the Blue-Green Factor
(https://www.nmbu.no/sites/default/files/methodfactsheetbluegreenfactor.pdf)

and Biotope Area Factor (European Commission, 2021, p. 428).

5.3.16 Soil vitality

Soil vitality or health is a precondition of the success of the NBS implementation and its sustainability and/or improvement, which is one of the most desired NBS impacts. Soil characteristics like organic content or microbial activity are responsible for the increase of soil water retention capacity, processing of pollutants (phytoremediation), regulation of diseases, sustainability of habitats for macro-fauna and flora. Soil services are often classified as supporting services which better defines

[5] http://noise-planet.org/noisemodelling.html (European Commission, 2021)

their key role in enabling the delivery of any other service. The soil vitality is defined as 'the capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health' (Doran, Zeiss, 2000). Healthy soils are usually characterized by above average productivity, sufficient supply of nutrients, appropriate organic matter content, correct drainage, dominating presence of beneficial organisms over pathogens, and high resistance to erosion and degradation (Guo, 2021).

There are numbers of methods that allow to evaluating soil health, all of which involve laboratory studies and some experiments. Total organic C content and particulate OM content as well as the abundance of earthworms or soil microbial biomass are the characteristics most relevant to soil health (Weil, Brady, 2017). The higher is the biodiversity the better is the soil condition and in consequence its resistance, and provision of services.

More complicated methods refer to soil metabolism intensity, like soil enzymes, soil respiration rate or community level physiological profiling (CLPP).

All biochemical reactions are catalysed by enzymes, hence making enzymes suitable as indicators of biological activity. Processes catalysed by enzymes are central to the functions that soils perform, which are at the basis of carbon, nitrogen, phosphorus, and sulphur cycling in soil. Major groupings of commonly assayed soil enzymes are: oxidoreductases (dehydrogenase, catalase, peroxidase, and polyphenol oxidases); hydrolases (phosphatase, sulphatase, β- and a - glucosidase, β- and α-galactosidase, amylase, cellulase, invertases, saccharase, sucrase, proteinases, peptidase, urease, asparginase, glutaminase, amidase); transferases (dextransucrase, thiosulphate Stransferase, rhodanese); lyases (glutamate decarboxylase, tyrosine decarboxylase, L-histidine ammonia lyase; and fluorescein diacetate hydrolysis (as a broad spectrum enzymes assay) (Dick, 1997).

Soil respiration measures CO2 emissions from several sources, including aerobic microbial decomposition of soil organic matter (SOM) to obtain energy for their growth and functioning (microbial respiration), plant root and faunal respiration, and eventually from the dissolution of carbonates in soil solution. Soil respiration is one measure of biological activity and decomposition. The rate of CO2 release is expressed as CO2-C kg/ha/d. It can be measured by field methods (e.g. Draeger-Tubes) or more sophisticated field and laboratory methods (Parkin et al., 1996, Buchmann, 2000).

CLPP method is a technique that offers an easily applied protocol yielding information regarding mixed microbial community function, with different communities compared and classified based on sole carbon source utilization patterns (CSUPs) gathered using standardized BIOLOG microplates (Weber and Legge, 2009).

5.3.17 % of biomass reuse on-site

The straightforward indicator which describes on-site use of biomass coming from cut grass, processed branches, falling leaves, wastes from local gardening practices (e.g. community gardens), etc. Thus it is calculated as a % difference between biomass produced and left on the site. The biomass can be just left on the site for natural processing or gathered in composting sites. In the latter case, a demo site can be a source of organic matter for the neighbourhood and/or serve educational purposes, e.g. demonstrating soil formation processes and the importance of soil biodiversity.

5.3.18 Plant & animal richness of selected native indicator species

Biodiversity is one of the basic indicators of ecosystem health, reflecting habitat diversity, low pressure of stressors, resilience of a system to disturbances. In the case of urban sites, the groups used for evaluation of NBS performance must be chosen carefully. The problem faced in highly transformed habitats is their vulnerability to invasions of pests or/and exotic species. Even small-scale restoration of habitats in a small scale may not sufficiently support native species, especially due to the common factors including UHI effect, water stress, the prevalence of adjacent novel ecosystems around, etc.

euPOLIS experts have chosen birds and insects of butterflies, wasp, and carabid groups as the most indicative. The occurrence of local amphibians is considered as the desired effect itself although not significant biodiversity within the group is expected. Regarding flora, the assessment of biodiversity is problematic as many plants are to be introduced/re-introduced to the sites during the NBS implementation process, which does not reflect the self-increasing biodiversity.

The detailed protocols for each group are under development, with the assumption of their universality independently of the geographical location of the demo site. The samples of insects can be collected and analysed centrally by a small group of experts. Birds and in some cases mammals need to be identified on-site during the surveys. The real effect on biodiversity will be however reached only 3-4 years after the intervention, thus beyond the euPOLIS lifetime.

Biodiversity surveys can be also play a part for local communities' involvement through citizen science. Lack of expertise in such cases can be compensated by application of commonly accessible tools like i-Naturalist (https://www.inaturalist.org) for a variety of groups of fauna and flora, Flora Incognita (https://floraincognita.com) for plant identification or Bird Net (https://apps.apple.com/us/app/birdnet/id1541842885) for identification of birds.

5.3.19 Changes in habitat quality/diversity also Changes in Habitat Diversity (Habitat Unit diversity)

Species diversity fosters ecosystem functioning through positive interspecies interactions, while the presence of different habitats within ecosystems can facilitate structural complementarity and exchange of material and energy, thus in consequence leads to higher ecosystem resilience. euPOLIS targets habitat quality improvement through diverse actions including creation of blue spaces, increase of biomass re-use, an increase of soil vitality, etc. The direct measure of improvement can be the diversity of habitats expressed by diversified local conditions (water gradient, temperature gradient, substrate type, vegetation type). Some habitats will be created as part of NBS implementation plans, some are expected to evolve spontaneously due to the prevalence of favourable conditions. The indicator will be estimated before and after the intervention, and preferably 3-4 years after the NBS implementation, with field surveys, observations and habitat mapping (for bigger sites it can involve using Earth observation data). Assessment of habitat diversity can be a way of activating of local communities or launching educational programmes.

5.3.20 Blue space availability and Green space accessibility

According to Biernacka and Kronenberg (2019) there are three levels of blue-green spaces (BGS) provision – availability, accessibility and attractiveness. They may not be available due to governmental and social failures, such as faulty decisions taken by officials, or the lack of social support for their preservation. Then existing and nearby BGS may not be accessible because of numerous physical and psychological barriers, e.g., busy streets, railways, fences, densely built-up areas, as well as social norms, entrance restrictions and discouraging surroundings. Finally, even when they are available and accessible, the BGS may not be attractive enough e.g., due to poor maintenance, congestion, noise and other nuisances (Dillen et al., 2012; Schipperijn et al., 2010; Grahn and Stigsdotter, 2010).

Thus, the first level question would be: "Does a green space exist? Is there a BGS in a certain distance to where the person lives?" Level two question would be: "Is the green space open and welcoming?

Does the person have access to this green space? Is it publicly accessible?". Level three question would be: "Are the green spaces designed and managed in a desired way? Does this green space correspond with the needs and preferences of users?" (Biernacka and Kronenberg, 2018).

euPOLIS deals with the challenge by adopting two approaches – desk study based calculation of the % of blue space availability within 1km of the participant's home, and the declared ability of a person to reach and access green spaces (meant as the distance from the residential location of each respondent to the nearest green space of each type considered). The latter can also be substituted with map-based analysis of presence and possibly accessibility of green areas within 500 m range from the resident's home.

5.3.21 Connectivity of urban green spaces

The connectivity of green spaces is measured as the degree to which urban green spaces allow humans and other species to move freely and ecological processes to function unimpeded. It can be evaluated with diverse tools emerging from population and conservation ecology. Connectivity marks two aspects of BGS and NBS: the role in the activating of people through the provision of sufficient interconnected areas to stimulate climate-neutral transportation, physical activity, contact with nature, pro-environmental actions, and secondly the ecological aspects related to reaching a critical mass of BGS to sustain ecosystem health under anthropogenic pressure and secure ecosystems' structure (biodiversity and interaction structure) and functions. In this sense, if euPOLIS intervention contributes to the overall higher connectivity of urban green spaces, they also secure reaching health and well-being goals also in the long-term perspective.

Many of the tools that can be used for this purpose are listed on the website: https://conservationcorridor.org/corridor-toolbox/programs-and-tools/

5.4 Circularity model

Environmental indicators embrace the circularity concept with several environment-related indicators:

- Avoided or additional net energy consumption (or GHG emissions),
- Site Water Autonomy for NBS,
- Potable water savings / Water reuse
- Wastewater (and stormwater) managed on-site, and
- % of biomass reuse on-site.

These indicators can serve the business model development being in the scope of WP10: Exploitation Activities, Route to the Market and Project Sustainability (KPI 9), while supplementing economic indicators of WP4. Both can apply the information to the various elements of the circularity chain as demonstrated by the scheme of circularity approach (Fig. 10).

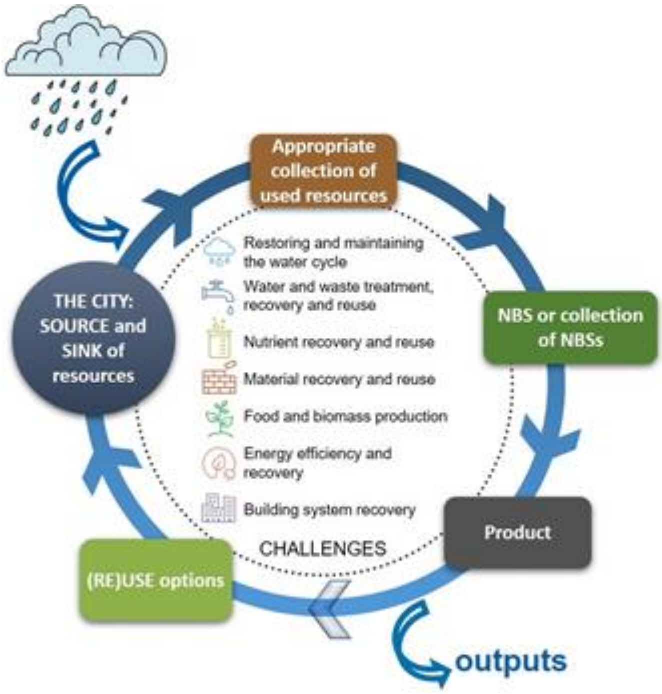

Figure 10. Circularity approach (source: Atanasova et al., 2021).

Out of the main highlighted elements the euPOLIS monitoring system deals with all but building system recovery, as the project has a strong focus on the development of blue-green infrastructure not urban regeneration per se, and optionally tackles material recovery and reuse. The recovering and maintaining water cycle are general goals for all actions. The circularity models serve in principle the well-being KPIs with very little attention to health, although all the attempts to reduce carbon or water footprints serve societal health in the long-term.

There are five general business models of circularity (Fig. 11):

1. Circular supplies;
2. Resource recovery;
3. Product life extension;
4. Sharing platform;
5. Product as services.

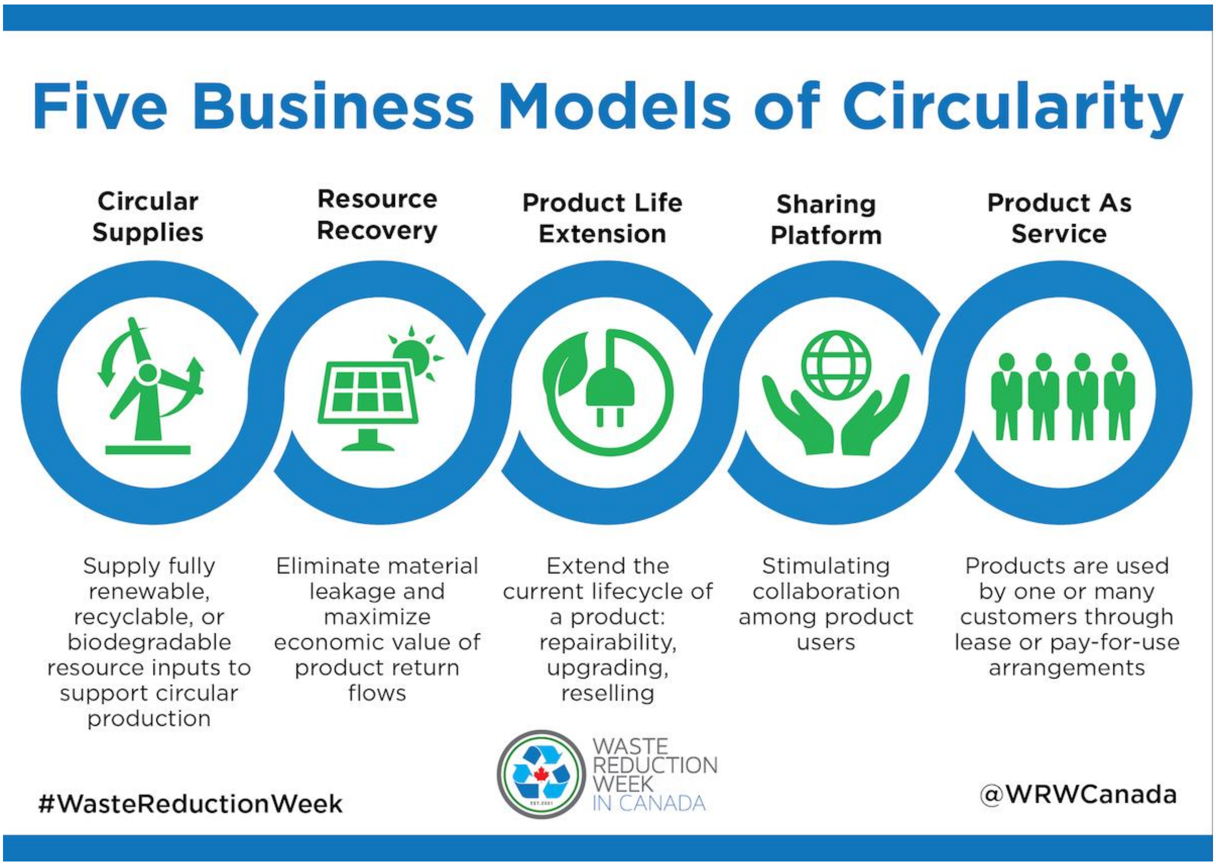

Figure 11. The business models of circularity by WRW Canada.

EuPOLIS cities and demo sites are good cases to apply one or a combination of models depending on the foreseen implementation schemes.

Model 1: assumes replacement of scarce resources with renewable or recyclable, while demo sites are to increase independency of NBS from external supplies e.g., by rainwater harvesting and storage or recycling of waste-water; at a very heart of implementation is to decrease the usage of materials with high environmental impact throughout their life cycle;

Model 2: euPOLIS applies NBS or hybrid solutions and is acquiring technology to create innovative approaches to urban environmental problems, they go i.e., into phytoremediation techniques, advanced information gathering technologies and education innovations;

Model 3: considers the extension of product life with remanufacturing, repairing, upgrading, or re-marketing, thus in many euPOLIS implementations already existing infrastructure is to be continuously used after refurbishing or repairing, which can also serve for recycling of ideas and knowledge of local communities and become a foundation for building the sense of place and ownership;

Model 4: is of smallest potential use for euPOLIS demo sites as it considers sharing of products and assets that have a low ownership or use rate, although land sharing in case of social gardens can be a case here;

Model 5: it is also rather of marginal importance pushing the customers to use products through a lease or pay-for-use arrangement vs. buy-to-own approach, as euPOLIS spaces and implementations are built upon the rule of broad and open access to products (e.g., ecosystem services). However, when considering the model as the one opening product to as many users as possible, when recycling the degraded urban space, then euPOLIS' approach well fits the model.

Another approach to circularity is tracing the flows of materials as done by the European Commission as part of Eurostat and illustrating them with the Sankey diagrams. It shows the flows of materials as they pass through the EU economy/country/site and are eventually discharged back into the environment or re-fed into the economic processing (Fig. 12).

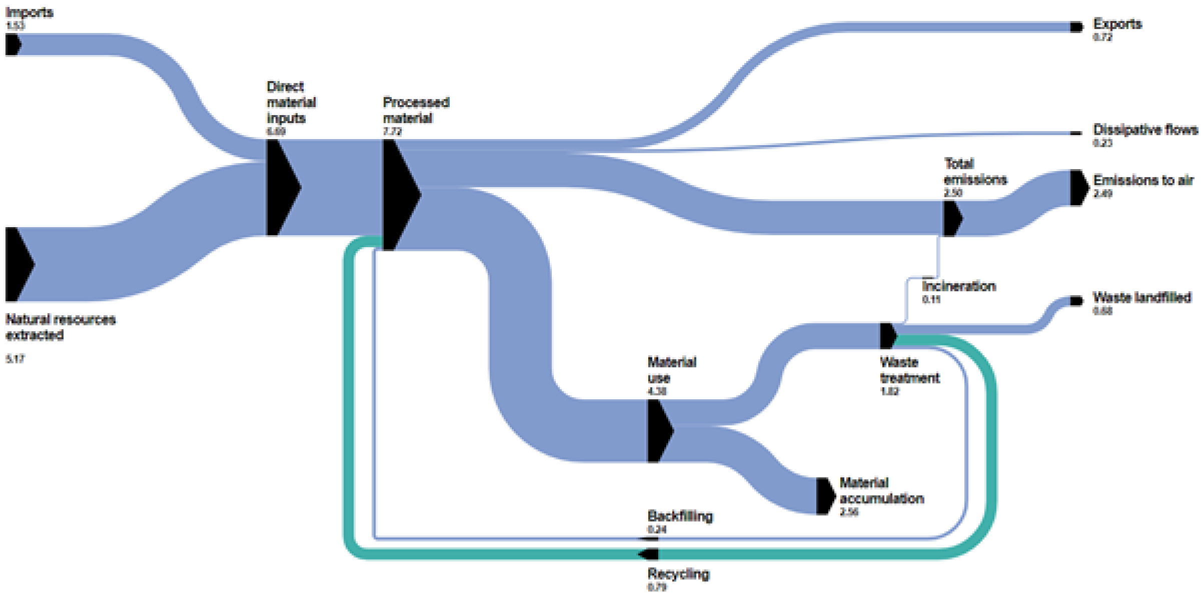

Figure 12. The exemplary Sankey diagram showing flow of materials through the economy of the European Union (27 countries) in 2020 (source: Eurostat, 2021).

From the point of view of euPOLIS implementations and its sites, it is possible to at least trace inputs and outputs of materials, organic matter and water for the site a prior and after the intervention.

The diagram illustrates flows in the way that:

- The width of the bands is proportional to the flow quantity;
- Materials are extracted from the environment to make products and assets or as a source of energy; they accumulate in societal stocks, and they are eventually discharged to the environment as residuals;
- Imports and exports, which are flows of products with other economies, are also shown;
- The closed-loop represents residuals which are not discharged into the environment but reused in the economy or used to produce secondary raw materials or for other purposes preventing further extraction of natural resources (Eurostat).

The approach, therefore, corresponds with the urban metabolism approach.

Using circularity models based on environmental circularity indicators opens the doors for convincing cities, investors from private sectors and civilians that respecting nature and stewardship can be economised. The disadvantages of the application of models may be availability of data to either illustrate well any of five business models or feed the site metabolism approach.

6 Conclusions

In this deliverable, we focus on methods and tools for the assessment of the economic, environmental, and socio-cultural impacts of Nature-Based Solutions. We further develop the multidimensional indicators' framework presented in Deliverable 4.1 indicating specific sources of data that will allow for the assessment of the changes in euPOLIS demo sites.

We discuss in detail our approach for the measurement of all indicators and specify appropriate methods and tools. Moreover, for each category of the indicators (social, economic, and environmental), we present an integrated strategy for the assessment of the intervention's impacts.

We start by describing the euPOLIS approach for the data collection. Regardless of the category of the indicators, we decided to use a longitudinal design. It will require at least two points of measurements separated in time – before and after the NBS implementation. Such an approach will allow for tracking the change and consequently the assessment of the intervention’s impacts.

For the assessment of impacts of Nature-Based Solutions, we developed a three layers theoretical approach. At its fundaments lays a set of evaluation indicators that were carefully selected to cover the whole spectrum of the social, economic, and environmental realm. Many of them are directly and indirectly related to the health and well-being of citizens. Using the proposed longitudinal approach and specific tools and methods, we will be able to measure their values in two data points – before and after the NBS implementation. While we perceive PH and WB as central areas of impact, we also point out the desired socio-economic impacts including local civic engagement (stimulated through the use and possibilities offered by NBS as well as indirectly resulting from better health), positive place attachment (which relates to mental well-being as well as the willingness to engage on the local level) and local economic growth (resulting from higher attractiveness of the area to people and businesses).

At the second layer, we introduced a modelling approach, which will allow to aggregate data and create complex indices for more synthetic impact assessment. This stage includes euPOLIS livability model (chapter 3.2) that integrates developed indicators into seven factors that match New European Bauhaus priorities: the sense of safety, multifunctionality, contact with nature, the comfort of use, walkability, friendliness, and sense of space. We will use our euPOLIS Livability Model for the assessment of direct and indirect social impacts of the Blue-Green spaces designed and implemented under the project. We will also employ the circularity model approach (chapter 5.4) to trace inputs and outputs of materials, organic matter, and water for the site a prior and after the intervention. The circularity approach will help to highlight the euPOLIS strong focus on the development of blue-green infrastructure to recover and maintain the water cycle and reduce waste.

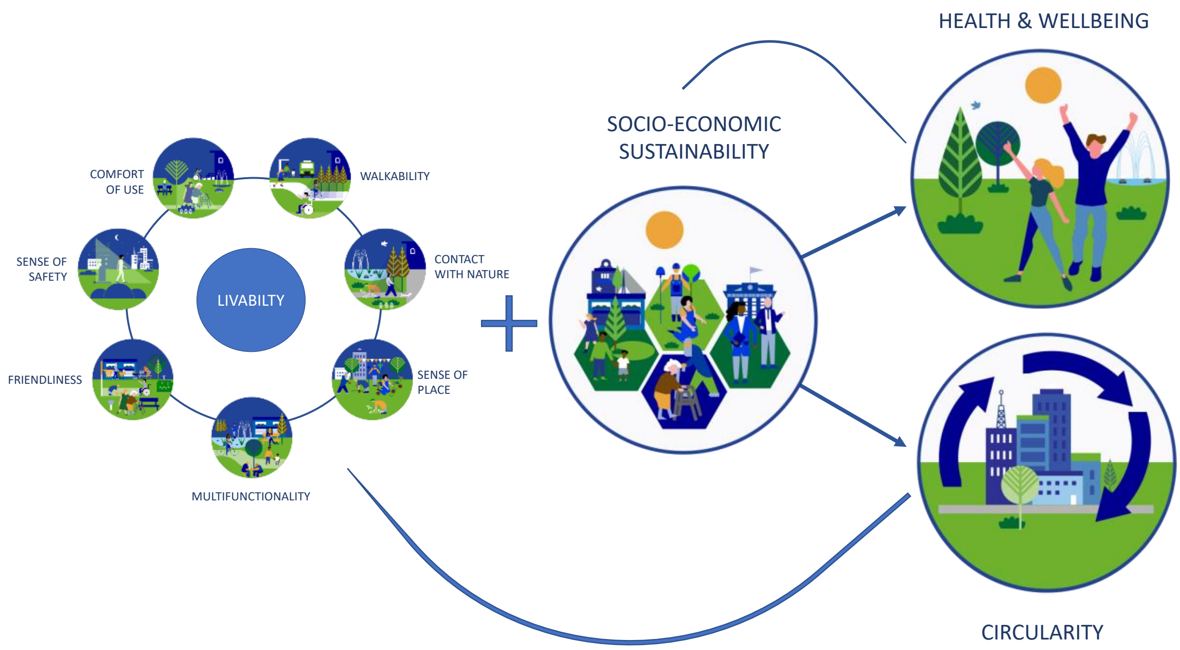

Figure 13. EuPOLIS holistic approach to urban planning and impact assessment.

Finally, as the third layer, we will use a social sustainability perspective and Business Activation Matrix to emphasise the importance of the long-term social and economic sustainability of our NBS interventions. Social sustainability emphasizes factors that help communities to embrace changes and take responsibility for maintaining innovations for the common good. This requires capacities for learning and self-organizations, mutual trust, shared vision of the community future and openness to diversity and new opportunities. The social sustainability concept will serve as a benchmark for the assessment of the long-term potential of NBSs.

On the other hand, the Business Activation Matrix approach allows for systematic mapping and linking resources that already exist in the given locality with potential benefits stemming from different forms of NBSs. As a result, BAM allows stakeholders to better plan and choose specific blue-green solutions and develop ways to maximalise their benefits for the local community as well as ensure their long-term maintenance.

To summarise, in euPOLIS we apply evidence-based indicators on the scale of the studied demo sites and their neighbouring communities. The comprehensive approach, based on modelling, allows us to better track the influence of NBS on the PH and WB of all residents regardless of their economical background, country of origin, ethnicity, faith, or other personal characteristics. By linking the indicators with specific places and their social and economic resources we are also looking to better understand the citizen's WB and PH in the context of specific use of NBSs.

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8 Annex 1

Annex 1

Example: locally existing resources in Front Runner Cities – Gladsaxe, Belgrade, Pireus, Łódź – work in progress

CITY RESOURCES 2 (R2) - LOCALLY EXISTING RESOURCES	Gladsaxe	Belgrade	Pireus	Łódź
Human resources (knowledge, training level/area)				
Any interested occupants could be engaged (for green planting, maintenance)	x		x	
Around some of the tenement houses, there are small gardens also sustained by the members of local communities.				x
Senior citizens - knowledge in gardening - flowers	x	x	x	x
Senior citizens - knowledge in gardening - food production	x	x	x	
The engagement of existing elderly society in the neighbourhood to be analyzed and proposals formulated (in line with GDPM proposed concepts)/ Senior citizens - knowledge in local facilities interesting to tourists and trained in euPOLIS interventions	x	x	x	x
Senior citizens - which will acquire knowledge in the euPOLIS approach and apply where required		x	x	
Training of youngsters - acquired different types, site & neighbourhood related knowledge as a resource	x	x	x	x
Young unemployed people willing to work	x	x	x	x
Professionals & consultants	x	x	x	
Professionals in medical, rehabilitation and recreational activities	x	x	x	
Professionals (possibly retired) in ESS testing and monitoring	x	x	x	x
Professional specialized in urban farms construction and operation		x		
Construction industry free-lancers	x	x		x
Small local retail		x	x	
Residents and developers from adjacent buildings	x	x	x	x
Material resources				
Recycling of water only	x			
Compost of all biomasses collected within the city		x		
The use of recycled material is not allowed.			x	
Open spaces - for refurbishment	x	x	x	x
Unused spaces - for NBS multipurpose use refurbishment and revitalization	x	x	x	x
Possibility for green roofs to create a nice atmosphere and dialogue between the build and the green areas.	x	x	x	x
Short term business: the existing infrastructure for relaxation, leisure sports is to be developed/invested/renovated. There is a need for more infrastructure – playground, barbecue places,	x	x	x	x

shops, small coffee point, small restaurant – places attractive for children, families, seniors, young people and other groups living in the community. There is also a need for social-cultural activities				
Introduce regular cleaning with recycling points	x	x		x
Introduce rich vegetation diversity - flowery bushes, long-lasting flower plants,	x	x	x	x
Regular paid business for residents: close to the south façades with balconies suggestions to quieter activities were mentioned: e.g. Spaces with rippling water, reeds or tall grasses, green wall constructions and south-facing benches.	x	x	x	x
Any additional resource	x	x	x	x
Cultural resources				
Existing library on site	x			
Possible collaboration to introduce cultural events – to be investigated	x	x		
Existing cultural heritage, antique buildings and work art		x	x	x
Existing cultural activities or work art		x		x
Possibility of new cultural events		x	x	x
The cultural potential of the site is limited by the fact, that it is a private residential area	x			
All across the area, there are not many cultural facilities /activities "			x	x
Any additional resource	x	x	x	x
Social resources - positive				
Active non-government organizations and unions on site. Especially in the field of development, education, culture, neighbourhood help, supporting the development of civil society, ecology, intersectoral cooperation; they implement them through workshops and training, meetings and discussions, cultural and social events, individual and group activities.			x	x
The municipality has developed a citizenship strategy, which ensures a strong involvement of citizens to become active participants in the city development.	x			
Active sport unions, institutions, organizations			x	
There are several socializing and recreational facilities at the site,	x	x	x	x
Street market pop-up events are possible. This is to be investigated	x			
The tradition to have regular outdoor events	x			
Social diversity of visitor's poor - to be improved				x
There are not sufficient free public spaces in the area for use by residents/visitors or are not enough (e.g., Parks, meeting places, etc.)	x		x	x
Any additional resource	x	x	x	x
Geographical resources (location advantages)				
The site has an excellent location well connected with public transport and on foot	x	x	x	x

The site is already a tourist hub with many hotels and restaurants			x	
A very good location e.g.: - vicinity of the main tourist spots and City Centre				x
Any additional resource	x	x	x	x
New local knowledge resources				
Contact with plant suppliers for the urban farming to be made and to learn about plants' best maintenance and care	x			
The area is an archaeological protection area with related knowledge			x	
Source of new knowledge: presently, urban agriculture is not developed in this location		x		
Not known				x
The euPOLIS project approach	x	x	x	x
Any additional resource	x			x
Outside - locally applicable resources				
Universities and institutes regular monitoring of waterways	x			
Any additional resource	x	x	x	x
Market receipt potential for new business (market non-saturated segments)				
Analysis of business drivers, with city supporting partners. The project will analyze existing businesses' interest in participating in any form.		x		x
Business existing and business infrastructure - existing and functioning in the area			x	x
Cultural and sport “big” infrastructure and tourist hub in the neighbourhood		x	x	x
Big office blocks and hotels could be considered for business generation				x
A huge variety of public transport connections		x	x	x
The conventional market potential of the site is limited. The local potential will be the empowerment of the residents and to create a positive social spiral.	x			
Several small businesses might be interested in gaining from site NBS improvements	x	x	x	x
There is a green guide available from the municipality. The local green guides write that citizens are in the process of collecting food waste locally. This can in the long term become a resource.	x			
There is a potential in communicating the relation between NBS, urban evaporation and the positive impact on the climate. This relation can be made into local storytelling being displayed on the site but as well on digital platforms.	x	x	x	x
All across the area, there are not sufficient sports facilities /activities "			x	
Any additional resource	x	x	x	x
Local problems as resources (solving problem creates business - the problem is costing someone and they pay for remedial action)				
Buildings do not have shading protection in summer. This is ok for now due to the mild climate. But warmer	x			

periods are expected in future and natural shading of facades should be considered and sometimes there is a problem with small flooding of basements				
People, who drink on-site place				x
Greenery maintenance standard - not conducive to quality PH&WB				x
The area was abandoned for a long period, but no new investment is happening, hence there might be this potential			x	
There is the presence of heat island effect			x	x
In all sites, the existing planting was not designed as a nature-based solution. The main purpose of the planting is ornamental. (Redesign business)	x	x	x	x
Any additional resource	x	x	x	x
Unemployed become employers (http://diytoolkit.org/tools/fast-idea-generator/)				
Any additional resource	x	x	x	x
Renewable energy resources				
Groundwater aquifers – not available				x
Potential of use groundwater and windy energy		x		
Sun energy will be a part of the energy source for the operation of the evaporation facility for the operation of pumps and measuring equipment. Solar energy can be also used by solar lamps – small and near ground located lamps securing the safety of the area while significantly reducing light pollution.	x		x	x
It is an aim to explore the potential of using rainwater to extract energy local using heat exchange technology.	x			
All with saltwater. The water temperature is to be investigated.			x	
Any additional resource	x			x
Energy				
The energy efficiency of existing buildings and infrastructure as a resource - money savings as usable refurbishment revenue - potential for the future saving of energy with shading exists	x			x
Removed vegetation that emits BVOC’s				x
Any additional resource	x	x	x	x
Waste management and recycling (links that create circular economy)				
Local districts are in the process of collecting food waste locally. This can in the long term become a resource.	x			
Private recycling not allowed, nonexistent – not planned	x			
The municipality is at present working on a fully updated status on achieving the set recycling targets, within the different categories of solid waste, that is sorted and collected in the municipality.	x			
Waste management is organized centrally by the devoted department within the city structure. There is a regularly updated plan for that purpose.		x		
Initiate waste recycling with the municipality				x
Any additional resource		x	x	x
Water & wastewater				

Water evaporation process - as a resource (regular maintenance of evaporation system)	x			
The wastewater treated in the euPOLIS experimental plant could be used for watering		x		x
In some areas, the rainwater will be led to existing recipients, in other areas more rainwater might be handled locally and on the surface.	x			
There is no solid waste management on the site, but EuPOLIS allow starting process				x
There is new wastewater infrastructure in place, to replace the old one that caused flooding and pollution. However, there is no local greywater treatment in place.			x	
Any additional resource	x	x	x	
Food & agriculture				
Regular care of any food, flowers or aromatic plants production modes that are not active now	x			x
Urban agriculture does not exist at the site. There is serious potential.	x			x
There are no regulative limitations for urban agriculture except for the ownership issue, which will be investigated.	x			
For nonconsumption purposes – mostly educational, and sensual recreation of handicapped people, there is a plan to transform patches of the passage into stands of flowers and herbs of various textures and fragrances				x
The introduction of flowering trees and shrubs or even fruit trees can be discussed with users of the area, with a clear goal of supporting local biodiversity.				x
Citizens will be reimbursed by the utility company if they take care of the rainwater themselves.	x			
Urban agriculture (producing food) is not permitted in the area, it is only possible for shops to have a demonstration, but the products not to be used for human consumption			x	
Urban farm ownership issue to be investigated	x			
Any additional resource		x	x	x
Healthcare				
Removed vegetation that emits BVOC's	x			
Work with vegetation represents the healing process for cognitive performance deficiencies and some other		x		x
Any additional resource	x	x	x	x
Housing & construction				
Define and implement all urban NBS based urban components treated by BGS which contribute to the increased neighbourhood value - who has interest from increased property value?	x			
Any additional resource	x	x	x	x
Information & communication technology				
EuPOLIS demonstration point - euPOLIS budget provides for an info kiosk/ info hub/ the hub for the education of citizens/researchers/professionals	x	x	x	

We do not see any information & communication technology potential here.				x
There is municipal wi-fi.		x	x	
The wi-fi coverage of the location to be analyzed	x			x
Any additional resource	x	x	x	x
Integral solution				
There is a sewerage collector conveniently placed along the site border (to be used for the euPOLIS WWT demonstration plant)		x		
Combination greenery and public place - new resource	x			
Combination greenery and public place with euPOLIS gender-related planning criteria - new resource	x	x		
Collaboration with SEF – prepare collaboration proposal			x	
Potential is the complete demo site				x
Any additional resource		x	X	x
Retail				
Small grill/hot-dog stand present at the site.	x			
Small retail units on site		x		
In the area (neighbourhood) there are small local businesses that have been listed above. The retail potential is quite high due to the localization of the demo site.				x
The increase of visitors/users is possible to motivate any kind of entrepreneurship in the area, too. The retail prices of areas 1 and 2 will rise due to the recreation of both areas, especially the rental prices of the shops.			x	
Any additional resource	x	x	x	x
Financing				
New locally created business as city income	x			
Considerable continuous areas without trees				x
Create small financial service create a small funding model for NBS and promote it to the city and businesses.	x			x
Promotion of NBS's benefits to surrounding businesses, for possible financial drivers' activation - additional business for locals and city	x	x	x	x
Create a financial small service to create a small financing model for NBSs and promote it with cities and businesses. Propose program for small grants for gardens and facilities for pollinators		x		
Any additional resource	x		x	x
Government				
Applied for government incentives for additional funds for the project – waiting for a response	x			
Government Incentives -additional interventions and reconstructions can also be expected in the area due to the municipality			x	
Government incentives - citizens related functional improvements – not existing		x		
The municipality refurbishment works in demo sites			x	

The municipality has developed a citizenship strategy, which ensures a strong involvement of citizens to become active participants in the city development.	x			
The municipality has developed in a participatory process design guidelines for the reconstruction of chosen streets				x
The municipal consultation committee is set up to foster social partners' and citizens' participation in the development policy of the city.			x	
The municipal activity bureau deals with communication with residents and coordinates all forms of participation – not only does it implement participatory processes itself but also it cooperates with departments conducting participation processes.				x
Representatives of cities, businesses and social and sports organizations, NGOs were willing to contribute to the co-process and the implementation of the project, engaging the members of their communities, according to its requirements.	x	x	x	x
The first centre to promote and support business innovation exclusively for blue growth and blue economy			x	
As part of euPOLIS efforts, we should negotiate with the government to adjust legislation related				x
Infrastructure projects financed by the European Commission generate additional revenues for the city	x	x	x	x
Any additional resource	x			x

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