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HANDBOOK

SALUTE4CE – HANDBOOK ON URBAN ENVIRONMENTAL ACUPUNCTURE


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Content

1. Urban environmental acupuncture (UEA)

1.1. Urban environmental acupuncture - general idea

Justyna Gorgoń, IETU - The Institute for Ecology of Industrial Areas

Urban environmental acupuncture is an urban planning concept that can be used for selective intervention in a defined urban space. The technique of urban environmental acupuncture draws its concept from traditional Chinese medicine. Following this concept, the urban environmental acupuncture approach treats cities like a living organism and provides its regeneration and urban renewal through “healing” selected weak areas. Just as the medical Chinese technique of acupuncture is aimed at relieving stress in the human body, the goal of urban environmental acupuncture (UEA) is to relieve stress in the urban structure. Urban environmental acupuncture projects are usually renewal projects of small urban, neglected spaces, such as squares, yards, fragments of streets, playgrounds, etc. As an instrument of urban planning, acupuncture became popular in the 1970s. It was then that micro solutions appeared that improved the quality of urban space, for example Paley Park in New York. Currently, this technique is widely used in the processes of urban revitalization and renewal. The most famous designers and promoters of urban acupuncture today are Jamie Lerner and Marco Casagrande.

Urban environmental acupuncture is perceived as an efficient alternative to the large-scale projects due to microtargeting and low-cost intervention, which could offer an attractive and socially accepted solution. In the time of constrained budgets and limited resources, this pinpointed approach could offer not only a new attractive quality of urban space but involve a large group of city stakeholders.

1.2. Ecosystem services

Jiří Kupka, Adéla Brázdová, Barbara Vojvodíková,IURS - Institute for Sustainable Development of Settlements

As previously explained, urban environmental acupuncture is based on the idea that many small green spots achieve positive environmental impacts (depending on their number) and is also based on the placement of Nature Based Solutions (NBS). The NBS are defined by the European Commission (EC) as “solutions inspired and supported by nature that are cost-effective, provide environmental, social and economic benefits and help build urban climate resilience.” (Eggermont et al., 2015).

Using strategies based on nature (on ecosystems) also contributes to its protection with current scientific and environmental trends. This strategy suggests that it is based on other closely related concepts, which are ecosystem services (Johnston, 2018).

An ecosystem is herein defined as a group (community) of different species of organisms living in a specific environment with interactions (it can be a tropical rainforest comprising all organisms, soil, energy, information and substance flows, but also an opening in a tree trunk filled with water) (Begon et al., 2013). Elements of green infrastructure in cities have the character of rather artificial ecosystems (Findlay, 2016), (De Martis et al., 2016).

Ecosystem services are the benefits that ecosystems provide to people. Various models are used for their determination (calculation), which make it possible to highlight the impacts in the event of their degradation or

final loss (financial quantification). In general, ecosystem services are divided into four categories: regulating services, provisioning services, cultural services, and supporting services. Provisioning services are usually the easiest to quantify (for example, food and feed production or soil fertility) (Ruskule et al., 2018).

Regulating services — working on the principle of positive and negative feedback (e.g., climate or disease regulation) and cultural services (e.g., recreational or relaxation) can be quantified worse. Supporting services, which are also difficult to quantify, provide "service" for the functioning of the previous three categories (for example, biogeochemical cycles, biodiversity, soil formation, etc.) (Kumar et al., 2010).

Urban green and blue infrastructure therefore play a much more important role than the aesthetic aspect or atmosphere of the place (for example, the impact on air quality, soil, and water retention). As this applies to urban areas, it will be more appropriate to use the term urban ecosystem services (Gómez-Baggethun, 2013).

When building urban green and blue infrastructure, artificial ecosystems with various combinations of artificial or natural elements (NBSs) are mainly used. Green urban infrastructure, urban ecosystem services and urban sustainability are closely related concepts.

Urban environmental acupuncture is part of the green blue as well as the gray infrastructure (Kopp et al., 2020). It combines Nature based solutions with technical elements that support natural processes. If we look at current publications and strategic documents, we encounter the context of adaptation to climate change, but also with guidelines and procedures aimed at solving specific urban problems that are not related to climate changes.

An example of a guide to tackling transport or industry is the London document "Using No Infrastructure to Protect People from Air Pollution". This guide summarizes the current best practice for how green infrastructure can reduce public exposure to air pollution in the urban environment. Many of the proposed measures are related to elements of urban environmental acupuncture.

In connection with adaptation strategies, the problem of heat island or heat stress in the urban structure is most often mentioned (Greinke et al., 2019), as is the necessity of solving extreme hydro-meteorological events. Extreme hydro-meteorological events, such as heavy precipitation or lack thereof, floods and droughts, are becoming more intense, which brings a problem not only with a fast and difficult-to-predict amount of rainwater, but also with the subsequent quality of recipients, which can be affected by flushing (Puczko et al., 2020). Creating a safe and comfortable environment for residents is a task that forces cities to address these issues. Even though climate change is a global problem, people perceive their discomfort locally. Therefore, even solutions at the local level can bring a significant degree of satisfaction and positive perception.

Negotiations on already specific adaptation strategies and works in response to climate change have a few difficult-to-cross barriers at the urban level (Hagen, 2016). For representatives, there may be a risk of wrong choice in the long run, when applying larger investments. A large investment would then not bring the expected effect, because the conditions will change and the city will, according to voters, spend disproportionate funds in the wrong direction. On the other hand, according to several studies (Ferenčuhová, 2020), residents do not believe that a small change in their public space can contribute to adaptation to climate change. People expect only large projects with global effects. Problems in implementation are often also at the level of competencies and planning methods. Therefore, a chapter describing a suitable position and experience in the preparation of Action Plans aimed at the implementation of urban environmental acupuncture is included as part of the publication. Finally, constraints in financial and human resources also contribute to the problems associated with planning and implementation.

Therefore, the elimination of some barriers is an advantage of urban environmental acupuncture focusing on relatively small sites. Many of the proposed solutions do not cover an area of more than 0.2 ha. A small area can eliminate barriers and financial problems, but also bring challenges in relation to public participation. The proposed solutions are often so closely tied to inheritance that their participation is essential for further successful function. Small and familiar areas around the residence facilitate easier involvement of residents. Residents have very good local knowledge, are motivated to get involved, and at the same time are future users interested in protecting the place. As "Participation" is an important element in the sustainability of the NBS, Chapter 6 is devoted to this topic.

Elements of green infrastructure and their placement in cities, is based on the concept of urban environmental acupuncture and on a complex influence on the urban environment (Brázdová et al., 2020a). One of the goals is also to create relaxation zones for residents. From this perspective, we can consider that the implementation of the urban environmental acupuncture (along with street furniture) is more than the current (in the context of the current global pandemic Covid-19) (Chakraborty and Maity, 2020). Appropriate measures (e.g., placing benches separated by Mobile Green Walls can give potential users a sense of privacy and security) (Brázdová et al., 2020b). Especially unrestricted browsing of inhabitants in an urban area and feeling a sense of safety during a pandemic at the same time is crucial. Using these elements of green infrastructure – on the one hand the maximum possible use of greenery (Urban environmental acupuncture) and on the other hand a response to current trends in society. This handbook will deal with the solutions in connection with this issue in the following chapters. In any case, the elements of urban environmental acupuncture allow intensive use of the core of cities even in the current situation associated with Covid-19.

Appropriate application of the urban environmental acupuncture principle provides the following ecosystem, sociological and socio-economic services. Acupuncture solutions can strengthen ecosystem services divided into:

- Provisioning services obtained from ecosystems there are water, food, genetic resources, and medicines.
- Regulating services are defined as the benefits obtained from the regulation of ecosystem processes such as climate regulation, natural hazard regulation, water purification and waste management, pollination, and pest control.
- Habitat services are defined by the importance of ecosystems to provide habitat for migratory species and to maintain the viability of gene pools.
- Cultural services include non-material benefits that people obtain from ecosystems such as, recreation and aesthetic values (Nature in Europe, online).

Specific ecosystem services obtained by introducing acupuncture solutions are presented below:

- Reduction of environment pollution.
- Reduction of heat stress.
- Improving rainwater management.
- Noise reduction.
- Increasing aesthetics.
- Increase the feeling of well-being and safety.
- Evaluation of real estate in the area.

The last point can also be considered as an indirect influence of the UEA. This point is related not only to the aesthetics of the space, but also to the operating costs and costs of property repairs.

Measuring the effect green spaces have on adjacent properties has become a common practice. Numerous studies have shown that housing and land value adjacent to green spaces may increase by 5% to 20%. For example, it is known that most people that want to buy a new place to live, are willing to pay more if the place is close to a park (Cicea, 2008).

Reducing the heat island does not only mean reducing the Universal Thermal Climate Index (UTCI) and the comfort of the population but also leads to a reduction in air conditioning costs. If we focus on elements of gray-green infrastructure such as roofs or walls, these are the effects described. The green wall reduces the temperature inside the building and in the immediate vicinity (Geletič et al., 2020). The green wall also insulates and reduces heating costs. The green roof behaves similarly and brings effects in the form of insulation. Thanks to the ability of the green roof to accumulate water, it can also have fire-fighting effects. Another financial effect is the protection of property. By applying UEA elements, we will create a storm water retention system and thus protect property, reduce the cost of necessary repairs, and thus provide a significant social benefit.

Clearly, the problem of the effects of urban environmental acupuncture is very broad and affects many topics and sectors. For a more detailed description, the following six problems have been selected in this handbook.

- Soil sealing and soil degradation reduction by application of urban environmental acupuncture solutions.
- Urban environmental acupuncture for reduction of habitat loss and fragmentation.
- Urban environmental acupuncture as one of solutions for the reduction of heat stress in urban space.
- Possibilities of application of urban environmental acupuncture in reducing problems with rainwater in the urban space.
- Urban environmental acupuncture for increasing air quality.
- Improvement of a social aspect.

The principle of urban environmental acupuncture affects several stakeholders. That is why their participation is essential.

Owners of the land and buildings within which this activity can occur, or it can be directly part of a new construction such as a green roof. How to motivate the owner? How to persuade private owners to be interested in investing with little or no expected financial return?

Stakeholders also include representatives of municipalities, who are often the organizers of the whole event. Municipality can create strategic plans and programs in which the urban environmental acupuncture element appears. Experts, architects, garden and landscape engineers are looking for the most suitable solution for a given place or location. The public can passively accept the results of the urban environmental acupuncture application, or actively participate in its creation or design. Chapter 6 deals with participation.

Environmental acupuncture has many forms. These forms can be from a green tree with a bench in a dense urban area, through green belts around roads, or the complex construction of green walls or green roofs. Even though it is an urban environmental acupuncture, small elements of the blue infrastructure such as mist generators, strands or fountains can also be part of the green space. Chapter 7 deals with individual elements, the Nature Based Solutions (NBS), in more details.

1.3. National strategies and urban environmental acupuncture

1.3.1. Czech Republic

Barbara Vojvodíková, IURS - Institute for Sustainable Development of Settlements

For the Czech Republic, we present here four key strategic documents at the state level that are related to or contain parts related to the UEA.

The first is the **State Environmental Policy of the Czech Republic 2012—2020**, which was last updated in 2017. It is an overarching strategic document that defines the implementation of effective environmental protection in the Czech Republic until 2020. The main goal is to ensure a healthy and quality environment for citizens living in the Czech Republic, to contribute to the efficient use of all resources and to minimize the negative human impact.

One of the points is the protection of nature and landscape - Improving the quality of the environment in settlements by strengthening the ecological functions of the landscape of settlements, especially the areas of gardens and parks and greenery in general, while considering specific requirements for their functional use and appearance. The document then focuses on green infrastructure for larger areas. The Document mentions the problem of water in cities. In the tasks, he mentions the need to support nature-friendly practices and the use of domestic tree species.

Another objective is the mitigation of the Impacts of Hazards, including Emergencies and Crisis Situations, in Relation to Climate Change Mitigation and Adaptation.

Therefore, the priority task will be the implementation of adaptation measures within water management and the setting of the optimal relationship between the water regime and the structure of the urban landscape.

The National Action Plan for Adaptation to Climate Change is an implementation document of the Strategy for Adaptation to Climate Change in the Czech Republic (2015) and was approved in 2017. The action plan is structured according to climate change, due to significant cross-sectoral overlaps of individual climate change and needs. There is an inter-ministerial cooperation in preventing or solving its following negative impacts: Long-term drought, floods and flash floods, rising temperatures, extreme meteorological phenomena, including heat waves. Many measures have multiple benefits, such as adaptation to manifestations of climate change, support for biodiversity, reduction of air pollution (dust, CO_2, etc.), support for recreational functions, etc.

Drought Protection Concept for the Territory of the Czech Republic approved in 2017. Support for rainwater management. The means to achieve this are the so-called decentralized drainage systems, which treat rainwater as close as possible to the point of its impact on the earth's (urbanized) surface. In addition to seepage, the capture and reuse of rainwater for irrigation and in households has begun to be promoted. In addition to the positive impact on slowing down runoff, the measure also has a positive impact on water quality in watercourses.

The Strategic Framework - the Czech Republic 2030 contains as one of the key chapters - Adaptation of settlements to climate change. The whole document creates a basic framework for other strategic documents at the national, regional and local levels. The document was approved in 2017. The key areas are Water and greenery in cities and less heat islands The tasks in connection with the NBS are saving water and retaining water, using rainwater. There is also the expansion of urban greenery, such as parks, but small islands of greenery,

including courtyards, lawns, walls and roofs of large buildings, and urban agriculture. Within the framework of spatial planning and decision-making to not allow disproportionate densification of existing housing estates, the task is to ensure the preservation and increase of the quality of greenery, a healthy environment and the quality of housing. For new construction in cities, preferably use brownfields and other suitable areas.

1.3.2. Germany

Juliane Mathey, Jessica Hemingway, IOER - Leibniz Institute of Ecological Urban and Regional Development, Dresden

In Germany a number of political strategies currently exist on different spatial and political levels that may influence the development of UEA.

The *National Sustainability Development Strategy of Germany* (DNS), which in 2021 was developed further, claims to reduce the land take for settlements and traffic infrastructure to less than 30 hectares per day by the year 2030 (Die Bundesregierung 2016, 2021). This aim is to be reached inter alia by avoiding urban sprawl and fostering compact cities. The latter goal, which is mainly addressed by infill development in existing urban structures, has an influence on the provision of green spaces in cities. To deal with this conflict, the approach of so-called 'dual inner development' has been introduced to ensure high-quality green space concurrent with building activities in urban areas (Kühnau et al., 2016).

In Germany currently, the concept of the 'green city' is being vigorously promoted through a number of political strategies at various spatial and political levels. Based on the *German Greenbook on Urban Green*, which summarizes the state of knowledge on urban green development (BMUB, 2015), a *White Book on Urban Green* Space has been released, which presents concrete recommendations for action and implementation related to securing and qualifying green areas and open spaces (BMUB, 2017). Additionally, the *Urban Nature Master Plan* is a federal government programme of measures related to lively cities, addressing the value of urban green areas for biodiversity and climate adaptation. Funding priorities are being established to support municipalities in these tasks (BMU, 2019). By the *Federal Green Infrastructure* Concept aspects of blue and green Infrastructure are covered. One of the main aims is the conservation and restoration of ecosystem services, and therefore the protection of natural capital (BfN, 2017).

The *German Strategy for Adaptation to Climate Change* (DAS) identifies necessary steps to implement adaptation measures in a timely and forward-looking manner. It presents possible consequences of climate change in various fields of action and identifies options for action. It thus lays the foundation for a medium-term process that will make Germany more resilient to climate change and its impacts (Die Bundesregierung, 2008). In the *Adaptation Action Plan* (APA), adopted in 2011, the goals and options for action mentioned in the DAS were underpinned with concrete measures. The measures in the action plans are currently updated every 4 years. Principles and goals of the German government's climate policy were stated in the *Climate Action Plan 2050* (BMU, 2016).

Example for climate change adaptation: The German Federal Ministry of Education and Research (BMBF) supported 7 regional projects via the federal KLIMZUG initiative. This has resulted in the creation of regional adaptation strategies throughout Germany. The Leibniz Institute of Ecological Urban and Regional Development (IOER) led a large regional project called REGKLAM (Development and Testing of an Integrated Regional Climate Change Adaptation Program for the Model Region of Dresden). Through REGKLAM many facets of climate change adaptation were examined, including anticipated climate change in urban areas; impacts to social and industrial sectors as well as potential solutions, adaptation innovations and stakeholder involvement. [http://regklam.de/en/about-regklam/project (accessed 12th October 2021)].

German biodiversity legislation is flanked by the *National Strategy on Biological Diversity* (NBS) (BMUB, 2007), providing guidance for different actors, and defining about 330 nature conservation goals that originally should have been reached by 2020. One of its concrete visions relates to urban landscapes and aims inter alia at increasing green spaces in settlements, e.g., by ecological upgrading of residential districts, unsealing, greening courtyards and buildings as well as by deconstructing and calming streets (BMUB, 2007).

As a result of the NBS, many German cities are currently developing Municipal biodiversity strategies, on a voluntary basis. Municipal biodiversity strategies have the task of conserving and fostering biodiversity in a city. They are useful tools to strengthen the position of urban green spaces and biodiversity and can help to improve urban green space systems by defining overall aims, providing spatial frames, and serving as firm bases for decision-making.

1.3.3. Poland

Justyna Gorgoń, Anna Starzewska-Sikorska, IETU - The Institute for Ecology of Industrial Areas

There is no reference to urban or green urban acupuncture in any of the national documents, because it is a work technique of a professional urban planner. On the other hand, there are documents relating to urban policy, revitalization and protection of biodiversity on national, regional, and local levels.

General solutions for the transformation of urban spaces, are included in the National Urban Policy 2023 and the Revitalization Act (http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20150001777).

Most of the issues related to the development of green areas and related ecosystem services are included in the Biodiversity Strategy (http://biodiv.gdos.gov.pl/).

In the document of the National Urban Policy 2023 there are many statements on actions directly related to development of green and blue infrastructure of a different scale. Developing urbanized areas must consider shaping a coherent grid of urban greenery, water areas, green belts, and fresh air corridors – the green infrastructure that will have a beneficial impact on the health of the residents, on improving air quality, reducing noise, on facilitating animal migrations, and on improving the attractiveness of the city for the residents and the investors, giving a specific character to individual city districts. Managing the blue-green infrastructure should combine ecological and leisure functions (integration with small infrastructure, pedestrian-cycling routes, city squares, etc.). Greenery may appear not only within green areas, but also along the streets, on the roofs, on the walls of buildings, on land that is temporarily exempted from use, and in the so-called urban farming formula.

On October 29, 2013, the Council of Ministers adopted the Strategic Adaptation Plan for sectors and areas sensitive to climate change until 2020 with a perspective until 2030, the so-called SPA2020. This is the first Polish strategic document that directly addresses the issue of adaptation to the ongoing climate change. SPA 2020 — a strategic adaptation plan for sectors and areas sensitive to climate changes.

Activities towards adaptation to climate change are being undertaken very intensively. The document SPA 2020 — a strategic adaptation plan for sectors and areas sensitive to climate changes by 2020, with an outlook by 2030, is aimed at ensuring sustainable development and effective operation of the economy and society in changing climate conditions by means of legislative, organisational, informative, and scientific activities. This is the first document in Poland of that type, dedicated directly to the adaptation to the ongoing climate changes.

The major objective of SPA 2020 is to ensure sustainable development and effective operation of the economy and society in changing climate conditions. The document presents the priority adaptation directives which should be initiated by 2020 in the areas most sensitive to climate changes, i.e., water management, agriculture, forestry, biological diversity, health, energy engineering, construction and spatial planning, urban areas, transport, mountain regions, and coastal regions.

The SPA document constituted guidelines for the development of Municipal Plans for Adaptation to climate change, the key element of which was the preparation of projects in the field of blue and green infrastructure. A significant part of them is aimed at introducing small green spaces into the urban fabric. From 2017 to 2019, 44 MPA has been elaborated for the biggest Polish cities. MPA implementation will change the everyday life of city dwellers. The modernised flood-protection system, effective water management procedures, and the development of the information and alarm systems in case of hazard will make the inhabitants feel safer. Aesthetic changes in the urban infrastructure have been developed by introducing green spaces into urban areas.

The development of plans to adapt to climate changes in cities with over 100 thousand inhabitants is an innovative project of the Ministry of the Environment. The activities proposed to the cities included implementation of blue and green infrastructure on different scale, as a response to extreme temperature and droughts observed.

Because of its range, this is the only initiative in Europe in which the Ministry of the Environment supports the authorities and local administration, coordinating the activities adapting to the climate change effects in several dozen cities at the same time. More information about the project: http://44mpa.pl/?lang=en

1.3.4. Slovakia

Barbara Vojvodíková, IURS - Institute for Sustainable Development of Settlements

Strategy for the Adaptation of the Slovak Republic to the Adverse Consequences of Climate changes (2014) — update 2018

The first more comprehensive document in this area, this seeks to link the scenarios and possible consequences of climate change with proposals for appropriate proactive adaptation measures in the widest possible range of areas and sectors.

The aim of adaptation is to reduce the vulnerability of the settlement environment to the adverse effects of climate change and to increase the ability of settlements to adapt to new, often extreme conditions. The horizontal and vertical structure of the seat greatly influences its microclimatic conditions. The built-up area, the share of paved and unpaved surfaces, the spatial distribution of green areas, shading, and the morphological properties of the terrain conditioning the air flow play an important role in creating microclimatic conditions of the settlement and a key role in adaptation. Water and green areas and elements will play an important role in fulfilling this goal, as they can affect the microclimatic conditions in settlements.

The aim is to support the use of the internal potential of cities for rehabilitation and resuscitation of non-functional urban zones (so-called “brownfields”), as well as areas in the outskirts for the implementation of adaptation measures in the headquarters; to ensure the assessment of current elements of green infrastructure near roads, their preservation, modification, and addition of other elements; and to increase the ability to cope with extreme situations such as drought or torrential rain, when it is necessary to slow down the outflow and ensure the capture of water, respectively ensure efficient drainage of water from the environment.

The Concept of Urban Development of the Slovak Republic until 2030 is a framework document that proposes generally beneficial and applicable principles and a comprehensive set of measures aimed at strengthening the role of cities in the overall development of Slovakia. It emphasizes the importance of a systems-based approach to urban adaptation to climate change adaptation. To ensure a systematic approach to adaptation, it recommends considering its requirements during spatial planning and supports ensuring the systematic integration of adaptation measures into spatial planning documentation.

1.3.5. Italy

Stefano Fraire, Matteo Tabasso, LINKS Foundation

In Italy the concept of urban or green urban acupuncture does not appear in any official act, but at national level it’s possible to underline some relevant strategies and laws concerning green infrastructures, biodiversity and climate change.

The national documents containing solutions that come close to UEA are the following:

Law No. 10/2013 “Rules for the development of urban green spaces”

The law recognizes the important role that greenery, and trees in particular, play in controlling emissions, protecting the soil, improving air quality, microclimate and the liveability of cities (first mention of elements similar to ecosystem services). Article 6 of the law urges the regions, provinces and municipalities to promote local initiatives for the development of urban green spaces.

National Biodiversity Strategy (2010-2020)

In 2010, Italy adopted a National Biodiversity Strategy as a result of a process of participation and sharing between the various institutional, social and economic actors involved, who are committed to working together to stop the decline of biodiversity. The Strategy and its mid-term review (2020) constitute a tool for integrating the conservation and sustainable use needs of natural resources into national sector policies, in line with the objectives set out in the European Biodiversity Strategy. Now that a review of the EU Biodiversity strategy for 2030 has been elaborated, the national document will be aligned

The Strategy Structure is divided into three key themes:

1. Biodiversity and ecosystem services
2. Biodiversity and climate change
3. Biodiversity and economic policies

The respective 3 strategic objectives are achieved with the contribution deriving from the various sector policies identified in 15 work areas.

National Strategy for Adaptation to Climate Change (2015)

The concept, termed “SNAC”, approved by decree No. 86 of 16 June 2015, identifies the main impacts of climate change for a series of socio-economic and natural sectors and proposes adaptation actions, consists of three documents, which constitute the updated basis of technical knowledge on the impacts of climate change and its vulnerability, providing a strategic perspective on adaptation.

The main objective of SNAC is to develop a national vision on the common paths to be taken to tackle climate change by contrasting and mitigating their impacts. To this end, SNAC identifies actions and guidelines to minimize the risks deriving from climate change, protect the health, well-being and assets of the population, preserve the natural heritage, maintain or improve the resilience and adaptability of natural, social and economic systems as well as taking advantage of any opportunities that may arise with the new climatic conditions.

To boost the implementation of SNAC, the preparation of the National Climate Change Adaptation Plan (PNACC) was started in May 2016. In July 2017, the first draft of the Plan was drawn up, which identifies Italian climate trends and identifies possible adaptation and monitoring actions, with the aim of choosing the most effective measures: including reforestation, urban green areas and other similar strategies.

2. Soil sealing and soil degradation reduction by application of urban environmental acupuncture solution and loss and fragmentation of habitats – biodiversity loss

2.1. Soil sealing and soil degradation

Anna Starzewska- Sikorska, Justyna Gorgoń, IETU - The Institute for Ecology of Industrial Areas

2.1.1. Soil sealing in the EU policy

The general definition of soil sealing in the EU used in the EC documents describes soil sealing as the covering of the ground by an impermeable material. It is one of the main causes of soil degradation in the EU. Soil sealing often affects fertile agricultural land, puts biodiversity at risk, increases the risk of flooding and water scarcity, and contributes to global warming. According to the European Environment Agency, since the mid-1950s the total surface area of cities in the EU has increased by 78%, whereas the population has grown by only 33%.

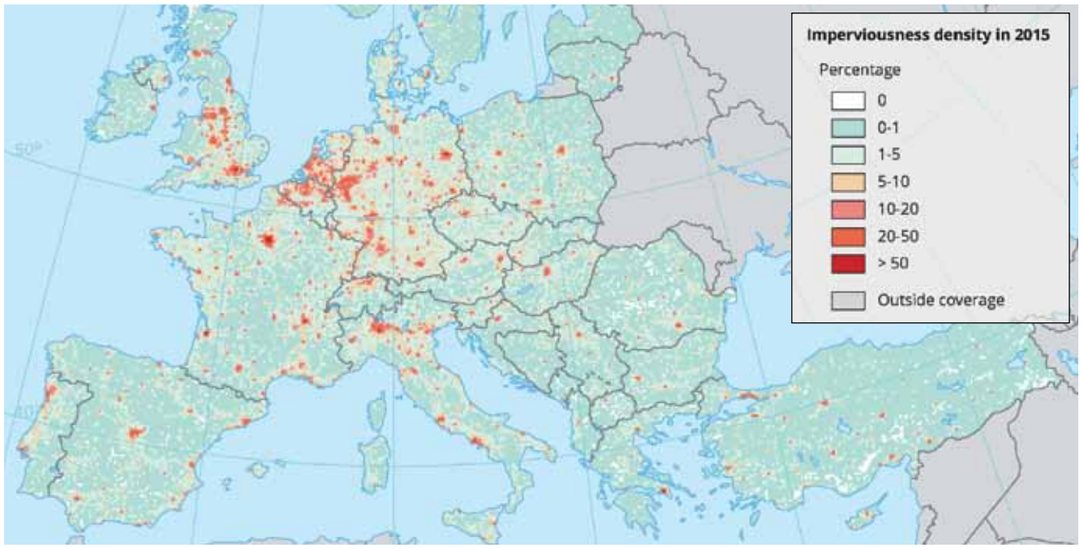


Figure 2.1. 1 Soil sealing indicated by imperviousness density in Europe (EEA, 2015)

Within the European context, two high level policy targets directly deal with the issues of soil sealing and land take:

- the EU Roadmap to Resource Efficient Europe, which demands “no net land take until 2050” (COM(2011) 571)
- the UN Sustainable Development Goal 15.3, which aims to “halt and reverse land degradation” until 2030 and which in 2017 introduced the concept of “Land Degradation Neutrality”, which the EU and its Member States have pledged to integrate.

The European Commission points out the need to develop best practices to mitigate the negative effects of sealing on soil functions. In line with this Road Map, in 2011 the European Commission published the report: Overview of best practices for limiting soil sealing or mitigating its effects in EU-27 presenting land take and soil sealing trends in the EU. The report contains an exhaustive overview of existing Member State policies and technical measures used to reduce and mitigate soil sealing.

Then, the European Commission departments have prepared Guidelines on best practice to limit, mitigate, and compensate soil sealing (SWD(2012)101final/2). The guidelines collect examples of policies, legislation, funding schemes, local planning tools, information campaigns, and many other best practices implemented throughout the EU. They are mainly addressed to competent authorities in Member States (at national, regional, and local levels), professionals dealing with land planning and soil management, and stakeholders in general, but it may also be of interest to individual citizens.

Analysis of the problem of soil sealing and land take are the subject of many projects concerning not only the definition of the problem scale but also looking for solutions. Also, recommendations for long-term strategic actions are being formulated. Among others, the following have been formulated by the RECARE project (https://esdac.jrc.ec.europa.eu/projects/recare):

- Establish an overall strategic aim and framework for actions to stop and reduce land take and soil sealing in urban areas in the long-term. This work needs to be aligned with ongoing efforts to achieve the Sustainable Development Goals 15.3 that aims for a Land Degradation Neutrality by 2030.
- Improve the implementation of existing and legally binding EU policies, which are key for preventing soil sealing and land take in the Member States such as Nature Directives, Environmental Impact Assessment Directive, Strategic Environmental Assessment Directive, Floods Directive, and Water Framework Directive.
- Dedicate and increase EU funds to more efficient land use and to reduce pressure on urban and peri-urban areas. For example, the Rural Development Funds, the LIFE+ programme, Cohesion fund, EU research funds, and the planned Trans-European Network for Green Infrastructure (post-2020) could more strongly support sustainable municipal planning, creation of green and blue areas in cities, remediation of contaminated and brownfield sites, and the development and implementation of new policy instruments to reduce soil sealing.

2.1.2. Instruments for urban intervention addressed to sealed and degraded areas

Land use planning and land management have the most efficient instruments for intervention regarding land take and soil sealing. In particular, the instruments addressing sealed and degraded areas are related to revitalization processes and urban renewal as well as those which introduce biodiversity in the urban space. Unsealing of sealed soil, as well as creation of new public space, with the application of pro-environmental solutions leads to the increase of biologically active land area, protection of city land and, in the long run, enhanced quality of the entire environment.

Also, the approach consisting in land recycling is in many cases strictly connected with land de-sealing in the process of preparation of a site for the new function. In the CIRCUSE project examples of circular land management in urban areas showed solutions requiring removal of land cover for compensation planting and creation of recreational public space on a recycled post-industrial area (https://ec.europa.eu/regional_policy/pl/projects/europe/circuse).

Innovative technical and technological solutions in unsealing of sealed soil are focused on enhancing the environmental comfort and supporting cities in the way of climate mitigation and adaptation to climate changes. Among selected solutions urban acupuncture seems to be one of the most interesting. In the context of urban soil sealing, selected and specific design intervention in limited location (urban acupuncture) could solve the problems of sealed public squares, marketplaces, courtyards, streets, and other public spaces.

Redevelopment and de-sealing of degraded urban land to perform new functions in the city is a good direction for the city and region, as regards protection of city landscape and open green areas against investment pressure and processes of uncontrolled urban sprawl. This process supports development of degraded and post-industrial space for the purposes of nature and recreation, which allows development of ecosystem-related services and to strengthen biodiversity. These are activities valid for the increase of comfort in urban environment and life quality of inhabitants as well as maintenance of biological diversity (Gorgoń, 2017).

2.1.3. Ecosystem services of soil

Soil is the foundation of terrestrial ecosystems and the majority of ecosystem services needed for human survival arise from soil (Kibblewhite et al., 2008). Ecosystem services provided by soil can by their nature be supporting (e.g., primary production and biodiversity) or regulatory (e.g., erosion control, water infiltration, nutrient retention, atmospheric gas regulation and pest control). By definition, ecosystem services benefit human welfare and represent nature's capital (Costanza et al., 1997; Robinson et al., 2012). For example, the economic value of soil microbial metabolic pathways in removing greenhouse gases from the atmosphere, abating nutrients, eradicating pathogens, and degrading organic pollutants has been estimated to be double that of the gross annual product (Guimaraes et al., 2010). Many ecosystem services inherently depend on soil health and biodiversity of the soil biota (Barrios, 2007; Brussaard, 2013). Soil health refers to the capacity of soil to function, meaning to sustain or improve productivity and health of plants and higher trophic levels, as well as air and water quality in natural and managed ecosystems (Kibblewhite et al., 2008).

2.1.4. Connection of soil ecosystem services with nature-based solutions (NBS)

One of the mitigating measures of soil sealing is de-sealing connected with providing for suitable areas of green space in urban regeneration activities, among others.

Nature-based solutions (NBS) involve nature to address societal challenges, providing benefits for both human well-being and biodiversity. They include actions that involve the protection, restoration, and management of natural and semi-natural ecosystems.

Nature based solutions have been applied in implementation of urban environmental acupuncture (UEA) in the SALUTE4CE project. Within the project 30 NBS have been selected as solutions that are suitable for being applied in UEA sites.

In many cases they can directly have an impact on soil sealing reduction, meaning that soil ecosystem services can be strengthened. The detailed analysis of NBSs proposed in the SALUTE4CE project as suitable ones for application in UEA regarding selection of those that can have a significant impact on reduction of soil sealing has been performed in two stages:

1. From the number of 30 NBSs we can exclude those which consist in vertical solutions or solutions installed on roofs as those do not entail using soil on the ground that relates to reduction of soil de-sealing.

2. From among the remaining 18 NBSs we mark out those that relate to blue infrastructure development: rain gardens, road-side swales, and linear wetlands.

The 15 NBSs can be assessed as strongly, medium, or weakly contributing to reduction of soil sealing, which means strengthening of soil ecosystem services. The table 1 below shows the results of the assessment (the numbers are coherent with the project table of all NBSs).

Table 2.1 Assessment of NBSs impact on strengthening of soil ecosystem services

No.	NBS name	NBS definition	Strong impact	Medium impact	Low impact
1.	Urban meadows	A multi-species plant community of native herbaceous plants in the form of mesotrophic or dry meadow created in urban space	x		
2.	Verges / flower beds with native perennials	Roadside linear features (verges) or patches (flower beds) of green space of reduced maintenance activities, sown with a wildflower-rich grassland seed mix, to provide nectar and pollen to attract foraging insect pollinator species	x		
3.	Ground cover plants	A patch of low vegetation - usually one species (perennials or low shrubs), of reduced maintenance activities, tightly and permanently covering bare earth	x		
3.	Lawn	An area of soil-covered land, planted with grasses, which are maintained at a short height and used for aesthetic and recreational purposes	x		
5.	Green pavements	Pavement with soil-filled gaps, with filter properties and with specific creeping grass species with a short growing and minimum maintenance		x	
6.	Street trees	Trees grown and planted in a manner consistent with the standards for street trees		x	
7.	Park trees	Trees planted in green (greened) areas other than traffic areas or town squares		x	
8.	Fruit trees/ shrubs	Trees or shrubs grown for edible fruit or seeds		x	
9.	Large shrubs	Shrub species / varieties growing up to a height exceeding 2 m		x	
13.	Natural pollinators' modules	Terrestrial micro-habitat (10-20 m2) designed to attract pollinators (and biodiversity in general), consisting of plants, water source, housing for biodiversity, and site furnishing			x
14.	Hedge/ hedgerow	A line of shrubs maintained to form a physical boundary (a hedge), in association with other flora and physical features (a hedgerow)		x	
15.	Rockery	A small garden constructed with aesthetically arranged rocks/stones, with small gaps between in which small plants are rooted			x
16.	Herb spiral	A small garden constructed as a raised, cone-shaped spiral bed, incorporating multiple levels, designed to provide herbs with a variety of growing conditions.			x
17.	Urban wilderness / succession area	A patch of vegetation in the urban tissue, where spontaneous but controlled succession takes place, and maintenance activities aim to ensure the sustainable provision of ES by a multi-species, self-supporting plant community	x		
18.	Ground crops of vegetables / herbs	A small garden constructed for soil cultivation (patches, containers) of vegetables/herbs		x	

2.2. Loss and fragmentation of habitats - biodiversity loss

Juliane Mathey, IOER - Leibniz Institute of Ecological Urban and Regional Development

"Biodiversity" *or* ***"Biological Diversity"*** means the variability among living organisms from all sources, and of the ecological contexts in which these living beings exist. Biodiversity includes diversity within species (genetic diversity), diversity between species (species diversity), and diversity of ecosystems (diversity of habitats) (UN 1992, Article 2. Use of Terms.).

Because of the specific environmental conditions in cities ***urban biodiversity*** is different from that in the open landscape. Cities are "Novel Ecosystems" intensively modified by human activities in both its abiotic and biotic components (Kowarik, 2011). They are highly fragmented environments creating a great array of different habitats, microhabitats, ecological niches, and highly varied habitat mosaic configurations, which range from preserved "natural" remnants to well managed green spaces and paved surfaces (Faeth et al., 2011). This characteristic "harlequin mosaic" of land uses, including high spatial and temporal dynamics, and the introduction of non-native species lead to high numbers of plants and animal species (Sukopp, 2005, Werner & Zahner, 2009) (Fig. 2.2.1, Fig. 2.2.2). Concerning biodiversity, cities play an ambivalent role. On one hand, they are refuges, substitute habitats, and steppingstone biotopes for many plants and animals, but on the other, urban development also means the loss, alteration, or disturbance of ecosystems (Mathey et al., 2017a).

Figure 2.2.1 Wild bee on knapweed (Cyanus montanus). Photo: R. Bendner

Figure 2.2.2 Biodiversity in an allotment garden. Photo: R. Bendner

The increasing urbanization leads to more ***habitat fragmentation*** and may cause the decline of biodiversity. Fragmentation creates patches that isolate populations and hinder movements among patches. This alters the quantity, quality, and pattern of habitats and is associated with changes in species richness of plants and animals (Faeth et al., 2011). A reduction in the size of areas leads to an increase in edge effects and hence also in disturbances, what makes it easier for non-native species to invade (Honnay et al., 1999 in Werner & Zahner, 2009).

In order ***tackling fragmentation of biodiversity loss***, it is essential that cities have richly structured and multifunctional green systems that satisfy ecological needs and at the same time are attractive, usable, low cost, and even profitable (Niemelä et al., 2010). A small-scale, tightly meshed and richly structured open

space system in an inner area, supplemented by larger green structures from the peripheral areas, offers good conditions for the preservation of diverse habitats (Mathey et al., 2017a). Structural and species-rich green spaces, e.g., urban wastelands with spontaneous vegetation, are valuable from a biodiversity perspective (e.g., Sukopp, 2005). Urban environmental acupuncture, including measures like unsealing of sealed soil, as well as implementing nature-based solutions (NBSs), is a suitable approach for upgrading urban biodiversity.

Biodiversity in the international, EU, and national policies: With the adoption of the *Convention on Biological Diversity* in 1992 (UN, 1992) the conservation of biodiversity on all levels is a crucial goal of international policy. In *European context* "*The New Leipzig Charter*" stated that well-designed, managed and connected green and blue areas are a precondition among others for developing biodiversity in cities (eu2020.de). The *European Biodiversity Strategy for 2030* will put Europe's biodiversity on the path to recovery by 2030, for the benefit of people, climate, and the planet (COM, 2020). On national level urban landscapes are included e.g., in the *German National Strategy on Biological Diversity*, where efforts are requested for providing new urban green space, e.g., by unsealing, greening courtyards and buildings, and deconstructing streets (BMU, 2007). In the *German Strategy for Adaptation to Climate Change*, the conservation of biodiversity is seen as a prerequisite for ensuring the adaptive capacity of natural (Die Bundesregierung, 2008). *Municipal biodiversity strategies* are useful tools to strengthen the position of urban green spaces and biodiversity and can help to improve urban green space systems by defining overall aims, providing spatial frames, and serving as firm bases for decision-making (Mathey et al., 2017b).

3. Urban environmental acupuncture as one solution for reduction of heat stress in urban space

Juliane Mathey, IOER – Leibniz Institute of Ecological Urban and Regional Development

3.1. Urban heat stress and climate change

Urban areas suffer from special climatic conditions: The phenomenon of the urban heat island (UHI) is characterized by dryness, heat, and lower wind strengths compared to the rural surroundings (Arnfield, 2003). Densely built-up and sealed areas are heat stores emitting heat to their surroundings, which is especially notable at night with negative influences on human health (Lehmann et al., 2014).

In large cities, heat islands with "tropical nights" above 20°C make it difficult to have the necessary recovery from the heat stress of the day. Sleep can be affected negatively, which may pose health hazards (Höppe, 1999). Vulnerable people such as the elderly, ill, and young children (infants and toddlers) are thus exposed to higher health hazards (Scherber et al., 2013). The urban heat island and extreme heat events can increase heat-related morbidity and mortality (Endlicher et al., 2016), like during the 2003 August summer heat wave, which caused 35,000 heat-related deaths across Europe (Larsen, 2006).

It is expected that climate change will exacerbate these conditions, in particular heat waves with higher frequencies and duration (Baldwin et al., 2019) intensifying heat dependant health problems (e.g., Pace et al., 2020). A sustainable urban development must deal with these foreseeable effects.

3.2. Urban environmental acupuncture against heat stress

3.2.1. Temperature regulation by urban green spaces

Urban green spaces are one option that can help to reduce heat stress in cities/FUA. They affect microclimate in various ways. For example, by regulating temperature, increasing humidity, and improving air circulation (Gill et al., 2007, 2009, Bowler et al., 2010), they can positively influence the health and well-being of residents (Li and Mathey, 2017). This is due to vegetative shade, evaporative cooling, and low heat storage (from daytime irradiation) that they provide.

Urban green spaces have beneficial cooling effects on the urban thermal environment (Bowler et al., 2010). Within tree-covered green areas the air humidity is 5-7% higher than in the surrounding area; in wooded areas and areas with larger plant stands it can increase by up to 30% compared to the open area up to a distance of 500 m (Pfützner in Greiner and Gelbrich, 1972)! The wind speed in green areas tends to be reduced by an average of 0.8 m/s in comparison to built-up areas (Greiner and Gelbrich, 1972). In the summer months, plant stands, especially leaves, can reduce wind speed by an average of 20-30% (Kuttler, 1998).

Thus, their climate-regulating and positive bioclimatic effects offer important starting points for urban environmental acupuncture to reduce heat stress and for planning cities adapted to climate change (e.g., Rößler, 2015). Vegetation can also play an important role in climate mitigation by acting as a temporary CO_2 sink to reduce greenhouse gases, and by using shady trees, greened walls, and roof-top greenery to help contain energy consumption by cooling buildings (Gill et al., 2007).

Regarding the climatically relevant functions of individual green spaces, it is to be distinguished between effects within the area (PCI = Park Cool Island), their effects on the environment (Parkbreeze) and continuing wind-driven air mass transport (Bongardt, 2006).

3.2.2. Cooling effects of different vegetation structures

But all green is not equal. Different types of green and green structures vary considerably in their impact on air temperature (Li and Mathey, 2017, Jiang et al., 2020). The micro-climatic situation in green spaces (PCI) is largely determined by the proportion of sealed areas, the vegetation inventory, the proportion of green cover, the vegetation structure, and the specific green volume (Cheng et al., 2015) (Fig. 3.1, Fig. 3.2).

Figure 3.1 Even small green spaces with trees can be cool places on a hot summer day. Photo: R. Bendner

Figure 3.2 Street trees give shade and cool on hot summer days. Photo: R. Bendner

The results of micro-climate modelling indicate that on a hot summer's day the average cooling effect of small green spots of size 1 ha (at a height of 1.2 meters), compared to a fully sealed asphalted surface, ranges between 0.1 K and 2.1 K over the course of the day (Fig. 3.3). Whilst green sites featuring young trees and partly dense woodland can achieve an average cooling effect of up to 2.1 K (Fig. 3.3, type 3), large grassy areas provide only 1.0 K cooling (Fig. 3.3, type 1). However, healthy grassy areas are still better than dry lawns that provide a similar daytime climatic effect to that of sealed areas (Mathey et al., 2011).

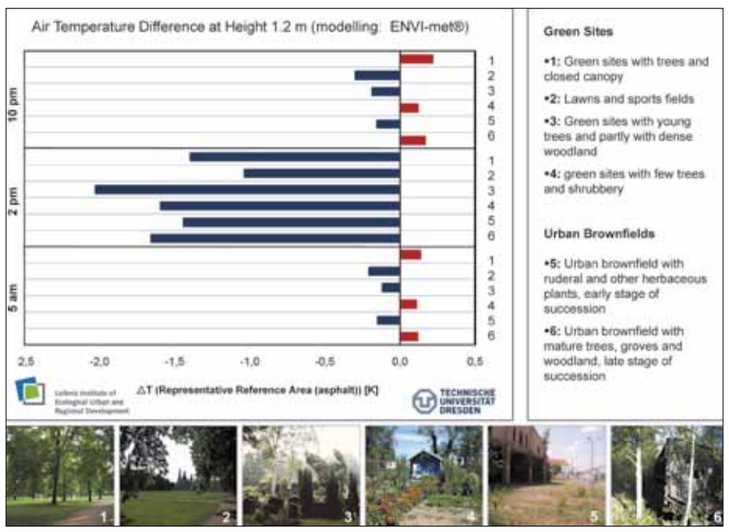


Figure 3.3 Microclimatic effects of selected urban green space types in Dresden (Germany) at 5 am, 2 pm, and 10 pm (modelled by ENVI-met®, Bruse and Fleer, 1998, modified after Mathey et al., 2015). © S. Rößler (Photo 1); R. Bendner (Photo 2, 4, 6); S. Stutzriemer (Photo 3); B. Kochan (Photo 5)

The regulative effects of various types of urban green spaces vary over the course of the day (Fig. 3.3). In the daytime, the lowering of temperatures in urban green spaces is especially perceptible in areas covered with trees. While open, unsealed sites such as lawns and meadows (Fig. 3.3, type 2) generally have a high cooling potential during the night, dense woodland (Fig. 3.3, type 1) can prevent surface cooling after sundown (Mathey et al., 2011). Overheating additionally can be lowered by greened walls as well as by roof-top greenery/roof gardens, which have climate regulation effects and thus the potential to reduce energy consumptions by reducing the need for air conditioning (Mathey et al., 2011). The shade provided by trees along roads, cycle paths, and footpaths (avenues) as well as by pergolas are very important in reducing heat stress and increasing the quality of life in public spaces.

3.2.3. Proportion and distribution of green in the city/FUA

In addition to vegetation coverage and vegetation structure, the size of a single urban green space is of importance with regard to their potential for temperature reduction. Perceptible climatic effects are described for urban green spaces from a size of 1 ha (Stülpnagel in Gill et al., 2007). According to Sperber (2007), a measurable and perceptible area of internal climate develops in a compact green area with a size of 2 ha, a maximum degree of soil sealing of 25%, and a grove-like population of old deciduous trees (crown cover of 60%) and shrub groups. Normally, large urban green spaces (over 40 ha) provide higher cooling effects than small ones. The doubling of the area causes a temperature reduction of 1 K; higher enlargement of the area can reduce the temperature between 1.5 K and 3 K. The larger an individual green space is, the longer the distances that can be overcome by the cooling effects. However, the climatic sphere of action of most urban green spaces ends, without influence of the topography, usually at distances of about 200–300 m (Stülpnagel, 1987). Nonetheless the sphere of action of a green space does not grow proportionally to the size of the area. This explains why smaller green spaces are sometimes more effective than larger ones (Scherer, 2007).

However, also individual trees can evaporate up to 500 litres of water per day, if provided with an appropriate water supply, thereby reducing the perceived temperature in its shade by 10°C to 15°C (Gillner et al., 2014). For example, a birch tree evaporates far more than 100 litres of water per day in high heat, a spruce only about 10 litres (Gretz and Prähofer, 2019). There are also differences in cooling effects between tree species. Generally speaking, tree species with low water requirements (e.g., rubies) cool better on hot days than tree species with dense leaf cover and high-water requirements (e.g., lime trees), which cool more effectively on mild summer days (Trautmann, 2019).

In most cities/FUAs, predominantly smaller green spaces (parks 5 to 15 ha) can be found (Bongardt, 2006). Therefore, the well-known climatic effects of these smaller (inner) urban open spaces make them a key field of action for heat stress reduction and climate adaptation. The obvious advantage of large green spaces is put into perspective when one considers that smaller and well-distributed green spaces can be reached more quickly and easily from neighbouring residential areas. This makes it easier for residents to avoid the heat stress by only walking short distances (Mathey et al., 2011). Keep in mind that the vegetation within the built-up areas contributes to the provision of climatic regulation effects. In addition, the conservation of spontaneous vegetation and the greening of urban wastelands support heat reduction (Mathey et al., 2015). In this context, small green spots with as few sealed areas as possible and a diverse vegetation structure with varying shrub and tree heights can be assessed as micro-climatically favourable (Mathey et al., 2011). So, it makes sense to start with the urban environmental acupuncture even on small spots in built-up areas.

In addition to the effects of individual green spaces, the interaction of all green spaces in a city/FUA is also of climatological importance. The cooling effect of a green space system depends on the size, distribution, and connectivity/interlinkage of green spaces. The higher the proportion of vegetation-covered areas is in a city/FUA, the higher the green volume and consequently also the cooling effect (Fig. 3.4, Mathey et al., 2011).

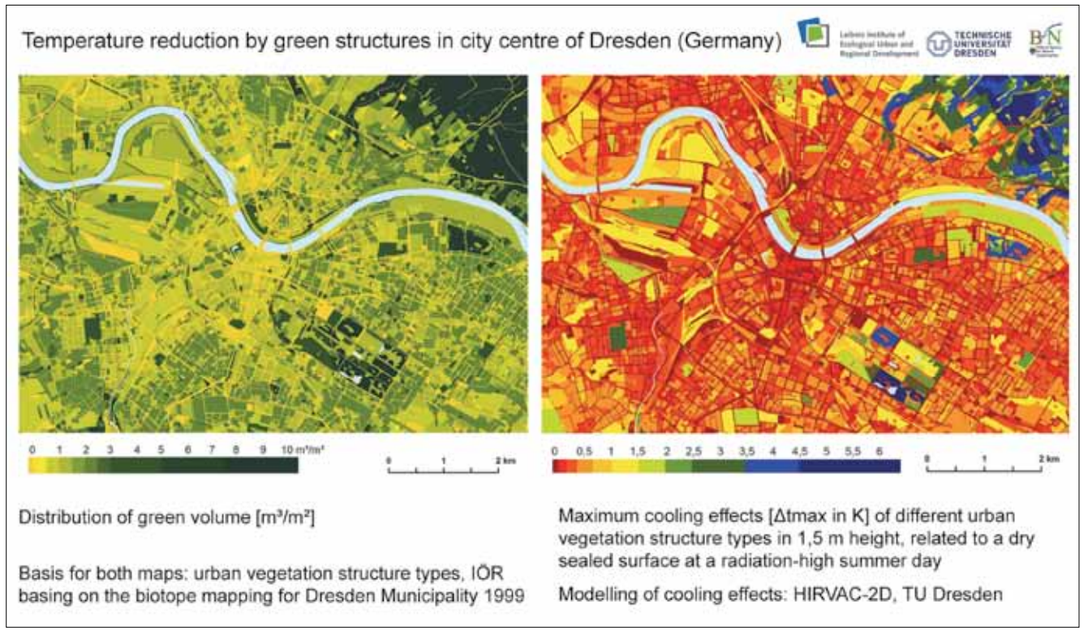


Figure 3.4 Distribution of green volume (left) and maximal cooling effects (right) on a summer day with high radiation in Dresden (after Mathey et al., 2011, modified)

3.2.4. Additional things to consider

Climate change will also have an impact on the biodiversity of urban areas, affecting the quality of green systems which may lead to changes in species composition and in vegetation structure, thereby undermining the vital role which such vegetation plays in providing those ecosystems services such as reducing heat stress (Roloff et al., 2008, Bowler et al., 2010).

The climatic impact is reduced if the green space is situated lower than the surrounding area, if it is bordered by walls or dense edge planting, or if it is surrounded by a dense building structure (Mathey et al., 2011).

Natural or artificial water bodies can be part of urban open spaces. The water surface, which is generally cooler than the surrounding area, leads to a so-called “oasis effect”. The boundary effects of water bodies can be very different for example, lake banks rich in vegetation lead to an increase in humidity; riversides can carry water-near layers of air in the direction of flow, making, larger rivers important in cold airways circulation within cities (Kuttler, 1998).

3.3. Conclusion for urban environmental acupuncture concepts

When developing urban environmental acupuncture concepts to combat heat stress in urban areas/FUAs after Mathey et al. (2011) the following should be taken into account. Consideration of different planning goals it is important in deciding what climatic effects are required at particular points (i.e., locations) in the urban fabric/FUA and whether the cooling effects shall be achieved by day or night. This depends strongly on the functions and uses of the green spaces in question. The following theses can be formulated for urban environmental acupuncture that takes adequate account of the need to reduce heat stress: (1) A richly structured green-space system in built-up areas supplemented by open cold air corridors from the periphery can affect the micro-climate of the entire city/FUA. (2) The higher the proportion of strongly vegetated urban green spots the better will be the impact on the urban climate. (3) The larger a single area, the more distinctive the internal climate will generally be. Nonetheless areas smaller than 1 ha in size can measurably reduce the temperature. (4) The structure and specific nature of vegetation in each green spot has a strong influence on the potential for climate regulation. (5) The highest cooling effects can be reached in green spots when the proportion of soil sealing is low and the vegetation structure is heterogeneous, featuring grassland, bushes, as well as small and high trees. (6) The impact of vegetation structures on the microclimate depends on the time of day. While open unsealed sites such as lawns and meadows generally have a high cooling potential during the night, dense woodland can prevent surface cooling after sundown. (7) Trees along roads, cycle paths, and footpaths are very important for reducing heat stress and increasing the quality of life in public spaces. (8) Overheating can also be reduced by greened walls and roof-top greenery. Particular consideration has to be given to maintenance requirements.

The above-mentioned points shall help to decide at which point in the urban fabric/UFA which NBSs (Nature Based Solutions) (see in SALUTE4CE Handbook Chapter 7 “Characteristics of Nature Based Solutions and their impact to urban environment”) are suitable in terms of an urban environmental acupuncture.

4. Possibilities of application of urban environmental acupuncture in reducing problems with rainwater in the urban space

Barbara Vojvodíková, Jiří Tylčer, IURS - Institute for Sustainable Development of Settlements

Water is the most important component of the Earth's natural environment. Water in the landscape sphere enables not only the movement of matter, but also its continuous transformation. It is the main driver in erosion processes. It also occupies a key position in human life and activity, and its role increases with the rate of development of society.

Human settlements have been firmly linked to water since historical times. Prehistoric settlements were established where water could be obtained for drinking, but far enough away from watercourses to avoid endangering them if they were to become waterlogged. Towns were often founded at fords where merchant trails passed. Medieval towns used the river as a defense line or sewerage. Water was brought into towns by aqueducts.

In the 20th century, water and the water element in the city were suppressed. In industrial production, the need to harness the power of water to drive machinery declined. Water was becoming a hostile element, and flood protection was a key objective. Watercourses were straightened, regulated, and dammed. Fountains in squares acquired a more esthetic function. How the relationship to water in the city evolved can be seen in the Fig. 4.1. The gradual trend towards a re-acceptance of water as part of the city at the beginning of the 21st century is complemented by issues more closely associated with stormwater management. A highly technically oriented society is becoming aware of the importance of water in cities. Several quick storms and associated heavy rains have shown that cities are not prepared to face these extreme events without major property damage. Climate change is beginning to be talked about.

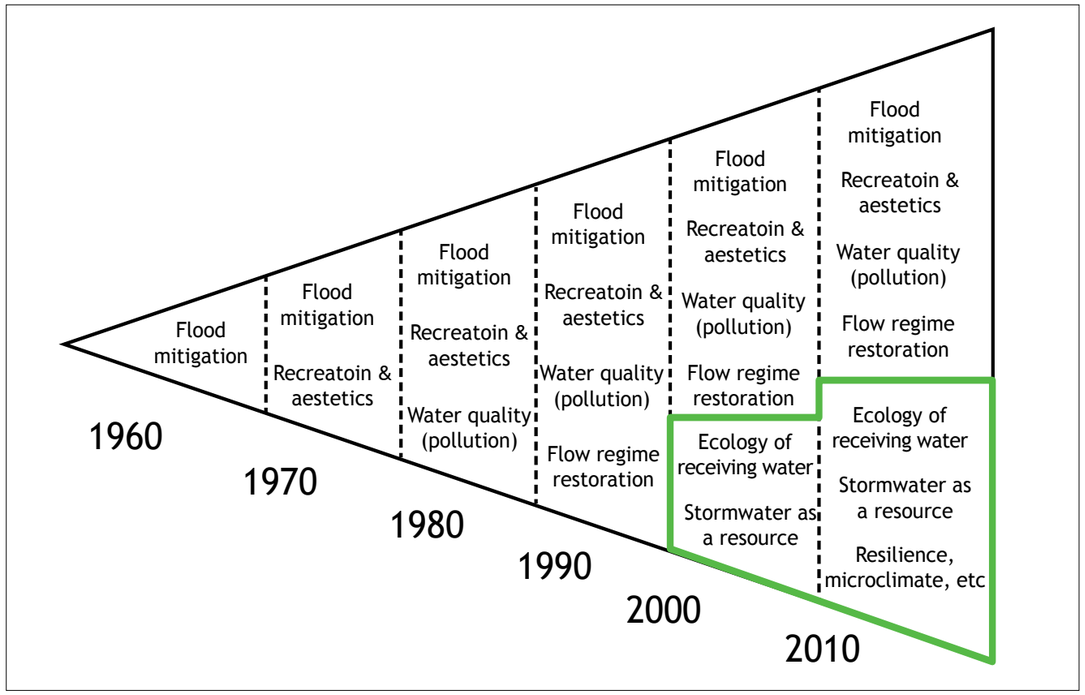


Figure 4.1 Evolution of urban drainage targets (after Fletcher et al., 2015) and (Stránský et al., 2019) (The green border indicates the areas covered by the content of this handbook, i.e., Urban environmental acupuncture.)

As a result (climate change is a natural phenomenon, but the rate of change is much more severe), cities around the world face several problems and challenges (Carter, et al., 2015; Rosezweig et al., 2011; Schär et al., 2004). This is compounded by resource depletion and changes in ecosystem degradation. Climate change leads to a gradual temperature rise in cities, which results in more intense heat islands (Bowler et al., 2010; Vargo et al., 2013; Yoon et al., 2019) (chapter 3.1 is devoted to this topic). Climate change also increases risk of floods (Dragoni and Sukhija, 2008) which is mainly associated with pluvial floods (Houston et al., 2011), causing local damage, often unrelated to overflowing persistent water body. In Europe, the average cost of flood damage between 2000 and 2012 is estimated at around €4.9 billion per year, rising to an estimated €23.5 billion per year by 2050 (Sörensen et al., 2016).

Unless cities adapt their current infrastructure and resource management, they will not be able to meet these challenges. In this chapter we highlight solutions based on nature-based processes (NBS). These solutions are one of the elements of urban environmental acupuncture (UEA) that can help transform settlements in the context of sustainability and resilience. As stated by the European Commission (EC 2015a, 2015b), UEA and NBS are an important part of future developments to provide resources and a livable environment, especially but not only in urban areas.

The difference between the blue-green infrastructure) and the UEA elements can be explained with a certain degree of simplification by the size of the elements. GBI sites can be large parks, dry polders by rivers, all with an emphasis on natural design. UEAs, on the other hand, are small elements in the urban fabric — a small park, a group of trees, a lawn by the roadside, where, in the UEA does not aim to prevent the effects of fluvial flooding. Rather, the goal of UEA applications is to mitigate the effects of pluvial flooding. In emergence planning and identifying the objects at risk specifically from stormwater during times of high rainfall, the key parameters are the surface and the volume of water that hits the surface. Research, e.g., (Szewranski et al., 2018) documents that the greatest risks are associated with impervious surfaces, not to mention large areas of transport infrastructure, roofs, buildings, and so on.

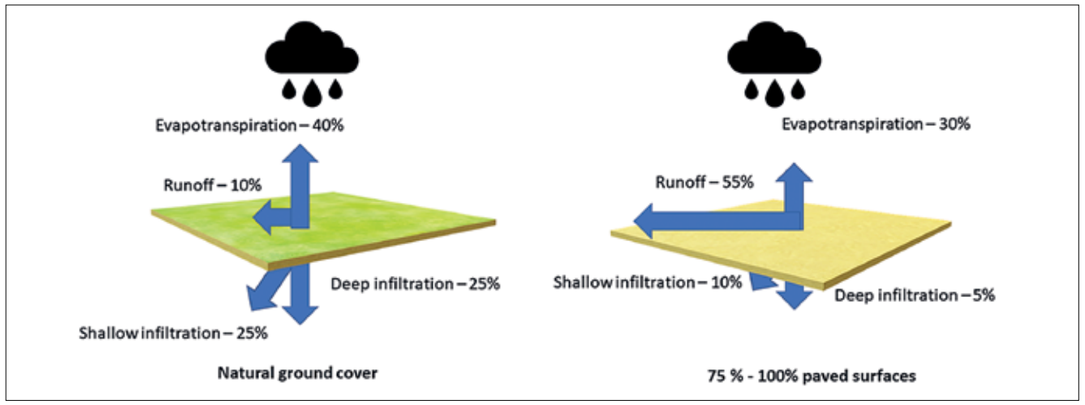


Figure 4.2 Typical hydrogram of change due to an increase of impermeable surfaces (based on information in : Tourbier and White, 2007)

As can be seen in Fig. 4.2, despite the great difficulty, part of the water in the built-up area reaches the groundwater, which forms an important part of the hydrological cycle. In built-up agglomerations there are major changes in the proportion of the different elements of the water balance. This is due to changes in land use and very often changes in groundwater use. In urban agglomerations, precipitation infiltration is mainly reduced. Building roofs, roads, other paved surfaces and drains radically affect surface runoff. For Barcelona, it is reported that 80% to 90% of the rainfall is discharged into the sewers immediately after it falls. The remainder is divided into surface runoff (which is negligible for rainfall with a frequency of less than 10 years), surface retention and infiltration. It has been verified that rainfall below 1 mm does not cause any increase in inflows to the sewer. This value is therefore considered as representative for the quantification of surface retention. In an average rainfall year, such light rainfall represents 10% of the total. This leaves only a few, at most 5% of the rainfall to infiltrate into groundwater (Vázquez-Suné, 2003). Compared to the open countryside, evapotranspiration is also radically reduced in urban agglomerations.

4.1. Effects of storm water arrival in the urban area, and solution for the reduction problem

A concomitant of climate change is a change in the seasonal distribution of precipitation. More often than in the past, we are faced with climatic extremes such as droughts followed by heavy rainfall and then localized flooding. The phenomenon of torrential rainfall has an impact on the capacity of the sewerage network, which may not be sufficient during these events.

The amount of water that falls on the surface (especially at the beginning of the rainy season) is only absorbed in a small percentage - in the case of lawns, it is often the aridity of the soil that does not allow immediate absorption. The paved surfaces of roads, car parks, roofs, and squares play a role, as mentioned several times above. Over a noticeably short period of time, large volumes of water run off the surface. Within a truly short time, the capacity of the stormwater drains and sewerage, the drainage system at the entrances to the underground car parks and the cellars is filled. As rainfall continues, water often penetrates entrances to underground garages and basements. Low-lying areas such as underpasses under railroads begin to fill with water as they become impassable, and property damage soars.

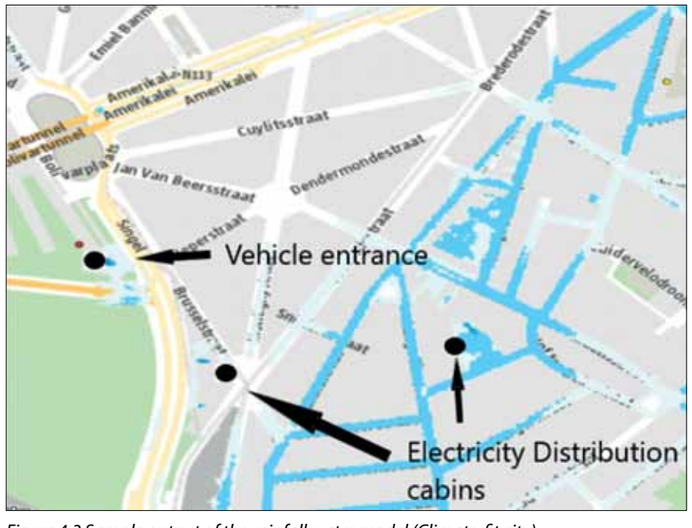


Figure 4.3 Sample output of the rainfall water model (Climate-fit city)

Fig. 4.3 shows an example of the stormwater model for the city of Antwerp, which was developed by Emergence Planning. Some problem areas are marked in the model. The model documents which important elements in the city may be at risk and therefore need to be given special attention and protected against heavy rainfall.

There are generally two basic solutions to stormwater problems.

- The first is to increase the capacity of the stormwater sewer drains, to significantly increase the capacity of the entire piping system, and to significantly increase the capacity of the drainage basins. These solutions are technically awfully expensive and often difficult to implement.
- The second option is to reduce the instantaneous volume of water. Divide the water so that it leaves the sewer gradually or allow it to infiltrate in or evaporate. To improve ecosystem services through infiltration and allowing evaporation, we also improve the environment of the site. For the proposed solutions to deliver these benefits they must be high quality and well-thought-out systems. Poor quality or unconsidered element design can lead to foundation waterlogging, basement flooding, conflicts with underground infrastructure in the area, and clogging of sewer drains with runoff.

Based on the inspiration from the Sýkorová et al. (2021), we have divided the solution options into two basic groups:

- The first group is the measures to improve the microclimate and prevent the occurrence of rainfall runoff.
- The second group consists of infiltration and retention facilities.

Both groups do not have strictly defined boundaries, often sharing elements at the intersection of the two groups. Despite these imprecisions, this division provides a good illustration of the design options.

Although other chapters of this handbook are devoted to a more detailed description of the individual elements of the UEA, some are only given in this chapter to illustrate possible solutions or the shortcomings of these solutions.

Prevention of rainfall runoff (we do not deal with drains or sewerage), is aimed at dealing with the stormwater directly at the point of impact (retention, allowing infiltration, evaporation). Evaporation of water, contributes positively to the microclimate, lowers the temperature and makes the environment more pleasant. This group

Figure 4.4 Tree planting as an element of UEA – green pavement. Photo: I. Tichá

Figure 4.5 Tree planting as an element of UEA – curbs. Photo: I. Tichá

of solutions mainly addresses the situation at the point of impact or in the immediate vicinity. Almost all of these solutions are closely linked to vegetation, which needs water for its existence. It is always advisable to consider whether something better could be done when installing such solutions. This seemingly obvious and banal advice, or rather the failure to use it, is documented in the following example. Fig. 4.4. and Fig. 4.5 show an example of a tree planting solution for two parking areas in Ostrava, Czech Republic.

In the picture with green pavement, the trees receive a large amount of water running off the parking area without restricting the parking area. The constant parking causes consolidation of the soil around the tree. The second example is a tree that is covered with gravel such that a car cannot park in the immediate vicinity, but the curb around the tree prevents water from flowing directly to the tree. Thus, the tree is only watered by rain falling on the defined area.

Other possibility to be included in this group of solutions includes gravel and packed gravel sidewalks (Fig. 4.6). Although gravel pavements are characterized by high permeability, walking on them is difficult and, for example, practically impossible for a person in a wheelchair. Therefore, decisions should always be made in relation to the functionality of the whole area. The solution is to divide the pavement into two parts with different surfaces. Smaller solutions such as flower beds or lawns should always be positioned so that water does not run off them onto the surrounding pavements and roads, but rather that water from the pavements runs into these areas. Fig. 4.7 shows a depression in the turf around the tree that allows water to be retained and the tree to be irrigated.

Figure 4.6 Gravel sidewalk. Photo: B. Vojvodíková

Figure 4.7 Lawn morphology allowing water retention. Photo: B. Vojvodíková

Figure 4.8 An example of a good idea with less than perfect execution. Photo: B. Vojvodíková

The element in Fig. 4.8 has a negative rather than positive effect when the water is discharged onto the road rather than the other way around. Not only does it not fulfil the function of temporarily reducing run-off, but it also leads to pollution of the roads and possibly clogging of the storm sewer inlets.

A green façade can also be a preventive measure, especially if the plants are rooted directly in the soil on the structure. If they are planted in a pot or container, their effectiveness is significantly reduced. What must always be respected, however, is that water always flows wherever it is given the opportunity and space to do so. If we choose to root plants in the soil next to the structure, we must protect the foundation structure from root penetration as well as from water leakage caused by cracks in the waterproofing.

Green roofs are a separate problem. Their ecosystem services are mentioned and are undeniable, but if we opt for a green roof, in addition to its very precise design and implementation, we must also be aware of the load on the roof structure, and entire building.

Figure 4.9 Green roof on a small shelter. Photo: B. Vojvodíková

Compared to a plain roof, water does not run off but is sucked in through the layers and often deliberately forms a retention layer. Just for illustration, if we create the possibility of a water column of 20 cm on a 10x10 m flat roof. This creates an additional long-term load of 20t of water. The green roof, or a very simplified version of it, can also be placed as part of a woodshed or over a bin. This element is technically unsophisticated but can be amazingly effective (Fig. 4.9).

Objects suitable for seepage and retention are a necessary part of whole system of rain-water management. The primary task of solution in this category is the seepage (intensity base of subsoil and its suitable seepage parameters). The design of these features allows surface runoff from impervious or poorly permeable surfaces to be received, retained, and gradually absorbed into the subsoil. The solution, the upper part of which is made by a grassed humus layer, ensures very good pre-treatment of the collected water. When situating the seepage solution, it is necessary to take into account that the subsoil takes in a relatively large amount of water. It is therefore necessary to pay attention to the quality of the groundwater. A vertical distance of at least 1 m between the seepage measure and the groundwater level always must be ensured. Another essential condition is to maintain the distance from the underground parts of the buildings. Especially older buildings with insufficient waterproofing could be at risk from seepage.

Fig. 4.10 shows an example of a well-made bioswale, which is located in the lowest part, its bottom positioned above the water table. The banks are made in such a way as to prevent erosion and thus gradual silting.

Figure 4.10 Creating a low-lying area will create a suitable space for rainwater retention. Photo: I. Tichá

Figure 4.11 Swale degraded by an irresistibly formed bridge for the transition. Photo: B. Vojvodíková

The bioswale around the roads in the picture are a historically known solution, but sometimes forgotten in the city. Unfortunately, the idea of a suitable area for stormwater drainage can be somewhat devalued by the actions of some residents Fig. 4.11.

If geological conditions do not allow rainwater to be absorbed, it can be at least temporarily retained, and its runoff slowed. If we expect to retain water in surface facilities (underground facilities are not the subject of this handbook) for a longer period and we want to place this facility in an urban area, we will have to face objections from residents about the risk of drowning of small children or mosquitoes. Again, incredibly careful consideration should be given to whether an engineering solution such as underground storage tanks with gradual soakage is not more appropriate in this location, with the possibility of further use of rainwater.

4.2. Conclusion for rain water solution

Water is an inseparable part of our lives, and lack of it leads to many problems. Though an excess of it, e.g., storm (heavy rain) water, also causes problems. But the behavior of water in urban environments, unlike tornadoes or fires for example, can be predicted very well. It is always the principle that it seeks the path of least resistance, that it always flows in the direction of gravity (not describing here the problem of a closed surface). Despite these clear inputs, damage to property and equipment still occurs. This is due to disregard for these principles, perhaps relying on the technical capabilities and invulnerability of man. However, all the elements of the UEA that can aid in effective rainwater management can only be fully functional if the laws of nature are truly respected.

5. Urban environmental acupuncture for increasing air quality

Matteo Tabasso, Elena Masala, LINKS Foundation

5.1. Air Pollution

Air pollution represents a huge problem in our cities, in fact about 3.8 million premature deaths annually are attributed to outdoor air pollution. According to the World Health Organisation, it represents the single largest environmental health risk in Europe, while the European Environment Agency (EEA) has warned that Air pollution causes between 400,0000 and 500,000 premature deaths every year on the continent (Air quality in Europe — 2015 report).

Indeed, air pollution is currently the most important environmental risk to human health in Europe, and it is perceived as the second biggest environmental concern for Europeans, after climate change (European Commission, 2017a).

A systematic review financed by David Suzuki Foundation (Zupancic, 2015) provided an analysis of the impact of green space on heat and air pollution in urban communities and identifies the most common air pollutants: particulate matter (PM), sulphur dioxide (SO2), ground-level ozone (O3), nitrogen dioxide (NO2) and carbon monoxide (CO).

Different air pollutants have different adverse health effects, and the World Health Organization estimates that, in particular PM contributes to approximately 800,000 premature deaths each year and 6.4 million lost years of healthy life in cities (Brauer, 2012). Exposure to sulphur dioxide (S02) was associated with preterm births, while exposure to PM2.5 is associated with low birth weights, preterm births, and gestational age births, while ozone exposure may also have negative effects on birth weight and neurodevelopment. According to Canadian studies, NO2 exposure is linked to an increased risk of ischemic heart disease (Crouse, 2015).

5.2. Mitigation interventions

A frequently used method to mitigate air pollution in our urban contexts is the implementation of Green Infrastructures (GI). In a recent study, Hewitt et al. (2019) analysed some specific Green Infrastructure interventions that can benefit air quality, in particular trees on streets and in parks, green walls, green roofs, and other means of introducing vegetation into the urban landscape, on the basis that pollutants deposit more efficiently onto vegetation than onto smoother, impervious, artificial surfaces.

Fields, parks, abandoned plots, and even rooftops and allotments are important because areas not sealed by concrete ensure cooler temperatures and help to keep the air clean.

The most effective intervention in reducing air pollution would be the reduction of emissions, but this is often difficult, and GI is unable to play a role. Another way to reduce human exposure to pollutants is extending the distance between sources and receptors. This can be achieved by increasing the distance between road vehicles and pedestrians, or by placing “barriers” between sources and receptors, such as Green Infrastructures, placed

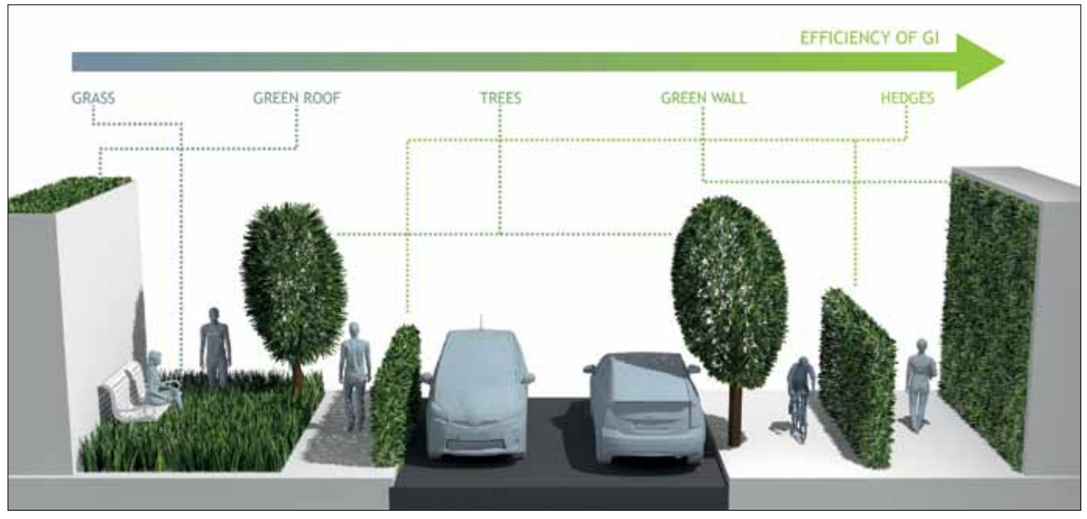


Figure 5.1 Efficiency of Green Infrastructures in absorption of pollutants

in different configurations. In fact, trees and hedges provide semi-permeable obstacles to airflow, virtually extending the distance and thus reducing the negative effects for the receptors.

The way vegetation interacts with airflow is influenced by different factors like plant typology, height, morphology, etc. (Baldauf. 2017).

Studies suggest that GI help improving urban air quality, but there is little unequivocal, empirical evidence or validation to support this.

In fact, most of the interventions of greening have usually positive effects on pollution, but the empirical evidence for the effectiveness of GI on air quality is weak and it is fundamental to know what, where and how to plant, in order to avoid unexpected (health) impacts and reduced resilience.

In urban contexts, pollutant concentrations change rapidly and the measure of small changes in concentrations due to the introduction of GI is very difficult.

For this reason, decisions on Green Infrastructures are mainly based on prediction models rather than on empirical evidence. Effectiveness may be hard to determine empirically. This is in contrast with other possible actions involving GI that may be detrimental to air quality (e.g., introducing trees into a street canyon, which may increase canopy closure and reduce ventilation rates), or those that may have no discernible effects on air quality (e.g., building green roofs).

Green Infrastructures are effective where deposition can be enhanced by holding air for nearer vegetation. The space domains in which Green Infrastructures are likely to be effective range in size from a small “green oasis” such as a bench closely surrounded by high hedges, to a dense urban woodland. (Hewitt et al., 2019).

The above-mentioned report from the Suzuki Foundation (Zupancic, 2015) examined various types and scales of green space, and generally found that urban green space can provide cooler, cleaner air at the site, neighbourhood, and city levels. Emerging evidence also suggests that closely spaced and connected smaller green spaces can provide greater cooling effects to adjacent urban areas than large individual parks with open grass areas.

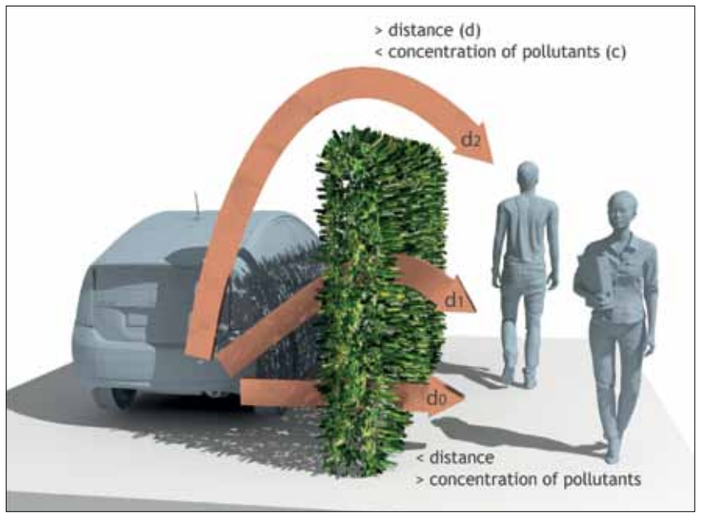


Figure 5.2 Effect of a permeable linear barrier or hedge on pollutant concentrations. Along the paths, pollutant concentrations are diluted by mixing and deposition. In the absence of the linear barrier, the receptor experiences higher concentration diluted over shorter distance and is not subject to enhanced deposition to vegetation.

5.3. Urban environmental acupuncture and air quality

Increasing the amount of vegetation indiscriminately doesn't necessarily reduce ground-level pollutant concentrations linearly (i.e., that doubling leaf area will not half pollutant concentrations). The vegetation deposition pit located is at a distance from the pollutant emission source, therefore, the atmospheric concentrations will always derive from a balance of emissions, advection, deposition, and reaction (Hewitt, 2019).

The worst and the best plant for air quality*

Canadian poplar / Populus x canadensis
English Oak / Quercus robur
Magnolia / Magnolia grandiflora
Scots pine / Oinus sylvestris
Bald cypress / Toxodium
Austrian pine /Pinus nigra
Holly Ilex Pear / Pyrus communis
White mulbelly / Morus alba
Maritime pine / Pinus pinaster
Downy birch / Betula pubescens
Norway Maple / Acer plantanoides
Cedar / Cedrus deodar
Horse chesnut / Aesculus hipocastanum
Tulip Tree / Liriodendron
Small leaved line / Tilia cordata

**Churchman Landscape Architects, 2018*

Figure 5.3 The worst and the best plant for air quality (Retrieved and adapted from Churchman Landscape Architects, 2018)

Furthermore, not all types of vegetation are suitable for improving air quality and, above all, it is demonstrated that sometimes, if the right types of plants are used, a smaller green area is enough to be a good deterrent against air pollution, and this a case for urban environmental acupuncture.

Trees can reduce NOx pollution by 40% and 60% for particulate matter (Source: Environmental Science and Technology: 2012), but not all trees have the ability to absorb pollution.

The three main characteristics that influence the efficiency of plants in reducing air pollution are:

- density,
- plant height,
- intrinsic characteristics of the leaves.

A study from the Churchman Landscape Architects (2018) identified a list of plants and classified them according to their effectiveness in adsorbing air pollutants (Fig. 5.3).

Other plants that help reducing air pollution are the Norway Maple, that has been shown to absorb as much as 3,800 kilograms of carbon dioxide in as little as 20 years), the Silver Birch, and the Turkey Oak, both of which able to absorb up to 3,100 kilograms of carbon dioxide in 20 years (Njeri, 2021).

Numerous studies have confirmed the theory that increased tree crown volume coverage (CVC) is positively associated with increased mitigation of PM, O3, NO2 and SO2. The Suzuki Foundation study (Zupancic, 2015) also suggests that a CVC of 2 m3/m2 is a good target for park design. This study also shows that younger and, therefore, smaller trees have good effectiveness in removing PM10, as they have much denser foliage.

The height of the plants is to be considered a very important factor within the research: several authors have shown that compact trees and shrubs growing low to the ground (such as Spiraea japonica) are more effective at capturing PM than large branched trees (such as P. hispanica) (Saebo et al., 2012; Dzieranowski et al., 2011).

Emerging evidence shows the importance of plant leaf traits on PM mitigation. Increased PM capture is associated with greater plant hair density, plant leaf density (Speak et al., 2012), greater leaf wax (such as species like Betulla pendula), and broader leaf surfaces (Hwang et al., 2011; Dzierżanowski et al., 2011). Leaf surface roughness was not found to be significant to PM accumulation in a study by Saebo et al. (2012). They found that pine species were particularly efficient at capturing PM despite the lack of leaf hair or rough surface. Studies by Tiwary et al. (2009) and Tallis et al. (2011) also found pine foliage to rank the highest in terms of PM accumulation.

Using urban environmental acupuncture interventions to improve urban air quality can be effective over a range of horizontal and vertical spatial scales, but there are some limitations. It is helpful to consider interventions in terms of their scale and dimensions. "When horizontal length scales and aspect ratios are small, residence times are short and there is little opportunity for deposition to become effective. When aspect ratios are large, especially at large horizontal scales, it becomes physically impossible to manufacture the GI4AQ intervention. GI4AQ is effective where deposition can be enhanced by holding air for longer near vegetatio" (Hewitt, 2019).

Urban environmental acupuncture can be useful as a mitigation measure for air pollution. However, the design process of these spaces must take into account many factors and variables that, if not considered, may invalidate the effectiveness in reducing toxic substances in the urban context. For these reasons, we recall a diagram proposed by Hewitt (2020) with the aim of analysing the effectiveness of urban acupuncture interventions: some are useful for the provision of ecosystem services but don't have an effect on air quality, while other interventions also have an effect on air quality and fall into the GI4AQ family.

In the table below (Fig. 5.4), several examples of possible urban acupuncture interventions are reported. Some are effective because they help improve air quality (a bench closely surrounded by high hedges, an extensive green wall in a street canyon, a tunnel or canopy of dense vegetation offering protection to pedestrians, green cover, green tunnel, and green hedges) others are mainly useful for providing ecosystem services (vertical forests and green roofs).

Vertical forests have modest horizontal extent and very large aspect ratios but will be ineffective in improving air quality because they do not produce either a closed canopy or an open-top green oasis. In contrast, green walls in street canyons may make appreciable differences in ground-level concentrations (Pugh et al., 2012).

Green roofs have wide horizontal scales and a ratio H/W « 1, demonstrating low effectiveness in improving air quality. In fact, they enhance the deposition of pollutants from the atmosphere by increasing the available

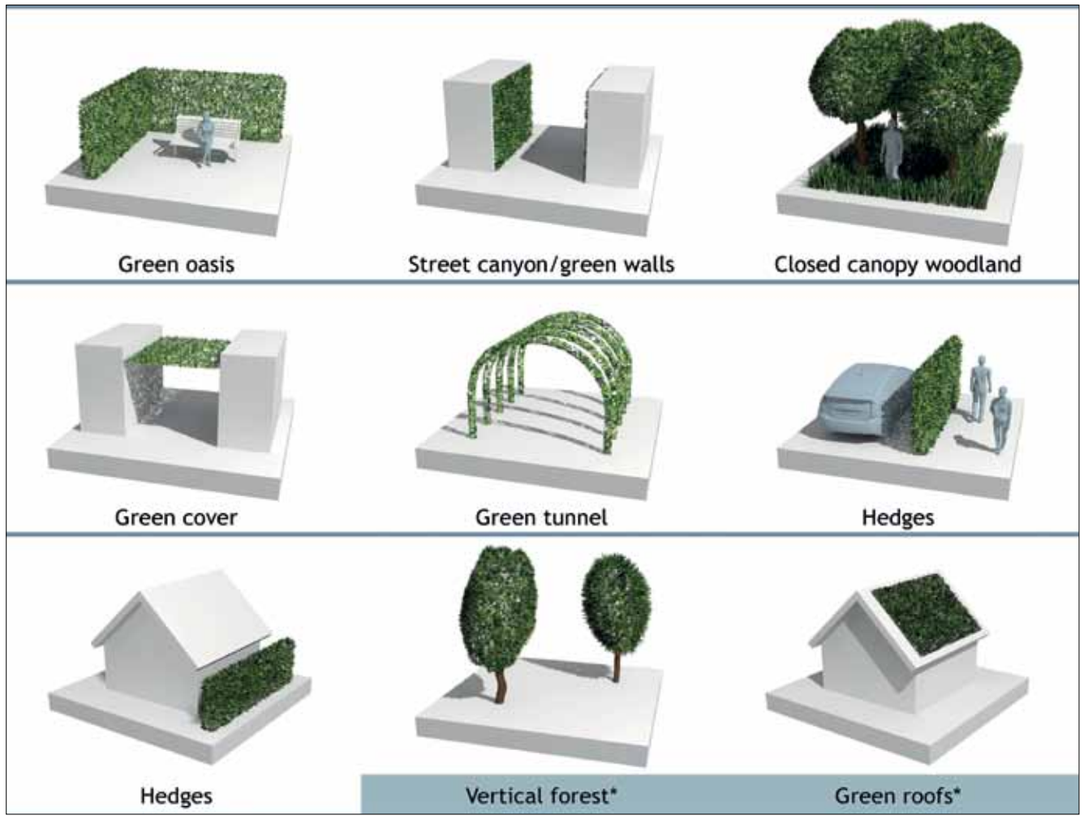


Figure 5.4 Some examples of urban environmental acupuncture interventions.

surface area but are unlikely to make an appreciable difference to ground-level pollutant concentrations since they act on the very large volume of air above the urban canopy (Pugh et al., 2012).

If we consider the effects of urban vegetation on particulate matter and gaseous pollutant concentrations, we find potential benefits of vegetation in changing dispersion and deposition processes but also possible problems. The planting of trees may enhance or reduce dispersion thus redistributing pollution but without removing it. Where vegetation acts as a barrier close to a source, concentrations immediately behind the barrier owing to that source can be reduced by a factor of about 2 compared to those which would occur without the barrier, whereas on the source side of the barrier concentrations are increased (Scottish Government, 2018).

Effects of vegetation in removing pollutants from urban air by deposition have been demonstrated in field measurements and using models. However, the magnitude of the reduction in concentration using trees, according to realistic planting schemes, is small and ranges from 2% to 10% for primary PM10. Conversely, for NO2, vegetation is not a very efficient sink, and as the deposition occurs in daytime, and primarily in the warmer months, there is little benefit for air quality (AQEG, 2019).

To help decision-making processes, Hewitt (2019) has formulated a flowchart that includes all necessary policy interventions to be considered to ensure the effectiveness of an intervention.

He envisages 6 types of intervention:

PI1	Carry out modelling (probably using computational fluid dynamics) to identify causes of reduced ventilation in streets with closed tree canopies where emission reductions have not been sufficient to achieve acceptable air quality. Modify canopy to increase street canyon ventilation accordingly
PI2	Introduce hedges (and other linear barriers) between traffic and pedestrians. Choose barrier height, porosity, and length to maximise benefits. This may require dispersion or computational fluid dynamics modelling
PI3	Provide long-term effective management of GI to ensure continuation and maximisation of the ecosystem service of enhanced pollutant deposition
PI4	Introduce and maximise areas of green walls in street canyons
PI5	Create “green oases”, i.e., slowly ventilated zones containing or surrounded by GI but with no internal pollution sources. Green oases may range in size from a bench closely surrounded by high hedges to a city park with a dense tree canopy
PI6	When planning to increase or change the urban tree population by more than 10% at the city-wide scale, assess the impact on ground-level ozone and choose low VOC-emitting tree species to minimise any increases in down-wind ozone pollution

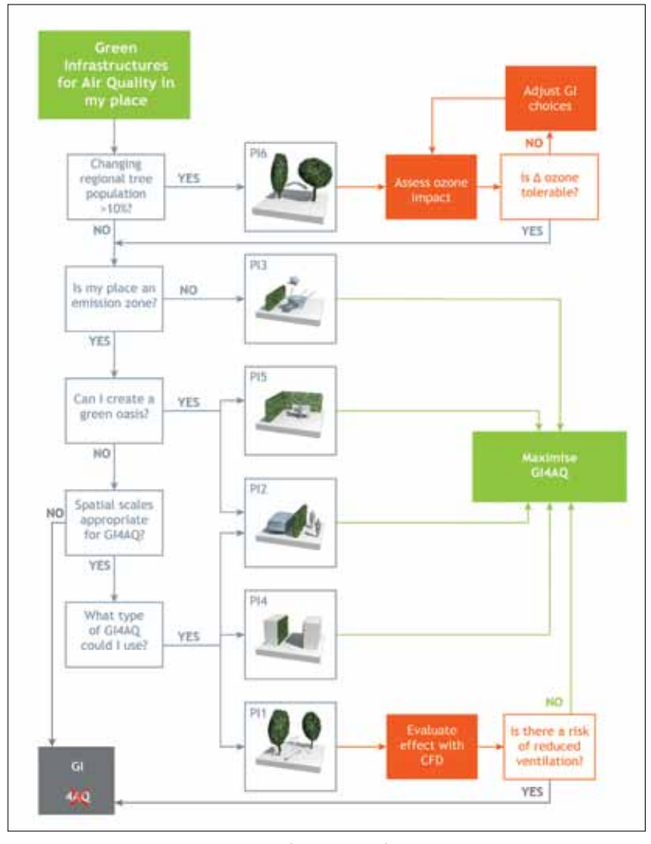


Figure 5.5 Flow chart to aid Green Infrastructure for Air Quality (GI4AQ) decision making.

In conclusion, we can say that urban environmental acupuncture can be useful as a mitigation measure for air pollution. However, the design process of these spaces must take into account many factors and variables that, if not considered, may not be effective in reducing toxic substances in the urban context. For these reasons we recall a diagram proposed by Hewitt (2020) with the aim of analysing the effectiveness of urban acupuncture interventions: some are useful for the provision of ecosystem services but don’t have any effect on air quality while other interventions also have an effect on air quality and fall into the GI4AQ family (Fig. 5.5).

Retrieved and adapted from Chris Churchman, Churchman Landscape Architects, “GI4AQ (Green Infrastructure for Air Quality): Does it all add up?”

Despite the complexities of modern cities, the conceptual framework outlined above, underpinned by research, allows us to provide guidance to policy makers on where and how GI can benefit urban

air quality. When proper consideration of context is made, there are clear and substantive opportunities to employ GI to improve air quality. The framework will also help practitioners and policy makers assess new research on GI and air quality as it becomes available. Properly designed and implemented Green Infrastructures may help cities meet several of the UN's Sustainable Development Goals, but poorly designed GI may be ineffective or even detrimental to urban air quality (Hewitt, 2019).

6. Improvement of social and cultural aspects of urban environmental acupuncture

Iva Tichá, Barbara Vojvodíková, IURS - Institute for Sustainable Development of Settlements

Urban environmental acupuncture applied through nature-based solutions provides several ecosystem services (Eggermont et al., 2015) and has several positive features described in the first chapters, which means positive social and cultural effects. These can often directly affect the lives and behavior of the population.

The authors of the chapter, when considering the social and cultural aspects, primarily identify with the ideas of Jan Gehl. That is why we quote this chapter with a quote from his book:

"… .. If the conditions for living outside are good, people engage in many necessary activities and the number of optional activities grows. Pedestrians are tempted to stop and enjoy the weather from the place and life in the city, or people go out and stay in the city, bring out chairs and children play outside…."
*(*Gehl, 2010)

Plesník and Plesníková (2018) state that greenery benefits physical and mental health. At the same time, we need to have greenery in our surroundings for several reasons: it improves air quality, reduces smog production, captures dust, shades sunlight, reduces noise and, in addition, beautifies the space. However deep research (James et al., 2015) on the impact of greenery in human settlements on the physical health of their inhabitants has yielded a number of other insights. James et al. (2015) found that the influence of greenery manifests itself differently in different sociodemographic groups of the population (women, children and youth, seniors) and in different socio-economic environments.

It may not be just large urban green areas that encourage walking, jogging, cycling, and other physical activities, to improve fitness and reduce obesity and the likelihood of heart arrhythmias, as reported (Lachowycz and Jones, 2011, De Jong et al., 2012, Mantler and Logan, 2015, Shanahan et al., 2016). van den Berg et al. (2015), Gascon et al. (2016) suggest that the presence and extent of green spaces reduces the mortality of urban residents, especially due to diseases of the respiratory and circulatory system and in the heat wave.

It has been repeatedly confirmed that parks, urban forests, gardens, green courtyards, and other green spaces in human settlements reduce stress, depression, and anxiety and sadness, and limit overly impulsive behaviour (Beyer et al., 2014, Reklaitiene et al., 2014, Pope et al., 2015), Urban green also improves sensory perception, memory, attention, ability to concentrate and logical thinking, even in hyperactive children, and accelerate the time of recovery from stress (Amoly et al., 2014, Lin et al., 2014, Markevych et al., 2014, Li and Sullivan, 2016).

6.1. Social aspects of UEA

Value of urban green spaces in promoting healthy living and wellbeing: prospects for planning. Risk Management and Healthcare Policy (2015:8 131–137) decrease, and at the same time facilitation of social contacts. At least the second and third also apply to small green points by Nature based solutions.

Urban green spaces affect the social determinants of health by providing a range of social and community benefits. Urban green spaces provide space for strengthening neighborhood relations, identification with the

community, strengthening the feeling of belonging to the surroundings of the residence and the feeling of satisfaction with the living environment. They help reduce social isolation, generate and increase social capital and personal psychological resilience and well-being (Lee et al., 2015).

6.1.2. Social and cultural aspects of the NBS

In this subchapter, we will try to name the individual effects of the function that the NBS may have if we use them in the UEA concept, i.e., small green points. Several authors (citations of individual publications below that deal with this issue focus on the social and cultural impacts of green infrastructure on nature and greenery in cities or on the NBS. However, it usually happens those larger areas as well as areas such as parks and urban meadows come to the fore. Despite this fact, we consider a few results to be interesting with the possibility of analogous application to small green spots. For the purposes of this publication, we will from time-to-time deviate from the strictly small greenspots of the urban structure without explicitly alerting the reader to this.

Cultural aspects of greenery and small green spots:

- recreational impacts,
- spiritual,
- religious,
- aesthetic,
- cultural heritage
- well-being,
- social interaction,
- safety advance.

Social aspects also include:

- duration,
- health,
- enhanced of equality, (da Rocha, 2017).

The recreational potential of the park with a workout playground and a running track is obvious. Nevertheless, recreational potential can also be attributed to the elements of the UEA (Fig.6.1 and 6.2).

… *"Recreation is a form of rest or leisure activity that is necessary for the existence and development of physical and mental energy. It provides a change of environment, monotonous work and way of life for the development of physical culture and often direct contact with nature."*

(Ústav územního rozvoje, 2021)

It follows from the above definition that sitting on the lawn, pocket park or green roof is also a popular form of recreation for residents in urban areas. In public hearings, city dwellers are often required to supplement those green areas with, for example, a place to barbecue, dog walking, a pentaquin court, and the like. Some NBSs can thus be complementary elements used for physical recreation, such as a disc golf playground.

Figure 6.1 Community Garden. Photo: B. Vojvodíková

Figure 6.2 Recreation on lawn. Photo: B. Vojvodíková

The spiritual or religious aspect is also significant. Spiritual values can be characterized as transcendental values, in that they are fundamental conceptions of the relationships of humans and nature (Kenter et al., 2015) The link between man and nature is reflected in the entire content of the NBS. It is a solution close to nature, and therefore this connection between man and nature is strengthened. In the works of philosophers, such as Charles Eisenstein, we can also follow the theme of ecospirituality. We can also see this connection in regarding the organic elements of architecture (Fig. 6.3).

Figure 6.3 Hundertwasser architecture in Vienna. Photo: B. Vojvodíková

Figure 6. 4 the alley in former cemitory. Photo: B. Vojvodíková

Religious aspects can be projected, both in primary connection with elements of nature, as places that motivate the inhabitants to calm and meditate. Typical small green areas of many cities are cemeteries or greenery surrounding churches. Historically, churches and cemeteries are often led by alleys that create a shadow or beautify the space in front of the church for the faithful (Fig 6.4). They also represent an aesthetic function. Even though the aesthetic property of the NBS is ranked in most evaluations, it is only for functions such as providing shadow or improving seepage.

There are also studies which, on the contrary, underline and state the aesthetic function as necessary for the success of the whole application. This analysis provides a total of seven lessons that must be respected if we want to be successful in the NBS application. As these are especially useful lessons, they are quoted verbatim in this text.

"From a cross-case comparative analysis we draw seven overarching lessons related to all stages of proof-of-concept and implementation of nature-based solutions in cities: (a) nature-based solutions need to be aesthetically appealing to citizens, (b) nature-based solutions create new green urban commons, (c) experimenting with nature-based solutions requires trust in the local government and in experimentation process itself, (d) co-creation of nature-based solutions requires diversity and learning from social innovation, (e) nature-based solutions require collaborative governance, (f) an inclusive narrative of mission for nature-based solutions can enable integration to many urban agendas and (g) design nature-based solutions so as to learn and replicate them on the long-term."
(Frantzeskaki, 2019)

Involving the public in deciding what the individual green spaces in the space will look like also ensures the satisfaction of residents with their appearance and aesthetic function. Finding a compromise from an aesthetic point of view is difficult. Small green areas can be suitably complemented by water features, play areas for children, and seating. For the NBS to permanently fulfil its aesthetic role, it is necessary to maintain the individual green points well, which is usually the task of municipalities.

The relationship between the NBS and cultural heritage is often mentioned in connection with mitigation measures and thus the protection of cultural heritage (Kabisch et al., 2016). Small green areas are an integral part of several historic sites, which complement them appropriately, providing, among other things, a long-term and sustainable example of good practice. In the aesthetic area of green dots, it is necessary to modify and maintain these areas, which are widely used by tourists, especially in the summer months.

The NBS, which is usually positively received by the general public, are community gardens, which are becoming an increasingly widespread urban phenomenon (Spilková, 2017). The term "community garden" encompasses a wide range of schemes and forms and cannot be defined simply and unambiguously, but a broad concept makes it possible to include many types of civic activities, types of ownership, organization, and democratic control (Ferris et al., 2001). What a community garden specifically refers to is purely up to their members, needs, visions, space, and conditions available in the locality (Firth et al., 2011). Community gardens are collectively managed gardens, they cultivate land in cities by growing plants and positive interpersonal relationships.

Wellbeing is often referred to in connection with Human health. The analysis shows that people's proximity to the natural environment is associated with less stress, faster recovery from psychological events, improved air quality, reduced heat, and increased levels of physical activity. From the point of view of perception and feelings, it does not have to be just mental problems or discomfort, but green areas have a positive effect in several other situations. Therefore, the NBS can contribute to a significant reduction in depression or restlessness based on the urban way of life and provide alternative ways of overcoming the negative effects on health (Kolokotsa et al., 2020).

As already mentioned, many elements of the NBS create opportunities for social interaction, support children's games, improve the sense of community and at the same time be a meeting place for residents. In general, greenery has a good effect on children's development, enabling children to understand and strengthen their relationship with nature, even though they live in cities. Children often do not need much space for their games, so this influence can also be assigned to individual NBSs.

For the creation of urban greenery, including the NBS, there is participation and integration into decision-making processes, transparency, equality between women and men, a sense of collective cooperation (da Rocha, 2017). At the same time, the NBS can often have a positive effect on civil society, especially neighborly relations and the creation of human (social) capital, and expand the secondary ties of the population.

Small green spaces can be created through the use of participatory tools, and residents can comment on them and select the appropriate element based on their own priorities. If the involvement of citizens and their participation in the proposals is underestimated, it may be rejected by the community during the construction of the NBS. We may encounter the NIMBY syndrome "Not in my backyard", meaning opposition to the implementation of the specific task of investment in each location despite general approval for the overall project (Beben, 2015). An example of the NBS is, for example, urban meadow. Improving biodiversity in low-cut urban meadows is also addressed, for example by (Norton et al., 2019). According to Southon et al., (2017), urban meadows,

once established, are perceived positively, but Southon et al., (2017) also admits that the positive impact on biodiversity needs to be explained to respondents. Residents are worried about insects, afraid of bees, ticks and pollen allergies. Places with an urban meadow created for them are not places of rest and recreation, but places where they do not enter, and which annoy them, and which they definitely do not want in places where they go for recreation with their children, and do not want to have them near their place of residence.

Another aspect that needs a deeper discussion is the concept of security. Feel the danger or threat they perceive when placing some elements of the NBS in the city space.

The relationship between the city's greenery and the feeling of security is not a new phenomenon (Kupka, 2010). Feeling of security appears in theories in the field of human needs. The most famous one is Maslow's hierarchy of needs (Maslow, 1943). At the top of the pyramid, needs of self-fulfillment can be found. This leads to interpretation (Maslow, 1954) that the feeling of safety and security is particularly important for the population, some preliminary surveys found out that some of the NBS cause residents to feel insecure.

Therefore, a survey among the population was carried out within the Salute4CE project. Research has confirmed that places that allow potential shelter of a perpetrator and limited visibility or escape on the are perceived as dangerous (Fisher and Nasar, 1992). Large shrubs, hedge / hedgerow, Urban wilderness can be considered such elements. The result therefore corresponds to the assumptions. Negative feelings from Urban wilderness are also confirmed by Mathey et al., (2016).

6.2. Urban green commons and application of NBS

To achieve the acceptance of the proposed elements by the population, it is appropriate to use the application of urban green commons (UGC).

UGCs offer a space for managing cultural diversity, promoting cultural integration; Therefore, to reduce potential social inconsistencies and conflicts in cities, UGCs provide active land management systems for a larger population of cities, important for building socio-environmental resilience.

UGCs for larger sites than the UEA may also have the dampening effects of social upheavals or development problems. UGCs support the ability to build capacity for learning and adaptation in the urban environment, e.g., by building cognitive resilience. An urban green community could be better designed in areas where people live and work. For example, UGCs may include residents in multi-family apartment buildings who have rights to manage the land where they live, although land ownership may be municipal or private (Colding et al., 2020).

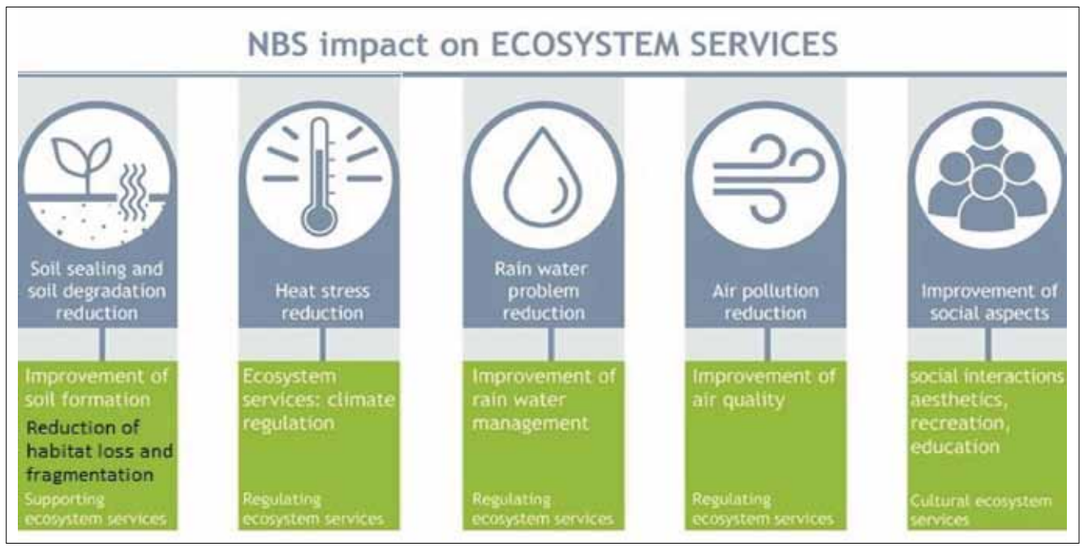
To reduce the Nimby syndrome, it is necessary to harmonize the educational function with the concept of public involvement in the creation of the NBS.

7. Characteristics of Nature Based Solutions and their impact on urban environment

This chapter is focused on the practical information about Nature based solutions (NBS) in Urban environmental acupuncture. Definition of the NBS according to the European Union Committee is: "Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits, and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions." A total of thirty NBS suitable for Urban Environmental Acupuncture were identified in this handbook.

In addition to a brief general description, each of the NBS is presented in terms of its function, such as the main ecosystem services provided and potential problems. The chapter will also contain tools for choosing appropriate individual solutions (in tables on the end of this chapter).

List of Nature Based Solutions					
No.	*NBS name*	No.	*NBS name*	No.	*NBS name*
1.	Urban meadows	11.	Road-side swales for retention and infiltration	21.	Green facades with climbing plants
2.	Verges / flower beds with native perennials	12.	Linear wetlands for stormwater filtration	22.	Wall-mounted living walls
3.	Ground cover plants	13.	Natural pollinators' modules	23.	Hydroponic mobile living walls/vertical gardens
4.	Lawn	14.	Hedge/hedgerow	24.	Vertical vegetable/herb gardens
5.	Green pavements	15.	Rockery	25.	Hanging wall planters (as green street furniture)
6.	Street trees	16.	Herb spiral	26.	Compacted pollinators' module
7.	Park trees	17.	Urban wilderness/succession area	27.	Rain gardens in planter (=self-contained)
8.	Fruit trees/ Fruit shrubs	18.	Ground crops of vegetables / herbs	28.	Street planters (as green street furniture)
9.	Large shrubs	19.	VRSS slopes with green fences	29.	Green covering shelters
10.	Rain gardens (under-drained)	20.	Green pergolas/green arbours	30.	Green roof/roof terrace



7.1. Descriptions of NBS

7.1.1. URBAN MEADOWS

Juliane Mathey, IOER – Leibniz Institute of Ecological Urban and Regional Development

Meadows are habitats, vegetated by grass, herbs, and other non-woody plants (Fig. 7.1.1.1, Fig. 7.1.1.2). They are ‘semi-natural grasslands’, meaning that they are largely composed of species native to the region, with only limited human intervention. Urban meadows are mostly maintained by humans (production of hay, fodder, and livestock). They attract a multitude of wildlife and support flora and fauna. They provide areas for courtship displays, nesting, food gathering, pollinating insects, and sometimes shelter, if the vegetation is high enough, making them ecologically important. There are multiple types of meadows, such as dry grassland, semi-arid grassland, and wet meadows (Jedicke and Jedicke, 1992, Wikipedia, 2021a).

Figure 7.1.1.1 Urban meadow in the city centre of Dresden (Germany). Photo: P. Wirth

Figure 7.1.1.2 Urban meadow near an apartment house in Dresden (Germany). Photo: R. Bendner

Meadows are perennial plant communities in which numerous herbs and grasses have sufficient time to complete their development to seed ripeness before they are mowed. Their growth (species, height, and density) can be regulated by cutting frequency and timing (Wolf, 1992). The typically species-rich plant communities provide habitats for a large number of animals (e.g., insects, but also vertebrates like mice and ground-nesting birds). Compared to conventional lawns, meadow maintenance is not very costly. Neither fertilization nor sprays are necessary, one to three cuts per year are sufficient. The composition of the plant cover depends strongly on the nutrient richness of the soil. The poorer the nutrients, the richer the flora (Jedicke and Jedicke, 1992). It should be kept in mind that flower meadows cannot be continuously trodden on making them unsuitable as playgrounds or sports fields, however they can contribute to aesthetical value.

The main ecosystem services provided by urban meadows are urban temperature regulation, nature-based recreation, water flow regulation and runoff mitigation, habitat services (preventing loss of biodiversity) and insect pollination. Possible challenges are climate change adaptation, loss of biodiversity, water management, potential of economic opportunities and green jobs, urban regeneration, public health and well-being, green space management, moreover increased number of pollinator species, increased connectivity to existing green and blue infrastructure.

7.1.2. VERGES / FLOWER BEDS WITH NATIVE PERENNIALS

Leszek Trząski, Katarzyna Galej-Ciwiś, Silesian Botanical Garden and Polish Academy of Sciences Botanical Garden Center for Biological Diversity Conservation in Powsin

The aim of this NBS is to produce long-term, self-sustaining landscape through use of native plant species grown from indigenous seed sources. This is one of the best methods for increasing biodiversity in cities through creation animal’s habitat — areas where it finds food, water, shelter, breeding and nesting space.

Figure 7.1.2.1 Flower beds with native perennials. Photo: K. Galej-Ciwiś

Maintained verge gardens (in front of the house) also increase the liveability of residential areas. For many people living in the city or commuting to work by road every day, verges can be their only daily contact with nature. There are various methods of implementing semi-natural grassland treatments. Methods include natural re-colonisation, translocation of sod, turve, and plugs, and direct intervention/implementation through hay-strewing or seeding. Autumn cut-and-removal is the perfect management for an established wildflower verge. It mimics the management of traditional hay meadows where the vegetation is cut in the late summer and then removed.

Main ecosystem services provided by verges / flower beds with native perennials (Fig. 7.1.2.1, Fig. 7.1.2.2, Fig. 7.1.2.3) are water flow regulation and runoff mitigation, habitat services – stopping loss of biodiversity and insect pollination. Possible challenges are loss of biodiversity, potential of economic opportunities and green jobs, and urban regeneration.

Figure 7.1.2.2 Flower beds with native perennials. Photo: K. Galej-Ciwiś

Figure 7.1.2.3 Flower beds with native perennials. Photo: K. Galej-Ciwiś

7.1.3. GROUND COVER PLANTS

Leszek Trząski, Katarzyna Galej-Ciwiś, Silesian Botanical Garden and Polish Academy of Sciences Botanical Garden Center for Biological Diversity Conservation in Powsin

Ground covers can be used to prevent soil erosion, as a design element, or where grass is not practical. Such species are good choice for areas where watering and mowing are difficult or that are unsuitable for grass: narrow strips between sidewalks and curbs or buildings; steep slopes (impractical to mow); hot, dry areas along south and west exposures of walls or fences; deeply shaded areas beneath trees or shrubs, and along north sides of walls and fences. It is necessary to take into account the presence of pedestrian paths at the design stage, because most ground covers will not tolerate excessive foot traffic. Randomly mixed perennial planting can be an interesting alternative for monotonous ground cover monoplantings (the link for more details is in the technical information section).

Ground cover plants (Fig. 7.1.3.1) are low-growing and spread easily, and they should be dense enough to inhibit weed emergence. Good choices for ground covers are species that produce rhizomes, stolons, or those that spread by offsets or tip layering. They provide a variety of textures and colour, and also help link together ornamental plants.

Main ecosystem services provided by ground cover plants are climate regulation by reduction of CO^2, water flow regulation and runoff mitigation, and insect pollination. A possible challenge is water management.

Figure 7.1.3.1 Groun cover palts. Photo: K. Galej-Ciwiś

7.1.4. LAWN

Leszek Trząski, Katarzyna Galej-Ciwiś, Silesian Botanical Garden and Polish Academy of Sciences Botanical Garden Center for Biological Diversity Conservation in Powsin

There are three types of lawns depending on the amount of work required to maintain it: high-maintenance lawns - lush, watered throughout the summer, and weed free; medium-maintenance - have some weeds, may be allowed to go dormant during the summer; low-maintenance - receive no fertilizer, are mowed infrequently, a lot of weeds. The amount of money and time spent will determine the quality of the lawn. Based on climatic requirements, lawns are classified into two categories — cool season (thrive at a temperature between 10°C and 25°C) and summer season grasses (25°C and 35°C).

Lawns (Fig. 7.1.4.1) provide the carpet upon which other plants are located and act as a unifying feature in the landscape. It is a natural green carpet and leads to unity in garden design. Lawns serve as play areas, pathways and gathering spaces. They are developed for aesthetic pleasure, as well as for other outdoor recreational purpose. Thick grass prevents soil erosion, filters contaminants from rainwater, and absorbs airborne pollutants.

Main ecosystem services provided by a lawn are nature-based recreation, water flow regulation and runoff mitigation. Possible challenges are water management, potential of economic opportunities and green jobs, and public health and well-being

Figure 7.1.4.1 Lawn. Photo: K. Galej-Ciwiś

7.1.5. GREEN GRASS PAVEMENTS

Jiří Kupka, Adéla Brázdová, IURS - Institute for Sustainable Development of Settlements

Green grass pavement is a permeable and porous pavement, allows rainwater absorption instead of repellence. Green pavement often means pavement built from recycled materials (Fig. 7.1.5.1).

Green grass pavement allows absorbing rainwater absorption and storage. This solution helping to cooling down the temperature of urban areas because of their subsequent evaporation. This type of pavement also significantly increases the attractiveness to users. It means that residents can live and enjoy recreation safely and comfortably. Thanks to rainwater retention and sunlight, we can expect growing grass in places with high density. Green pavements have other benefits as modular dimensions, low maintenance, budget-friendliness, and are suitable for light, vehicular traffic.

Main ecosystem services provided by green grass pavements are regulation of air quality (mainly by urban trees, forests, shrubs), urban temperature regulation and water flow regulation and runoff mitigation. Possible challenges are water management, urban regeneration, and climate change mitigation and adaptation.

Figure 7.1.5.1 green grass pavement. Photo: B. Vojvodíková

7.1.6. STREET TREES

Jiří Kupka, Adéla Brázdová, IURS - Institute for Sustainable Development of Settlements

A street tree is any tree that is growing in an urban area right-of-way, whether between the sidewalk and the curb or in an unimproved right-of-way (Fig. 7.1.6.1).

Figure 7.1.6.1 Street trees. Photo: B. Vojvodíková

Street trees mitigate the effects of urban heat island through evapotranspiration and the shading of streets and buildings. Street trees improve air quality by absorbing pollutants e.g., nitrogen dioxide, ammonia, and particulate matter. Other benefits include noise control, traffic control, and glare control. This all improves human comfort as well.

Main ecosystem services provided by street trees are regulation of air quality (mainly by urban trees, forests, shrubs), urban temperature regulation, and climate regulation by reduction of CO^2. Possible challenges are climate change mitigation and adaptation, air quality, and public health and well-being.

Figure 7.1.6.2 Street trees. Photo: B. Vojvodíková

7.1.7. PARK TREES

Anna Starzewska- Sikorska, IETU - The Institute for Ecology of Industrial Areas

Trees absorb carbon dioxide as they grow, and the carbon that they store in their wood helps slow the rate of global warming. They reduce wind speeds and cool the air as they lose moisture and reflect heat upwards from their leaves. It's estimated that trees can reduce the temperature in a city by up to 7°C. Trees also help prevent flooding and soil erosion, absorbing thousands of litres of stormwater. Trees host complex microhabitats, and offer habitation and food to communities of birds, insects, lichen, and fungi. Their trunks also provide the hollow cover needed by species such as bats, woodboring beetles, tawny owls, and woodpeckers.

Urban parks with trees can be used as an educational resource and to bring groups together for activities like walking and birdwatching. (Fig. 7.1.7.1) Park trees, especially in urban areas, act as a physical filter, trapping dust and absorbing pollutants from the air. Each individual tree removes up to 1.7 kilograms every year. They also provide shade from solar radiation and reduce noise.

The main ecosystem services provided by park trees are regulation of air quality (mainly by urban trees, forests, shrubs), urban temperature regulation, and climate regulation by reduction of CO^2. Possible challenges are climate change mitigation and adaptation, air quality, urban regeneration, public health and well-being.

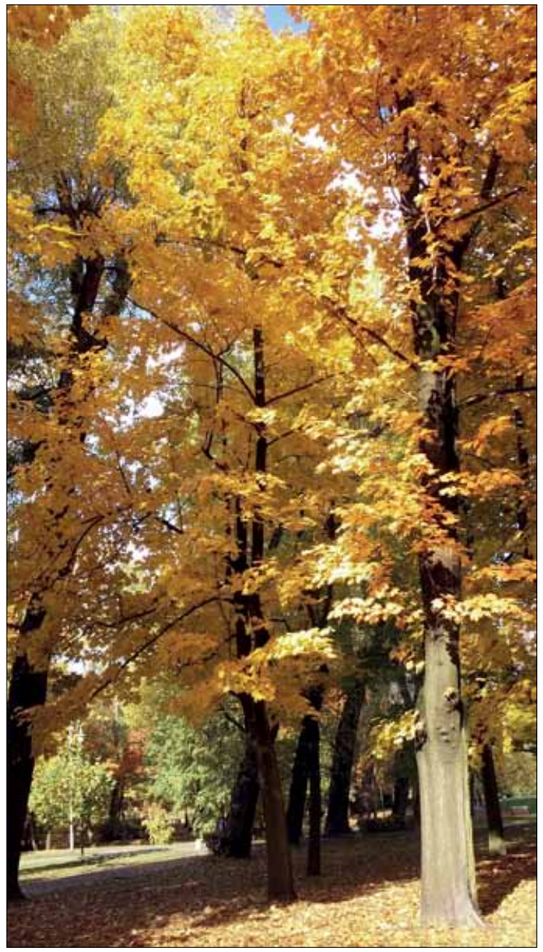


Figure 7.1.7.1 Park trees in Katowice. Photo: J.Gorgoń

7.1.8. FRUIT TREES, FRUIT SHRUBS

Juliane Mathey, Jessica Hemingway, IOER – Leibniz Institute of Ecological Urban and Regional Development

Fruit trees or fruit shrubs bear fruits that are consumed or used by humans and some animals (Fig. 7.1.8.1, Fig. 7.1.8.2). All trees that are flowering plants produce fruit — the ripened ovaries of flowers containing one or more seeds. In horticultural usage, the term 'fruit tree' is limited to those that provide fruit for human food (Wikipedia, 2021b).

Figure 7.1.8.1 Plum tree in spring. Photo: R. Bendner.

Figure 7.1.8.2 Redcurrant bush in summer. Photo: R. Bendner.

Traditional fruit tree orchards (with mixed fruit trees, in German: Streuobstwiesen) are particularly diverse in species. Fruit trees and fruit shrubs are good habitats for wildlife. Features such as hollow trunks, rot holes, dead wood, and sap runs, are important for over 400 species of saproxylic invertebrates that live on decaying wood. Fruit tree blossom is an important source of nectar for pollinating insects including bees, hoverflies and butterflies. Orchards also feed and provide homes to numerous birds and various mammals (e.g., bats, squirrels, hedgehogs, voles) (The Orchard Project 2021a). Additionally, they provide a range of ecosystem services to humans (e.g., oxygen, shade and windbreak, reduce noise, aesthetical functions, social services) (The Orchard Project, 2021b).

Main ecosystem services provided by fruit trees or fruit shrubs are regulation of air quality, urban temperature regulation, nature-based recreation, climate regulation by reduction of CO_2, habitat services (stopping loss of biodiversity), insect pollination and nature-based education. Possible challenges are climate change mitigation and adaptation, loss of biodiversity, air quality, potential of economic opportunities and green jobs (e.g., maintenance of trees, fruit harvesting), social justice and social cohesion, and public health and well-being.

7.1.9. LARGE SHRUBS

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Shrubs can be categorized based on foliage: dense foliage (between 70% and 100% foliage coverage); mid-dense foliage (with only 30% to 70% foliage coverage); sparse foliage: (only 10% to 30% foliage coverage, as those in Australia); very sparse foliage (those with less than 10% foliage coverage, typically found in desert climates). Thanks to their size, large shrubs have a marked vocation to appear as single or isolated specimens, especially in case of species with flowers or more commonly with particularly ornamental leaves.

These plants are used to create vegetable barriers or screens, an effect that can be achieved by placing them in rows. Shrubs are plants that have several woody stems. Large-sized shrubs are typically till 6-8 meters in height, and play important roles in urban areas because of their dense foliage relatively close to the ground. The foliage provides dark shade and cool moist conditions at soil level, cover for both wildlife habitat and movement and visual screening for people (Fig. 7.1.9.1, Fig. 7.1.9.2).

Figure 7.1.9.1 Large shrubs. Photo: B. Vojvodíková

Figure 7.1.9.2 Large shrubs. Photo: B. Vojvodíková

The main ecosystem services provided by large shrubs are regulation of air quality (mainly by urban trees, forests, shrubs), urban temperature regulation, and insect pollination. Possible challenges are regulation of air quality (mainly by urban trees, forests, shrubs), urban temperature regulation, and insect pollination.

7.1.10. RAIN GARDENS (UNDER-DRAINED)

Anna Starzewska- Sikorska, IETU - The Institute for Ecology of Industrial Areas

A rain garden is a garden of native shrubs, perennials, and flowers planted in a small depression, generally formed on a natural slope. It is designed to temporarily hold and soak in rainwater runoff that flows from roofs, driveways, patios, and lawns. Rain gardens are effective in removing up to 90% of nutrients and chemicals, and up to 80% of sediments from the rainwater runoff (Fig. 7.1.10.1, Fig. 7.1.10.2).

Under-drained rain gardens are designed to drain within 2 hours of the design storm event. This is achieved through the use of highly porous planting media and underdrains, which carry the cleaned rainwater away from the garden. Shallow basins are filled with porous soil mixture and covered with native vegetation capable of phytoremediation, designed for retention, treatment and infiltration of stormwater.

The main ecosystem services provided by under drained rain gardens are water flow regulation and runoff mitigation, habitat services (stopping loss of biodiversity) and insect pollination. Possible challenges are climate change mitigation and adaptation, water management and urban regeneration.

Figure 7.1.10.1 Rain garden. Photo: A. Starzewska

Figure. 7.1.10.2 Rain garden. Photo: A. Starzewska

7.1.11. ROAD-SIDE SWALES FOR RETENTION AND INFILTRATION

Jiří Kupka, Adéla Brázdová, IURS - Institute for Sustainable Development of Settlements

Road-side swales can be an important tool for retention and detention of stormwater runoff (Fig. 7.1.11.1) Depending on design and construction, swales may provide additional benefits, including cleaner air, carbon sequestration, improved biological habitat, and aesthetic value.

Figure 7.1.11.1 Road side swales. Photo: I. Tichá

Road-side swales work based on physical, physicochemical, and biological processes. Sedimentation is a fundamental physical process that helps remove primary runoff pollutants (sediment and particulate-bound heavy metals and nutrients). Infiltration is the physical process of entry and downward movement of rainfall, other precipitation, and runoff into soil and filtration removes sediment and particle-bound pollutants and is defined by physical straining through natural vegetation. Sorption is a chemical process necessary to treat dissolved pollutants because they exist in both particulate (particle-bound) and dissolved forms. Biological processes involve plants, algae, and microbes in pollutant removal.

Main ecosystem services provided by road-side swales are water flow regulation and runoff mitigation, regulation of air quality (mainly by urban trees, forests, shrubs), and climate regulation by reduction of CO^2. Possible challenges are water management, climate change mitigation and adaptation and air quality.

7.1.12. LINEAR WETLANDS FOR STORMWATER FILTRATION

Jacek Krzyżak, IETU - The Institute for Ecology of Industrial Areas

Shallow, linear basins with impervious bottoms, filled with a porous soil/gravel mixture and covered with native vegetation with phytoremediation features. Designed for treatment and filtration of stormwater through surface and subsurface flow. The Linear wetlands harnesses some of the same biological processes found in natural wetlands in order to collect, transform, and remove even the most harmful pollutants. The Linear wetlands for stormwater filtration utilize multi-stage treatment processes, including a pre-treatment chamber that houses a settling basin and media cartridge pre-filters that are designed to remove coarse to fine sediment and hydrocarbons from entering the subsequent wetland chamber. The wetland chamber media provides chemical and biological filtration and secondary physical filtration. This system is housed in a modular precast concrete structure that can be designed in many inlet configurations. The Linear wetlands provide water quality treatment of captured flows through the processes of separation, sedimentation, filtration, adsorption, absorption, sequestration, volatilization, ion exchange, biological remediation, and uptake. Stormwater filtration systems provide water quality treatment of captured flows through several physical, biological, and chemical unit processes.

Linear Wetlands harnesses some of the same biological processes found in natural wetlands in order to collect, transform, and remove even the most harmful pollutants. Linear wetlands re-establish nature's presence and rejuvenate waterways in urban areas.

Main ecosystem services provided by Linear wetlands for stormwater filtration are regulation of air quality, urban temperature regulation, nature-based recreation, climate regulation by reduction of CO^2, habitat services – stopping loss of biodiversity, nature-based education. Possible challenges are climate change mitigation and adaptation, water management, potential of economic opportunities and green jobs, urban regeneration, social justice and social cohesion, participatory planning and governance, public health and well-being.

7.1.13. NATURAL POLLINATOR MODULES

Jacek Krzyżak, IETU - The Institute for Ecology of Industrial Areas

Terrestrial micro-habitat (10-20 m2), which will attract pollinators and other animals by availability food and weather conditions (colder areas in hot periods and refuge in winter) and consisting of plants, water source, housing (for example, pollinators hotels and balcony garden. for biodiversity (pollinators, birds, other insects, etc.). These pollinator-nesting blocks (also called pollinator houses, bee houses or bee hotels) will support biodiversity by creating wildlife-friendly spots or areas and contribute to preserve and enhance the local biodiversity. Additionally, these modules could include some site furnishing as street seats, drinking water fountains, or some elements to create shadow areas as trees or shadow pergolas with plants.

It could include a rain garden (see factsheet) that contributes to the management of water, as it is a bioretention shallow basin designed to collect, store, filter and treat water runoff. An irrigation system could be installed to supply needs if necessary. The distance between spaces will depend on: Urban spacer characteristics, the presence of trees, bush lines, space availability etc. This solution is completed with Compacted Pollinator modules, which are helpful to connected urban green areas. These green spaces will be attractive to pollinators and other animal species e.g., birds and small reptiles, and thus will have functions of home and will increase the level of citizen-awareness. This is installed in order cultivation new habitats in urban spaces, attract and increase the number of pollinator species and other insects.

Main ecosystem services provided by natural pollinator's modules are regulation of air quality, urban temperature regulation, nature-based recreation, climate regulation by reduction of CO^2, water flow regulation and runoff mitigation, biodiversity, insect pollination, nature-based education. Possible challenges are green space management, air quality, water management, moreover - perceptions of connectivity and mobility, pollinator species increase (number), increased connectivity to existing GI.

7.1.14. HEDGES/HEDGEROWS

Anna Starzewska- Sikorska, IETU - The Institute for Ecology of Industrial Areas

Living hedges of native shrubs may take different forms. A traditional garden hedge is often just one species. Also, there are several petite native shrubs that can create beautiful hedges for smaller spaces. For larger areas, there are many ways you can group together different species to create a dynamic hedgerow with multiple wildlife benefits. This linking of habitats would be a huge boost to plant and animal diversity. It would also provide ecosystem resiliency, support animal and plant migration, and enable fauna and flora populations to shift with our warming climate (Fig. 7.1.14.1).

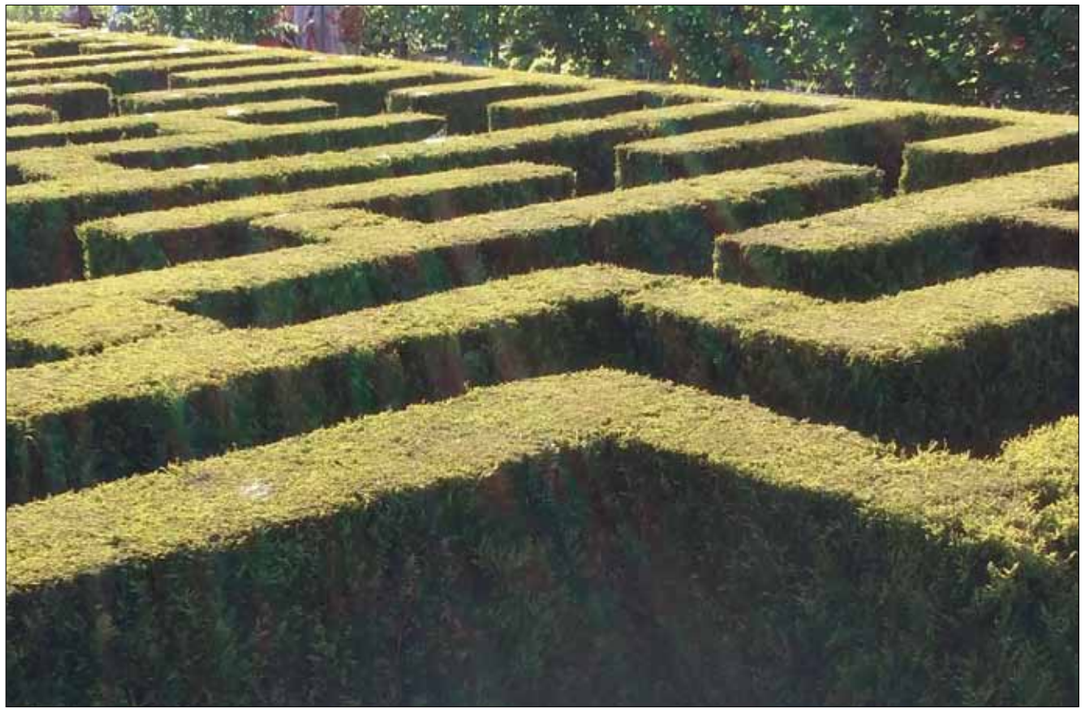

Figure 7.1.14.1 Hedgerows in Pszczyna. Photo: J. Gorgoń

A hedgerow is a line of different types of bushes and small trees growing very close together, especially between fields or along the sides of roads. Hedgerows are important for a wide range of species, providing nesting sites and food for birds, insects, and small mammals, whilst also acting as wildlife corridors, connecting otherwise isolated habitats.

Main ecosystem services provided by hedges or hedgerows are regulation of air quality (mainly by urban trees, forests, shrubs), noise mitigated by urban vegetation, and urban temperature regulation. Possible challenges are climate change mitigation and adaptation, air quality, and urban regeneration.

7.1.15. ROCKERY

Leszek Trząski, Katarzyna Galej-Ciwiś, Silesian Botanical Garden and Polish Academy of Sciences Botanical Garden Center for Biological Diversity Conservation in Powsin

A rock garden is an integrated combination of rocks and plants selected to enhance cultural and aesthetic quality of the garden. The ideal location for a rock garden is a natural slope or terrace. An effective rock garden should have several large rocks, some weighing more than 90 kilograms, but the size of the rocks should be in proportion to the size of the rockery. There are two main rockery categories – formal (architectural) and informal (naturalistic). Dry walls and paving stones inhabited by plants are an example of formal rockery, and serve utilitarian purposes. Naturalistic rock gardens are more popular, can have a very interesting form, e.g., outcrop, moraine, and scree or boulder field (Fig. 7.1.15.1, Fig. 7.1.15.2).

This style of gardening focuses on creating an ideal growing site for alpine species. Plants need to be relatively low growing and have a growth habit that complements the natural effect of the rocks. When laying rocks and stones, it is necessary to leave free spaces of different sizes, which are then covered by the ground. It is necessary to provide good drainage because most plants suitable for rock gardens require a well-drained soil.

Figure 7.1.15.1 Rockery. Photo: K. Galej-Ciwiś

Main ecosystem services provided by rockery are habitat services – stopping loss of biodiversity and insect pollination. Possible challenges are loss of biodiversity, potential of economic opportunities and green jobs, and social justice and social cohesion.

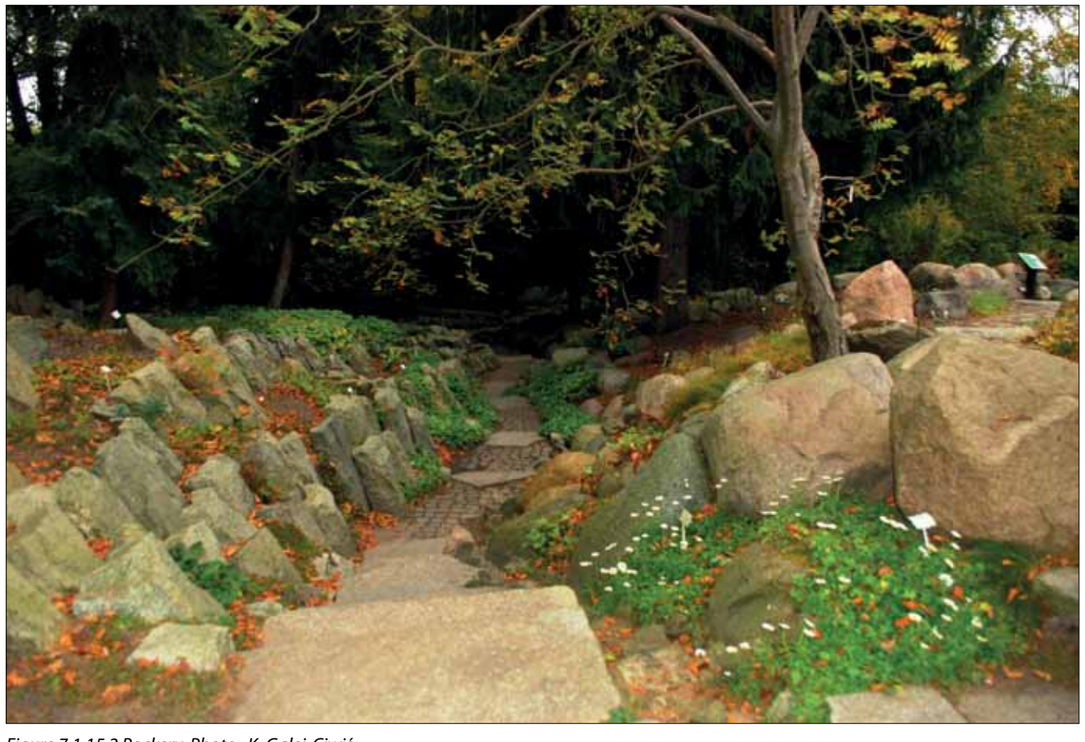

Figure 7.1.15.2 Rockery. Photo: K. Galej-Ciwiś

7.1.16. HERB SPIRAL

Leszek Trząski, Katarzyna Galej-Ciwiś, Silesian Botanical Garden and Polish Academy of Sciences Botanical Garden Center for Biological Diversity Conservation in Powsin

Herbal spiral is a structure typically measuring 1-2 meters wide at the diameter, spiralling up to a height of 1-1.5 meters. There is a planting path running up it. To increase biodiversity, there is also potential to create a small pond or bog at the base of the spiral. Almost all building materials can be used to construct it: stones, bricks, wooden stakes, even scrap tyres and bottles. In the vertical section, the spiral should consist of a layer of small rocks, gravel, sand, and compost on the top (layers create the drainage preferred by most herbs). It is possible to use multiple spirals to create a more complex design (Fig. 7.1.16.1).

Making use of both vertical and horizontal space, and by the circle shape of herbal spiral, allows maximum use of small area. It offers both sun and shaded positions for plants, gravity drainage from top to bottom, and creates good conditions for dry plants on top and moisture-loving plants at the bottom.

Main ecosystem services provided by rockery are habitat services – stopping loss of biodiversity, insect pollination and nature-based education. Possible challenges are loss of biodiversity, social justice and social cohesion, and public health and well-being.

Figure 7.1.16.1 Herb spiral. Photo: K. Galej-Ciwiś

7.1.17. URBAN WILDERNESS / SUCCESSION AREA

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The concept of urban wilderness feels like a paradox since natural and urban environments have long been viewed as antithetical. However, the concept of urban wilderness answers different challenges: supporting biodiversity in cities, facilitating human experiences of nature, and management of wild areas that are developing in cities after post-industrial transformation. Yet there is confusion between the definition of wilderness and how man can interact in it. A unifying framework envisions urban wilderness as a social-ecological system (Kowarik, 2011).

Urban wilderness areas are tracts of cities that evolve without human interference. IUCN defines a wilderness area as follows: “protected areas that are usually large, unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition”. Succession areas consist in restoring nature (greenery and wildlife) in cities. Restoring greenery is particularly beneficial in cities, as it contributes to create an urban ecosystem.

Figure 7.1.17.1 Urban wilderness. Photo: B. Vojvodíková

The main ecosystem services provided by urban wilderness / succession areas are regulation of air quality (mainly by urban trees, forests, shrubs), nature-based recreation, and climate regulation by reduction of CO_2. Possible challenges are loss of biodiversity, air quality, and public health and well-being.

Figure 7.1.17.2 Urban wilderness. Photo: B. Vojvodíková

7.1.18. GROUND CROPS OF VEGETABLES/HERBS

Juliane Mathey, Jessica Hemingway, IOER – Leibniz Institute of Ecological Urban and Regional Development

Ground crops of vegetables or herbs are defined as a small garden constructed for soil cultivation (patches, containers) of vegetables or herbs (Fig. 7.1.18.1, Fig. 7.1.18.2). Vegetable farming is the growing of vegetables for human consumption. Ground crops of vegetables or herbs can be grown in private or public gardens, parks, and wastelands, as well as in planters with an impervious bottom (micro-habitats: 4-5 m^2) or in flowerpots, even on roofs or balconies. It can be a wide variety of crops, vegetable, grains, corn, and herbs. Ideally, these are site-adapted, native — but in many cases non-native — species that are grown manually, without the use of pesticides, herbicides, and with as little fertiliser as possible. In order to ensure crop rotation, it is advisable to divide up the areas under cultivation. The high-nutrient demanding plants, low-nutrient demanding plants, and leguminous plants are cultivated in annual rotation. Innovative forms of vegetable farming, community gardens, and urban gardening are becoming more and more popular in many European countries. Also new methods such as aquaponics, raised beds and cultivation under glass are developing forms of vegetable cultivation (howstuffworks, 2021).

Depending on the plant composition, ground crops of vegetables or herbs can provide flowers that attract and increase number of pollinator species as well as other insects and vertebrates like birds or small mammals. There are a number of vegetable varieties that promote the accumulation of nitrogen in the soil and thus contribute to soil improvement (e.g., peas). Some vegetables or herbs loosen the soil, supply the soil with nutrients, enrich the soil with humus, improve the structure and water storage capacity of the soil and help against some stubborn soil pests. Planted in the right plant composition and crop rotation, there is no need for using pesticides and herbicides as well as fertiliser (Wikipedia, 2021c).

The main ecosystem services provided by ground crops of vegetables or herbs are urban temperature regulation, nature-based recreation, water flow regulation and runoff mitigation, habitat services (stopping loss of biodiversity), insect pollination, and nature-based education. Possible challenges are potential of economic opportunities and green jobs (e.g., maintaining crops and herbs, harvesting of vegetables and herbs), social justice and social cohesion, public health and well-being.

Figure 7.1.18.1 Herb bed in a public garden. Photo: R. Bendner

Figure 7.1.18.2 Vegetable beds in a prefabricated housing area. Photo: A. Seiwert

7.1.19. Vegetated reinforced soil slope SLOPES WITH GREEN FENCES

LAMORO Agenzia di sviluppo del territorio

A vegetated reinforced soil slope (VRSS) is basically built out of impregnated wood and covered with flowering plants in particular. It is not a continuous fence along the river. It is interrupted in some spots. Its height varies but it is not higher than the eye level of a sitting person around the sitting areas (3 x 10 cm pickets, 5 x 10 cm backers, heights 120-150 cm).

Green fences (Fig. 7.1.19.1) provide a green separation between river/ditch and pedestrians and create little habitats for wildlife. It is built as a part of river and riverbank re-naturing. They are wooden fences, covered with climbers and shrubs, situated on vegetated reinforced soil slope (VRSS), functioning as both green safety elements and biodiversity habitat, separating the space for pedestrians or cyclists from the river/ditch.

Main ecosystem services provided by VRSS slopes with green fences are regulation of air quality (mainly by urban trees, forests, shrubs), nature-based recreation and nature-based education. Possible challenges are loss of biodiversity, air quality, and public health and well-being.

Figure 7.1.19.1 Green fence. Photo: B. Vojvodíková

7.1.20. GREEN PERGOLAS/GREEN ARBOURS

Juliane Mathey, Jessica Hemingway, IOER – Leibniz Institute of Ecological Urban and Regional Development

Green pergolas or green arbours are defined as a structure supporting climbing plants, creating a shaded or semi-shaded space. It is identified by having two or more posts or columns and an open roof. Pergolas are designed to accommodate climbing plants, to provide shade and a space to relax (Fig. 7.1.20.1, Fig. 7.1.20.2). Usually they are strong, frame-shaped constructions made of wood or metal with wooden crossbeams, between which cables can be stretched to make it easier for plants to climb the pergola. The pergola can be built next to a building or can be a freestanding construction to divide the space or to build vegetation covered walkways or colonnades, for example (FassadenGrün, 2021a, 2021b). There are a number of suitable native or exotic climbers, e.g., vines, climbing roses, clematis, wisteria, English ivy, honeysuckle (more examples see under: FassadenGrün, 2021c). But also, trees can be arranged and cut into arcades (e.g., plane trees).

Depending on the plant composition (one species/several species, native/exotic), they can provide a lot of ecosystem services, e.g., regulating services for climate adaptation, provision of oxygen, shade and windbreak, noise reduction, aesthetical functions, and contributions to recreation of residents. In addition, they provide habitat and food services for animals, like various insects and vertebrates in particular for birds e.g., as breeding places.

Figure 7.1.20.2 Pergola in public garden. Photo: J. Mathey.

Figure 7.1.20.1 Rose arch in an allotment garden. Photo: R. Bendner.

7.1.21. GREEN FACADES WITH CLIMBING PLANTS

Leszek Trząski, Katarzyna Galej-Ciwiś, Silesian Botanical Garden and Polish Academy of Sciences Botanical Garden Center for Biological Diversity Conservation in Powsin

A green facade is a wall or fence completely or partially covered by greenery of climbing plants, using a trellis system to hold the vines of plants that are rooted in the ground or containers. Green facades have many advantages: cooling the exterior of buildings by as much as 4°C, reduce indoor air temperatures by reducing the heat flux into the building's exterior walls and indoor space, and provide a healthier indoor air quality as well as a more beautiful space (Fig. 7.1.21.1).

The advantage of Green Facades with climbing plants is that it takes up little space in an already intensively used urban area, while providing many vertical metres of green. Plants are most attached to concrete walls but can attach to almost anything. In order to have as little maintenance as possible it would be opportune to choose a plant with a natural growing height equal to the desired growth height on the facade. There are many plant species that can be used, it is important that they belong to one of the following groups: adhesive-sucker climbers, root climbers, vines (twining plants), leaf-steam climbers, leaf climbers or scrambling plants.

Main ecosystem services provided by green facades with climbing plants are regulation of air quality (mainly by urban trees, forests, shrubs) and urban temperature regulation. Possible challenges are air quality and public health and well-being.

Figure 7.1.21.1 Green façade with climbing plants. Photo: J. Gorgon

7.1.22. WALL-MOUNTED LIVING WALLS

Jiří Kupka, Adéla Brázdová, IURS - Institute for Sustainable Development of Settlements

Green walls are defined as a vertical greening structure, where a vertical construction is intentionally covered by vegetation (Fig. 7.1.22.1). Green walls include a vertically applied growth medium such as soil or substitute substrate. In some situations, it is appropriate to use hydroculture felt or an integrated hydration and fertigation delivery system as well. Green walls are known also as living walls or vertical gardens. Green walls are also suitable in very dry areas. Therefore, the circulating water on a vertical wall is less likely to evaporate than in horizontal gardens (Fig. 7.1.22.1).

Green walls are widely associated with the delivery of many beneficial ecosystem services, and they are found most often in urban environments. There plants have a bigger opportunity to reduce overall temperatures of the building and protect from heavy rainwater. They're also known for remediation of poor air quality, water re-use, acoustic and noise protection.

The main ecosystem services provided by wall-mounted living walls are urban temperature regulation, climate regulation by reduction of CO^2 and insect pollination. Possible challenges are climate change mitigation and adaptation and urban regeneration.

Figure 7.1.22.1 Wall-mounted living wall. Photo: A. Brázdová

7.1.23. HYDROPONIC MOBILE LIVING WALLS / VERTICAL GARDENS

Leszek Trząski, Katarzyna Galej-Ciwiś, Silesian Botanical Garden and Polish Academy of Sciences Botanical Garden Center for Biological Diversity Conservation in Powsin

Moveable living walls can be used for shading walls, windows, and doors, for providing gardening, food-growing, and learning opportunities for occupants of multi-story buildings. Two main types of mobile living walls can be distinguished: a free-standing outer panels on wheels and kinetic façades (the hinged green window wall, and the sliding balcony door green wall, folding green brise-soleil) (Fig. 7.1.23.1).

It is a self-supporting constructive system based on metallic structure equipped with waterproof layer, hydroponic textile substrate for vegetation growth, water collection system, and automated irrigation system. This NBS can be located anywhere in the city, as long as in that place there are a water source and a connection to the energy network. Mobile living wall can also be mounted on a building (with move option).

Main ecosystem service provided by hydroponic mobile living walls / vertical gardens is nature-based recreation. Possible challenges are air quality, public health and well-being.

Figure 7.1.23.1 Vertical hydroponic wall. Photo: A. Brázdová

7.1.24. VERTICAL VEGETABLE OR HERB GARDEN

Juliane Mathey, Jessica Hemingway, IOER – Leibniz Institute of Ecological Urban and Regional Development

Vertical vegetable or herb gardens are defined as vertical free-standing or wall-mounted structures for growing vegetables or herbs for human consumption. Such ways of growing vegetables or herbs can be suitable when space is limited, like in small gardens or backyards. Better use of the available space can be made by encouraging vegetables to grow vertically (Clarke, 2015). This can also be beneficial for minimizing problems with diseases and keeps vegetables clean and in good condition. Suitable vegetables include tomatoes, cucumbers, melons, squash or beans, radishes, carrots, and garlic (McMahon, 2013, Google, 2021); suitable herbs are rosemary, parsley, chives, basil, oregano, mint. If trellises are used for vertical gardening, a great deal of vegetables are going to need help to get them started climbing up the trellis, e.g., by wrapping them around the trellis (McMahon, 2013). The plants can grow on various constructions, such as trellises, and vertically suspended panels that are freestanding or attached to a wall (Google, 2021). Depending on the plant composition, vertical vegetables or herbs can provide flowers that attract and increase the number of pollinator species as well as other insects and spiders.

Main ecosystem services provided by vertical vegetable or herb gardens are urban temperature regulation, habitat services (preventing loss of biodiversity), insect pollination and nature-based education. Possible challenges are climate change mitigation and adaptation, loss of biodiversity, social justice, and social cohesion (e.g., increased access to vegetables or herbs), public health and well-being, potential of economic opportunities and green jobs (e.g., maintaining crops and herbs, harvesting of vegetables and herbs) and lack of space for vegetable and herb gardens.

Figure 7.1.24.1. Vertical herbs garden. Photo: A. Brázdová

7.1.25. HANGING WALL PLANTERS (AS GREEN STREET FURNITURE)

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These are decorative elements that can be implemented by both the public and the private sector. The owner of buildings and/or other structures (fences, sheds...) can be involved in the planting and care of potted perennials with the common goal of beautifying urban contexts. In Italy, many cities (small or large) each year announce competitions to reward the most beautiful “green balconies”. This acts as a stimulus for the citizen who takes action to take care of their spaces for the benefit of the city as well. Baskets, flowerpots, boxes, etc., with decorative perennials, hung on walls, posts, fences, sheds, and balustrades, etc.

The choice of perennial species is very important for the sustainability of decorative solutions. Baskets, flowerpots, boxes, etc., with decorative perennials, hung on walls, posts, fences, sheds, balustrades, etc. The choice of perennial species is very important for the sustainability of decorative solutions (Fig.7.1.25.1, 7.1.25.2).

Main ecosystem services provided by Hanging wall planters (as green street furniture) are insect pollination and nature-based education. Possible challenges are participatory planning and governance.

Figure 7.1.25.1 Boxes. Photo: B. Vojvodíková

Figure 7.1.25.2 Boxes. Photo: B. Vojvodíková

7.1.26. COMPACTED POLLINATOR’S MODULES

Jacek Krzyżak, IETU - The Institute for Ecology of Industrial Areas

Micro-habitat (4-5m^2) created in a planter with an impervious bottom, designed to attract pollinators (and biodiversity in general), consisting of flowering plant species, water source, housing (for example pollinators hotels and balcony garden, and drinking troughs) for different animal species (pollinators, birds, other insects, etc.).

These pollinator-nesting blocks (also called pollinator houses, bee houses or bee hotels) will support biodiversity by creating wildlife-friendly spots and areas and contribute to preserve and enhance the local biodiversity in urban areas. Compacted Pollinator’s modules could include street seats, a drinking water fountain, street lighting or some elements to create shadow-areas as trees or shadow pergolas with plants. Modules should be designed in a simple way with elements which make the replication easier by citizens in balconies or terraces. These places will constitute natural surfaces which let birds and insects have their niches. The function of this solution is to connect isolated urban green areas and will be projected to created connections between green and blue areas in the urban environment. The small spaces create in areas without availability of natural soil will be designed in order cultivation new habitats in urban spaces, attract and increase (number) of pollinator species as well as other insects.

The main ecosystem services provided by compacted pollinator’s modules are regulation of air quality, urban temperature regulation, nature-based recreation, climate regulation by reduction of CO_2, increase biodiversity, insect pollination, and nature-based education. Possible challenges are green space management, air quality, water management and, moreover, perceptions of connectivity and mobility, pollinator species increase (number), and increased connectivity to existing GI.

7.1.27. RAIN GARDENS IN PLANTERS

Anna Starzewska- Sikorska, IETU - The Institute for Ecology of Industrial Areas

Rain gardens in planters are irrigated with rainfall from the roof and filled with a base layer of gravel, which allows for drainage, followed by a rain garden sand/soil mix and native perennial plants. These planters intercept and slow stormwater, and filter and cool the water that has flowed off of a hot, dirty roof.

Native perennial plants are best because they are low maintenance, return yearly, and have deep, extensive root systems that allow them to absorb water. As a homeowner, one of the great benefits of having this type of stormwater management tool, aside from effectively capturing water, is the size.

Rain gardens in planters are landscaped planter boxes that capture rainwater from the roof, and function in a similar way as a rain garden, but instead within a container. These planters are often custom built and can be designed to complement the architecture and landscape of a home. They can be constructed using different materials such as wood, concrete, or stone, and can be fashioned into any desired shape or size.

Main ecosystem services provided by rain gardens in planters are Water flow regulation and runoff mitigation, insect pollination, and nature-based recreation. Possible challenges are climate change mitigation and adaptation, water management, urban regeneration, and public health and well-being (Fig.7.1.27.1).

Figure 7.1.27.1 Rain garden in planter in Augsburg. Photo: A.Starzewska

7.1.28. STREET PLANTERS (AS GREEN STREET FURNITURE)

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The planter is considered a real design element. The choice between different types of planters is very wide, regarding both the shape and the materials with which they are produced. In cities, planters can be used to guarantee perimeter security and to create pedestrian zones with limited traffic and access. In this way, planters can protect public spaces where people socialize and meet each other (i.e., squares, parks, and open spaces etc.).

Figure 7.1.28.1 Street furniture. Photo: B. Vojvodíková

Free standing planters are of various shapes, sizes, and made of various materials, e.g., wood, concrete, metal, recycled plastic, fiberglass. Not only perennials, but also bushes and trees can be planted in street planters. Planters are a very important element of urban furniture. They are used to enhance the well-being of people.

The main ecosystem services provided by street planters (as green street furniture) are regulation of air quality (mainly by urban trees, forests, shrubs), nature-based recreation, and climate regulation by reduction of CO_2. Possible challenges are air quality, participatory planning and governance, and public health and well-being.

Figure 7.1.28.2 Street furniture. Photo: B. Vojvodíková

Figure 7.1.28.3 Street furniture. Photo: B. Vojvodíková

Figure 7.1.28.4 Street furniture. Photo: B. Vojvodíková

7.1.29. GREEN COVERING SHELTERS

LAMORO Development Agency

Green covering shelters help to adapt towns and cities to climate change, providing habitat for nature, reducing urban heat islands and indoor temperatures, and support healthy and resilient communities (Fig. 7.1.29.1).

It is a very light type of green roof covered with very light, thin substrate and small vegetation. Installed on small or big coverage infrastructures, such as bus shelters or existing covering shelters. It's important to avoid excess roof weight, and the vegetation should be small.

Main ecosystem services provided by green covering shelters are nature-based recreation, climate regulation by reduction of CO_2, water flow regulation, and runoff mitigation. Possible challenges are climate change mitigation and adaptation, water management, and potential of economic opportunities and green jobs.

Figure 7.1.29.1 Green covering schelters. Photo: B. Vojvodíková

7.1.30. GREEN ROOF / ROOF TERRACE

LAMORO Development Agency

Green roofs grow living organisms like trees, shrubs, herbs, grasses, ferns, and mosses that typically grow in permanent sites. In addition, they absorb water and inorganic substances, as well as synthesize nutrients. These green roof structures can be immense, block-long buildings, small abodes and residences, or something in-between.

Green roofs are the external upper covering of a building, the main objective of which is to favour the growth of vegetation. It consists of several layers ensuring water tightness and resistance to the penetration of roots as well as allowing the correct development of the vegetation. Green roofs have traditionally been categorised as 'extensive' or 'intensive': extensive green roofs are lightweight while intensive green roofs are generally heavier and support a wider variety of plant types (Fig. 7.1.30.1, 7.1.30.2).

Main ecosystem services provided by green roof / roof terrace are regulation of air quality (mainly by urban trees, forests, and shrubs), climate regulation by reduction of CO_2, water flow regulation, and runoff mitigation. Possible challenges are climate change mitigation and adaptation, water management and potential

Figure. 7.1.30.1 Intezive green roof. Photo: B. Vojvodíková

Figure. 7.1.30.2 Extenzive green roof. Photo: B. Vojvodíková

7.2. Simplified Tool for choosing appropriate individual solutions

For easier orientation, selection of nature-based solutions are provided in the following tables. These tables compare individual NBS from view of spatial disposition, technical and economic aspects (labour intensity of maintenance, expected efficacy, approximate lifespan, and investment costs) and environmental aspects.

In the following tables, the individual NBSs shown by their number given in the table “List of Nature based solutions” at the beginning of this chapter.

	Spatial disposition – **Spatial characteristics**	
Point	Linear	Area
Verges / flower beds with native perennials	Green pavements	Urban meadows
Rain gardens (under-drained)	Street trees	Ground cover plants
Natural pollinators‘ modules	Road-side swales for retention and infiltration	Lawn
Herb spiral		Park trees
VRSS slopes with green fences	Linear wetlands for stormwater filtration	Fruit trees / shrubs /
Green pergolas/ green arbors	Hedge/hedgerow	Large shrubs
Hydroponic mobile living walls / vertical gardens	Rockery	Urban wilderness / succession area
Vertical vegetable / herb gardens		Ground crops of vegetables / herbs
Hanging wall planters (as green street furniture)		Ground crops of vegetables / herbs
Compacted pollinators‘ module		Green facades with climbing plants
Rain gardens in planter (=self-contained)		Wall-mounted living walls
Street planters (as green street furniture)		Green covering shelters
		Green roof / roof terrace

	Technical and economic aspects	
	Labour intensity of maintenance	
Low labour intensity	Moderate labour intensity	High labour intensity
Urban meadows Verges / flower beds with native perennials Ground cover plants Park trees Large shrubs Rain gardens (under-drained) Herb spiral VRSS slopes with green fences Green facades with climbing plants Hydroponic mobile living walls / vertical gardens Hanging wall planters (as green street furniture) Rain gardens in planter (=self-contained) Street planters (as green street furniture) Green covering shelters	Green pavements Street trees Fruit trees / shrubs / Road-side swales for retention and infiltration Linear wetlands for stormwater filtration Natural pollinators‘ modules Hedge/hedgerow Urban wilderness / succession area Ground crops of vegetables / herbs Green pergolas / green arbours Compacted pollinators‘ module Green roof / roof terrace	Lawn Rockery Wall-mounted living walls Vertical vegetable / herb gardens

	Expected efficacy	
Immediate (0-1 year)	Medium term (up to 5 years)	Long term (more than 5 years)
Urban meadows Verges / flower beds with native perennials Ground cover plants Lawn Green pavements Large shrubs Rain gardens (under-drained) Road-side swales for retention and infiltration Rockery Herb spiral Urban wilderness / succession area Ground crops of vegetables / herbs VRSS slopes with green fences Wall-mounted living walls Hydroponic mobile living walls / vertical gardens Vertical vegetable / herb gardens Hanging wall planters (as green street furniture) Rain gardens in planter (=self-contained) Street planters (as green street furniture) Green covering shelters Green roof /roof terrace	Street trees Fruit trees / Fruit shrubs Hedge/hedgerow Green pergolas / green arbours	Park trees Linear wetlands for stormwater filtration Natural pollinators‘ modules Green facades with climbing plants Compacted pollinators‘ module

	Approximate lifespan	
Short (up to 10 years)	Medium (11-30 years)	Long (more than 30 years)
Urban meadows	Ground cover plants	Verges / flower beds with native perennials
Rain gardens (under-drained)	Lawn	Green pavements
Linear wetlands for stormwater filtration	Hedge / hedgerow	Street trees
Natural pollinators‘ modules	Rockery	Park trees
Ground crops of vegetables / herbs	Herb spiral	Fruit trees / shrubs /
Wall-mounted living walls	VRSS slopes with green fences	Large shrubs
Hydroponic mobile living walls / vertical gardens	Green roof / roof terrace	Road-side swales for retention and infiltration
Vertical vegetable / herb gardens		Urban wilderness / succession area
Hanging wall planters (as green street furniture)		Green pergolas / green arbors
Compacted pollinators‘ module		Green facades with climbing plants
Rain gardens in planter (=self-contained)		
Street planters (as green street furniture)		
Green covering shelters		

	Investment costs	
Low cost	Moderate costs	High costs
Urban meadows	Verges / flower beds with native perennials	Park trees
Ground cover plants	Lawn	Fruit trees / shrubs /
Large shrubs	Green pavements	Linear wetlands for stormwater filtration
Herb spiral	Street trees	Rockery
Urban wilderness / succession area	Rain gardens (under-drained)	Green pergolas / green arbors
Ground crops of vegetables / herbs	Road-side swales for retention and infiltration	Wall-mounted living walls
Hanging wall planters (as green street furniture)	Natural pollinators‘ modules	Street planters (as green street furniture)
	Hedge / hedgerow	Green roof / roof terrace
	VRSS slopes with green fences	
	Green facades with climbing plants	
	Hydroponic mobile living walls / vertical gardens	
	Vertical vegetable / herb gardens	
	Compacted pollinators‘ module	
	Rain gardens in planter (=self-contained)	
	Green covering shelters	

Environmental aspects **Effect on environment**				
Soil protection	**Water management**	**Heat stress**	**Social aspect**	**Air quality**
1.Urban meadows	1.Urban meadows	1.Urban meadows	1.Urban meadows	6.Street trees
3.Ground cover plants	3.Ground cover plants	3.Ground cover plants	2.Verges/flower beds with native perennials	7.Park trees
4.Lawn	4.Lawn	4.Lawn	3.Ground cover plants	8.Fruit trees/shrubs
5.Green pavements	5.Green pavements	5.Green pavements	4.Lawn	9.Large shrubs
6.Street trees	6.Street trees	6.Street trees	5.Green pavements	14.Hedge/hedgerow
7.Park trees	7.Park trees	7.Park trees	6.Street trees	17.Urban wilderness /succession area
8.Fruit trees/shrubs	8.Fruit trees/ shrubs/	8.Fruit trees/ shrubs	7.Park trees	19.VRSS slopes with green fences
9.Large shrubs	9.Large shrubs	9.Large shrubs	8.Fruit trees/shrubs	20.Green pergolas/ green arbors
14.Hedge/hedgerow	10.Rain gardens (under-drained)	10.Rain gardens (under-drained)	9.Large shrubs	21.Green facades with climbing plants
17.Urban wilderness /succession area	11.Road-side swales for retention and infiltration	12.Linear wetlands for stormwater filtration	10.Rain gardens (under-drained)	22.Wall-mounted living walls
19.VRSS slopes with green fences	12.Linear wetlands for stormwater filtration	14.Hedge/hedgerow	12.Linear wetlands for stormwater filtration	24.Vertical vegetable/ herb gardens
	14.Hedge/hedgerow	17.Urban wilderness / succession area	13.Natural pollinators‘ modules	25.Hanging wall planters (as green street furniture)
	17.Urban wilderness / succession area		14.Hedge/hedgerow	28.Street planters (as green street furniture)
	27.Rain gardens in planter (=self-contained)		15.Rockery	
	30.Green roof/roof terrace		16.Herb spiral	
			18.Ground crops of vegetables/herbs	
			19.VRSS slopes with green fences	
			20.Green pergolas/green arbours	
			21.Green facades with climbing plants	
			22.Wall-mounted living walls	
			23.Hydroponic mobile living walls/vertical gardens	
			24.Vertical vegetable/ herb gardens	
			25.Hanging wall planters (as green street furniture)	
			26.Compacted pollinators‘ module	
			27.Rain gardens in planter (=self-contained)	
			28.Street planters (as green street furniture)	
			29.Green covering shelters	
			30.Green roof /roof terrace	

8. Plants in urban environmental acupuncture

Leszek Trząski, Katarzyna Galej-Ciwiś, SIBG – Silesian Botanical Garden and The Polish Academy of Sciences Botanical Diversity Conservation in Powsin Silesian Botanical Garden and Polish Academy of Sciences Botanical Garden Center for Biological Diversity Conservation in Powsin

8.1. Introduction

This chapter provides general as well as specific recommendations on how to select plants for UEA. These recommendations are worth following in any FUA (Functional Urban Area), with regard to each Action Plan and each green spot.

The creation of a green spot should provide the residents and users of the city with a good quality of stay, and this effect should be achieved and sustained at a reasonable cost. A good selection of plants is one that will allow you to achieve this goal quickly and permanently, without generating environmental problems, threats, conflicts, and excessive maintenance work. Any mistakes, even seemingly minor ones, in the selection of plants for urban green spots may have a very unfavourable impact on the implementation of the goals of the entire UEA Action Plan.

8.2. The most general principles of selecting plants for UEA

A good plant selection is only possible if all of the following conditions are met:

- Selection of plant species and varieties, and their combinations, must be consistent with the environmental conditions of the FUA, including the location in the proper hardiness zone, as well as with the specifics of the site, and with social expectations, and be adjusted to the type of intervention - i.e., the type of green-spot and types of NBS (Nature Based Solutions).
- We also need to be sure that there is no risk of expansion in the urban ecosystem and, in the case of biogeographically alien species, no risk of invasion of wildlife. For these reasons, only native or naturalized species can be recommended for use in UEA (the meanings of “native” and “naturalized” are explained later in this chapter). However, also native species can be overly expansive in an urban ecosystem, and practical knowledge of this subject must be taken into account in the process of selecting plants for the green spot.
- When selecting plant material for UEA, we cannot afford to experiment! The origin of a specific seedling and the history of the species in the context of a specific place must be well documented. If we have a choice between the wild form and the cultivar, we should always choose the wild one. We only choose the best quality material. If there is a green standard in a given city, the quality of the material must at least meet this standard. If there is no such - let’s look for a nearby town.
- Selection of species and varieties, as well as selection of plant material should be done by a TEAM of people with complementary competences, which combines thorough knowledge of the site conditions and knowledge of the expectations of local stakeholders with practical knowledge of the specificity of a given NBS, practical knowledge of gardening, and competence in the field of landscape architecture.

8.3. At what stage in the design of a green spot should plant species be selected?

In each FUA and for each green spot, the selection of plants should be considered from the earliest stages of design. We recommend that the development of an initial, comprehensive list of life forms and species should follow the initial vision of the green spot, understood as in our Deliverable 1.2.1 (Report on principles for selection of interventions, 2020) on page 13. Later, as the target vision of the green spot is created (this stage of green spot planning is discussed in the Deliverable 1.2.1 on page 23), the list of plants will be specified in relation to the selection of specific NBS.

It should always be remembered that even the most beautiful vision of a green spot may collapse in the face of hard market realities — if it turns out that plant material with the desired characteristics is unavailable or its acquisition or use exceeds financial or logistical possibilities. Therefore, even before starting a specific green design, it is worth analysing the supply of plant material on the local market.

It is also worth realizing that the future user of a green spot is not interested in the list of NBS used; for him the key is to answer the question of how he will be able to use this place and what will be the quality of stay. The aesthetic values and the symbolism associated with specific plant species are also very important. The choice of this species and not another may also determine the elements of the identity of a place and may have an effect — either positive or negative — on people's emotions. All this means that in some cases the presence of a given species or variety may be a foregone conclusion at the time of making a decision to transform a given site into a green spot; the site selection procedure is described in detail in Deliverable 1.1.1 (Methodology of selection of spots for UEA, 2020). Fig. 8.1 shows the proposed logic for selecting plant material in correlation with the background of the green spot planning and design procedure.

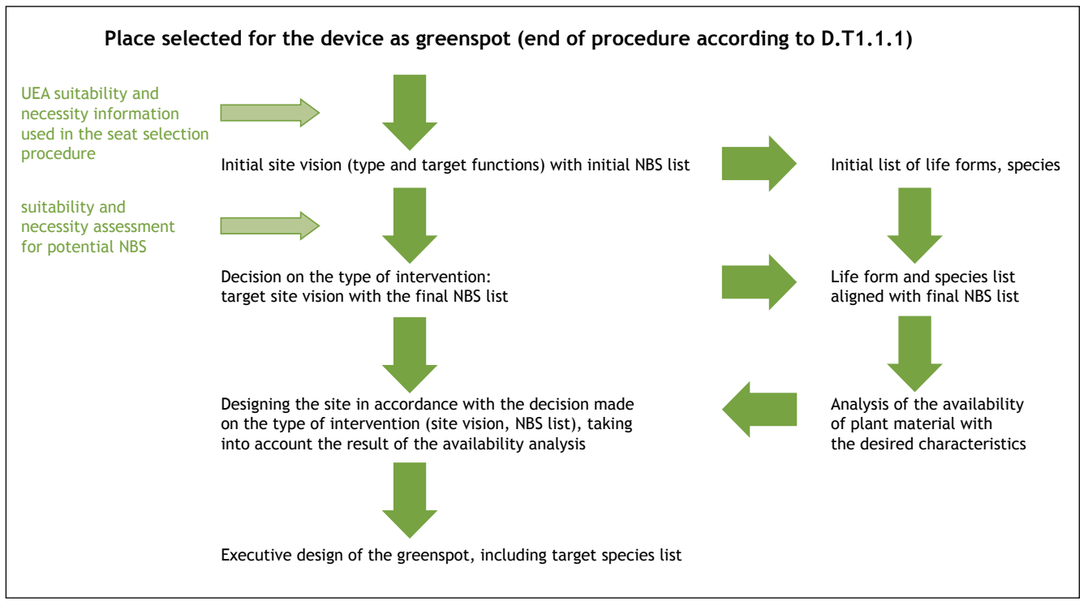

Figure 8.1 Interdependence of green spot design processes and selection of plant material. Authors' own source

8.4. Plants recommended for use in UEA according to the biogeographic and historical criterion - native species and country-specific species

8.4.1. Biogeographic principles for the selection of plant species for UEA

We recommend that native species of trees, shrubs, climbers, perennials and sometimes also annual plants should be preferred in UEA. The simplest justification for such an approach is contained in the sentence below:

"Native (…) plants are adapted to our local pests and climate, and will require less maintenance in the long run than most ornamentals. Planting natives in an urban situation also provides wildlife habitat where it is often scarce or degraded. This lists emphasizes smaller trees to remain in proportion with the urban surroundings and lessen interference with power lines and buildings" (Native plants for urban landscapes, 2021).

There are many definitions of "native species"; some of them are cited by Plants of the World Online / Kew Science (2021), or EUNIS species datatbase (2021), or San-Miguel-Ayanz et al. (2016), or used by practitioners (Rodomsky-Bish 2018, Carlton 2020). Likewise, the terms "naturalized" and "country specific" have different meanings. Without getting into unnecessary definitional disputes, we explain the meaning of all these concepts adopted in this handbook for purely practical reasons.

This handbook is written primarily for Central European city practitioners, and we therefore assume here that "native" means that the plant is native to anywhere in CE. We reserve that Central Europe is an area defined not only by the administrative borders of the CE Program, but also as an area where several biogeographic zones of Europe meet. "Native" in the meaning of this handbook is a species that meets two conditions: it comes from the continental, Alpine or Pannonian biogeographical region of Europe, and at the same time its natural range extends to the administratively understood CE region. We define biogeographical regions according to the European Environment Agency (Biogeographical regions, 2016). Thus, within the meaning of this handbook, the "native" category does not include, for example, a species originating in southern Italy or the Adriatic coast of Croatia (Mediterranean zone) or western Germany (Atlantic zone).

A particular subcategory of native plants are indigenous species. Such a species is native for particular area, like particular region of country. It is not difficult to check the natural range of a given plant species in Europe. We suggest using studies made available on public servers, e.g.:

- Kew Royal Botanic Gardens (Plants of the World Online / Kew Science, 2021)
- Flora Europea (EUNIS species database, 2021)
- European Commission Service Web Site (San-Miguel-Ayanz et al., 2016) (tree species)

For the purposes of UEA, as "naturalized" in CE we define a non-native species, that is, originating — in the biogeographical sense — from outside CE, but at the same time is described in Plants of the World Online (ibid) as "naturalized" in the countries. We can unequivocally recommend this species for use in UEA, if they are meeting all the following conditions:

- is a permanent (for two or more centuries), a desired element of the landscape of Central European cities,
- in the CE area, it does not penetrate from urban plantings to extra-urban ecosystems,
- possible expansion to areas adjacent to urban plantings, even if it happens, it is easy to control and stop,
- provides well-documented benefits for urban biodiversity (e.g., good for insects, provides food for birds, is highly soil-forming, etc.).

As in the case of native species, within the meaning of this handbook, the category of “naturalized” does not include, for example, non-CE species whose traditional settlement in cities is limited to the southern Italian or Adriatic coast of Croatia (Mediterranean zone) or western Germany (Atlantic zone).

In general, we recommend that for the UEA should be mainly used species that fall into the category of “native species” extended to “naturalized” species (see Fig. 8.2 — boxes with a green background), with a preference for the former.

A “country specific” (as defined in this handbook) is a plant species whose natural range or area of traditional settlement in cities (naturalization) covers wholly or partially, a given country within the CE Program area. In the case of a species naturalized in a given country (it means outside its natural range), however, all the following conditions should be met:

- It is a permanent (for at least two centuries) element of the landscape of cities in a given country,

- It is not listed on the national or regional invasive plant list,

- It is well adapted to the specificity of the urban climate and tolerates well the climate changes occurring in a given country / region.

Thus, a “country specific” species is one that is a permanent element of urban ecosystems in the region to which a given FUA belongs.

In general, we recommend that in a given FUA, at least some of the native species used for UEA should be both “country specific” and “indigenous”.

Recommended logic for selecting plant species for UEA according to the biogeographic key, taking into account the history of cultivation in cities, are presented in Fig. 8.2.

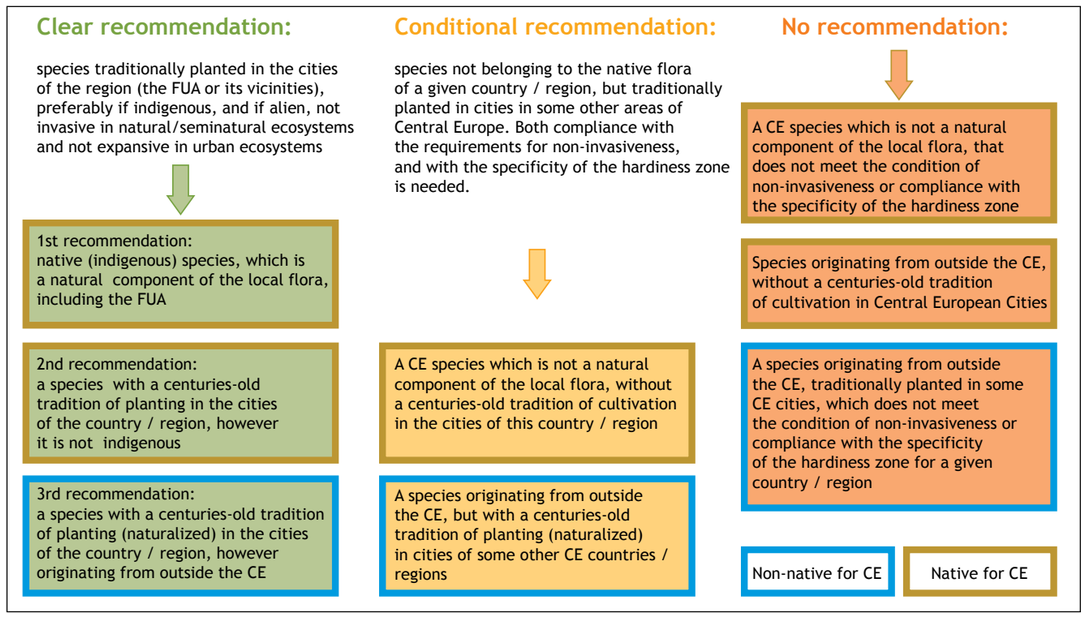

Figure 8.2 Biogeographic recommendations for the selection of plant species for UEA in Central European cities. Authors' own source

8.4.2. Plant species native to the entire area of Central Europe or naturalized throughout this area, recommended for UEA

In these paragraphs we give the names of several hundred plant species deserving to be used in UEA in cities throughout Central Europe. These are species native to the entire CE area or naturalized in it, and at the same time well adapted to urban conditions and do not show invasive features. These are the species that we would place on the left in Fig. 8.2 - in the boxes with a green background (see also Fig. 8.3 - the boxes on the left).

For each type of NBS, numerous examples of species are given, based on a very extensive source material including practical guides, scientific publications, textbooks, specialist portals, case studies, electronic databases, specialized publications on social profiles, as well as our own practical experience and our own observations made in urban spaces on various occasions, for many years.

We included only those plant species that we can unequivocally recommend. In this way, we want to help designers of all kinds of green spots in the right selection of plants for the planned solutions. The proposed species do not have high requirements as to the type of substrate, and their maintenance is not particularly cost-intensive and does not require highly specialized knowledge. For almost all NBS we recommend the use of wild forms (exception: dwarf varieties recommended in case of insufficient space) with sufficient utility and aesthetic qualities. The choice of species reflects the state of the art: all proposed species are already being used, on a smaller or larger scale, as components of green infrastructure in European cities. Moreover, these species are already successfully applied to the given NBS type.

However, it should be remembered that the proposed lists are to provide designers with a good starting point to work on the selection of species but will not replace the analysis to be carried out according to the scheme proposed in chapter 8.3. This is due to the following circumstances:

- the proposed lists are not a closed set - only the Central European species suitable for use in flower meadows are several hundred; there are slightly fewer species of trees, shrubs, bedding perennials, etc, cultivated in Central European cities;

- not every proposed species can be used for a particular green spot as the NBS type designation does not yet invalidate interspecies differences in light requirements, substrate properties and humidity; in addition, a given NBS type may contain species with a different target habit and different growth rates; that is why it is so important to know the conditions of a given place and to have a good understanding of the consequences of these conditions;

- apart from native species for the entire CE region, one should also remember about country specific species, native / established in a given country or part of it, although not in the whole of Central Europe. Such species can be particularly valuable when applied to UEA, but for obvious reasons we were unable to include them here.

The following paragraphs provide sources for further information on the plant species suitable for a given NBS type. However, it should be remembered that in these sources there are no recommendations for use / non-use in the CE area. How this additional information will be used by the designers of the green spot depends on their knowledge and inquisitiveness.

Urban wildflower meadows

When selecting several dozens of several hundred possible species of meadow plants, the assumption was made that in urban conditions we usually deal with dry meadows (grasslands), sometimes also medium-moist

meadows, but not wet meadows. Colorfully flowering perennials as well as biennials and annuals are included; there grasses were also included.

Flowering plants: *Achillea millefolium, Agrimonia eupatoria, Anagallis arvensis, Anthemis arvensis, Ballota nigra, Bellis perennis, Berteroa incana, Betonica officinalis, Calendula arvensis, Campanula rapunculus, Carum carvi, Centaurea cyanus, Centaurea jacea, Centaurea scabiosa, Centaurium erythraea, Cichorium intybus, Coronilla varia, Cota tinctoria, Daucus carota, Dianthus deltoides, Echium vulgare, Fumaria officinalis, Galium album, Galium verum, Helianthemum nummularia, Hypericum perforatum, Hypochaeris radicata, Knautia arvensis, Lathyrus latifolius, Lentodon hispidus, Leucanthemum vulgare, Lotus corniculatus, Lychni viscaria, Malva sylvestris, Matricaria chamomilla, Melilotus albus, Melilotus officinalis, Origanum vulgare, Papaver rhoeas, Plantago lanceolata, Plantago major, Potentilla argentea, Potentilla recta, Prunella vulgaris, Ranunculus acris, Raphanus raphanistrum, Salvia nemorosa, Salvia pratensis, Salvia verticillata, Sanguisorba minor, Saponaria officinalis, Scabiosa columbaria, Scabiosa, ochroleuca, Silene latifolia, Silene vulgaris, Sinapis arvensis, Succisa pratensis, Tanacetum corymbosum, Thymus pulegioides, Tragopogon pratensis, Trifolium campestre, Trifolium pratense, Tripleurospermum inodorum, Verbascum nigrum, Verbascum thapsus, Verbena officinalis, Veronica teucrium, Vicia cracca, Vicia grandiflora, Vicia villosa, Viola tricolor*

Grasses: *Agrostis capillaris, Anthoxanthum odoratum, Deschampsia cespitosa, Festuca rubra, Festuca rupicola, Koeleria macrantha, Koeleria pyramidata*

For more information see: Łuczaj, 2021, Wildflowershop.co.uk. 2021, Wild Flower Lawns and Meadows, 2021.

Verges / flower beds with native perennials.

Species were selected that, apart from their aesthetic value, provide significant benefits for pollinators. In nature, these are species associated with meadows and their edges. In addition to species that prefer dry habitats, several species have also been identified related to places where the soil is incidentally wet, because in urban spaces there are places where from time to time excess rainwater appears, infiltrating the ground.

Achillea millefolium, Agrimonia eupatoria, Ajuga reptans, Betonica officinalis, Centaurea jacea, Cichorium intybus, Convallaria maialis, Dianthus deltoides, Eupatorum cannabinum, Filipendula ulmaria, Galium molugo, Galium verum, Garanium pratense, Geranium phaeum, Iris sibirica, Knautia arvensis, Lamium galeobdolon, Leucanthemum vulgare, Lotus corniculatus, Lotus pedunculatus, Lychnis flos-cuculi, Lysimachia vulgaris, Matricaria chamomilla, Saponaria officinalis, Scabiosa columbaria, Valeriana officinalis, Viscaria vulgaris

For more information see: Carlton 2020, Guidance - Pollinators in Planning and Construction guide, 2021, Horticulture Magazine, 2021, Łuczaj, 2021, Wildflowershop.co.uk. 2021, Wild Flower Lawns and Meadows, 2021.

Ground cover plants

Plants capable of quickly and permanently covering the ground with a single-species carpet were indicated. They include perennials (both short and tall), shrubs and low shrubs. The list includes both light-loving, shade-tolerant and shade-loving plants.

Ajuga reptans, Aristolochia clematitis, Aruncus dioicus, Asarum europaeum, Aurinia saxatilis, Centaurea scabiosa, Cerastium arvense, Cerastium tomentosum, Convallaria maialis, Cotoneaster horizontalis, Galeobdolon luteum, Geranium phaeum, Glechoma hederacea, Lamium galeobdolon, Lamium maculatum, Lysimachia nummularia, Matteuccia struthiopteris, Pulmonaria obscura, Sedum acre, Sedum rupestre, Vinca minor, Viola odorata

For more information see: Horticulture Magazine, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021, Wild Flower Lawns and Meadows, 2021.

Lawns

Perennials associated with dry meadows, including urban flower meadows, but also found on lawns were indicated. All these species tolerate multiple mowing a year and under such conditions they can bloom and even produce seeds. We suggest using them in addition to standard grass mixes (grass species are not included in the list).

Achillea millefolium, Anthemis noblis, Bellis perennis, Centaurea scabiosa, Galium verum, Lathyrus pratensis, Leucanthemum vulgare, Lotus corniculatus, Lotus pedunculatus, native grass species, Origanum vulgare, Primula veris, Prunella vulgaris, Ranunculus acris, Taraxacum officinale, Trifolium pratensis, Trifolium repens, Vicia cracca, Viola tricolor

For more information see: Wild Flower Lawns and Meadows, 2021.

Green pavements

Species of low perennials have been indicated, in natural conditions associated with rock, gravel and rocky ground. They all tolerate long-term water deficit, trampling and mechanical damage. Each of these species can be used to green the gaps filled with soil in various types of surfaces - both pedestrian paths, access roads and parking spaces.

Ajuga reptans, Bryum argenteum, Ceratodon purpureus, Dianthus deltoides, Festuca rubra, Lotus corniculatus, Mchy, Origanum vulgare, Phedimus spurius, Polytrichum piliferum, Sagina procumbens, Sagina subulata, Sedum acre, Sedum spurium, Thymus praecox, Thymus serpyllum, Trifolium repens, Viola riviniana

For more information see: Horticulture Magazine, 2021, Plant selection guides, 2021, Wild Flower Lawns and Meadows, 2021.

Street trees

Each of the selected species is known for its considerable resistance to unfavourable urban impacts, including soil drought, soil compactness, air pollution, and periodically very high temperatures. At the same time, they are relatively long-lived species, and if properly formed - they do not require significant maintenance in their mature age. Each of these species is commercially available not only as a wild form, but also - if necessary, for example due to space restrictions - as a variety with limited growth.

Acer campestre, Acer platanoides, Acer pseudoplatanus, Betula pendula, Carpinus betulus, Crataegus monogyna, Eleagnus angustifolia, Fagus sylvatica, Prunus avium, Prunus mahaleb, Pyrus communis, Quercus petraea, Quercus robur, Sorbus aria, Sorbus torminalis, Tilia cordata, Tilia platyphyllos, Ulmus laevis, Ulmus minor

For more information see: Plant selection guides, 2021, San-Miguel-Ayanz et al., 2016, Wildflowershop.co.uk. 2021.

Park trees

In addition to species recommended also as street trees, the list includes several other species particularly valuable due to their habitat-forming and landscape values, although they include short-lived species or species that tend to form wide crowns.

Acer campestre, Acer platanoides, Acer pseudoplatanus, Aesculus hippocastanum, Betula pendula, Carpinus betulus, Crataegus monogyna, Fagus sylvatica, Hippophae rhamnoides, Populus alba, Quercus petraea, Quercus robur, Salix alba, Sorbus aria, Sorbus aucuparia, Sorbus torminalis, Tilia cordata, Ulmus laevis, Ulmus minor

For more information see: Plant selection guides, 2021, San-Miguel-Ayanz et al., 2016, Wildflowershop.co.uk. 2021.

Fruit trees / shrubs

Species that do not require specialist care have been selected, and at the same time are known for their resistance to adverse urban impacts, and under difficult conditions, they maintain their flowering and fruiting capacity. These species can be introduced into various types of green spots, not only in urban orchards and gardens. All proposed species have significant aesthetic values and at the same time they provide benefits for pollinators, birds and other small animals

Cornus mas, Hippophae rhamnoides, Malus domestica, Mespilus germanica, Prunus cerasus, Pyrus communis, Ribes nigrum, Ribes rubrum, Ribes rubrum, Ribes uva-crispa, Rubus fruticosus, Rubus idaeus, Sorbus domestica

For more information see: Carlton 2020, Guidance - Pollinators in Planning and Construction guide, 2021, Horticulture Magazine, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021.

Large shrubs

Each of the proposed species combines significant resistance to adverse urban impacts, high aesthetic values, ease of care and providing significant benefits to small animals.

Cornus sanguinea, Corylus avellana, Cotoneaster integerrimus, Crataegus laevigata, Crataegus monogyna, Euonymus europaeus, Hippophae rhamnoides, Ligustrum vulgare, Lonicera xylosteum, Prunus cerasifera, Prunus mahaleb, Prunus spinosa, Ribes alpinum, Rosa canina, Rosa gallica, Sambucus nigra, Staphylea pinnata, Syringa vulgaris, Taxus baccata, Viburnum lantana, Viburnun opulus

For more information see: Horticulture Magazine, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021.

Rain gardens (under-drained)

The proposed species are well-adapted to ephemeral wet / dry soil conditions and have extensive root / rhizome systems. Each of them has already been successfully used in bioretention systems with the infiltration of excess water into the ground. In various regions, individual species are officially recommended for use in bioengineering solutions that integrate greenery management with rainwater management and shaping the urban landscape.

Aquilegia vulgaris, Aruncus dioicus, Caltha palustris, Carex pseudocyperus, Carex pseudocyperus, Cornus sanguinea, Equisetum hyemale, Eupatorium cannabinum, Filipendulaa ulmaria, Geum rivale, Iris pseudacorus, Iris sibirica, Juncus effusus, Lythrum salicaria, Menyanthes trifoliata, Myosotis scorpioides, Trollius europaeus, Viburnum opulus

For more information see: Aberdeenshire.gov.uk. 2012, Lord, Loh and Sia, 2014, Woods, Ballard et al., 2015, SuDS Construction Specification Clauses, 2016, Horticulture Magazine, 2021, Plant selection guides, 2021.

Road-side swales for retention and infiltration

Each of the proposed plant species is well-adapted to ephemeral wet / dry soil conditions and have extensive root / rhizome systems. It is a mix of species typical for marshes, pond margins and wet meadows. The possibility of using trees, shrubs and large rush perennials (Phragmites, Typha) depends only on the availability of space.

Agrostis stolonifera, Caltha palustris, Cardamine pratensis, Carex acutiformis, Carex nigra, Carex riparia, Filipendula ulmaria, Filipendula vulgaris, Glyceria fluitans, Glyceria maxima, Iris pseudacorus, Iris sibirica, Juncus effusus, Lychnis flos-cuculi, Mentha aquatica, Menyanthes trifoliata, Myosotis scorpioides, Nasturtium officinale, Padus avium, Phragmites australis, Polygonum persicaria, Ranunculus flammula, Salix caprea, Salix cinerea, Sparganium erectum, Stachys palustris, Typha angustifolia, Typha latifolia, Veronica beccabunga, Viburnum opulus

For more information see: Aberdeenshire.gov.uk. 2012, Lord, Loh and Sia, 2014, Woods, Ballard et al., 2015, SuDS Construction Specification Clauses, 2016, Horticulture Magazine, 2021, Plant selection guides, 202.1

Linear wetlands for stormwater filtration

Each of the proposed plant species is well-adapted to ephemeral wet / dry soil conditions and have extensive root / rhizome systems. It is a mix of species typical for marshes, pond margins and wet meadows. Species that can grow also if the ground is occasionally covered with shallow water, as well as in conditions where water seeps horizontally under the ground, have a significant share in this list.

Butomus umbellatus, Caltha palustris, Cardamine pratensis, Glyceria maxima, Iris pseudacorus, Juncus effusus, Lotus uliginosus, Lychnis flos-cuculi, Lythrum salicaria, Mentha aquatica, Menyanthes trifoliata, Myosotis scorpioides, Nasturtium officinale, Phalaris arundinaceae, Phragmites australis, Ranunculus flammula, Sparganium erectum, Stachys palustris, Typha angustifolia, Typha latifolia, Veronica beccabunga

For more information see: Aberdeenshire.gov.uk. 2012, Lord, Loh and Sia, 2014, Woods, Ballard et al., 2015, SuDS Construction Specification Clauses, 2016, Horticulture Magazine, 2021, Plant selection guides, 2021.

Natural pollinators' modules

The proposed list includes trees, shrubs as well as tall and low perennials, because all these life forms must be included in the module. Each of the proposed species is beneficial for pollinators, and the coexistence of all life forms creates a convenient habitat for various small animals.

Acer campestre, Aquilegia vulgaris, Aster amellus, Carduus nutans, Centaurea cyanus, Corylus avellana, Crataegus monogyna, Digitalis grandiflora, Echinops sphaerocephalus, Hedera helix, Lonicera caprifolium, Malus domestica, Mentha x piperita, Nepeta nuda, Papaver rhoeas, Prunus cerasus, Prunus spinosa, Salvia glutinosa, Salvia pratensis, Scabiosa columbaria, Stachys sylvatica, Thymus pulegioides, Trifolium pratense, Trifolium repens

For more information see: Carlton 2020, Guidance - Pollinators in Planning and Construction guide, 2021, Horticulture Magazine, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021, Wild Flower Lawns and Meadows, 2021.

Hedges / hedgerows

Our proposal includes only species for tall hedges - apart from shrubs, also species of trees for formed hedges. All proposed species are known for their high resistance to unfavourable conditions, and at the same time they have habitat-forming feature, and provide benefits for small animals, including pollinators.

Acer campestre, Berberis vulgaris, Carpinus betulus, Cornus sanguinea, Corylus avellana, Crataegus laevigata, Euonymus europaeus, Euonymus europaeus, Fagus silvatica, Ligustrum vulgare, Malus sylvestris, Prunus cerasifera, Prunus spinosa, Rosa canina, Rosa gallica, Sorbus aucuparia, Viburnum opulus

For more information see: Horticulture Magazine, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021.

Rockery

The proposed species are low perennials. They are light-requiring, easy to care for, and able to settle on rocks, as well as gravel and walls. Almost all of them are also plants that provide benefits for pollinators.

Ajuga reptans, Aurinia saxatilis, Carex flacca, Cerastium arvense, Cymbalaria muralis, Dianthus deltoides, Dryas octopetala, Festuca emethystina, Festuca ovina, Geranium robertianum, Geranium sanguineum, Glechoma hederacea, Koeleria glauca, Lysimachia nummularia, Origanum vulgare, Potentilla neumanniana, Primula auricula, Pulsatilla vulgaris, Sagina subulata, Saxifraga paniculata, Sedum acre, Sedum sexangulare, Sempervivum globiferum, Sesleria albicans, Thymus serpyllum, Veronica prostrata, Vinca minor, Viola odorata

For more information see: Horticulture Magazine, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021

Herb spiral

The list includes herb species with different requirements regarding the light and moisture of the substrate - both those that should be at the top of the installation and those that should be planted at the base of the spiral on its shaded side

Allium schoenoprasum, Althaea officinalis, Anethum graveolens, Artemisia dracunculus, Calendula officinalis, Carum carvi, Centaurium erythraea, Chamaemelum nobile, Cichorium intybus, Coriandrum sativum, Diplotaxis muralis, Eruca vesicaria (rocket), Filipendula ulmaria, Fragaria vesca, Hyssopus officinalis (hyssop), Matricaria chamomilla, Mentha piperita, Mentha spicata, Nasturtium officinale, Origanum vulgare, Petroselinum crispum, Ruta graveolens, Salvia pratensis, Thymus pulegioides, Tropaeolum majus

For more information see: Busby, 2014, Horticulture Magazine, 2021, Plant selection guides, 2021, Vertical Garden Plant Species Guide, 2021, Wildflowershop.co.uk. 2021.

Urban wilderness / succession area

The list includes species, the presence of which indicates a favourable course of the current, spontaneous succession of vegetation in the “abandoned” area. Individual species are associated with different stages of succession, which ultimately leads to the formation of forest coverings. The significant share of species from the presented list indicates that when adapting a given place to the target function related to the stay of people, it is worth preserving the existing greenery on the entire green spot or on a significant part of it.

Acer campestre, Acer platanoides, Agropyron repens, Agrostis canina, Anthyllis vulneraria, Artemisia vulgaris, Betula pendula, Brachypodium pinnatum, Bromus erectus, Cirsium arvense, Crataegus monogyna, Dactylis glomerata, Eriophorum vaginatum, Festuca rubra, Festuca rupicola, Fraxinus excelsior, Juncus effusus, Leucanthemum vulgare, Lolium perenne, Lotus corniculatus, Melilotus albus, Molinia caerulea, Plantago maior, Poa pratensis, Populus tremula, Quercus robur, Sambucus nigra, Sedum album, Sorbus aucuparia, Tanacetum vulgare, Tussilago farfara, Urtica dioica

For more information see: Kowarik, 2005, Kowarik et al., 2019.

Ground crops of vegetables/herbs

Examples are given of species whose non-commercial cultivation in the ground is possible in the entire CE area without special devices protecting against unfavorable weather conditions, such as e.g., a cold greenhouse, a foil tent, an irrigation system.

*Allium cepa, Allium sativum (*garlic*), Allium schoenoprasum, Allium ursinum, Anethum graveolens, Apium graveolens, Brassica oleracea var. Sabellica (*kale*), Daucus carota, Fragaria vesca, Fragaria x ananassa, Lactuca sativa, Origanum vulgare, Petroselinum crispum, Ruta graveolens, Solanum lycopersicum, Spinacia oleracea (*spinach*)*

For more information see: Busby, 2014, Horticulture Magazine, 2021, Plant selection guides, 2021, Vertical Garden Plant Species Guide, 2021, Wildflowershop.co.uk. 2021.

VRSS slopes with green fences

The list includes only examples of vines for fences, as the species of accompanying trees, shrubs and perennials are also associated with other NBS. In some cases, fast-growing vines can be used, also recommended for greening tall facades and pergolas. On the presented list, however, there are also species whose shoots are too small to be recommended for greening structures larger than a fence.

Bryonia dioica, Clematis alpina, Clematis vitalba, Convolvulus arvensis, Convolvulus sepium, Hedera helix, Humulus lupulus, Lathyrus odoratus, Lonicera caprifolium, Lonicera periclymenum, Rosa canina (climbing varieties), Solanum dulcamara, Vicia sepium, Vitis vinifera

For more information see: Horticulture Magazine, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021

Green pergolas/ green arbours

The list of proposed species of climbers is similar to the list for tall facades, but is a bit more extensive as it also includes climbers that are smaller in size but are very fast growing.

Clematis vitalba, Convolvulus sepium, Hedera helix, Humulus lupulus, Lathyrus odoratus, Lonicera caprifolium, Lonicera periclymenum, Rosa canina (climbing varieties), Vitis vinifera

For more information see: Horticulture Magazine, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021.

Green facades with climbing plants

The list of proposed species of creepers is similar to the list for tall facades, but a bit more extensive, as it also includes vines that are smaller in size but are characterized by very rapid growth.

Clematis vitalbaHedera helix, Humulus lupulus, Lonicera caprifolium, Lonicera periclymenum, Rosa canina (climbing varieties), Vitis vinifera

For more information see: Horticulture Magazine, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021.

Wall-mounted living walls

The list includes species that take root particularly easily in artificial ground, having the characteristics of ground cover plants; only some of them are also known as vines. The proposed collection of species includes

both light and shade-loving plants, growing in nature on various substrates and in various plant communities. They also have different requirements for soil moisture and fertility, so not all of them can grow on the same wall. Their common features are high decorative values, ease of planting and uncomplicated maintenance.

Ajuga reptans, Armeria maritima, Asplenium trichomanes, Festuca ovina, Fragaria x ananassa (strawberry), Hedera helix, Helianthemum nummularium, Lotus corniculatus, Lysimachia nummularia, Mentha piperita, Origanum vulgare, Origanum vulgare, Polypodium vulgare, Polypodium vulgare, Prunella vulgaris, Sagina subulata, Salvia nemorosa, Saxifraga paniculata, Scabiosa columbaria, Sedum acre, Sedum reflectum, Sempervivum tectorum, Thymus pulegioides, Tropaeolum majus, Vinca minor, Viola odorata, Viola tricolor

For more information see: Bąbelek and Bednorz, 2015, Plants for a living wall, 2019, Horticulture Magazine, 2021, Lacey, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021.

Green roof / roof terrace

Species examples are given for an extensive green roof, limited to small (up to 15 cm high) grassland plants and succulents. This list includes both perennials and annual species that are to be part of the

multispecies plant community covering the roof.

Arenaria serpyllifolia, Briza media, Carex flacca, Cynosurus cristatus, Dianthus deltoides, Festuca ovina, Filipendula vulgaris, Gentiana cruciata, Geranium robertianum, Helianthemum nummularium, Helichrysum arenarium, Hieracium pilosella, Lotus corniculatus, Matricaria chamomilla, Origanum vulgare, Papaver argemone, Prunella grandiflora, Prunella vulgaris, Sagina procumbens, Saxifraga granulata, Saxifraga paniculata, Sedum acre, Sedum album, Sedum reflectum, Sedum rupestre, Sedum sexangulare, Sempervivum globiferum, Sempervivum tectorum, Sesleria caerulea, Thymus pulegioides, Veronica teucrium

For more information see: Cruz de Carvalho, Varela, do Paço and Branquinho, 2019, Kożuchowska and Kożuchowski, 2021, Horticulture Magazine, 2021, Optigrün Roof Greening, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021.

Hydroponic mobile living walls / vertical gardens

Many plant species are suitable for hydroponic living walls. In this case, the decisive factor in the composition of the species list is the small size of the installation, which can function as street furniture. Therefore, only small perennials and dwarf shrubs, easy to root and easy to care for, were proposed. The list includes species known as cover plants, including both light-loving and shade-growing.

Ajuga reptans, Asplenium scolopendrium, Asplenium trichomanes, Campanula rotundifolia, Carex nigra, Cyclamen purpurascens, Fragaria vesca, Helianthemum nummularium, Lysimachia nummularia, Melissa officinalis, Mentha piperita, Myosotis alpestris, Polypodium vulgare, Sedum reflectum, Sempervivum tectorum, Thymus vulgaris, Tropaeolum majus, Vinca minor, Viola odorata

For more information see: Salas et al., 2012, Plants for a living wall, 2019, Horticulture Magazine, 2021, Lacey, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021.

Vertical vegetable/herb gardens

The list includes only those species of vegetables and herbs, which can be cultivated in a non-commercial vertical garden in the entire CE area without the use of special devices protecting against adverse weather conditions, such as e.g., a cold greenhouse or a foil tent.

Allium schoenoprasum (chives), *Apium graveolens* (celery), *Brassica oleracea var. Sabellica* (kale), *Brassica rapa* (bok choy), *Daucus carota* (carrot), *Fragaria x ananassa* (strawberry), *Lactuca sativa* (lettuce), *Melissa officinalis, Mentha spicata, Origanum vulgare, Petroselinum crispum* (parsley), *Solanum lycopersicum* (tomato), *Spinacia oleracea* (spinach), *Thymus pulegioides, Thymus vulgaris* (thyme)

more information: Busby, 2014, Horticulture Magazine, 2021, Plant selection guides, 2021, Vertical Garden Plant Species Guide, 2021, Wildflowershop.co.uk. 2021.

Compacted pollinators' module

The same herbaceous species can be used in this NBS as for the Natural Pollinators' Modules. The difference lies in the smaller species and smaller varieties of trees and shrubs, and it results from the limitation of the space occupied by the compact module.

Acer campestre (dwarf varieties), *Aquilegia vulgaris, Aster amellus, Carduus nutans, Centaurea cyanus, Cotoneaster horizontalis, Crataegus monogyna* (dwarf varieties), *Digitalis grandiflora, Echinops sphaerocephalus, Mentha x piperita, Nepeta nuda, Papaver rhoeas, Prunus cerasus* (dwarf varieties), *Prunus mahaleb, Ribes nigrum, Ribes uva-crispa, Salvia glutinosa, Salvia pratensis, Scabiosa columbaria, Stachys sylvatica, Thymus pulegioides, Trifolium pratense, Trifolium repens*

For more information see: Carlton 2020, Guidance - Pollinators in Planning and Construction guide, 2021, Horticulture Magazine, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021, Wild Flower Lawns and Meadows, 2021.

Rain gardens in planter (=self-contained)

The proposed plant species can also be found in the list dedicated to uderdrain rain garden. In the case of a self-contained garden, however, shrubs and several species of large perennials were omitted due to the limitation of the size of the area occupied by this installation.

Athyrium filix-femina, Bistorta officinalis, Carex flacca, Carex nigra, Dryopteris filix-mas, Eleocharis palustris, Equisetum hyemale, Iris pseudacorus, Lysimachia nummularia, Lythrum salicaria, Mentha aquatica, Menyanthes trifoliata, Myosotis scorpioides, Trollius europaeus

For more information see: Lord, Loh and Sia, 2014, Woods, Ballard et al., 2015, SuDS Construction Specification Clauses, 2016, Horticulture Magazine, 2021, Plant selection guides, 2021.

Street planters (as green street furniture)

Almost any plant species can be grown in a sufficiently large planter. In this case, the decisive factor in the composition of the list of species and varieties is the size of the planter - such that its installation or movement in the city space would not be a significant logistical challenge. Only trees and shrubs, mostly dwarf forms, were proposed, assuming that the planter may also be a convenient place for all species of shrubs, perennials and annual plants that we recommend for use in urban spaces.

Acer campestre (dwarf varieties), *Betula penduka* (dwarf varieties), *Carpinus betulus* (dwarf varieties), *Cornus mas, Cotoneaster horizontalis, Crataegus monogyna* (dwarf varieties), *Crataegus x media* (dwarf varieties), *Fagus sylvatica* (dwarf varieties), *Hippophaë rhamnoides* (dwarf varieties), *Lonicera xylosteum, Prunus avium* (dwarf varieties), *Prunus cerasifera* (dwarf varieties), *Prunus mahaleb, Quercus robur* (dwarf columnar varieties), *Ribes alpinum, Ribes petraeum, Rosa sp., Salix purpurea (dwarf varieties), Ulmus minor* (dwarf varieties), *Viburnum lantana* (dwarf varieties), *Viburnum opulus* (dwarf varieties)

For more information see: Horticulture Magazine, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021.

Hanging wall planters (as green street furniture)

The list includes species with high aesthetic values, and at the same time growing well in various types of hanging outdoor planter (pots, baskets, boxes). They include both climbers, bedding perennials and annual species. The list includes both species that look spectacular throughout most of the season, and those that bloom in unusual seasons, even in winter. The proposal covers both species known as ornamental plants and plants commonly grown as herbs, vegetables or for edible fruit.

*Centaurea cyanus, Cerastium tomentosum, Cyclamen purpurascens, Dianthus barbatus, Fragaria x ananassa (*e.g "tristan" variety*), Hedera helix, Helleborus niger, Helleborus purpurascens, Lathyrus odoratus, Lobularia maritima, Lonicera caprifolium, Origanum vulgare, Scabiosa columbaria, Solanum lycopersicum - (*cherry tomato, e.g., "Tumbling Tom"*, Tagetes erecta, Thymus praecox, Tropaeolum maius, Verbena officinalis, Vinca minor, Viola tricolor var. Hortensis*

For more information see: Horticulture Magazine, 2021, Plant selection guides, 2021, Wildflowershop.co.uk. 2021, Wild Flower Lawns and Meadows, 2021.

Green covering shelters

The list includes only those species recommended for use on extensive green roofs, which create a very low biomass and have minimum requirements for the thickness of the substrate. In addition, we offer several species of moss known to easily inhabit green roofs throughout the CE area.

Bryum argenteum, Ceratodon purpureus, Didymodon fallax, Phedimus spurius, Polytrichum piliferum, Sagina procumbens, Sedum acre, Sedum album, Sedum reflectum, Sedum rupestre, Sedum sexangulare, Syntrichia laevipila, Trichostomum crispulum

For more information see: Cruz de Carvalho, Varela, do Paço and Branquinho, 2019, Kożuchowska and Kożuchowski, 2021, Optigrün Roof Greening, 2021, Plant selection guides, 2021.

8.5. Plant species that cannot be recommended for UEA in the CE region

It is not recommended to use in UEA invasive plant species defined by the definition of Invasive Alien Species (IAS) throughout the European Union:

"Invasive alien species (IAS) are non-native species that are deliberately or unintentionally introduced by human action outside their natural habitats where they establish, proliferate and spread in ways that cause damage to biological diversity" (Invasive Alien Species, 2021). These are, in particular, species included in the Invasive Alien Species of Union concern (union list) (ibid.).

When considering the selection of plants for UEA to be used in a given FUA, one should also completely abandon species listed on official or semi-official, country-specific / regional lists of alien invasive species. For example, in Poland, the list is published in the legal document (Dziennik Ustaw poz. 1260, 2011) and on the website of the state administration (Lista gatunków obcych roślin, GDOŚ 2021). Further information on individual species is available at atlas-roslin.pl (Snowarski, 2021).

The official list of invasive plants for Slovakia can be found at the website of ministry of environment (Nepôvodné a inázne druhy, 2021). Systematized information about Slovakia is also included in the studies available at sopsr.sk (Gojdičová, Cvachová and Karasová, 2016). In Thuringia, similar information is available at the website of the state administration (Thüringer Landesamt für Umwelt, 2021).

We also do not recommend invasive species from regional lists, according to the European NOBANIS database (NOBANIS, 2021).

There are also plant species whose natural range extends over the continental zone of Europe, but they are highly invasive and therefore are included in the national lists of invasive plants in Central Europe. We do not recommend such species for use in UEA in any FUA in Central Europe.

We also warn against "experimenting" within the UEA, involving the use of species of foreign origin, with a wide range of tolerance to environmental conditions (especially those recently imported from other regions of the world), the invasiveness of which in Central Europe has not yet been tested.

8.6. Plant species, including aliens, the possible use of which in UEA requires special care

Any decision to introduce a species of foreign origin (including a species naturalized in CE cities) should be preceded by checking the information about its possible (potential) invasiveness. Any decision to use non-native species not included in the official lists of invasive plants - whether in the EU, or in a given country or region - should therefore be preceded by an analysis of scientific databases dedicated to invasive species, e.g. the CAB International (Invasive Species Compendium, 2021).

If the species is listed in a specialized database of this type, its use in UEA requires special care and the decision should be preceded by an analysis including:

- assessment of information on invasiveness and / or expansion as derived from the content of databases
- assessment of the closer and further surroundings of the planned UEA site, in the context of possible threats to biodiversity of neighboring urban or suburban areas
- reference to the practical knowledge of city gardeners, foresters and botanists about the biology of a given species.

There are quite a lot of plant species with a wide range of tolerance to habitat requirements, including those traditionally grown in cities, with a proven potential for being invasive or expansive, but not on European, national or local invasive species lists.

Information on the potential invasiveness or expansion of alien species not officially listed as invasive plants should be obtained from all available country-specific or regional-specific sources. For example, for Poland, such information can be found at gdos.gov.pl and also in scientific databases (Tokarska-Guzik et al., 2012). Similar information can be easily found for most countries and regions, like for exapmple the northern part of Italy (Galasso et al., 2018).

It should also be checked whether new reports on plant invasiveness have appeared in the specialist literature, which may refer to the CE area, a given country or even a given FUA. It may be especially useful to consult the international database of invasive species (Pagad et al., 2018).

The biogeographic selection principles presented in this chapter and the previous chapters may initially appear confusing. The proposed way of using them is explained on the following three examples.

a/ *Acer negundo* - this species cannot be recommended for use in UEA in any Central European city because it is on the European list of invasive plants

b/ *Symphoricarpos albus* - this species is native to America, however, it has been cultivated in European cities for several centuries. This species is not on the European list of invasive plants, nor on the national lists for the Central European region Therefore, it should be checked whether this species can be considered permanently established in our city. If it meets this condition, the risk of penetration from the assumed location into valuable, natural ecosystems still needs to be assessed (especially if there are old forests or historic parks in the area).

c/ *Ulex europaeus*. This is an exceptional case, the natural range of this species is in the continental zone of Europe, but in Central European conditions it shows invasive features. If it is on the national or local list of invasive plants - it cannot be used in the UEA (this is the case, for example, in Poland). However, even if it is not included in the locally valid list of invasive plants, its possible use in UEA must be preceded by a particularly careful assessment of the risk of penetration from the assumed location into valuable natural ecosystems.

8.7. What to prefer: straight species or cultivated varieties/forms?

Plants significantly different from the wild type of a given species, as well as interspecies hybrids are widely available on the market. Commonly used terms are wild type (= straight species), variety, clone, cultivar, nativar, hybrid. In this handbook, we understand these concepts as proposed at Rodomsky-Bish, 2018. This classification clearly defines, sufficiently for practitioners, when we are dealing with a natural subspecies or a variety found in wildlife and propagated from seeds, and when, for example, with a cultivar, i.e., a plant obtained by cloning.

The ability to distinguish between wild-type plants and cultivated varieties/forms that are altered and /or grown differently than from seeds is important for a number of reasons. First, the environmental requirements of cultivated varieties/forms often differ significantly from those of wild-type plants of the same species. The rate of growth and the target size are also different, as well as altered longevity and hardiness. Moreover, there is a growing body of scientific evidence that “altered” plants provide less benefit to the urban ecosystem than wild-type plants. For example, it is known that in the case of trees and shrubs, varieties (including nativars) with discolored leaves are not preferred by insects. It is also known that in the case of perennials, pollinators do not always visit nativar as eagerly as the wild form, although it is species-dependent, both for nativars and for insects.

Our recommendations regarding the choice between straight species and plants changed in such a different way are presented in Fig. 8.3. In accordance with these recommendations, if there is a choice between straight species and nativar of a given species, we choose a wild form, especially if is to be of benefit to the city’s biodiversity.

We generally do not recommend UEA to use clones, cultivars other than nativars, or cross-species hybrids, especially if their impact on the city’s biodiversity is unknown or their environmental requirements are not well understood. We especially do not recommend selecting showy plants with an unclear taxonomic status.

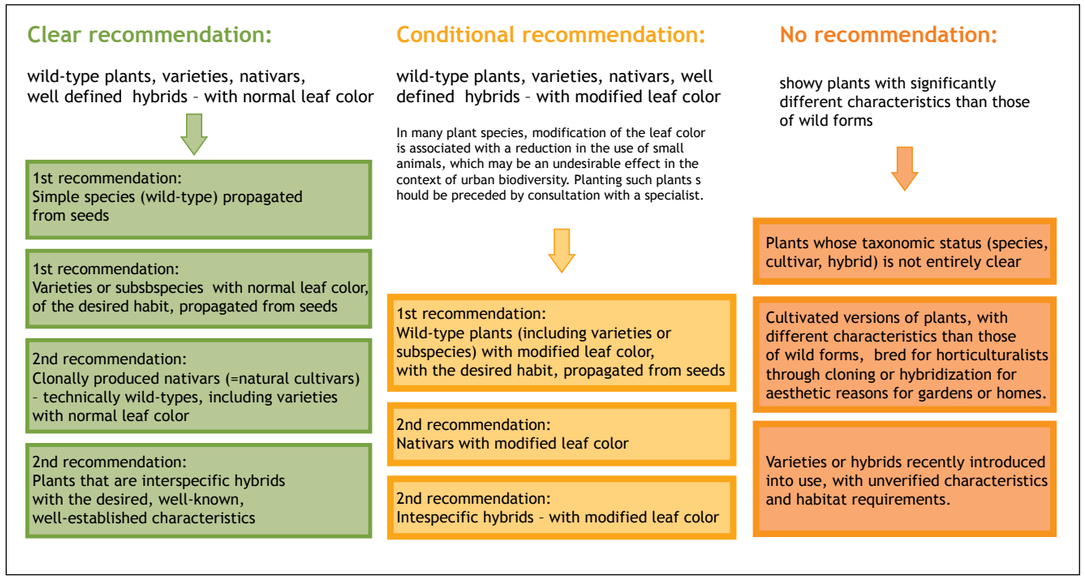

Figure 8.3 Recommendations regarding the choice between straight species and plants changed in such a different way. Authors’ own source

8.8. Requirements that should be met in order for a given plant species to be selected into the UEA

Whenever we intend to select species and varieties for use in the UEA, no matter what type of NBS is planned, the following general recommendations and specific recommendations should be followed:

General recommendations

The selection of plants should be limited to those species and varieties for which habitat requirements, impacts on other plants, humans, animals and infrastructure, as well as their growth rate, target habit, target size and required care are fully recognised

In order to permanently fulfil the target functions of greenery in the selection of species and varieties it is necessary to take into account in-depth recognition of:

social needs and expected benefits for the local community,

environmental conditions and biodiversity issues,

already existing plant cover at the site,

available space as well as current and planned infrastructure,

formal and legal restrictions,

availability of specialists with practical knowledge in FUA, for the introduction as well as subsequent care of such plants,

expected long-term cost of greenery introduction and care,

requirements of aesthetics of the place and urban landscape,

Avoiding, also in the long run, the use of space, high labour intensity and high cost of plant care.

In each practical case, the possibility of adapting existing plant cover elements, including spontaneously shaped, to the target functions should be considered.

When selecting plant material, both the short and medium and long-term use prospects of the adopted solutions should be taken into account.

Specific recommendations:

Full compliance with local environmental conditions

The key environmental factors are:

- soil fertility, depth, texture, type and degree of pollution, permeability, water holding capacity
- soil moisture and availability of irrigation, water
- access to sunlight
- exposure to strong wind and prevailing ventilation conditions
- he possibility of replacing or improving the ground (soil),
- the possibility of cultivation without ground contact (vertical NBS, green roofs, plants in containers)
- the hardiness zone in which the FUA is located – see Plantmaps - Hardiness Zone Maps and Much More, 2021

Regardless of the specifics of the site, there should be preferred these species and varieties that possible combine:

a wide range of tolerance to extreme temperatures - both high and early spring cold

high tolerance to extremely changing humidity conditions (long periods of rainless, heavy rains)

resistance to strong wind

low soil requirements

low requirements for lighting conditions (wide range of tolerance)

To reduce the risk of failure, preference should be given to those species and varieties that:

are known for being readily accepted in a new place (high plantability).

are already tested in practice in a given FUA under similar conditions

In the case of planting or sowing herbaceous plants (meadow, verge, green roof, lawn, pollinator's modules etc.), as far as possible, authorized, multi-species mixes adapted to the specificity of a given FUA and urban conditions should be used.

Providing big benefits in terms of regulative ecosystem services

There should be preferred these species and varieties that possible combine:

improving the conditions of air circulation (ventilation of the city)

reduction of air pollution

limiting the spread of noise

reduction of the UHI effect

There should be preferred those species whose use will be maximally beneficial for rainwater management.

On heavily contaminated soil, or in the case of rainwater pre-treatment (e.g., rain gardens, linear wetlands), plants with recognized phytoremediation properties should be preferred.

In some circumstances, the possibility of use plants as a bioindicators can be a selection criterion (e.g., air quality).

Compliance with the needs of protecting and strengthening biodiversity

There should be preferred:

native species and, secondly, species of foreign origin but permanently inscribed in the urban landscapes of the region, provided that they have low expansiveness potential

plant species or multi-species sets forming habitat and food base for small animals, including birds and pollinating insects

plant species and multi-species sets, with proven ability to limit the expansion of wild-growing invasive plant species

multi-species sets, providing long-term benefit for pollinators, from early spring to autumn

Promoting expected social benefits

There should be preferred these species and varieties that possible combine the following features:

provide the comfort of stay to the greatest extent, thanks to the local reduction of the heat island effect, local reduction of other onerous environmental factors, and also due to the improvement of aesthetic values of a given place

possibly improve the visual attractiveness of urban space, especially in reference to the local cultural heritage or urban layout

provide the widest possible range of benefits attributable to given type of green spot and given type of NBS

promote the multi-functionality of public space in UEA site and in its surroundings

ensure the maturity of the adopted solution as quickly as possible (the maturity understood as the capability to provide the target range of ecosystem services)

help to underline symbolic values of the site

have decorative qualities (flowers, leaves, fruits, bark, habit) for the longest possible period of the season

Conflicts / risk avoidance

The selection of plants should be limited to those species and varieties that meet the full set of the following conditions:

compliance with regulations regarding the avoidance of conflicts with infrastructure

not causing difficulties / nuisances in the daily use of adjacent areas

not creating threats resulting from the properties of plants (fragile branches, the possibility of secretion, poisoning, etc.)

not creating danger to people in connection with plant care or technical service of the site,

not creating obstacles / barriers for necessary works related to maintenance or reconstruction of technical infrastructure, both above-ground and underground

Facilitating further maintenance of the UEA site actual implementation

When choosing plant material among species and varieties with similar properties, preference should be given to those species or varieties:

whose care requires less labour, lower costs and less expertise

the use of which will bring a faster desired effect

which has less tendency for uncontrolled expansion in urban space

whose planting creates a chance for greater durability of a given solution and its functioning without the need for major renovation works

for which any errors or failure to care do not cause significant losses or risks

whose care will not include work at height

8.9. Required properties of the plant material for use in the UEA

For each species, variety, life form of the plant and for each type of NBS, the plant material MUST meet all of the following requirements:

- be certified, comply with the provisions / recommendations in force in the given FUA,
- be of the highest quality, free from defects identified as being unacceptable in accordance with existing regulations, standards, and recommendations,
- be properly protected during transport and storage,
- come only from authorized sources,
- be fully labelled according to local regulations,

- licensed varieties should be purchased based on the presentation of license documentation.

If the plant was delivered as rooted in a container, an obligatory condition is that such a plant was grown in that container for a sufficiently long time. In this case, the container parameters and its symbol must be indicated on the label.

In addition, you should always keep in mind the following principles:

Having an excess of plant material of a given species or variety at hand, should be preferred the one that gives the chance to achieve the target dimensions and ability to perform the intended features faster.

For planting native species, plant material produced from local nurseries, or from wild population that is as close as possible to the FUA should be preferred.

For planting on very poor urban soils, plant material produced on appropriately weak soils (pre-adapted) is preferred.

In the case of trees, shrubs and creepers, the following requirements MUST also be met:

the material was formed in the nursery in a manner adequate to the end use at UEA (the type of NBS, possible interactions with urban infrastructure, avoidance of social/spatial conflicts etc.)

morphological features, dendrometric parameters, as well as the shape of the root system are in accordance with locally applicable standards, regulations, and recommendations regarding urban greenery

8.10. Summary

The correct selection of plants for UEA is not a simple task. It requires a combination of efforts and competences of specialists from various fields.

Plant selection should be considered from the earliest stages of the green spot designing process. The list of plants should be verified several times during the development of the green spot project, incl. in connection with the decision to apply such and no other NBS.

We do not experiment in the selection of species and varieties; we only use species and varieties whose properties are well-known and whose behaviour in the urban ecosystem is predictable.

There are many plant species that, according to the biogeographic criterion, can be clearly recommended for use in any FUA throughout Central Europe, and at the same time are already proven in urban applications. In

this chapter, we present the names of several hundred such species, along with their assignment to individual NBS. We expect that such a list of species will be helpful especially in the initial stages of designing a green spot.

We do not use invasive plants; we do not allow the use of species on the locally valid list of invasive plant species. We also give up on a species that is not on official lists, if we are not sure whether it will reveal excessive expansiveness in a specific location and will not get out of control.

We prefer native species over naturalized species. Under certain conditions, we also allow alien species, if they are already permanently established in a given city.

We prefer natural (wild) varieties and forms of a given plant species. In particular, we avoid ornamental varieties bred by cloning or hybridization.

In practice, the choice of plant species for a given green spot will usually be a compromise between the recommendation to prefer native species, the recommendation to use the species best suited to the specifics of the urban environment (often they will be species of foreign origin) and the need to adapt your choice to the specific conditions of the site. At the same time, you need to be guided by the following premises:

- full compliance with local environmental conditions
- providing big benefits in terms of regulative ecosystem services
- compliance with the needs of protecting and strengthening biodiversity
- promoting expected social benefits
- conflicts / risk avoidance
- facilitating further maintenance of the UEA site actual implementation

The quality of the plant material is just as important as the selection of species and varieties.

We use only the highest quality, certified plant material, correctly labelled, delivered from an authorized source, and properly protected during transport and storage. It is especially advisable that the material is pre-adapted to harsh urban conditions and that it comes from a nearby nursery.

9. A concept for local action planning utilizing urban environmental acupuncture

Jessica Hemingway, IOER - Leibniz Institute of Ecological Urban and Regional Development, Dresden

9.1. Action planning in the SALUTE4CE Project

The implementation of 16 small green spots transnationally is no small feat. That is why researchers from the research area Landscape, Ecosystems and Biodiversity at Leibniz Institute of Ecological Urban and Regional Development have created the transnational concept for action plans. The concept is used as a guide for local actors and is adjusted to fit the individual needs of each FUA (Fig. 9.1). Action plans play a decisive role in SALUTE4CE project. They aid in implementation of measures needed to create small green spots within the four FUA's. The creation of a transnational concept for action plans generates continuity among action plans and pilot projects by bringing together visions, goals, and implementation strategies for small green spots at the local level.

Figure 9.1 Map of UEA pilot project locations where action plans were created. (Source: IOER, 2019)

Action planning is the process of creating a written document that describes how a specific set of actions are to take place to bring predetermined goals and visions to fruition. An action plan contains different elements which typically occur in chronological order (Tab. 9.1). There are various definitions of action plans, however the most suitable definition for the SALUTE4CE project comes from (Coyle, 2011); an expert in developing sustainable and resilient communities:

> *"It [an action plan] should be used to identify the specific tasks, timelines, and resources necessary for implementation. It will activate the community's vision by enabling the desired outcomes appropriate to the people and place, including the protection of natural landscapes."*

9.2. The process of action planning

Problem Statement and Goal Formulation

Begin the action planning process with general considerations relating to UEA. Identify the need or reason for using UEA. Is there a lack of large open space and thus a need to utilize small, underutilized plots for use as green space? Consider whether UEA is suitable in your FUA, city or district in relation to its advantages and potentials for instance, the low budget and fast implementation character, as well as the opportunities of citizen involvement. Identify and describe the potential of UEA to contribute and or relate to current and future planning policies (local, state, or regional). In general, it must be decided how UEA may help to address current planning challenges being faced.

Creating a local action plan

First identify the areas of your planning jurisdiction that have the potential to benefit from UEA. Example challenges addressed within the SALUTE4CE pilot projects include extreme heat, lack of vegetation, social dissidence, and a lack of biodiversity.

9.2.1. Phase one - the preparation phase (preliminary activities):

Deciding on responsible parties (e.g., forming an action planning team)

In the preparation phase a planning team that will be responsible for action planning needs to be assembled. This is dependent upon the needs of your project; however, some pointers are provided here. Firstly, an internal coordinator should be selected; this is the person in charge of leading the implementation of the plan. In addition, three to five core action planning team members should be designated. Within this team a contact person for citizen and resident concerns should be chosen; this can be the coordinator or an additional individual. Other potential members of the action planning team include individuals from municipality departments (e. g. planning, environment, parks, and gardens) as well as other relevant institutions or organizations that possess applicable expertise and interest in terms of green infrastructure (e.g., environmental organizations). The action planning team should consider whether an external moderator – outside of the core members (i.e., a neutral person who is not a formal member of the planning team or project) or someone from a planning office should be involved. It is important that the action planning team possess the skills, competency, and authority necessary to carry out tasks of the analysis and implementation phases. Considering the balance of skills within the core group is also important. It is useful to have Individuals on the action planning team that are influential and valuable in the process of planning for the UEA sites, they should also be motivated and have the time to contribute to the process (GreenKeys Team, 2008).

What types of activities does an action planning team carry out? The tasks of the action planning team include defining responsibility, creating pilot project visions and goals, organizing public participation activities, public relations, collecting data and external expert outreach among others. It will be necessary to create a working plan with deadlines for the team to ensure that goals are met. Specifying who is responsible for which task and by when. Also important is identifying required formal (legal) procedures which need to be considered as part of the planning and implementation process (GreenKeys Team, 2008). In addition to identifying individuals and assigning roles, the action planning team will be responsible for initiating the planning process, coordinating implementation and citizen involvement. The latter can be realised with a press release, an information note in the local official gazette and/or a post in the social media. Having additional support for your UEA project is essential to ensure success in all phases of the planning process.

What kind of support is needed locally to ensure success of my UEA project? Public, political, and financial support play an important role in UEA planning, it is important to win support for your project in the preparation phase:

Gaining support for the pilot project

Public support

This may include residents, interest groups and relevant experts and stakeholders. This is particularly important where the community should be involved in planning, building, maintaining, or monitoring UEA sites. The public should be included throughout the planning process; and be kept up to date about the progress of planning, including the development of planning procedures. Additionally, the public can contribute to building visions by making the needs of the community known. By getting to know residents or the future potential users of the respective small green spot, one can gain knowledge concerning the local situation and the needs of various groups and their expectations (i.e., what ecosystem services are particularly needed). The public can participate in UEA action planning in a variety of ways including both formal and informal collaboration (i.e., living labs, public events, goal-oriented workshops, or PR campaigns (GreenKeys Team, 2008)).

Political support

In the best-case scenario political support should be had at the beginning stages of planning and steadily improved upon throughout the planning process. Local political support should be obtained from the mayor and/or city council in the form of an approval letter or resolution. Political support is especially important when challenges arise in the planning process (implementation of tasks and actions) and can be important when presenting results of the pilot projects. Additionally, visions, goals and targets need to be accepted and confirmed by local representatives. The political support gained early in the planning process will prove to be vital in the planning process in later. In order to maintain a dialog, the action planning team is recommended to inform the city council and mayor of the planning process and the potential of UEA sites to improve green infrastructure or quality of life within the respective FUA, City or district (GreenKeys Team, 2008).

Financial support

Within the framework of the SALUTE4CE project it was necessary for pilot project partners to obtain additional

financial support outside of the project funding to implement UEA sites. In most cases it may be necessary to pool financial resources from several origins to create, implement and maintain UEA sites. Potential sources of financing include but are not limited to citizen donations related to city greening initiatives, a commitment from the mayor through the city budget, European Union funding or federal or state funds allocated to support biodiversity or climate change adaptation. Or other sources of funding that are less conventional such as funds collected as part of a lottery (GreenKeys Team, 2008).

9.2.2. Phase two - the analytical phase (gather and evaluate information):

Here information will be compiled concerning your FUA, city or district referred to as a profile and information concerning the physical conditions as related to greenspace.

Create a profile of your FUA, city or district

The purpose of the description of general conditions should result in background information necessary to understand how UEA sites fit into the bigger picture and may contribute to green infrastructure within your FUA, city or district. The focus of this section should be on demographics (i.e., population size and characteristics), the planning framework (i.e., relevant local administrative organizations, planning and legislative context, and national and international concepts and strategies relevant to small green space) and economic and financial circumstances (i.e., financial standing of your FUA, city or district, financing possibilities). Documents that may aid in creation of your profile include landscape, land use, strategic and comprehensive strategies, and plans.

Pre-selection of UEA sites

The collection of information concerning potential UEA sites will result in understanding the main physical conditions of your FUA and potential UEA sites. This will help to identify the key problems and the spatial hot spots. The characteristics of the physical conditions may include but are not limited to the quantity of greenspace/ green infrastructure in the FUA, city or district information concerning areas selected for a potential green space (soil properties, plant and animal species, environmental hazards, etc.), green networks/human resources (complimentary initiatives for potential cooperation) and number of residents within walking distance of UEA sites. For the selection of potential UEA sites the involvement of the local population is crucial. Often local people have a good knowledge about their neighbourhood and can enrich the analyses. A press campaign could support these activities and award the best proposals. The process of selecting the UEA sites in the analysis phase includes selecting the relevant intervention areas of your FUA or city, identifying potential sites within these areas and analysing the potential sites in preparation for the final selection.

Data collection & generation if necessary

If some of the required data is not available, it may have to be self-generated via templates or surveys or procured from an organization possessing the skills and tools. The process of generating data is a separate process from living labs. Keep in mind that the data collected or generated should be reliable and up to date to support proper decision-making and planning in the developmental phase.

9.2.3. Phase three - the developmental phase (decide and plan actions):

In order to be able to decide on and plan actions in this phase you will conduct three activities, the final selection of UEA sites, defining plan measures and conducting a living lab to gain final input on the selected measures.

Final selection of UEA sites

Based on results of the analytical phase a short list of potential UEA sites has been created. Subsequently, selection of the green spot type and assessment of NBS applicability will be conducted resulting in a final selection of NBS. Selection of the type of green spot to be implemented is based on the type of site that one is working with such as: traffic areas, multifunctional public areas, areas for peace/reflection, semi-public areas, or fallow (vacant) areas. It must be decided whether the original function of the site will remain the same, be changed or if it is at all possible to transform the site into a certain type of UEA site (e.g., urban orchard, green roof, community garden, etc.).

Defining plan measures

Based on the NBS selected, the action planning team will have to select actions necessary to implement the pilot projects. This includes targets or goals of the pilot project, that is, what is the purpose of your UEA sites? Which NBS have been selected and what must be constructed? This should include planting greenery such as, trees, bushes, climbing plants and grass and where pertinent benches, small architecture, or gaming tables. Your action planning team can further consider what restrictions exist after the UEA sites have been selected (i.e., whether certain features are permitted such as greenery or flowers requiring care or large trees).

Public feedback on the planning process - living labs

Living labs are to be conducted in the FUA, city or district with local inhabitants and stakeholders. Workshops should be organized locally together with project partners and other professionals. Living labs should consist of a guided discussion (e.g., round tables) and workshops to develop action plans for the UEA sites. This includes local and regional public authorities. The goals of the living labs should be to aid in criteria for selection of UEA sites, setting priorities and gaining knowledge from local stakeholders (SALUTE4CE, 2019). Conducting a living lab before you begin plan implementation may help to avoid any unnecessary conflicts or help to remind stakeholders of the tasks that they agreed on doing. The action plan should be finished at the conclusion of the developmental phase as it will guide implementation to create your small green spaces.

9.3. Plan Implementation

The actions have already been defined as specific targets and measures identified in the developmental stage. This includes the task, date of completion and individuals responsible for carrying out the task. You should proceed after the developmental phase with plan implementation based on pre-determined actions. After implementation maintenance and management plans can be created to ensure that pilot projects are maintained in the future. What is more, monitoring and evaluation of the implemented UEA sites can be conducted to measure the impact of UEA site creation (for more information see chapter 8). This is based on a set of indicators selected by the action planning team. Finally, a summary of the outlook and future perspectives for your pilot projects is recommended.

Steps of the Process	Task Description
Problem statement – Goal formulation	
Step 1: Preparation Phase (preliminary activities)	-Deciding on responsible parties (e.g., forming an action planning team) -Gaining support for the UEA sites (e.g., public, political & financial) -Defining planning procedures (e.g., Set milestones, work program, time-table)
Step 2: Analytical Phase (gather information, evaluation)	-Creation of a profile of your city/municipality (i.e., knowledge concerning general conditions and the local situation) -Pre-selection of UEA sites -Data collection & generation
Step 3: Developmental Phase (formation of action plan)	-Final selection of UEA sites and NBS types -Defining plan targets and measures -Public feedback on planning process and concept to improve the action plan (i.e., living labs)
Plan Implementation	

Table 9.1 The process of action planning for Urban Environmental Acupuncture

9.4. Lessons learned from project partners during action plan preparation

This information is based on the capacity building report deliverable D.T2.4.1 of the SALUTE4CE project.

From the Germany:	"The competencies of all those involved [in UEA planning] must be further developed to keep up with the demands [of green infrastructure planning]. To this end, the willingness must be awoken and kept alive. The city must succeed in strengthening communication between all stakeholders and work closely with private partners from business and civil society to stimulate cooperative ventures that tap previously unrealized savings and substitution potential. To implement projects and thus achieve goals, a widespread network of well-integrated stakeholders is needed to support and sustain the process. The establishment of support structures or the integration of existing approaches into the process is therefore an important task regarding long-term commitment of the actors."
From Slovakia:	"The list of UEA sites should be a living document and should also be updated and supplemented regularly or at occasional interval."
From Italy:	"The planning process can be improved through private intervention/contribution, associations involvement, and a multi-annual planning carried out by the Administration. Indeed, UEA has great potential. The effects of the climate change will oblige us to rethinking the use-destination of many small green spaces in the urban city centers (parking, small squares, etc.).
From Poland:	"The main differences [between planning for large and small green spaces] are the budget, momentum, number of entities involved in the realizations, size of the space, which must be found for the investment. The first step in improving the planning process for UEA is to convince decision-makers that such investments are important and necessary."

9.5. Summary

An important part of being successful at implementing urban environmental acupuncture is good preparation beforehand. This chapter has presented the basics of action planning for UEA and the process of creating an action plan as a means of good preparation. After action planning has been completed, you and your team should be well equipped to implement green space using the concept of urban environmental acupuncture. With an action plan in hand you will have collected the required information to implement micro green space in your city and possess a written document to share with others as well. Including, the purpose of the action plan, specific to your city as well as advantages and potentials of urban environmental acupuncture in addressing pressing urban problems. You will have identified those responsible for specific tasks, increasing the likelihood of plan implementation. Visions and goals of your community related to micro-green space have been identified and expanded upon during outreach activities such as living labs. What is more, public, political and financial support have been garnered and official agreements made to increase the likelihood of successfully implementing UEA within your city or FUA. The collection of data (spatial, population, environmental, etc.) and its analysis or expansion has been used to select UEA sites and project types resulting in sound decision-making. Maintenance and management plans have been prepared helping to preserve good quality public green spaces for the future. Finally, you and your action planning team have prepared monitoring and evaluation concepts for each UEA site in order to track progress in meeting the goals (e.g. increasing biodiversity, social engagement, student learning, etc.) of the community and stakeholders in the future.

10. Participation and communication with stakeholders and end users of urban environmental acupuncture

10.1. The concept of participation

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In a traditional understanding, participation means forms of involvement, inclusion, or integration of people. Participation can be seen as cooperation, communication, and interplay in relation to public tasks and goals. It is often understood as a form of governance, involving people in political decision making and planning. According to Bernard (2011), the possibility of participation should be understood as balancing inequalities of power between citizens and public administration. Following this idea, participation can contribute to build trust and make transparent the intricate procedures of planning.

Against this understanding it is no wonder that participation approaches are often a component of Green Infrastructure concepts as highlighted in this book. People in urban agglomerations depend strongly on urban green structures. This may relate to a playground for children, with dog walking, with the aesthetic value of urban green and other services. In our case we see a great potential to interconnect the idea of urban acupuncture with decision making processes in cities towards urban sustainability.

There is plenty of academic literature about participation in public decision making and planning, also in the field of environmental policy and management. Having a closer look at it, it can be distinguished *two main notions of participation*. One is interpreting public participation as a civil right in democratic societies (e.g., Calderon and Butler, 2019; Elling and Nielsen, 2017). In this notion it stands for the empowerment of people to take a stand for their civil rights beyond state authorities (e.g., Wright, 2012). Another one is highlighting participation as a tool to enhance the quality of public policies, decisions, programmes and plans. In this notion it serves to strengthen the legitimacy of political decisions and to create acceptance (Jami and Walsh, 2014; Reed, 2008). Both notions together have formed over the last decades the general understanding of participation.

Under these general considerations, we can distinguish some typologies which seem to be appropriate both for conceptualising participation and for designing practical participatory approaches which can be seen as well-established (e.g., Jami and Walsh, 2014; Reed, 2008).

At *first*, we can find a typology based on different *degrees of participation on a continuum*. Jami and Walsh (2014) proclaim that participation can mean to inform, consult, involve, collaborate, or empower people, in a close relation to Sherry Arnstein (1969) (Figure 10.1) who drafted a "ladder of participation" as a metaphor for different intensities of people's involvement in planning processes. The ladder consists of eight rungs describing the level of participation from the lowest to the highest. The steps can be divided into three categories: non-participation (manipulation, therapy), tokenism (information, consultation, involvement) and civic influence (partnership, delegated power, civic control). This classic model by Arnstein was further developed by other authors (e.g., Wilcox, 1994). Younger empirical research has shown that the need for participation depends highly on framework conditions and the nature of the problem (Hurlbert and Gupta, 2015, p. 100).

Figure 10.1 The ladder of participation as created by Arnstein (1969) – a milestone in participation research.

The *second typology is focusing on the forms, formats, and techniques of participation and the direction of communication flows*. As techniques of participation Jami and Walsh (2014) state referenda, hearings, surveys, negotiated rule makings, consensus conferences, citizen juries/panels, citizen advisory committees, and focus groups. As indicated, the form of participation needs to be in line with the purpose. In younger times the variety of participation formats increased. One technique to integrate civil society intensively in urban development is living labs. We will come back to these formats later in this chapter.

The *third typology focuses on the normative principles of participation*. As important aspects to achieve acceptance for public policies and decisions are seen fairness and justice. The fairness of outcomes and process justice can be understood as a precondition for public acceptance (Innes and Booher, 2004; Wolsink, 2007; Wüstenhagen et al., 2007). Deficits in justice and "the general feelings of loss and control" can provoke opposition e.g., against infrastructure projects (Cain and Nelson, 2013). Schweizer et al. (2016) underline that participants must have a real influence on the result and that the mandate for the participants as well as the limits of their influence should be clear from the beginning.

Other studies — this leads to the *fourth typology of participation* — are highlighting success factors of participation like the involvement of lay knowledge, the openness of the process, and social capital building on local level (including creating a network of actors during the implementation) (e.g., Drazkiewicz et al., 2015). Whereas participation can be seen on the one hand as a "planner-centred" process, suitable to legitimise planning decisions, it can be seen on the other hand as "people-centred" to develop local democracy and to empower stakeholders (Michener, 1998). Also, Nanz and Fritsche (2012) highlight the potential benefits and the relevance for the involved parties in participative processes. They interpret participation as a form of preserving and regaining of political scope for action and the creation of new places for deliberative co-determination.

When we summarise these typologies, we could come to the result that the higher the quality of participation is the better are the results of planning processes as well as their acceptance (e.g., Reed, 2008). But there is also a lot of scepticism when we look at the practical experiences. Participation would often be "insufficient and strongly controlled by the authorities" (Elling and Nielsen, 2017, p. 11). "The literature often romanticizes participation." (Hurlbert and Gupta, 2015, p. 101) Frequently contributors in participation processes perceive the methods as inadequate and inefficient. In a general criticism Innes and Booher (2004, p. 419) proclaim that "methods of public participation in government decision making in the US public hearings, review and comment procedures in particular do not work". Also, in other contexts there is still a "gap between citizen expectations and satisfaction with participation" in local decision making (Weymouth and Hartz-Karp, 2019).

We can learn from this that many decision makers in policy and public administrations try to use participation in a way to manipulate the public regarding the social, economic, and environmental impacts of investments. Heery and Noon (2008) determine some common ways of "pseudo-participation" — an approach in which keypersons "cultivate an impression of openness but are careful to retain decision-making" :

- informing the public only after the decision has been made, without any opportunity to comment on it; this includes various forms of distracting the public and its activities for really important issues as well as for irrelevant ones.
- gaining the public — also only after the decision — the authority's effort to positively present the decision already made and to get the citizens on their side.
- consultation of the public just before the decision or publication of the plans in a "usual place" is done to minimize public awareness and obtain only formal feedback from the "affected" citizens.

Against the negative experiences, research has, on the one hand, investigated participation processes in the last years more critical, asking whether the idealistic assumptions which dominated in policy and research over decades can really be confirmed. On the other hand, new forms of involvement of people in development processes emerged, defining the roles of "experts" and "citizens" in a new way. From a research perspective this approach is called citizen science. It can be described as "scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions" (OED, 2014). It strengthens, in general, the position of laypersons in the field of knowledge generation in relation to researchers (co-creation of knowledge). Citizen science is seen both as a potential to improve the capacity as well as the results of scientific communities, and to increase the public's understanding of science (Hecker et al., 2018). So, it also does not come as a surprise that the implementation of Sustainable Development goals is seen as a field for citizen science. (Fritz et al., 2019)

Such a close relationship of local actors and researchers/planners (e.g., in urban development processes) is also a feature of living labs. Renn (2018) states that a goal of real world laboratories is the finding of strategies for more sustainable practices in a protected space to derive policy-compatible solutions for the future. The idea behind this is to co-create knowledge that is more robust and instrumental for triggering intended behaviour changes. This approach is also used in SALUTE4CE project to test the implementation capacity of urban acupuncture projects (for more details see 10.2.1).

Lastly, digitalisation opened new opportunities for participation. E-governance and e-participation are referring to the use of information and communication technologies in decision making processes. The use of public media is increasing the opportunities of involvement. In SALUTE4CE we are working with an Interactive Visualisation Tool (InViTo; see 10.2.2 and 10.2.3). Its main functions are the exchange of information, the support of knowledge co-creation as well as the knowledge transfer.

After many years of experience, there is a lot of guidance regarding basic principles of participation. Agora (2002) defined 7 basic values of civic participation which are (1) everyone affected shall be involved in the decision-making process, (2) public suggestion should have substantial influence on the final decision, (3) opinions of all involved actors and actor groups should be respected, (4) the involvement of the public is guaranteed as early as possible, (5) method(s) of participation should involve as much affected people as possible, (6) everyone has access to the relevant information, and (7) feedback is provided to anyone who contributed in any way.

The timely involvement of the public is of great importance. This means in an early phase of the planning, respectively decision-making process, considering also decision-making alternatives. All materials presented to the public should be comprehensible to all citizens. At public forums, the experts shall use commonly-used language. The tools and methods used should be proportionate. The number of inhabitants affected by the problem must be taken into account.

In addition to the human and material needs, financial resources are also needed to manage an adequate participation process. This can lead to higher process costs, which have to be an essential part of the planning budget.

It is necessary to have a comprehensive view of the issue of civic participation, which means to carefully consider the entire course of the public consultation process. Another principle of the participatory process is its transparency, which combines the easy availability of the discussed documents, which is also an opportunity to build trust.

Finally, Diváková (2018) offers some hints for facilitators of participation processes. Following the authors' opinion, the person in charge must clearly explain the purpose and the importance of civic participation, should be familiar with the methods of participation, encourage citizens to cooperate, trust people's skills and experience, and make meetings with citizens more pleasant. The facilitator shall support the discussion and listen to the opinions, proposals, and ideas of participants.

10.2. SALUTE4CE approach to participation

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SALUTE4CE project has among its objectives the implementation of four different action plans, in which different types of stakeholders are invited to contribute with their ideas and will. Thus, the action plans are organized as a participated approach also involving citizens in the successful implementation of the project.

In order to reach the highest rungs of participation ladder (Figure 10.1), SALUTE4CE project aims at introducing two elements in a participatory process. The first is the use of Living Labs approach and the second is the use of a digital tool for the improvement of knowledge and awareness of involved people.

10.2.1. From Participatory Processes to Living Labs

The concept of a living lab means many different things to different people, and various definitions abound. However, we are not on a quest to an ultimate definition here, but rather want to investigate the innovative approaches to city making and implement them in each one of the pilot cases, adapting to specific circumstances. For that purpose, we have found a common understanding of two central characteristics. First, living labs involve stakeholders and citizens in a process of "open innovation" (Chesbrough, 2003). That means that users (or citizens) play an important part in the design process. Not merely as 'product testers' at the end of a development cycle, but as co-designers in various parts of the design process. This is a shift from a 'user-centric' model to a "user-driven" one, meaning that users are not just "objects of the product development cycle, but … active subjects … - equal partners with the public sector, academia, and business" (Helsinkilivinglab.fi).

This involvement in the first stages of the process, namely in the definition of the problems, is a peculiar characteristic distinguishing living labs from traditional participatory planning: it's not only about listening and consulting users once professionals or politicians decided to tackle one problematic issue, but it's about finding

out together with all the actors involved what's wrong with our living environment and organizing a process for finding and realizing solutions.

Second: the design process takes place in an actual, physical environment. That is: a new technology or service is not developed in the lab, and then brought to the street. Rather, it is developed through iterative prototyping in the setting in which the final product is to be implemented. (Almirall, Wareham, 2008; Bergvall-Kareborn, Stahlbrost, 2009; Bergvall-Kåreborn, Ihlström Eriksson, Ståhlbröst, Svensson, 2009; Niitamo, Kulkki, Eriksson, Hribernik, 2006; Pallot, Trousse, Senach, Scapin, 2010; Sauer, 2013; Schaffers, Sallstrom et al., 2011; Schaffers, Komninos et al., 2011).

Living labs can thus be understood as "innovative ways to innovate", involving users as co-creators as well as using real life settings as the development environment. This definition of urban living labs in a recent report by Friedrich, Karlsson and Federley sums up all these issues nicely:

Urban Living Labs are development environments that integrate residents and other stakeholders to develop and test new solutions in their daily life. The users of the new services or solutions are active partners in the whole development process, which happens in the real urban context. Urban Living Labs utilize various co-design methods for understanding the needs, generating solution ideas, presenting ideas and evaluating the solutions in practice. In addition, citizen participation methods are used for participation in decision making and taking action (Friedrich, Karlsson, Federley, 2014).

As such, living labs are presented as a way to overcome the top-down bottom-up dichotomy. The living lab approach merges institutional organization with the knowledge of situated communities. However, when comparing various projects, there is also a large variation in the actual level of citizen and stakeholder engagement, and various visions on the role divisions between professional designers and institutions and citizens. In a comparative study of close to 50 living labs, Concilio, Puerari and Rizzo define living labs as "design laboratories … led by professional designers." Many of the examples described in the literature underpin this point. It is usually institutions or companies that take the lead and set the stage, asking citizens for their input, or aiming to harvest the "wisdom of the crowd" to develop a solution for a problem that they have put on the agenda. Living lab approaches are often connected to broader innovation strategies such as "Public-Private-People-Partnerships" (Tang, Hämäläinen, 2014) and the Quadruple and even Quintuple Helix (Baccarne et al., 2014; Carayannis, Campbell, 2011), again meaning that various stakeholders (private companies, research institutions, governments and citizens) work together in an actual environment.

Yet, Concilio et al. also acknowledge that this does not necessarily need to be the case. Quite a few of the examples that these authors describe are initiated by citizens, who have set up some kind of (often) online platform on which they can set the agenda themselves, sometimes in order to find solutions between the platform users, at other times aimed at "engaging public institutions into them." (Concilio, Puerari, Rizzo, 2013) Similarly Baccarne et al. describe a living lab as a 'platform for grassroots service creation in a city'. These authors connect these platforms with a so-called "hacker's ethic". With this they mean a DIY-culture that "promotes the idea that anyone is capable of performing a variety of tasks rather than relying on paid experts or specialists" (Baccarne et al., 2014). In this vision, living labs are platforms or events such as hackathons where citizens come together to take on urban issues themselves.

10.2.2. Introduction of digital tools in the participative process

The practice of decision-making processes encounters two main obstacles to overcome. The first is due to its inner structure based on uncertainties about the future, and often laying on incomplete and fragmented data. The second is due to external relations in which the communication play the main role.

Specific tools known as Decision Support Systems (DSS) can support both these issues, providing an organised framework by means of a scientific approach, which aims at being a transparent, objective, and rational method for dealing with the questions to be solved. In order to support the decision-making processes, both the academic research and commercial companies have produced a large number of tools and methods, providing wide opportunities of choice. However, only a part of these instruments is able to offer user-friendly ways of communication so to improve knowledge and awareness.

Many DSS base their outputs on automatic processing derived from complex mathematical formulas, asking users to trust on their black box systems (Latour, 1987), instead of building a relationship between users and information to be communicated. As reported by Te Brömmelstroet (2010), important bottlenecks concern communication issues between models and users, such as "low communication value, lack of user friendliness" and lack of "interaction". These complex tools increase the mistrust in technological supports among professionals involved in decision-making processes and have strong consequences on their usability (Klosterman, Landis, 1988; Couclelis, 1989, 2005; Scholten, Stillwell, 1990; Harris, Batty, 1993; Bishop, 1998; Sheppard et al., 1999; Stillwell et al., 1999; Uran, Janssen, 2003; Batty, 2003; Geertman, Stillwell, 2003; Vonk et al., 2005; Andrienko et al., 2007; Pinto, Antunes, 2007; Klosterman, 2008, 2012; Geertman, Stillwell, 2009; te Brömmelstroet, 2010).

Scientific literature agrees on considering tools as a support and an extension of professionals' abilities (McLuhan, 1967), outlining the need for products which could enhance human capabilities towards building knowledge and awareness. Klosterman (1997) interprets DSS as an "information framework", in which technology is conceived as a means to enable the individual experience and expertise of actors involved in the building of informed decisions.

In the decision-making process, people have to interact, communicate, exchange ideas, share information, but also defend their interests and carry out their reasoning. This can be easily supported by a personal investigation of the information contained within data, where information is intended as the essential step before knowledge and awareness. In particular, the process of decision-making requires that all the stakeholders involved are aware of all the possible consequences to their choices. The opportunities given by ICT can aid their activities, especially by simplifying the processes of information sharing and enabling the exploration of data.

MacEachren and Taylor (1994), MacEachren et al. (2004), Thomas and Cook (2005) outline how many of the problems related to information can gain benefits from the combined use of visual and interactive communication systems. While visualisation can overcome language barriers by offering a common visual basis for sharing information and enhancing discussions, interactive interfaces allow data readability, exploration, and discovery, improving the direct dialogue between users and data (Andrienko and Dykes,2011; Andrienko, et al., 2007; 2011; Masala and Pensa, 2014). This approach allows to integrate the "power of computational methods with human's background knowledge, flexible thinking, imagination, and capacity for insight" (Andrienko, 2007).

"Through perception and intuition, visual communication allows actors to quickly implement their skills in reasoning. In addition, if accompanied by an interactive system, visualisation can be a very effective method for the construction of knowledge (MacEachren et al., 2004), which can be both individual and collective, and that would make actors aware of their choices as well as of the effects of such choices" (Pensa and Masala, 2014a).

By using interactive and user-friendly interfaces, users can create a form of dialogue with data. Filtered by their human experience and exploiting their individual skills, users are allowed to build their personal reading of information through connecting data and shaping hierarchies between the parts. Therefore, interactive interfaces facilitate the process of self-learning, in which users build their knowledge and are supported in taking aware decisions.

In this context, the academic literature agrees on the abilities of visual and interactive tools in transferring knowledge, considering their use as a possible methodology for enabling new approaches within participated processes, where a heterogeneous public is generally involved, and effective communication is essential for a well-performed activity and a successful result.

10.2.3. The example of the use of Interactive Visualisation Tool (InViTo)

The research experience gained by PP06 – LINKS during a number of European projects brought to the implementation of a tool for supporting system for decision-making, named Interactive Visualisation Tool (InViTo) (Pensa & Masala, 2014a; 2014b; Pensa, Masala, Lami & Rosa, 2014; Masala, Pensa & Tabasso, 2019). Based on the interactive visualization of data, InViTo produces multicriteria weighted maps by the setting of filters and buffered effects managed by users. The tool is an open web-platforms which uses dynamic maps in order to translate data into a visual and intuitive language. Resulting maps can be used for exploring the connections between data, their hierarchy and spatial distribution across territories.

Several workshops performed during the last decade showed that experts often look for problem explanations instead of problem solutions (Abastante, et al., 2014; Masala, Pensa, and Tabasso, 2014). Therefore, the development of the tool was oriented in implementing a system, which does not aim at providing definitive solutions, but at helping users in:

- identifying most relevant elements in the production of an effect;
- understanding which are the most-important elements that can significantly contribute to the development of their strategies.

In order to achieve this target, new methods for visualize spatial data have been investigated so to improve the process of communication and knowledge of spatial features. First of all, data can be filtered along different levels of details. On a lower level, information can be grouped in macro-categories such as layers or fields, while on a higher level, databases can be investigated based on single records allowing the identification of each single part. Secondly, by applying filters such as sliding cursors, scroll-down menus or checkboxes, map-users can obtain information about each single attribute and relate it to other elements. The exploration of these relationships between data is essential to draw a hierarchy between the parts and build a personal structure of information. Lastly, the easy interaction with large databases allows users to define the relationships between the parts and the whole, providing them with a map useful for detecting factors of inefficiency, ineffectiveness or critical areas which need further reasoning concerning their planning or design.

During the LUMAT Interreg CE project, the tool was applied also in a series of local workshops where both politicians and technicians positively valued the tool. Firstly, they appreciated the use of the tool as a stimulator of debate and, secondly, as an important support for decision-making processes. In particular, they found the possibility to visualize the entire area at once very important, providing a general “perception of the whole” of FUA, where municipal boundaries were overcome by environmental needs and necessary common solutions. (Masala & Tabasso, 2018)

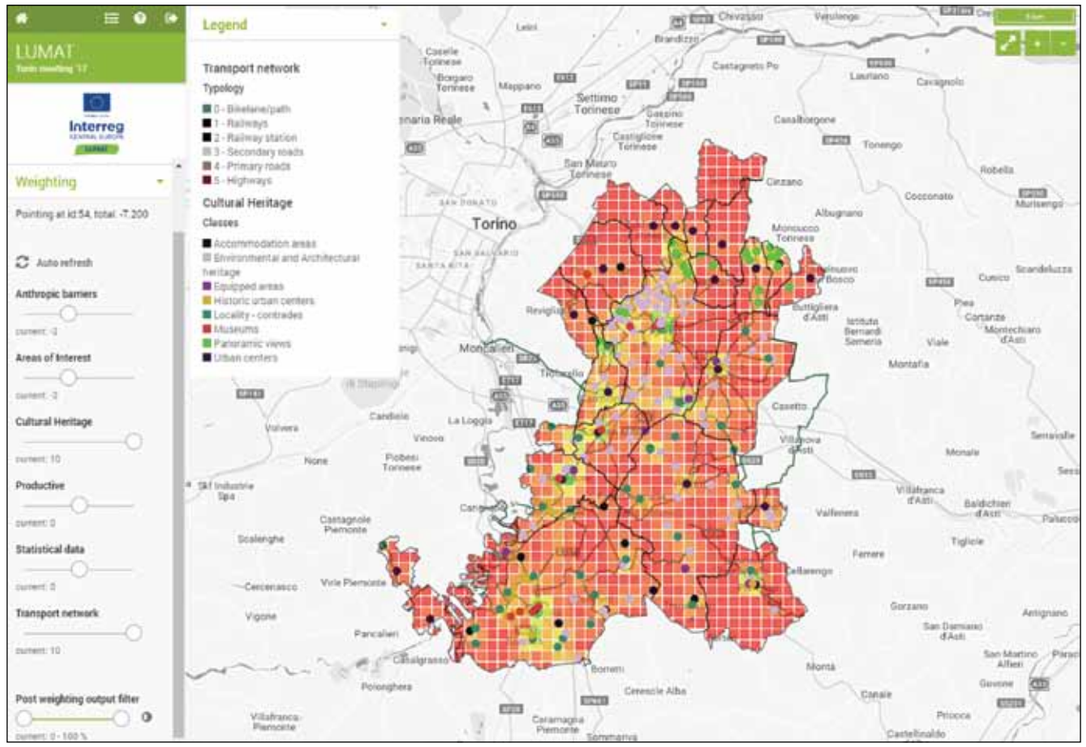

Figure 10.2 Example of InViTo interface. In this illustration, the tool was applied to evaluate the accessibility to FUA Cultural Heritage by different kind of public and private transport services within the LUMAT Interreg CE project.

Past experience showed that the use of InViTo in participated workshops enhanced the knowledge building of stakeholders involved. It did not provided solutions but supported the actors in understanding territories by themselves, outlining critical elements and existing opportunities.

In SALUTE4CE project, the use of the tool is planned for improving the involvement of citizens in participative processes on urban environmental acupuncture. It will introduce a multidisciplinary, trans-sectoral approach to implementation of UEA action plans on FUA scale, providing evidence of benefit on different spatial scales. This activity will strongly contribute to the implementation of the local pilot actions. Producing dynamic maps, it can show to actors involved different information such as the soil and climate conditions, the presence of blue and green infrastructures, eco-system services as well as maps with the identification of measures and actions able to improve the urban environmental management of FUAs while meeting the needs of citizens and residents.

10.3. Overview of participation forms and techniques

Iva Tichá, IURS - Institute for Sustainable Development of Settlements

Many handy, digital tools and methods are available, providing wide opportunities of choice at different levels of communication for the improvement of knowledge and awareness of involved people.

Questionnaires, surveys, interviews

Questionnaires, surveys, and interviews are considered tools of public involvement in some cases of the 1st and 2nd degree. However, well-constructed target group interviews can be very helpful for the whole participatory process and, ultimately, can help encouraging public involvement. A basic survey of public opinions allows figuring out the needs of citizens, but it can also be a mediator who finds out about the public opinions and attitudes towards the city or municipality management.

Addressing the public in different times of the day, in different places, in different environments is necessary to reach the largest possible sample of people. However, if information is needed from only one specific target group, interviews should be realized in places where a target group is most likely to occur.

Public discussion, Public hearing

Public hearing is often used for discussing professional topics. It involves public representatives, for example, the investor, the office, and/or politicians, who explain the problem to citizens. Citizens can actively enter the process through questions raised at the panel. It starts with the introduction of the so-called key players – for example clients, investors, etc. There are not usually more than 5 people, which is the recommended number. The moderator has the role of facilitator, just passing the word on to the individual panellists.

Tip: Make use of area maps, zoning plans, studies, and such. If the public hearing is not very professionally focused, use the form of public hearing with the agenda instead.

Public discussion with the agenda

Public discussion with the agenda is a very effective form of public discussion.

Round table discussion

The idea of the Round Table, at which are no edges and therefore everyone is equal, dates back to the time of King Arthur. The principle is very similar to contemporary round table discussions. It very much depends on who convenes them and what authorities are invited. Nevertheless, it is a very interactive form of public involvement, and we time it for the third or fourth stage of the participatory process, as it expects active discussion and output from all its participants. The round table should set parameters for problem solving and in most cases it is not uncommon that very often a series of round tables is implemented, in some cases with different target groups. It is also possible to hold a public round table — a public discussion of personalities representing different opinions — but this type is not very interesting for “listeners”. Mutual agreements are concluded at round tables.

The round table must be led by an experienced moderator or facilitator.

The number of people at a closed round table is max. 15 (the higher the number interactivity disappears).

Tip: Use the round table as another level of public involvement, as a concretization of proposals in the presence of experts. The round table is not suitable for supplying participants with initial information. Everyone should have the same information base.

Workshop

It is focused on processing comments on specific topics, seeking mutual understanding and preparation for consensus, such as brainstorming. In this case, a decision or a proposal for further action must be made.

Based on the needs and availability of organizers, it can last all day.

The workshop must be run by an experienced facilitator. Since it generally has a long duration, it can be quite exhausting.

Planning day/weekend event

The planning weekend or day (duration: 1 to 3 days) is used in cases where the public administration needs the active participation of citizens in the preparation of implementation. Mostly it is about planning the modifications of public spaces and is preceded by almost all the above activities, supplemented by others - art contests for children, building of models, etc.

The planning day must be led by experienced facilitators, depending on the number of people, but at least 1 main facilitator, 2-3 auxiliary. Today, this form is used very often and is accepted by an increasing number of public administration representatives, as it already has its specific outputs and examples.

The planning day has its clearly defined rules, and their methodology is described in detail in the publication SALUTE4CE – D.C.6.1.

Tip: The whole event must be very well organized. If you do not have a sufficiently experienced team, do not embark on event-planning, and choose another method.

Conference

One or multi-day meeting where technical experts and representatives of different groups meet to discuss a predetermined topic. Conferences also include presentations.

A conference or a series of conferences may also lead to an agreement between technical experts.

Living Labs

Living labs involve users as co-creators, using citizen participation methods for participation in decision making and action-taking.

Living labs aim at finding out together with all the actors involved what’s wrong with our living environment and organizing a process for finding and realizing solutions.

Furthermore, the design process takes place in an actual, physical environment. A new technology or service is developed through iterative prototyping in the setting in which the final product is to be implemented.

Digital tools

Visual and interactive tools are recognized as effective means for transferring knowledge and enabling new approaches within participated processes, where a heterogeneous public is generally involved, and effective communication is essential for a well-performed activity and a successful result.

While visualisation can overcome language barriers by offering a common visual basis for sharing information and enhancing discussions, interactive interfaces allow data readability, exploration, and discovery, improving knowledge building process, which can be both individual and collective, and that would increase awareness among the audience.

The advantages and disadvantages of each participation tool are summarised in Table 10.1.

Table 10.1 Advantages and disadvantages of each participation tool

	Advantages	*Disadvantages*
Questionnaires, surveys, interviews	Little time consuming	
Public discussion, Public Hearing	Simple and financially not very demanding form of public involvement, relatively well-known and interesting for the media, well managed feedback from the public	People usually consider this event more of a staged play and you must be ready for that. Beware of the weather, it can greatly affect the course of this event.
Public discussion with the agenda	A very effective form for informing the public that „something is going on“. It is also an opportunity to receive many opinions in one place in a short time.	People usually consider this event more of a staged play and you must be ready for that. Beware of the weather, it can greatly affect the course of this event.
Round table discussion	Great interactivity, inexpensive. In most cases there is an agreement.	Very demanding in terms of organization. Duration: maximum1.5 hrs
Workshop	The workshop is very effective if all the previous steps have already been taken, the participants know each other and know what they can expect from each other; a concrete conclusion and proposal can be reached.	Time-consuming and demanding in terms of organization
Planning day/weekend event	Very active participation of citizens, adoption of a „general“ consensus to the plan	Time-consuming preparation, relatively high costs
Conference	They are able to create a „common group feeling“ or consensus among the leading experts, which can serve as the most expert estimate when trying to solve the most difficult technical problems.	A lot of time required for preparation and very high costs
Living Labs	It brings to a shared solution and to a physical final product.	It is time-consuming and needs very good moderators in group management. Difficulty in carrying on the process from the starting point to the final solution.
Digital tools	Sharing of information through visual languages, recognized as more intuitive. All you need is a computer connected to the internet and a projector.	It requires almost half a day preparation of the audience with a pre-workshop.

11. Case studies

On the basis of documents from *Jody Marco Abate from* Municipality of Alessandria, Christian Bachmann from Impulse Region, Agata Beryt from Urząd Miasta Chorzów, Jana Kormaniková from Mestský úrad Liptovský Mikuláš, elaborated by Eduard Vojvodík IURS — Institute for Sustainable Development of Settlements

This chapter aims to show what can be built in a city space with the NBS application. It will show how long the processes take and how much everything costs. The aim is not to describe the details but the basic idea and goals.

The chapter is divided according to the main types of solutions that have been implemented for the SALUTE4CE project: green walls, public gardens, pocket parks and greenery in public spaces.

The following cities where an element of the NBS was created were represented in the project — Liptovský Mikuláš (Slovakia), Alessandria (Italy), Chorzow (Poland), and Apolda, Erfurt, Jena, Weimar (Germany).

11.1. Green walls (facades) in the SALute4CE project

Green walls also, known as facades, were built in Slovakia (Liptovský Mikuláš), Poland (Chorzow), and Germany (Apolda). In Chorzów (Poland), the overall regeneration of the site includes a green facade made of climbing plants. This is an example of another vertical green element in acity space.

A green vertical wall in the House of Culture in Liptovský Mikuláš (Slovakia). The House of Culture built in the 1980s is located in the historical part of Liptovský Mikuláš. It is a square building with a flat terraced roof and a light brown marble exterior. The facade, on which a green wall has been installed, consists of a marble wall with small architectural elements and windows. The entrance to the building is adjacent to a tarmac area, partly used as a car park. The House of Culture provides the citizens of the town and the region with a rich offer of cultural and social events. (Fig.11.1)

Figure 11.1 Green wall in Liptovský Mikuláš — before. Photo: P. Starek

Figure 11.2 Green wall in Liptovský Mikuláš — after. Photo: P. Starek

A green wall with a water collection and distribution system for irrigating the greenery was planned and built.

The green wall area is 51 m^2. On 23.7.2021 the competition of applicants for construction was announced and proposals were submitted on 4.8.2021. The building contract with a winning applicant was signed on 20.8.2021. The planned costs were EUR 29,070. First and second unsuccessful public procurements were held from May to June 2021. The third one took place in July and August. Works on property started on 22.9.2021 and in line with the contract were finalised on 30.11.2021. (Fig.11.2)

Another example of a green wall is the green wall on Chorzow Cultural Centre in Chorzow Sienkiewicza Street.

The location is on a street lacking greenery. The city is expected to construct a green wall, install an automatic irrigation system and wall lighting. Size of the space is 50 m^2. (Fig.11.3)

The Chorzów Cultural Centre is located in the city centre. Nearby are the Chorzów Centre of Paediatrics and Oncology, food outlets, bank, and Wolności Street, which is a city promenade. The project concerns the northern building elevations of the Chorzów Cultural Centre with an entrance. In front of the entrance to the Centre there is a square with a concrete cube surface. The same type of paving stone was used to make the surface of Sienkiewicza Street. The cube is laid on the same level, thanks to which the square is not separated.

The tender for the public procurement was opened to firms in May 2021. A contractor was selected in the first round and completed the green wall in September 2021. (Fig.11.4)

The total cost was approximately EUR 27,500.

Figure 11.3 Green wall in Chorzow — before. Photo A.Beryt

Figure 11.4 Green wall in Chorzow — after. Photo: A.Beryt

Another example where a green wall is employed to improve the environment in the city is in Apolda (Postgarten) in Germany. Unlike the previous examples, this is not a socially exposed site that was part of a brownfield site.

The area is located in front of a retirement home. Size of the locality is 0.157 ha (green wall 40 m^2). The building was a post office in the past and is now being rebuilt. Apoldas Train Station is 500m away. The "Bahnhofstraße" runs to the building. Following the road, the city centre is 400m away.

In addition to the retirement home, the Postgarten is being redesigned. This will be open to the public. With the reconstruction and renovation of the investment area, the different generations living together should be promoted.

The spot in Apolda will be a ground-based green wall. In addition, the goal is to install benches. The public procurement started in July 2021. The tender was closed in December 2021. The trellises will be completed by the end of January. Planting with climbing plants will then take place in March 2022, temperature permitting. Therefore, the trellises and climbing plants are not yet shown in Fig. 11.6. According to the construction company's offer, the expected costs are EUR 17,350. (Fig.11.6)

Figure 11.5 Green wall in Apolda — before. Photo: C. Bachmann

Figure 11.6 Green wall in Apolda — after. Photo: C. Bachmann

Green roadside in Moniuszko Street (Chorzow). Area is located on a dead-end street and was completely lacking greenery. Size of the locality is 300 m^2. A fragment of a roadside on Moniuszko Street bounded by a retaining wall (exit from the flyover behind the wall). The location in the city centre, with a view of the flyover and the building of the Main Post Office. On the other side of the street there is a row of tenements. The tenements windows overlook a concrete retaining wall. (Fig.11.7)

The project leads to the preparation of a separate green belt at the side of the street, the construction of free-standing structure to support climbing plants, the planting of climbing plants, and the reconstruction of the stairs.

Public procurement was finalized by signing of the agreement on February 2021. On 03.03.2021, the construction site was handed over. The works will be performed in accordance with the design.

The site is in the immediate vicinity of the post office and its location is atypical. It is part of a complex transport infrastructure whose grey walls are very unpleasant and uncomfortable. Despite the fact that it is not

Figure 11.7 Green roadside in Chorzow — before. Photo: A.Beryt

Figure 11.8 Green roadside in Chorzow — after. Photo: A.Beryt

a key investment, it is obvious that the moment the implementation is made and the wall will really grow. It will make the whole site more pleasant, reduce noise and dust. Users include primarily owners and inhabitants of buildings located nearby the street, but also those who use the car park at the described street section.

Regeneration was finalized in September 2021, costing approximately EUR 14,400. (Fig.11.8)

11.2. Public gardens and green courtyard in the SALute4CE project

Public gardens are represented in the Salute4Ce project by three sites. The first two examples are closely linked to schools. In both cases, the pupils were actively involved in the design and the actual implementation. The subchapter concludes with an example of the regeneration of a courtyard from a place that was unsightly and ugly to a place where people like to spend their leisure time.

LIptovský Mikuláš — Grandma's Garden at Demänovská grammar school.

The area on which the public garden is designed is part of the of the Primary School and Kindergarten on Demänovská Street in the Palúdzka district. The area is located in its north-eastern part. It is separated on three sides from the rest of the school grounds by a fence. There is free access to it from the west side. The school wanted to incorporate the area into its educational activities for kindergarten children and first and second grade pupils of a primary school (science, biology, practical, and technical education). The garden is now available to pupils, their parents, and to the residents of the apartment building that is part of the school grounds. (Fig.11.9)

Pupils of the school were involved in the design process for this approximately 600 m^2 site. Due to legislative constraints, the pupils could not prepare the entire implementation, including the project documentation, so a specialized company had to be engaged. So, on 28.4.2021 they asked local companies to go through the project documentation and tell them price for construction and material. On 17.6.2021 the contract for work was signed with a winning applicant. On 18.6.2021 the final version of the project and documentation of public procurement was sent to local the FLC for approval. On 21.7.2021 the FLC approved public procurement. Construction started on 5.8.2021 and ended on 24.10.2021. Pupils of the school participated in the planting of several trees and parts of flower beds under expert guidance. (Fig.11.10)

For 2022, sowing and planting of special types of plants is planned. The approximate cost of the whole project was EUR 12,939.

Figure 11.9 Grandma's Garden in Liptovský Mikuláš — before. Photo: . Photo: P. Starek

Figure 11.10 Grandma's Garden in Liptovský Mikuláš — after. Photo: P. Starek

Figure 11.11 Urban orchard in Alessandria — before. Photo: J.M. Abate

Figure 11.12 Urban orchard in Alessandria — after. Photo: J.M. Abate

Another example of a public garden is an urban orchard in Alessandria. The spot is a rectangular grass-grown level ground, 1,600 m^2, situated at the corner of via De Gasperi and via Galvani crossroad, in Europa's neighbourhood. The garden was a previously disused piece of land next to the school Villaggio Europa. City decided to turn it into a garden, where pupils from nearby school can play and take care of it. Teachers, pupils and their families participated in the implementation phases, didactic activities, and the care of the greenery. The area had long been uncultivated and poorly equipped: the aim was to create an 'urban orchard' by planting native fruit trees and sowing a mixture of wildflowers useful for pollinating insects. (Fig.11.11)

An unofficial meeting with residents and stakeholders was organized in September 2019.This meeting has been useful for the investment preparation documentation. Public procurement was undertaken between Dec. 11-15 2020. On 15.12.2020 the City called for offers of construction companies. On 30.12.2020 it was ended, and a contract was signed. Construction works started on 13.5.2021 and were finished on 30.9.2021. Benches were set up, a tree was planted in the middle of circle with wildflowers, a few other trees were planted around, and information desks were set up. The approximate cost was EUR 25,300. (Fig.11.12)

The Erfurt community garden is intended for active recreation for the residents of the settlements around the site.

Figure 11.13 Community garden in Erfurt — before. Photo: C. Bachmann

Figure 11.14 Community garden in Erfurt — after. Photo: C. Bachmann

The site in which the community garden is situated is part of 0.183 ha plot and is located in the Körnerstraße. This plot you can find in the vicinity of residential building block of flats , which are made with precast concrete slabs. On the location there is also a soccer field, which is concreted. In addition, a basketball hoop was added afterwards. The football field is surrounded by a metal fence. Parking is available at the edge of the area. A school is located about 500 metres away. (Fig.11.13)

The partner of Erfurt wanted to expand the possibilities of use (recreation, etc.) in order to increase the quality of visits. Therefore, an open space should be created, which families from the residential area can use. In the garden, people can grow fruit for their own use and for further education. In addition, the goal was to plant some trees and install benches. The partner of Erfurt has expanded the possibilities of use (recreation, etc.) in order to increase the quality of visits. Public procurement started in September 2021 and finished in October. Directly after this time the works started. Works on the area were completed in December 2021. The construction costs totalled EUR 22,764. (Fig.11.14)

Green courtyard in Armii Krajowej Street in Chorzow. Size of the locality is 511 m^2.

The tenement house with a yard is the property of the City of Chorzów and is managed by the PGM Municipal Plant. The project focused on a courtyard of approximately 300 m^2 located at the rear of the building. The front wall of the tenement is adjacent to one of the main streets of the city with heavy traffic. The yard was only used as a car park. Due to its dilapidated condition, the yard needed to be modernized. The area was shaded and without greenery, limited by the concrete retaining wall of the railway embankment, visible from the windows of the apartment building. The building was visible from the side of the building, which was visible from the building's wall. (Fig.11.15)

After regeneration of greenery and addition of furniture, the yard is used by inhabitants. There are 21 residents in this building. In October 2020, a company (after public procurement) carried out cleaning works. The works continue in the second quarter of 2021. The construction was finished on 20.6.2021. The approximate cost was EUR 5,500. (Fig.11.16)

Figure 11.15 Green courtyard in Chorzow — before Photo: A. Beryt

Figure 11.16 Green courtyard in Chorzow — after. Photo: A.Beryt

11.3. Pocket parks in the SALute4CE project

Now, we are getting to the third example of NBS, Pocket Park. First, we're going to introduce Pocket Park on Square of Peace in Liptovský Mikuláš.

Mierové náměstí is located in the central part of Liptovský Mikuláš, close to shopping centres. It has the shape of a triangle, the northern part of which consists of a car park of a department store, the eastern part of a cycle path, and the southern part of a local road. The current park is only a part of the original park, which was occupied by an asphalt car park and paved access areas to the department store. The area of the square is grassed with a few coniferous and deciduous trees. The total area is approximately 1,859 m^2. The location in which the park is located is one of the busiest parts of the city, and in proximity there is also the city library, a hotel, bicycle path, and shops with various goods. In its wider surroundings there is a House of Culture (green wall), and a synagogue. (Fig.11.17)

The project is meant as revitalization of an area pedestrian zone. Pocket Park was planned to include new trees, water elements, benches, and trampolines. On 24.5.2021 the city called for offers from construction companies. On 17.6.2021 a contract was signed with the winning applicant. On 18.6.2021 the final version of a public procurement was sent to local FLC for control, and on 27.8.2021 the FLC approved the public procurement. Construction works were started on 3.9.2021 and were finished till 17.12.2021. The approximate cost should be EUR 44,012. (Fig.11.18)

Figure 11.17 Pocked park in Liptovský Mikuláš — before. Photo: P. Starek

Figure 11.18 Pocked park in Liptovský Mikuláš — after. Photo: P. Starek

The site in Jena (Schützenhofstraße) will create a pocket park on the site of a school as a small area around and between buildings covered with trees and shrubs with publicly accessible greenery. Size of locality: 0.195 ha

The so-called 'Grünzug Schützenhofstraße' is secured as a green corridor in the Jena city plan for the long term.

The investment site is located in an area where there are buildings made of precast concrete slabs. In addition, the area has a sloping terrain. A staircase was installed to overcome the height difference. There is a car park and trees on the edge of the site. (Fig.11.19)

The regeneration of the previously neglected and unused site focused on planting adapted to the climatic conditions. It also emphasised the improvement of the entire site with urban furniture, especially benches.

The tender for the contractor was opened in May 2021. The selection of the contractor was completed with the signing of the contract in September 2021. The reconstruction and revitalisation of the area will run from October 2021 to March 2022.

The total expenditure is expected to be approximately EUR 32,000. (Fig.11.20)

Figure 11.19 Pocket park in Jena — before. Photo: C. Bachmann

Figure 11.20 Pocket park in Jena — after. Photo: C. Bachmann

11.4. Public green space in the SALute4CE project

The term public green space encompasses all the other investments that have been implemented from the SALUTE4CE project. They are all different, but all have a common feature, the improvement of the condition of green spaces, green spots in the area of residential zones and city streets. The individual examples are inspiring and show how diverse the solutions can be.

First, we can mention Neighbourhood green space in the inner block in the Podbreziny residential area, which is in Liptovský Mikuláš.

The location is part of the suburb of Liptovský Mikuláš. Podbreziny is located in the eastern part of the town. The area selected for revitalization is defined on three sides by apartment buildings. From the eastern side it opens into an open space. A pedestrian and cycling path run along this side and the Smrečianka River flows in close proximity. Its area is about 0.2 ha. Before the revitalisation it was a grassy area with pedestrian paths, a few coniferous trees planted by the residents of the residential block, and several elements of a children's playground. Due to the location of the individual blocks, it is a relatively shaded area. In the shaded areas (south-western part of the site) the ground floor parts of the walls are covered in moss. The planned revitalisation will positively improve the living environment for the residents of the apartment block (approx. 600 people). (Fig.11.21)

The preparation of the revitalization began in 2019 with the preparation of a proposal and discussion of the proposals with citizens at a public meeting. The final form of the proposal, which contains the elements of new trees and shrubs, a barefoot pathway and dry hill wall, was the result of this public consultation. On 21.5.2021 the city called for offers of construction companies. On 17.6.2021 a contract was signed. Precisely six months later the work should be done. On 18.6.2021 public procurement was sent to the local FLC and on 27.8.2021 was approved. Construction started on 6.9.2021. By 22.10.2021 all construction works were finished, and they were waiting for delivery of workout assembly. The approximate cost is EUR 63,845. (Fig.11.22)

Figure 11.21 Green public space in Podbreziny — before. Photo: P. Starek

Figure 11.22 Green public space in Podbreziny — after. Photo: P. Starek

Another example of public green space is in Alessandria — Refuge Forest

The area is an irregular shaped, grass-grown, irregular levelled ground of 1,225 m². This area is crossed by a huge asphalt string in front of the primary school "Morando", seated in via Benedetto Croce. The Institute was involved in the green-care (especialy plant cultivation) and in didactic activities. The project's goal was the realization of the "Refuge forest" through the plantation of trees and berry bushes in order to help the wild fauna. (Fig.11.23)

Figure 11.23 Refuge Forest in Alessandria — before. Photo: J.M. Abate

An unofficial meeting with residents and stakeholders was organized in September 2019. During this occasion, the project outline and selection of the best sites were shared with citizens. This meeting has been useful for the investment preparation documentation and drafting of the projects.

Figure 11.24 Refuge Forest in Alessandria — after. Photo: J.M. Abate

Public procurement started on 11.12.2020 and ended on 15.12.2020. The City called for offers on 15.12.2020 and ended competition of offers on 30.12.2020. Construction works were undertaken from 13.5.2021 to 30.9.2021. Trees, berry bushes, and a wildflower meadow were planted, description desks set up. The approximate cost was EUR 25,000. (Fig.11.24)

Another example of the regeneration of green public space can be found in Weimar. A green space is being created on the Weimar site (Insektenweide) as a playground and an area for outdoor learning both, for older and young generation.

Figure 11.25 Place of games and education in Weimar — before. Photo: C. Bachmann

Figure 11.26 Place of games and education in Weimar — after. Photo: C. Bachmann

Before regeneration it was a fallow field. The size of locality is 0.2 ha There is a nursery school in the immediate vicinity. There are residential buildings on the east and west sides of the area.

The site was originally covered in rubbish and partially enclosed. (Fig.11.25)

The site in Weimar is now a green space designed for outdoor play and learning for older and younger people. The city of Weimar has transformed an urban green space to promote biodiversity in order to create an additional food supply for insects. Public procurement started in September 2020 and finished in November of the same year. Work on this site started in the begin of 2021.

Works on the area were completed in August 2021. The construction costs totalled EUR 34,607. (Fig.11.26)

A green place for fun, relaxation, and sport has also been created in Alessandria — named the City's green lung (Via Teresa Michel) (Fig.11.27)

Figure 11.27 City's green lung in Alessandria — before Photo: J.M. Abate

It is a rectangular grass-grown area of 2,000m^2. On the south side the area is delimitated by a footpath planted with trees, and on the north side by the extension of the urban cemetery of Alessandria. Native forest trees are planned for planting, and a new pathway will be included with equipment for outdoor sports.

An unofficial meeting with residents and stakeholders was organized in September 2019. This meeting has been useful for the investment preparation.

Fig. 11.28 City's green lung in Alessandria — after Photo: J.M. Abate

Figure 11.29 Green Bankowa Street in Chorzow — before Photo: A. Beryt

Figure 11.30 Green Bankowa Street in Chorzow — after Photo: A. Beryt

Public procurement started on 11.12.2020 and ended on 15.12.2020. Offers were received and analysed between 15.12. and 30.12.2020. Construction took place from 13.5.2021 to 30.9.2021. The approximate cost for the project was EUR 24,700. (Fig.11.28)

Public spaces were reconstructed in other cities, such as Chorzow. We can mention the green Bankowa Street. The size of locality is 1,613 m^2. It was an asphalt street connecting General H. Dąbrowského Street with F. Chopin Street. Along the western edge of the street there is a cliff covered with trees (mostly small-leaved lime, sycamore, and maple) and shrubs (Chenault's snow, horizontal rockrose, and viburnum). The eastern edge of the street is adjacent to a flat area partly built up with greenery, with a pavement at the corner building.

The location is in the centre of the town and had the following problems: low plant diversity, poor surface condition, and use pattern. (Fig.11.29)

The key task of reconstruction was to replace the asphalt surface of the road with a grass surface, construction of sidewalk from natural materials, and planting plants to increase biodiversity.

In 2020, the company (after public procurement) purchased some material (litter bins and materials for the mineral-resin surface) and carried out sanitary cutting of trees. Currently, demolition works are carried out on the asphalt surface of the street. Concrete slabs for the pavement of the street were also purchased. All works were finished in June 2021.

Overall, the space is now pleasant and cheerful. People walking through the space feel comfortable. Yet, of course, the residents do not always agree with this investment. It must be said that the condition of the site has improved considerably. The approximate cost was EUR 65,726. (Fig.11.30)

The following example is a bit different, a bit atypical, but shows very suitable solution options, especially for city centres where planting directly into the soil is not possible.

In Alexandria's city centre, green planters have been targeted, 300 planters have been or will be implemented in the city's infrastructure to improve the wellbeing of residents. The old town is characterised by a lack of green space due to the almost complete lack of green areas. The aim of the project was to "metamorphosize" this area with the presence of planters containing bioindicative plants, on which an analysis will be carried out to evaluate air pollution. The aim of the project was to realise a "green space in the city centre".

Figure 11.31 Planters in Alessandria. Photo: J.M. Abate

No public procurement was carried out because the municipality carried out the entire project.

The works started on 1 July 2021 and finished on 30 September 2021. The approximate cost was EUR 34,800. (Fig.11.31)

11.5. Recommendations

Based on the experience of individual cities and the implementation of NBS in the city structure, the following recommendations have been prepared:

3. Locality selection - it is essential to pay attention to locality selection. It is necessary to check if the proposed development is not in conflict with any of the planning documents, for example a masterplan. It is necessary to check that another project has not already been prepared and approved for the locality (many years earlier). For example, for public spaces, if they have undergone renovation, it is necessary, as with buildings, to check whether there may be a conflict with the authorisation of the work.
4. Sufficient time - time is an important, key, and often limiting factor. If the investment is a public investment, the preparation of the tender and the subsequent competition are usually necessary. It must always be taken into account that a contractor may not be found in the first and sometimes in the second round. Then the whole project may be unpleasantly delayed and the investment may not be realised.
5. Money - The prices, unfortunately in the last two years due to the COVID-19 problems the prices of construction works and building materials, have increased. This trend can be expected to continue and lead to significant price increases.
6. Residents - any investment in public space directly affects residents. Therefore, it is essential to inform citizens as early and as thoroughly as possible about upcoming events. If the nature of the investment allows it, it is advisable to involve them both passively - filling in questionnaires, drawing proposals at workshops, and actively planting trees, making pots, etc. The involvement of school children is appropriate. Children are enthusiastic and very proud when they succeed.
7. Do not forget about experts and professional institutions. Getting more expert opinions and involving a wide range of organisations and institutions improves communication, awareness, and reduces possible negative practices if we make these people and institutions co-responsible for the process.

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